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Cost Dynamics of Microfinance Institutions with Rural and Urban Loan Portfolios

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Abstract

This study investigates cost dynamics of Microfinance Institutions (MFIs) engaged in joint production of rural and urban loans. Employing a translog cost function, the paper examines economies of scale, cost complementarities, and elasticities of substitution using three MFI categories: those offering both deposits and loans (Dep-MFIs), those offering only loans (Non-Dep-MFIs), and the aggregate sample. The analysis utilizes data from 2008 to 2015, sourced from over 1,000 MFIs worldwide. Results indicate increasing economies of scale for all MFI categories, with Dep-MFIs demonstrating the most significant cost reductions over time. Urban loans are generally more expensive to produce for Non-Dep-MFIs, while rural loans remain costlier for Dep-MFIs and the aggregate sample. Despite positive but minimal cost complementarities, approximately one-fifth of Dep-MFIs experience negative cost complementarities, suggesting potential learning effects. These findings contribute to the literature on financial inclusion by offering empirical insights into cost efficiencies and production dynamics within MFIs.

Keywords: Microfinance Institutions (MFIs), Cost Dynamics, Cost complementarities, Rural and -Urban Loan Portfolios, Translog Cost Function, Dposit vs. Non-Deposit MFIs

1. Introduction

Microfinance Institutions (MFIs) have significantly expanded their outreach, playing a crucial role in enhancing financial inclusion. However, this growth has predominantly been happening in urban areas, thus leaving rural populations with limited access to MFI credit services (Garcia et al., 2020; Mia et al., 2022). This urban-rural disparity raises critical questions about the underlying cost dynamics and operational strategies of MFIs. Addressing this issue, the study evaluates the cost dynamics of MFIs jointly offering urban and rural loan products across different MFI of different type.

The decision by MFIs to offer both rural and urban loans is based almost entirely on their internal structure. There are arguments that this decision is affected by pull factors – positive environmental conditions in urban areas – and push factors –negative conditions in rural areas (Tsai, 2004, and Parikh 2006). However, less is known to what extent MFI costs play a role in the decision of MFI to offer one type of loans or another, or both. Analysis of the cost dynamics of MFIs can help to mitigate the uneven distribution of MFI credit services and offer nuanced policy-relevant insights.

One of the contributions of this paper is to the scope economy literature. Most of the scope economy studies in the MFI literature, such as Hartarska et al. (2011), Hartarska et al. (2013), Delgado et al. (2015), Malikov and Hartarska (2018), Malikov et al., (2020) examined the possibility of scope economies from joint offering of loans and savings. The focus on this work is on the cost dynamics of joint production of urban and rural loans. Of special interest are cost complementarities that may arise from the joint production of rural and urban loans, as MFIs learn from their experience with urban loans and use that knowledge in the production of rural loans. The objective of this work is to compare estimates from the aggregate MFI sample to those in voluntary deposit collecting MFIs (Dep-MFIs), and non-depository, loan-only MFIs (Non-Dep-MFIs). Both the scale and elements of scope economies are estimated for each MFI type that produces both rural and urban loans. The results offer new insights useful to development economists and policy makers in designing more effective incentives to encourage sustainable growth of MFIs and improve financial inclusion in both urban and rural areas.

We find statistically significant evidence of economies of scale in both Dep-MFIs and Non-Dep-MFIs. For Non-Dep-MFIs, the estimated urban loan cost elasticity is greater than the rural loan cost elasticity, which is somewhat surprising but consistent with the findings of Mie et al. (2022). However, over the sample period of 2008–2015, we observe that for Non-Dep-MFIs, both rural and urban loan cost elasticities declined, while they appeared to plateau for Dep-MFIs. The results indicate that the cost shares of financial inputs of both Non-Dep-MFIs and Dep-MFIs increased over the sample period. For Dep-MFIs, this increase substituted the share of capital costs in total costs, while for Non-Dep-MFIs, it replaced the share of labor costs in total costs. Allen elasticity of substitution computations reveal that, in both Non-Dep-MFIs and Dep-MFIs, labor-financial inputs were the closest substitutes, whereas financial capital inputs were the weakest. Finally, results from cost complementarity computations across all MFI categories are very small in magnitude but positive, indicating that offering both types of loan products is costly. However, approximately one-fifth of Dep-MFIs experienced negative cost complementarities from the joint provision of urban and rural loans, suggesting that, in at least some of these MFIs, there is evidence of learning across rural and urban markets.

The remainder of the paper is organized as follows: Section two details the conceptual framework and methodology, Section three describes the data, Section four presents empirical results, and Section five concludes with implications and recommendations.

