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Investigating the unobserved heterogeneity effect on outreach to women: lessons from microfinance institutions

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Abstract

The main objective of this study is to assess the impact of unobserved heterogeneity on microfinance social efficiency analysis. Based on recent nonparametric techniques and directional distances, we identify a latent heterogeneity factor related to the microfinance institute (MFI) manager's ability to promote women, independent of MFI size. We test for the significance of this unobserved factor and analyze the impact of MFI social inefficiency measures. Using a cross-country sample of 501 MFIs in 2011 from six main regions of the world, our findings reveal a significant effect of unobserved heterogeneity on the frontier and hence stress the importance of subjective factors in defining the set of production possibilities. We assess the robustness of our findings with the considered profit-oriented status and analyze the link between our unobserved heterogeneity factor and institutional and socioeconomic indicators.

Keywords OR in developing countries · Microfinance · Gender · Social efficiency · Unobserved heterogeneity · Nonparametric robust frontier models

1 Introduction

Microfinance institutions are financial enterprises with a social mission. They are hybrid organizations with a dual mission (Battilana & Dorado, 2010), alleviating poverty while

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also being profitable. Some experimental studies relativize the scope of the social impact of microfinance (Banerjee et al., 2015a, 2015b; Meager, 2019), suggesting that although micro-credit is an important field, its transformative effects on the poor are unclear. Nevertheless, microfinance is still perceived as an effective tool in fighting poverty and as an instrument promoting financial inclusion, especially women empowerment.

Investigating how microfinance institutions contribute to women empowerment through easing access to credit and the driving factors behind is relevant for at least two reasons. First, women are the most vulnerable and the greatest victims of inequality and financial exclusion in most developing countries. They experience greater discrimination in terms of access to resources (land and assets), property, income, education, financing and decision-making within households (Pitt et al., 2006). According to the World Bank (2021), 8 out of 10 female workers are engaged in vulnerable activities. By targeting women, microfinance institutions improve women's empowerment through access to credit. In addition, women are less risky borrowers insofar as female borrowers repay loans more than men (Abdullah & Quayes, 2016; Armendáriz & Morduch, 2010; D'espallier et al., 2013; Hermes & Lensink, 2011; Shahriar et al., 2020). For these two main reasons, social microfinance funders strongly encourage the targeting of women.

The current literature on the drivers of MFI social performance concentrates more on nondiscretionary or observable components of MFI social performance (e.g., Assefa et al., 2013; Barry & Tacneng, 2014; Cull et al., 2007; Hartarska & Nadolnyak, 2007; Hartarska & Mersland, 2012; Hartarska et al., 2014).

Concerning women empowerment and discrimination specifically with regard to access to credit, the current literature on microfinance has mainly documented the impact of observable factors on women's access to credit (e.g., Blanco-Oliver et al., 2021; Cozarenco & Szafarz, 2018; Nyarko, 2022). In addition, the analysis of the efficiency and performance of MFIs using nonparametric efficiency techniques is growing in the microfinance literature. To benchmark, compare, and to some extent identify good practices, some MFIs only focus on factors under the control of MFIs (e.g., Gutiérrez-Nieto et al., 2009; Piot-Lepetit & Nzongang, 2014; Piot-Lepetit & Tchakoute Tchuigoua, 2021).

The social orientation or greater social impact of microfinance may also depend on the ability of managers to use resources efficiently. The choice of an optimal combination of input to achieve better social efficiency is a managerial decision that depends not only on the technology, the quantity and the quality of inputs, and on environmental factors but also, and above all, on discretionary factors that are, by nature, latent and unobservable. The objective of this study is to assess the effect of latent heterogeneity on the social efficiency of microfinance institutions and to characterize these unobserved discretionary factors.

Taking heterogeneity into account is of paramount interest in microfinance, especially in the work of estimating efficiency frontiers. It is fundamental for improving the robustness of efficiency frontiers. The interest in taking this into account is increasingly understood by researchers. Recent works in the banking and microfinance literature systematically attempt to understand the role of heterogeneity factors on the effectiveness of microfinance (Chen & Lu, 2021; Fall et al., 2021; Yin, 2021; Zheng & Zhang, 2021). Heterogeneity is linked to any factor beyond the control of managers that influences the effectiveness of institutions. For example, the type of banking regulation, the level of poverty, the degree of corruption, the robustness of the country's legal institutions, and the level of security are all factors that can influence the efficiency of financial institutions. Likewise, certain factors within institutions are totally or partially beyond the control of managers and have an impact on managerial efficiency. The efficiency of a financial institution, beyond the combination of inputs and outputs, can be affected by the age and size of the institution, its financial structure, the quality of the staff,

the nature of the board of directors, and management skill. The impact of these factors on the efficiency of microfinance is of increasing interest to researchers. However, the studies are more interested in the ex post impact of these factors on the effectiveness of microfinance than in their actual inclusion in the estimation of borders. Moreover, taking heterogeneity into account in estimating efficiency frontiers has hardly been the subject of work in the literature. The recent contribution by Fall et al. (2021) is one of the rare studies to estimate the efficiency frontier of microfinance, taking into account the effect of heterogeneity. However, this work was interested in observed heterogeneity. There are unobserved factors of heterogeneity that influence the efficiency frontier, and not taking them into account can bias the estimated efficiency.

Modeling MFIs' social efficiency in the presence of latent heterogeneity and assessing its effects on firms' policies, accounting outcomes, and firms' efficiency requires quantifying these unobservable factors that are likely to drive efficiency. Existing studies on the quantification of this latent heterogeneity take two directions. A first stream, using Demerjian et al. (2012) latent heterogeneity quantification procedure, literature shows that latent heterogeneity such as managerial skills influences firm policies, accounting, risk and financial outcomes (e.g., Banna et al., 2019; De Franco et al., 2017; Demerjian et al., 2012; Demerjian et al., 2013; Vo et al., 2021). To quantify unobserved heterogeneity or managerial ability, Demerjian et al. (2012) and related studies adopt a three-step procedure. They first apply DEA or SFA efficiency methodology to generate firm efficiency measures. They then regress efficiency scores on several factors, including firm size and age, to distinguish between firms' efficiency-driven factors and unobserved factors, such as talent, managerial ability, or the quality of the management captured by the residual of the regression.¹ Finally, firms' financial and accounting outcomes are regressed on managerial ability to assess whether quality is a driving factor of firm performance and risk. Demerjian et al. (2012) show that the association between equity financing and future abnormal returns is mitigated by managerial ability. Demerjian et al. (2013) find that managerial ability is associated with better financial reporting quality and that earnings are of better quality in firms with higher-ability managers. Andreou et al. (2016), using bank-level data, find that liquidity creation and risk-taking behavior increase in banks with higher-ability managers, but the effect on liquidity creation decreases during bad times in more able managed banks. Using loan-level data from U.S. banks, De Franco et al. (2017) find that higher borrowers' managerial ability is associated with bank loan prices, suggesting that banks value managerial ability in pricing loans. Higher-ability borrowers are more likely to improve financial disclosure and thus mitigate information asymmetries in loan contracts. Curi and Lozano-Vivas (2020) considered managerial ability as a tool for financial stability and prudential regulation. They observe that during the latest global financial crisis, risk-taking behavior decreased in European Union small banks with higher-ability managers. Vo et al. (2021), using bank-level data, investigate the effect of managerial ability on bank lending behavior and document that a manager with greater ability is associated with a larger loan size and greater asset quality (loan portfolio quality). Banna et al. (2019) find a financial performance increase in MFIs with higher managerial ability.

A second stream is based on Simar et al. (2016) latent heterogeneity quantification approach that has been recently applied in studying efficiency in the public sector (Daraio et al., 2021) or in macroeconomics (Mastromarco & Simar, 2021). The implementation of the Simar et al. (2016) approach first requires quantifying the unobserved heterogeneity, which is the unobserved component of resources (inputs) or output after the elimination of some

¹ Note that several papers have documented the methodological issues raised by two-step methods, as in Simar and Wilson (2007) or Simar and Wilson (2011).

observable factors. The latent heterogeneity or the quality indicator is therefore the residuals of the regression of resources or the output on some characteristics of MFIs, which favors the financial inclusion of women. A nonconditional frontier and a conditional frontier are then estimated to test the effects of unobserved heterogeneity on efficiency and levels of inefficiency.

The objective of our study is to take into account unobserved heterogeneity factors in the analysis of MFIs' social efficiency. We thus apply Simar et al. (2016) cross-sectional framework to the specific setting of microfinance and we model MFI social efficiency in the presence of both observed and unobserved heterogeneity using non parametric estimation methods. We show that building an efficiency frontier in the presence of latent factors may contribute to improving women's access to credit and then pave the way for their empowerment.

Our study makes at least two contributions to the existing literature. First, to date, little is known about how latent heterogeneity impacts MFIs' conditional frontier and inefficiency level. Relevant academic studies on the effect of latent heterogeneity are scarce and limited to Banna et al. (2019). We thus extend these previous MFI efficiency studies by modeling MFI social efficiency in the presence of both observed and latent heterogeneity.

Second, to the best of our knowledge, our study is the first that applies the Simar et al. (2016) framework to investigate the effect of the latent heterogeneity in microfinance setting. Moreover, studies based on the Simar et al. (2016) approach identify some unobserved environmental variable (latent heterogeneity) correlated with input with applications in public sector organizations such as schools (Simar et al., 2016), universities (Simar et al., 2021), or in, or in macroeconomics (Mastromarco & Simar, 2021). We contribute to this existing literature by investigating how latent heterogeneity affects the efficiency of financial organizations with a social mission, assuming that this latent heterogeneity is related to our MFIs' social output, namely, the percentage of female borrowers.

Our findings reveal a significant effect of the unobserved heterogeneity on the frontier and hence stress the importance of subjective factors in defining the set of production possibilities. These results emphasize the importance of considering unobserved heterogeneity to analyze MFI social efficiency and how running an analysis without accounting for this additional latent factor may yield incomplete global picture (as found in Fall et al. (2021)). Finally, we interpret this unobserved discretionary factor as manager sensitivity to gender inclusion, which depends on the country's legal enforcement environment and country gender inequality framework.

The remainder of the paper is organized as follows. Section 2 presents the methodology. Section 3 describes the data. Section 4 discusses the results, and Sect. 5 concludes.

2 Methodology

In this section, we recall the theoretical statistical framework used to include unobserved heterogeneity effects in the analysis of the gender effect on MFI efficiency. We first present the frontier estimation framework with the nonparametric estimation of conditional efficiencies before introducing unobserved heterogeneity factor in the model. The first part is more standard and has already been applied in microfinance context by Fall et al. (2021) (see Moradi-Motlagh and Emrouznejad (2022) for an overview of trends in nonparametric techniques in frontier production) whereas the second part is novel for the MFI context.

2.1 Nonparametric estimation of conditional efficiencies

The frontier estimation framework is based on a nonparametric conditional FDH approach (as presented in Cazals et al. (2002) and Daraio and Simar (2005)). We also consider a robust version of order- α (Aragon et al., 2005) and the general directional distance approach to measure inefficiency levels (Chambers et al., 1996). The FDH approach is among the most flexible methods since it requires very few assumptions on the shape of the frontier function (only free disposability of inputs and outputs), and it avoids in particular assuming convexity of the frontier (which is required for DEA methods).

Let $x \in \mathbb{R}_+^p$ denote a vector of inputs and $y \in \mathbb{R}_+^q$ a vector of outputs. The attainable set Ψ is the set of values (x, y) , which are technically possible:

$$\Psi = \{(x, y) \mid x \text{ can produce } y\}.$$

Consider the random vector (X, Y) of inputs and outputs and define the following probability function: $H_{XY}(x, y) = \text{Prob}(X \leq x, Y \geq y)$ which is the probability of finding a unit (X, Y) dominating the point (x, y) . Under the assumption of free disposability of inputs and outputs, Ψ can be interpreted as the support of H : $\Psi = \{(x, y) \mid H_{XY}(x, y) > 0\}$.

In the presence of environmental factors $Z \in \mathbb{R}^r$, we consider a conditional probability function

$$H_{XY|Z}(x, y|Z = z) = \text{Prob}(X \leq x, Y \geq y|Z = z),$$

and the attainable set for units facing environmental factor $Z = z$ is:

$$\begin{aligned}\Psi^z &= \{(x, y) \mid Z = z, x \text{ can produce } y\}, \\ &= \{(x, y) \mid H_{XY|Z}(x, y|Z = z) > 0\}.\end{aligned}$$

The environmental factor Z can affect both the distribution of inefficiencies defined independently from Z and the boundary of the attainable set with respect to which inefficiencies are measured. Using the conditional attainable set Ψ^z to define inefficiency measures allows us to not ignore any of these effects.

We also focus on the directional distance approach and consider directions $d_x \in \mathbb{R}_+^p$ (for the inputs) and $d_y \in \mathbb{R}_+^q$ (for the outputs) to measure the distance from the efficiency boundary of a unit operating at level (x, y) . Under the free disposability assumption, the unconditional directional distance is defined as:

$$\begin{aligned}\beta(x, y) &= \sup\{\beta > 0 \mid (x - \beta d_x, y + \beta d_y) \in \Psi\}, \\ &= \sup\{\beta > 0 \mid H_{XY}(x - \beta d_x, y + \beta d_y) > 0\}.\end{aligned}$$

It measures the distance of unit (x, y) toward the boundary of Ψ along the path determined by (d'_x, d'_y) . An equivalent definition is provided in the conditional setting:

$$\begin{aligned}\beta(x, y|z) &= \sup\{\beta > 0 \mid (x - \beta d_x, y + \beta d_y) \in \Psi^z\}, \\ &= \sup\{\beta > 0 \mid H_{XY|Z}(x - \beta d_x, y + \beta d_y|Z = z) > 0\}.\end{aligned}$$

The flexibility of directional efficiency measures lies in the choice of the direction (d'_x, d'_y) . For example, $d_x = 0$ and $d_y = y$ allow us to recover the output-oriented radial measure, and the input-oriented case would be obtained with $d_x = x$ and $d_y = 0$. A practical choice for (d'_x, d'_y) is a benchmark value similar to the median of clouds $d_x = \text{median}(X)$ and $d_y = \text{median}(Y)$.