2. Methodology

This paper adopts a cost function estimation to compute economies of scale and scope. The arguments of the cost function are output levels and input prices. In order to best represent the MFIs cost structure, this study applies the standard second-order Taylor approximation-based translog function. The general form of the translog cost function is

$$(1)\ \ \mathrm{lnc_{it}} = \alpha_o + \sum_i \beta_i \,\mathrm{lny_i} + \frac{1}{2}\sum_i \sum_j \beta_{ij}\, \mathrm{lnw_i lnw_j} + \varepsilon_{it}$$

where $\mathrm{lnc_{it}}$ is the logarithm of the cost of production, $\mathrm{lny_{it}}$ is the logarithm of the output, $\mathrm{lnw_i}$ and $\mathrm{lnw_j}$ represent logarithms of the prices of input factors.

There is well-developed literature that provides insights into the appropriate techniques for estimating the cost functions of financial institutions. To mention a few studies, Goisis et al. (2010), Altunbas and Molyneux (1996), and Huang and Wang (2001) utilize a trans-logarithmic function to empirically estimate economies of scope and scale in the European banking sector, while Kim (1986) utilizes a similar function to analyze credit unions in British Colombia. The specific form of the translog cost function adopted for this study is

$$(2)\ \ \mathrm{lnc} = \alpha_o + \sum_i \beta_{it}\, \mathrm{lny_{it}} + \frac{1}{2}\sum_i \sum_j \beta_{it}\, \mathrm{lny_{it} lny_{jt}} + \sum_i \gamma_{it}\, \mathrm{lnw_{it}} + \frac{1}{2}\sum_i \sum_j \gamma_{ijt}\, \mathrm{lnw_{it} lnw_{jt}} +$$
$$\sum_i \sum_j \delta_{it}\, \mathrm{lnw_{it}}\, \mathrm{lny_{it}} + \varphi_{it} \mathrm{ln}r_{it} + \frac{1}{2}\varphi_{it}\mathrm{ln}r_{it}^2 + \sum_i \varphi_{it}\mathrm{ln}r_{it}\mathrm{lny_{it}} + \sum_i \varphi_{it}\mathrm{lnw_{it}}\mathrm{ln}r_{it} +$$
$$\varphi_{it}\mathrm{ln}r_{it}t_i + \omega_{it}t_i + \frac{1}{2}\omega_{it}t_i^2 + \sum_i \omega_{it}t_i \mathrm{lny_{it}} + \sum_i \omega_{it}\mathrm{lnw_{it}}t_i + \varepsilon_{it}$$

where $\mathrm{y_{it}}$ are rural loans, $\mathrm{y_{jt}}$ are urban loans, $\mathrm{w_{it}}$ are input prices, r_{it} is loan portfolio risk, and t_i is the time trend. The input prices $\mathrm{w_{it}}$ include three MFI input prices: capital/administrative expenses k, labor expenses l, and financial capital expenses fk.

Before estimating the model, symmetry restrictions ($\beta_{ij} = \beta_{ji}, \gamma_{ij} = \gamma_{ji}, \delta_{ij} = \delta_{ji},\ \varphi_{ij} = \varphi_{ji}\ and\ \omega_{ij} = \omega_{ji}$) and homogeneity restrictions ($\sum_i \gamma_i = 1, \sum_i \sum_j \gamma_{ij} = 0, \sum_i \sum_j \delta_{ij} = 0, \mathrm{and} \sum_i \omega_i = 0$, are imposed. To enhance the efficiency of the estimation, we estimate the translog cost function jointly with the cost share equations derived using Shepard's Lemma. This provides information on the share of each input's cost in total cost.

(3) $\frac{\partial \mathrm{lnc}}{\partial \mathrm{lnw_i}} = \mathrm{s_{it}} = \gamma_{it} + \frac{1}{2}\sum_j \gamma_{ijt}\,\mathrm{lnw_{jt}} + \sum_i \delta_{it}\mathrm{ln}\,\mathrm{y_{it}} + \varphi_{it}\mathrm{ln}r_{it} + \omega_{it}\mathrm{t} + \varepsilon_{sit}$

where $\mathrm{s_{it}}$ is the share of each input factor cost in total cost that includes the share costs of MFI inputs: administrative $\mathrm{sk_{it}}$, labor $\mathrm{sl_{it}}$, and financial expenses $\mathrm{sfk_{it}}$.

The system of equations is estimated by the seemingly unrelated regression (SUR) method with Shepard's Lemma and cross-equation restrictions requiring that the coefficients in equation (3) to be equal to those in equation (2). To ensure efficient and accurate inference, standard errors are bootstrapped.