In this paper, we consider robust approximation to avoid the sensitivity of FDH estimators to outliers and extreme values. Here, we present the order- α directional distances (see Simar & Vanhems, 2012) defined as follows:

$$\begin{aligned}\beta_\alpha(x, y) &= \sup\{\beta > 0 | H_{XY}(x - \beta d_x, y + \beta d_y) > 1 - \alpha\}, \\ \beta_\alpha(x, y|z) &= \sup\{\beta > 0 | H_{XY|Z}(x - \beta d_x, y + \beta d_y | Z = z) > 1 - \alpha\}.\end{aligned}$$

Note that contrary to nonrobust versions, $\beta_\alpha(x, y)$ and $\beta_\alpha(x, y|z)$ can be negative, which indicates that point (x, y) is above the frontier. The tuning parameter $\alpha > 0$ allows us to evaluate the number of points left above the frontier, and when $\alpha \rightarrow 0$, we recover the full inefficiency measure β .

A classical way to proceed to calibrate the parameter α is to use the outlier detection rule by Simar (2003), or to calibrate this tuning parameter in order to leave a fixed (and small) percentage of points above the frontier (as suggested by Daraio & Simar, 2014). In our application, as in Fall et al. (2021), we choose α so that approximately 8% points are left above the frontier.

Consider now a sample of observations $(X_i, Y_i, Z_i)_{i=1, \dots, n}$. Nonparametric estimators are obtained by plugging nonparametric estimators of H_{XY} and $H_{XY|Z}$ into the previous formulas. More precisely, we replace H_{XY} with its empirical counterpart and $H_{XY|Z}$ with a smooth kernel estimator (Daraio et al., 2020). The bandwidth parameter choice associated with kernel estimation is performed using least square cross validation. Finally, to avoid the classical curse of dimensionality associated with the nonparametric FDH method, we use aggregation methods for inputs (Daraio & Simar, 2007; Wilson 2018), and we check that the aggregated input is highly correlated with the initial input.

2.2 Introducing an unobserved heterogeneity factor

In this part, we introduce an unobserved heterogeneity factor Z_u , to be distinguished from observed heterogeneity factors Z_o . The general environmental factor Z is then split into two parts: Z_o and Z_u .

More specifically, we follow the approach from Simar et al. (2016) to identify a latent factor Z_u linked to some output Y^1 . We define the link between the latent factor Z_u and the output Y^1 using a nonparametric nonseparable model:

$$Y^1 = \phi(W, Z_u),$$

where W is an auxiliary vector correlated with Y^1 and independent from Z_u . To identify Z_u , we assume that ϕ is monotonic with respect to Z_u and that Z_u is uniformly distributed on $[0, 1]$. Under these assumptions, Z_u is identified by the conditional distribution of Y^1 given W :

$$Z_u = F_{Y^1|W}.$$

Note that the uniform distribution assumption is just a matter of scaling Z_u and allows us to interpret ϕ as a quantile function. The factor Z_u can be interpreted as the part of Y^1 independent of W . The choices for Y^1 and W are discussed in the next section.

Replacing the generic heterogeneity factor Z by (Z'_o, Z_u) in the definitions of $\beta_\alpha(x, y)$ and $\beta_\alpha(x, y|z)$ allows us to define inefficiency measures conditional on both observed and unobserved heterogeneity factors. To derive the associated estimated inefficiency measures, we have to replace Z_u with a nonparametric conditional distribution estimate (see Simar et al., 2016 for more details).

2.3 Heterogeneity effect on the frontier and the level of inefficiency

Our objective is to analyze the impact of $Z = (Z'_o, Z_u)$ on the conditional efficiency level $\beta_\alpha(x, y|z)$ and on the difference between conditional and unconditional efficiency levels $(\beta_\alpha(x, y|z) - \beta_\alpha(x, y))$.

We perform a nonparametric local linear regression of both differences of inefficiencies and inefficiency levels on Z , and we test the significance of the link with Z . Following Racine (1997) and Daraio and Simar (2014), we apply a wild double bootstrap procedure to test for the effect of Z on the difference of inefficiencies and inefficiency levels. We fix $B_1 = 1000$ and $B_2 = 100$ for the two bootstrap loops and provide the pvalue of the test to conclude on the effect of Z .

A positive effect of Z on the difference of inefficiencies can be interpreted as a shift above the frontier, which allows us to reach higher efficiency points than without the exogenous variable. Similarly, a negative effect of Z on the inefficiency level can be interpreted as a drop in the inefficiency level.

3 Data

3.1 Sample

The data used in this study come from the Microfinance Information eXchange database, which reports institutional, financial, and social data of approximately 2995 MFIs over the period from 1999 to 2019 for a total of 19,781 unevenly distributed MFI-year observations.

One of the key variables of our study is boardroom gender diversity (the percentage of female directors), which measures the observed heterogeneity, that is, an environmental variable under the control of the manager that can affect the attainable frontier. This variable is available only in the database from 2008.

As in the general framework presented in Simar et al. (2016), our study is cross-sectional and we chose 2011 as the year of study.² The choice of this specific year allows to recover a large number of MFIs represented in the database, i.e., approximately 13% of the sample.

The MIX classifies MFIs according to their degree of transparency and uses a five-point ordinal scale from 1 to 5 to rank MFIs according to their disclosure quality. We then excluded the MFIs without transparency grades as well as those with grade 0. This led us to construct a sample of 1,474 MFIs, composed of 72 MFIs of grade 1, 5 MFIs of grade 2, 372 MFIs of grade 3, 715 MFIs of grade 4, and finally 110 MFIs of grade 5. The classification of MFIs according to the quality of disclosure also implies that the MFIs with the highest grades are those with the most reliable data. Similar to some previous studies (e.g., Fall et al., 2021; Piot-Lepetit & Tchakoute Tchuigoua, 2021), we have retained the MFIs ranked 4 and 5, which are those whose financial statements are audited and certified by audit firms and some of which are rated by rating agencies. Following Goodell et al. (2020), we also include grade 3 MFIs in our sample and consider that the data quality of MFI will be better if they are rated at least 3 on the MIX scale. Finally, as MIX is a self-reported database, data and variables are sometimes missing, as MFIs may decide to not disclose data for a given year or simply

² Note that the analysis performed below has also been repeated in 2010 and 2012 to check for robustness of our results. The results were consistent with 2011 but we chose not to include them in the paper to save space.

not report some variables. For 2011, therefore, we have deleted all MFIs with missing data for the variables used in the study, as detailed in the next sub-section.³

These filters allowed us to build a final sample composed of 501 MFIs from the six main regions of the world defined by MIX (sub-Saharan Africa (43 MFIs), East Asia and the Pacific (58 MFIs), Eastern Europe and Central Asia (77 MFIs), Latin America and the Caribbean (203 MFIs), the Middle East and North Africa (10 MFIs) and South Asia (110 MFIs). We also distinguish between for-profit MFIs comprising banks, and non-bank (47 percent of the sample) and non-profit MFIs consisting of NGOs (Non Governmental Organizations) and cooperatives (53 percent of the sample). Table 1 presents the summary of the sample distribution by region and by profit status.

3.2 Variables

We use the production approach and consider an MFI as a DMU that combines production factors (capital, labor, physical) to achieve a social output, namely, deliver financial services that contribute to financial inclusion and poverty eradication through a better targeting of women.

Inputs and output selection We consider two physical inputs widely used in previous studies on MFI efficiency: the number of employees and operating expenses. We focus on the operating expenses and the number of employees to be consistent with previous studies benchmarking MFIs using efficiency measures of performance (e.g., Banna et al., 2019; Fall et al., 2021; Gutiérrez-Nieto et al., 2009; Piot-Lepetit & Nzongang, 2014; Piot-Lepetit & Tchakoute Tchuigoua, 2021). We found a correlation of approximately 0.6135 between the two inputs. To limit the effect of this collinearity on the frontier, we base on Daraio and Simar (2007) and Wilson (2018) to aggregate both inputs to obtain a unique input dimension. The output, the social dimension of MFI performance, is captured by the percentage of female borrowers. In our study, we assume that MFIs contribute to women empowerment by easing access to credit. Our output variable is thus a breadth of outreach indicator that we measure by the percentage of female borrowers.

Remark 1 Using the average loan size, the depth of outreach and even the quality of MFIs loan as output could have been interesting for a study like ours which deals with social performance. We recall that the study focus is on women access to credit. It is for this reason that we have focused on the percentage of female borrowers. The MIX database from which we extracted the data certainly provides the average size of loans and the depth of outreach (targeting indicator for the poor) but unfortunately does not provide us with data allowing us to capture an indicator of poor women target such as number of poor female borrowers.

Heterogeneity factors The heterogeneity factor Z is decomposed into two parts, an observed heterogeneity factor Z_o and an unobserved factor Z_u . First, we define the observed heterogeneity factor Z_o as the percentage of women on the board of directors.⁴

³ This explains in particular why our sample size is smaller than in Fall et al. (2021). Indeed, we have introduced several new variables to characterise the unobserved heterogeneity (one auxiliary variable and six external socio-economic variables) and datapoints for these variables were sometimes missing for the year 2011. Dropping cross-sections with missing data lead us to base our analysis on a sample of 501 MFIs.

⁴ Note that, as suggested by a peer reviewer, we could have completed the analysis by using the number of female loan officers as an additional observed heterogeneity factor [as in Fall et al. (2021)]. We chose a single heterogeneity factor and favored the representation of women on the boards of directors for one main reason: targeting women is a strategic decision in MFIs and this strategic decision must be ratified by the board of

Second, we assume that the latent heterogeneity factor Z_u evaluates the ability of MFI managers to implement credit policies in favor of women's inclusiveness and empowerment. It is defined as the residuals in the nonparametric nonseparable regression of the social performance on one auxiliary variable W capturing size effect: the logarithm of offices. In our study, unobserved heterogeneity is linked to social output, i.e., the percentage of female borrowers that measures the outreach to females, and the ability of an MFI to favor women's empowerment through access to credit. To solve the endogeneity issue resulting from the latent heterogeneity factor, we had to find an instrument; a possible candidate is the firm's size measured by the natural logarithm of the book value of the asset (Simar et al., 2016), which also appears to be correlated with both the breadth and depth of outreach in some microfinance studies (e.g., Barry & Tacneng, 2014; Cull et al., 2011). In our work, instead of measuring the size by the book value of the total assets as in previous studies, we proxy the MFI size by the number of offices that better reflect the microfinance business model, which is based on proximity between MFIs and their clients. The closer an MFI is to its clients, the more likely women will be to access credit. Therefore, Z_u controls for the part of social performance unexplained by the size effect. In practice, we can confirm that our estimated factor Z_u is indeed very weakly correlated with W ($\text{corr}(Z_u, W) = 0.03$, p value = 0.20).

We can also check that the link with the observed heterogeneity factor Z_o is rather weak ($\text{corr} = 0.10$), which shows that the unobserved heterogeneity factor captures an effect different from the observed heterogeneity factor. We also verify that the link with social output is still strong ($\text{corr} = 0.87$), which confirms that unobserved heterogeneity indeed captures an important part of social output.

External socioeconomic variables Finally, we guess that this unobserved heterogeneity factor may reveal the link our output and several observable indicators such as country governance quality and legal enforcement and the state of women's inequality across gender. These indicators are taken from the Human Development Data Center of the United Nations Development Program (UNDP) (<http://hdr.undp.org/en/data>) and from the World Bank's World Development Indicators (WDI). Public policies, rules, and regulations favoring financial inclusion and the empowerment of women certainly exist in several countries. However, their effect on the degree of financial inclusion depends on the capacity of countries to enforce them. The first set of variables that is related to the latent heterogeneity from Kaufmann et al. (2011) worldwide governance indicators that includes three indicators: the voice and accountability index, the governance effectiveness index and the rule of law index. The second set of variables is related to gender inequality and includes three indicators: the gender inequality index, the female human development index, and the gender development index. In countries where women are less emancipated, MFI manager talent will be an important factor of gender inclusiveness and emancipation. We will investigate the link between the unobserved heterogeneity and these external variables later in the paper to enrich the analysis and interpretation of Z_u . Note that we do not intend to characterize in an exhaustive way the unobserved heterogeneity. In this study we explore a potential link between the latent variable and macroeconomic factors related to gender inequality or country governance quality.

Table 2 gives the definition of the variables used in the study, and Table 3 provides descriptive evidence.

Footnote 4 Continued

directors. Having women represented on the boards of directors can therefore encourage MFIs to deliver more financial services to women (financial inclusion of women).

4 Results and discussion

In this section, we analyze the impact of gender and unobserved heterogeneity on the social efficiency of MFIs for the full sample and across MFI's profit status to check the robustness of our results on the whole sample). We also empirically check whether the unobserved factor Z_u may be related to some known institutional and socioeconomic indicators to better characterize this unobserved factor.

First, we study the impact of both observed and unobserved heterogeneity variables on the shape of the production set. This effect is captured by the analysis of the link between inefficiencies (conditional and nonconditional) and the environmental factor. When the link is positive and significant, it means that considering the environmental factor allows reaching higher levels of efficiency, and the achievable frontier is shifted upwards.

Second, we study the impact of both heterogeneity variables on conditional managerial efficiency for a given environmental condition. This second effect is captured by the link between the conditional measure of inefficiency and the environmental factor (either observed or unobserved). If the link is negative, it means that taking into account the environmental factor allows reducing the level of inefficiency. In both cases, we focus on the gender effect on the robust estimators of order- α to be able to apply the double bootstrap methodology developed by Racine (1997). In all figures, the value of the parameter α is set so that approximately 8% of units are above the unconditional frontier (as specified in Sect. 2), and the pvalue is computed from the double bootstrap procedure, as detailed in Daraio and Simar (2014). A pvalue less than 5% indicates that all derivatives of the local linear approximation with respect to the factor Z are significantly different from 0, so we can interpret the shape of the local linear regression.

4.1 Results on the full sample

4.1.1 Effect on the frontier

We observe a significant positive effect of the unobserved heterogeneity and no effect of the observed heterogeneity defined as the % of female on the board of directors (see Fig. 1, left column). This result shows that the unobserved heterogeneity has a positive impact on the conditional attainable set (see Fig. 1, bottom left), whereas the observed heterogeneity has no significant impact on the conditional attainable set (see Fig. 1 middle left). Taking into account the unobserved factors allows the MFIs in the sample to achieve higher levels of social efficiency. Moreover, we can see in Fig. 1 (bottom left) that this effect of unobserved heterogeneity on the conditional frontier is independent of the distribution of observed heterogeneity (% of women on boards of directors).

This result shows how essential it is to go beyond the factors observed in estimating efficiency frontiers. Above all, it shows that taking into account the unobserved heterogeneity improves the level of social efficiency of microfinance, unlike Fall et al. (2021), who find no effect of the observed heterogeneity on the frontier. Compared to the result obtained in Fall et al. (2021), we observe a crowding out effect of the unobserved heterogeneity on the observed heterogeneity, which shows that beyond the presence of women on the board of directors, there are additional hidden factors that influence the social efficiency of microfinance.

We assume that MFI social efficiency depends on factors under managers' control as well as on factors related to managers, such as managers' abilities and talents, which, by nature, are latent and unobservable. Our unobserved heterogeneity factor can be interpreted as the

discretionary component that reflects the managerial latitude enjoyed by MFI managers. Managers who are sensitive to gender inequality issues and to those related to gender discrimination will be able to use their managerial latitude to make loan allocation decisions that would promote women's access to credit. Therefore, we can conclude that MFI managers use their discretion to promote financial inclusion and women's empowerment through access to credit.

4.1.2 Effect on inefficiency

Again, only the unobserved heterogeneity factor has a significant negative impact on the level of inefficiency and contributes to reducing it (see Fig. 1, right column). We see on Fig. 1 on the bottom right that the link between inefficiency and unobserved heterogeneity is convex for low unobserved heterogeneity and concave for large unobserved heterogeneity, and it is independent of the level of observed heterogeneity. The reduction of inefficiency is more important when the unobserved heterogeneity is low. Therefore, these results reveal nonlinear significant effects of the unobserved heterogeneity factor and no significant effect of the observed heterogeneity, whereas in Fall et al. (2021), the impact of the observed heterogeneity on the level of inefficiency was significant but linear.

Our findings suggest that managers who are sensitive to gender inequalities and enjoy greater managerial discretion will be able to free MFIs from the strong pressures of the socioeconomic environment that are unfavorable to women. They will, thus, tend to reduce the sources of inefficiency in the loan decision process and ultimately significantly improve women's access to credit.

Conversely, as evidenced by the literature (e.g., Berger & Udell, 2002), having greater managerial discretion may increase agency problems insofar as managers and loan officers may have incentives to use their discretion to promote weak female loan applications or even select female applications that generate private benefits for them. Figure 1 on the bottom right shows that having women seated on a board, regardless of the size, serves to better constrain managerial discretion by loan officers and managers. The presence of women contributes to restricting the managerial latitude of managers and, above all, limiting their use of managerial discretion for purposes other than women's empowerment.

4.2 Heterogeneous effect across MFI's profit status

We carried out additional analyses considering the uniqueness of the microfinance market, characterized by the presence of for-profit MFIs and nonprofit MFIs. We thus split the sample into two subgroups (for-profit MFIs versus nonprofit MFIs) to answer the question of whether the effect of unobserved heterogeneity on the frontier and conditional inefficiencies could vary depending on whether an MFI is for-profit or not.

4.2.1 Effect on the frontier

As shown in the left columns of Figs. 2 and 3, we find similar results for both subsamples as for the full sample regarding the effect of unobserved heterogeneity on the frontier. Note that Fall et al. (2021) document a positive and significant effect of observed heterogeneity on the frontier on both types of MFIs, and this effect is now only captured by the unobserved heterogeneity.

The importance of considering unobserved heterogeneity is still justified in the subsamples of commercial and social MFIs. This impact of unobserved heterogeneity on the frontier remains positive and significant regardless of the nature of the MFI. Therefore, taking into account the unobserved heterogeneity factor allows us to reach higher levels of efficiency.

4.2.2 Effect on inefficiency

For the unobserved heterogeneity, in the for-profit MFIs subsample as well as in the nonprofit sample, the impact on the level of inefficiency is significant and negative regardless of the level of observed heterogeneity (see Fig. 2 bottom right). As in the full sample estimation, our findings also show that the inefficiency curve is not linked to observed heterogeneity. Taking into account unobserved heterogeneity allows us to reveal that observed heterogeneity might not have a significant impact, contrary to what was initially tested (Fall et al., 2021). Moreover, we can see that the nonlinear link between inefficiency and unobserved heterogeneity is robust to MFIs' profit status.

4.3 Interpretation of unobserved heterogeneity

We now deepen our understanding of the unobserved heterogeneity factor by analyzing the link with various external variables.

The links with government effectiveness, rule of law, voice and accountability are positive and significant, suggesting that our latent heterogeneity factor is positively linked to the country legal and institutional framework (see Fig. 4a–c). In some countries, laws promoting financial inclusion and the empowerment of women are not always effective when voted. Strong legal enforcement allows law and legal enforceability and may, thus, provide incentives for managers to use their discretion or may reinforce their sensitivity to gender inequality issues.

We can also analyze the link with variables evaluating human and female development in the country: the Gender Inequality Index (GII), the Human Development Index (HDI), and the Gender Development Index (GDI). The positive and significant link between unobserved heterogeneity and the gender inequality index (Fig. 4d) shows that the latent factor is more linked to socioeconomic factors that act against women in terms of progress and treatment between men and women. The negative correlation between unobserved heterogeneity and human development and gender development indices (Fig. 4e, f) supports this point of view and clearly shows that unobserved heterogeneity is linked to factors that act negatively on the three dimensions of human development, namely, women's reproductive health, empowerment and employment opportunities.

In developing countries, there is a set of social or political institutions that shape human behavior and interactions and act on inequalities between men and women (Branisa et al., 2013). These social institutions are enduring norms, values and codes of conduct that find expression in traditions, customs, cultural practices and formal laws (Branisa et al., 2014). They affect the distribution of power between men and women in the private sphere of the family, the economic sphere and public life and can constitute a constraint on the empowerment of women (Sen, 2014).

The unobserved factor, with regard to the correlations established with the context variables, refers to the elements of the institutional, socioeconomic and cultural environment of the country that negatively influence the autonomy of women and their financial inclusion. In very restrictive contexts for the emancipation of women, the social effectiveness of microfi-

nance can be strongly constrained, and women's access to credit, beyond the diversity of the boards of directors of MFIs, depends heavily on the discretionary power of managers. It is this discretionary power of managers that allows MFIs to achieve better social performance despite the harmful influence of the sociocultural context.

5 Conclusion

In this paper, we introduce an unobserved heterogeneity factor to enrich the analysis of MFI inefficiency measures. This latent heterogeneity factor intends to reflect managers' abilities and talents that can be used to promote women's access to credit.

The heterogeneity factor Z is decomposed into two parts, an observed heterogeneity factor Z_o defined as the percentage of women on the board of directors and an unobserved heterogeneity factor Z_u that reflects managers' abilities). Frontier efficiency is estimated by using a robust nonparametric conditional FDH, and inefficiency levels are measured by using a robust version of order- α and the directional distance approach. The heterogeneity effect is analyzed by comparing unconditional and conditional inefficiency levels with respect to the heterogeneity factor and using a local linear approach.

Our results show that taking into account unobserved heterogeneity factors allows MFIs to achieve higher levels of efficiency and reduce their social inefficiencies. This impact of unobserved heterogeneity on the frontier is robust regardless of the status of the MFI.

Moreover, compared to the result obtained in Fall et al. (2021), we show that taking into account unobserved heterogeneity cancels the effect of the observed heterogeneity, which further confirms the importance of considering the effect of the unobserved factor in the estimation of microfinance efficiency frontiers. Beyond the presence of women on microfinance boards, there are unobserved factors that influence the policy of targeting women. This is particularly the case for the discretionary power of microfinance managers, which can lead MFIs to continue targeting women, despite the constraints of the sociocultural context.

We also find that the impact of unobserved heterogeneity on the frontier and social inefficiencies of microfinance is broadly the same regardless of the magnitude of the observed heterogeneity. The effect of the discretionary power of managers on the frontier and on social inefficiencies is generally strong in highly unequal sociocultural contexts, regardless of the presence of women on the boards of directors of MFIs.

Beyond the methodological implications on the importance of considering factors of unobserved heterogeneity, this contribution is rich in terms of recommendations on microfinance policies. It is clear that in a socioeconomic and cultural context strongly marked by gender inequalities, the quality of managers is fundamental for the promotion of the social efficiency of microfinance. In such a context, having a manager sensitive to the empowerment of women is a crucial element in promoting women's access to credit, regardless of the representation of women on the board of directors. This result shows that policies promoting microfinance in these contexts must pay attention to the gender sensitivity of managers. Finally, this contribution teaches us that the social effectiveness of microfinance, beyond factors related to the management of MFIs, also depends on the sociocultural context. Thus, improving the effectiveness of microfinance also requires improving the living conditions of women in restrictive contexts.

As noted earlier in the paper, we have also duplicated the analysis in 2010 and 2012 to check the robustness of our results. Extending the methodology proposed by Simar et al. (2016) by considering panel data would certainly be of interest and would allow to evaluate

the effect of latent variables through time [as in Mastromarco and Simar (2021)]. This is left for future research.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Appendix: Tables and Figures

See Tables 1, 2 and 3.

Table 1 MFI distribution by institutional form and region

Region	MFI institutional forms			Total
	Shareholder or for-profit MFIs	Nonprofit MFIs Credit Unions/Cooperatives	NGO	
Sub-Saharan Africa	14	13	16	43
East Asia and the Pacific	29	11	18	58
Eastern Europe and Central Asia	65	10	2	77
Latin America and The Caribbean	83	39	81	203
Middle East and North Africa	5		5	10
South Asia	40	7	63	110
Total	236	80	185	501

Table 2 Variable definition. *Sources:* MIX Market, UNDP website, World Bank database

Variable	Definition
Input 1: Operating expenses	Expenses not related to financial and credit loss impairment, such as personnel expenses, depreciation, amortization and administrative expenses
Input 2: Number of employees	Number of individuals who are actively employed by an entity. It 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
Output: Percent of female borrowers	Number of active female borrowers divided by the number of active borrowers
Z_0 : % of female board members	Of women who sit on the board of directors divided by the total number of directors
W_1 : log of offices	
GII: Gender inequality index	Measures gender inequalities in three important aspects of human development reproductive health: (1) maternal mortality ratio and adolescent birth rates; (2) empowerment, measured by proportion of parliamentary seats occupied by females and proportion of adult females and males aged 25 years and older with at least some secondary education; and (3) economic status, expressed as labor market participation and measured by labor force participation rate of female and male populations aged 15 years and older. The higher the GII value, the greater the disparity between females and males and the greater the loss to human development

Table 2 continued

Variable	Definition
HDI: Human inequality index	Measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living
GDI: Gender inequality index	Measures gender gaps in human development achievements by accounting for disparities between women and men in three basic dimensions of human development health, knowledge and living standards using the same component indicators as in the HDI. The GDI is the ratio of the HDIs calculated separately for females and males using the same methodology as in the HDI. It is a direct measure of gender gap showing the female HDI as a percentage of the male HDI
Government effectiveness	Captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. The estimate gives the country's score on the aggregate indicator in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5 .
Rule of law	Captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. The estimate gives the country's score on the aggregate indicator in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5
Voice and accountability	Reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. The estimate gives the country's score on the aggregate indicator in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5

Table 3 Descriptive evidence

	Mean	Standard deviation	Minimum	Maximum
Input 1: Operating expenses	7,083,358	21,718,785	16,094	310,000,000
Input 2: Number of employees	501	1587	2	21,422
Output: Percent of female borrowers	66%	25%	0%	100%
Z_0 : % of female board members	30%	24%	0%	100%
W_1 : log of offices	48	193	1	3154
GII: Gender inequality index	0.45	0.11	0.16	0.74
HDI: Human inequality index	0.63	0.11	0.27	0.85
GDI: Gender inequality index	0.92	0.08	0.61	1.02
Government effectiveness	-0.36	0.42	-1.67	1.25
Rule of law	-0.58	0.44	-1.89	1.36
Voice and accountability	-0.17	0.53	-2.12	1.07

Impact of heterogeneity variables on the frontier and inefficiency

See Figs. 1, 2 and 3.

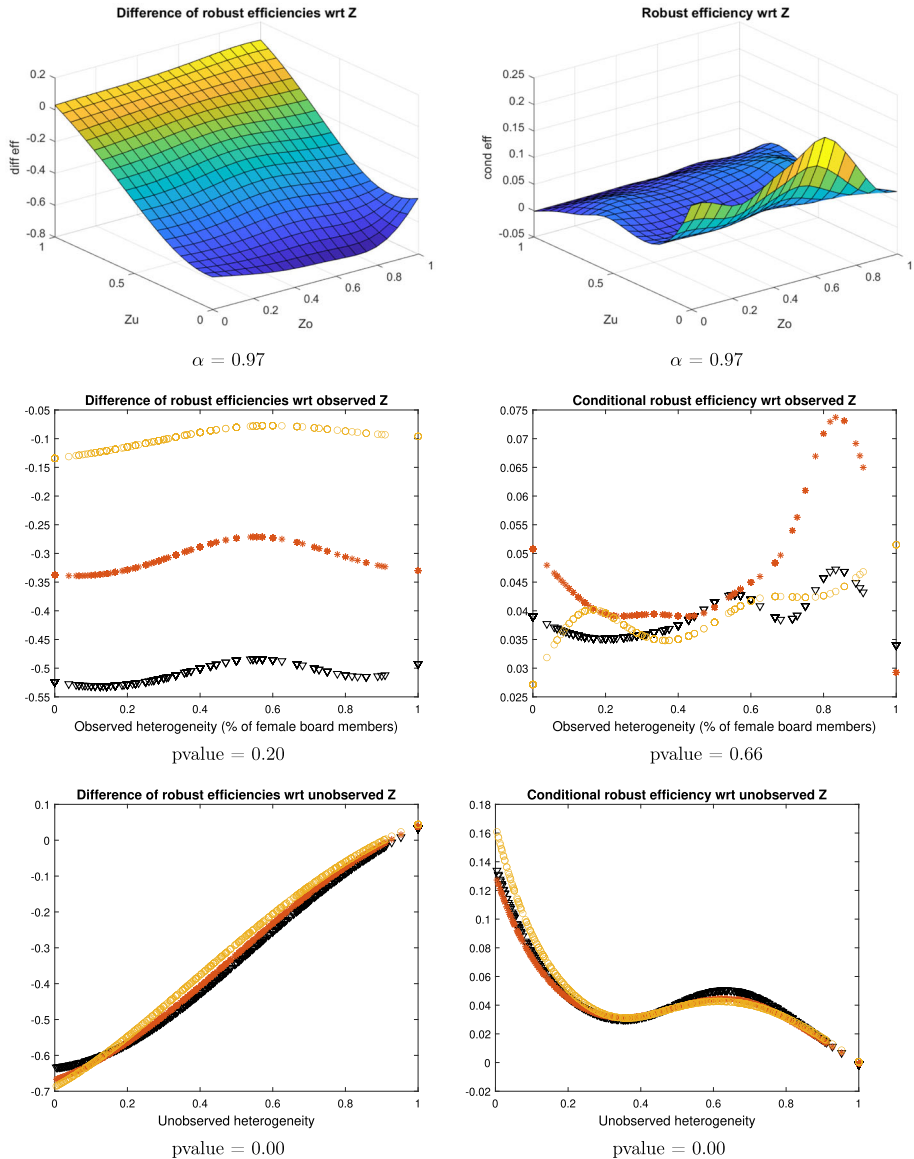


Fig. 1 Gender effect (unobserved and observed heterogeneity) for the *full sample*. The three figures on the left correspond to the effect on the frontier, and the three figures on the right correspond to the effect on the inefficiency level. The two figures on the top correspond to the 3D plot with the observed and unobserved heterogeneity (observed heterogeneity is % of Female board members). The two figures in the middle (in the bottom) correspond to the 2-D plot with the observed heterogeneity (unobserved heterogeneity) for the quantile values of the unobserved heterogeneity (observed heterogeneity). The symbols for the three quantile values are ∇ for Q1, $*$ for Q2 and $\circ$ for Q3. The p-values correspond to the test evaluating the impact of the heterogeneity variable on the frontier or on the inefficiency level

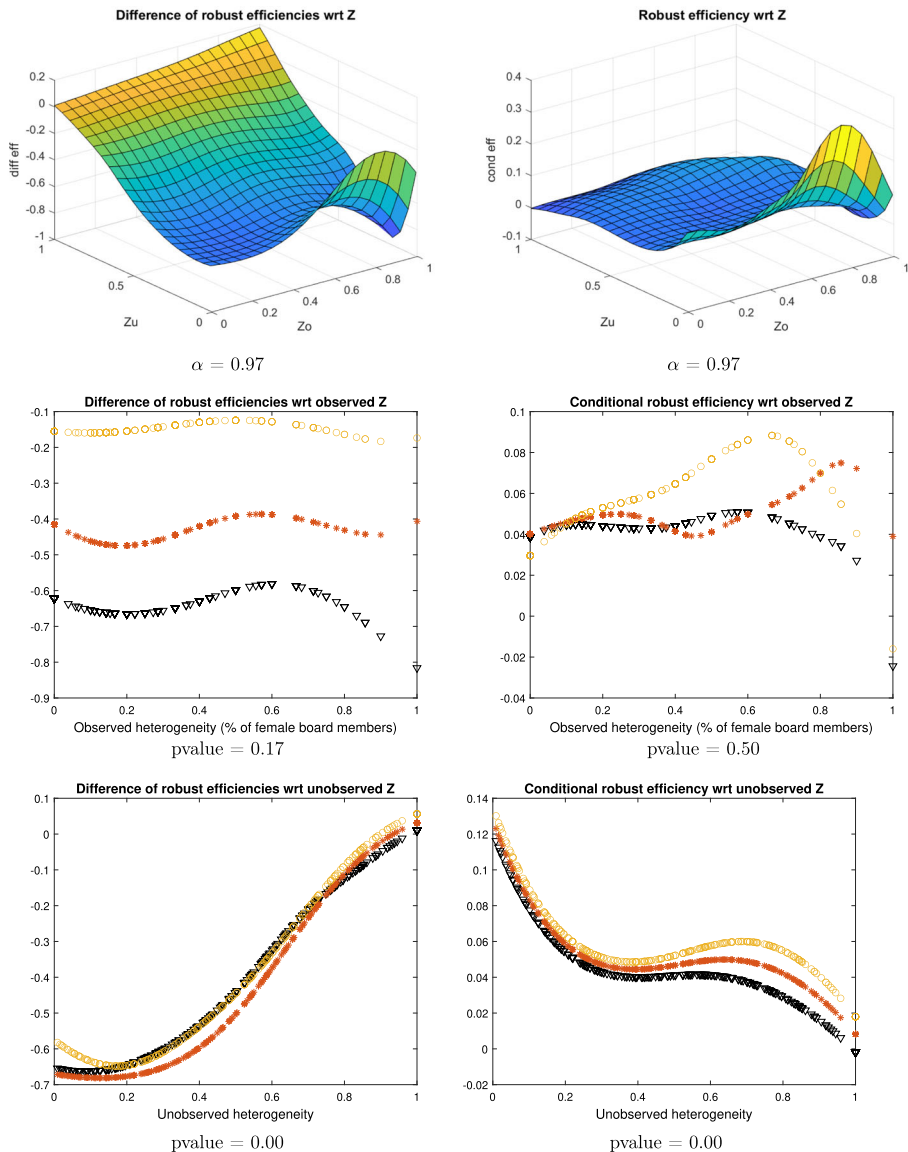


Fig. 2 Gender effect (unobserved and observed heterogeneity) for the *for-profit sample*. The three figures on the left correspond to the effect on the frontier, and the three figures on the right correspond to the effect on the inefficiency level. The two figures on the top correspond to the 3D plot with the observed and unobserved heterogeneity (observed heterogeneity is % of Female board members). The two figures in the middle (in the bottom) correspond to the 2-D plot with the observed heterogeneity (unobserved heterogeneity) for the quantile values of the unobserved heterogeneity (observed heterogeneity). The symbols for the three quantile values are ∇ for Q1, $*$ for Q2 and for Q3. The pvalues correspond to the test evaluating the impact of the heterogeneity variable on the frontier or on the inefficiency level

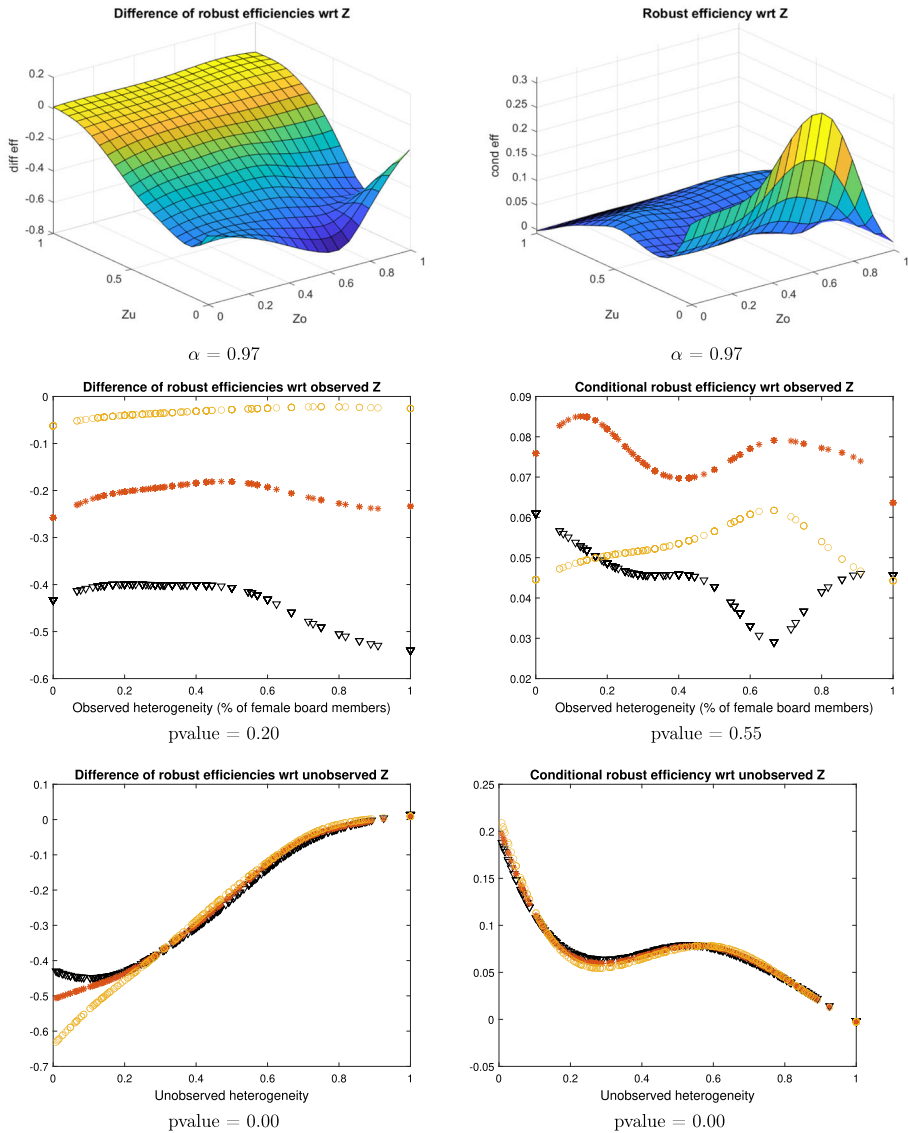


Fig. 3 Gender effect (unobserved and observed heterogeneity) for the *nonprofit sample*. The three figures on the left correspond to the effect on the frontier, and the three figures on the right correspond to the effect on the inefficiency level. The two figures on the top correspond to the 3D plot with the observed and unobserved heterogeneity (observed heterogeneity is % of Female board members). The two figures in the middle (in the bottom) correspond to the 2-D plot with the observed heterogeneity (unobserved heterogeneity) for the quantile values of the unobserved heterogeneity (observed heterogeneity). The symbols for the three quantile values are ∇ for Q1, $*$ for Q2 and o for Q3. The pvalues correspond to the test evaluating the impact of the heterogeneity variable on the frontier or on the inefficiency level

Characterization of the unobserved heterogeneity

See Fig. 4.

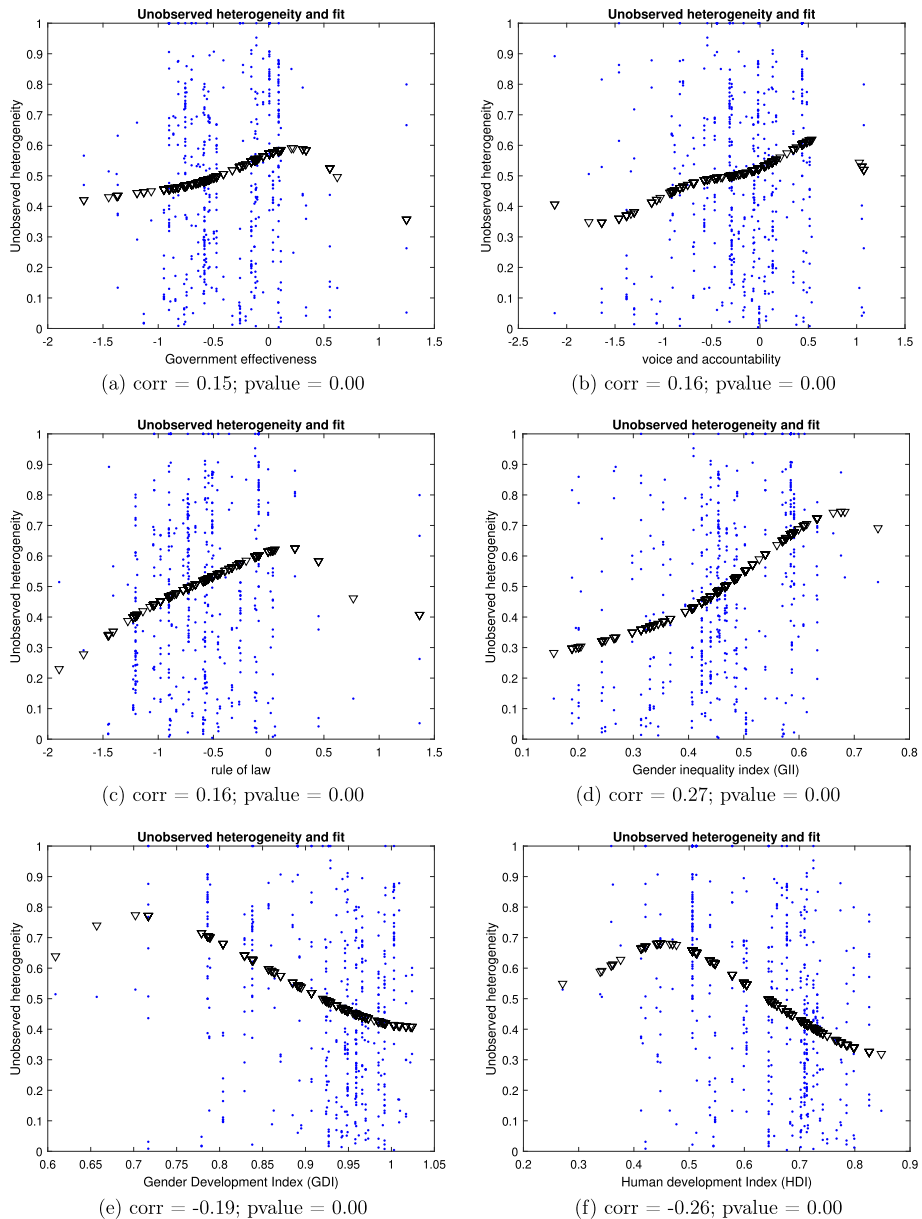


Fig. 4 Link between the unobserved heterogeneity and external variables: **a** Government effectiveness; **b** Voice and accountability; **c** Rule of law; **d** Gender Inequality Index (GII); **e** Gender Development Index (GDI); and **f** Human Development Index (HDI). The inverted triangles represent the local linear fit to the sample of points. The pvalues correspond to the test evaluating the impact of the external variable on the unobserved heterogeneity

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