Equations (4) and (5) show cost elasticities with respect to output and economies of scale. Following Baumol (1986) and Panzar and Willig (1977), the measure of overall scale economies is given by the inverse of the cost-output elasticity –the inverse of the derivative of the translog model with respect to output, which is the ratio of the marginal cost to average cost:

(4) $\frac{\partial \mathrm{lnc}_{it}}{\partial \mathrm{lny_{it}}} = \beta_{it} + \beta_{it}\mathrm{lny_{it}} + \sum_j \delta_{ij}\,\mathrm{lnw_{it}} + \varphi_i\mathrm{ln}r_{it} + \omega_{it}t_i$

(5) $\mathrm{SE} = \frac{1}{\sum_i\left(\frac{\partial \mathrm{lnc_{it}}}{\partial \mathrm{lny_{it}}}\right)}$

We follow a procedure similar to Hunter and Timme (1991) who investigated the impact of technological change on commercial banks in the US, Hunter and Timme (1986) who analyzed a panel of commercial banks in the American banking system, Apergis and Rezitis (2004) who analyzed the Greek banking sector, and Simper (1999) who evaluated Italian savings banks. We measure technological change through a time index t_i that captures not only possible internal sources of technological advancement but also external environmental factors such as laws, policies, and market innovations that may have influenced the production process of the MFIs. In this model, the change in the MFIs' cost of production is measured by equation (6) below that reflects the annual percentage change in total costs approximating technological progress. The value of the derivative less (greater) than zero indicates a change in technology –*ceteris paribus*, an MFI can produce the same or a higher level of output at a lower (greater) cost.

(6) $\frac{\partial \mathrm{lnc}}{\partial \mathrm{t}} = \omega_{it} + \omega_{it}t_i + \sum_i \omega_{it}\mathrm{lny_{it}} + \sum_i \omega_{it}\mathrm{lnw_{it}} + \mathrm{ln}r_{it}$

As MFIs are in the business of sustainable lending, they have to evaluate the creditworthiness of their borrowers, generally by appraisal of repayment capacity and asset backed lending. However, the MFIs', like other lenders, face the problems of adverse selection and moral hazard that increase default risk. To account for this, we follow Hartaska et al. (2011), Malikov and Hartaska (2018), and Hartaska et al. (2010) by including the portfolio-at–risk thirty days (r_{it}), which is the percentage rate of the total loan portfolio currently outstanding for more than thirty days. The impact of higher default risk on the cost of MFIs is measured by the percentage change in cost from one percentage change in the portfolio at risk (equation 7). If the value of the derivative is greater than zero then an increase in default risk, *ceteris paribus*, increases the costs.

$$(7) \qquad \frac{\partial \mathrm{lnc_{it}}}{\partial \mathrm{lnr_{it}}} = \varphi_{\mathrm{it}} + \varphi_{\mathrm{it}}\mathrm{ln}r_{it} + \sum_{\mathrm{i}} \varphi_{\mathrm{it}}\mathrm{lny_{it}} + \sum_{\mathrm{i}} \varphi_{\mathrm{it}}\mathrm{lnw_{it}} + t_i$$

Financial institutions diversify their financial service portfolios for several reasons: to reduce risk, increase revenue, and lower production cost. We analyze the cost determinants of the production of urban and rural loans and the effect of their integrated production on the cost dynamics of MFIs.

In general, economies of scope for MFIs mean that the integrated production of both rural and urban loans is less costly than the combined costs of producing them separately. The degree of the scope economies in MFIs is defined as the difference of the integrated loan production costs from the sum of specialized loan production costs divided by the integrated loan production costs. We focus on one element of the overall scope economy – namely potential cost complementarity when MFIs jointly produce rural and urban loans. In practice this happens when MFIs learn from offering urban loans and that knowledge helps them improve their rural lending and vice versa. Following Hardwick (1990), the existence of these cost complementarities from producing both rural and urban loan outputs occurs if the marginal cost of producing one loan type decreases when production of the second loan type increases. The interaction between the marginal cost of one loan type and the output of the second loan type is a second order partial derivative implying that MFIs that jointly produce rural and urban loans experience cost complementarities/economies of scale if the value of the derivative in (8) is less than zero.

$$(8) \qquad \frac{\partial^2 TC}{\partial y_1 \partial y_2} = \frac{TC}{y_1 y_2}\left[\frac{\partial lnTC}{\partial lny_1 \partial lny_2} + \left(\frac{\partial lnTC}{\partial lny_1}\right)\left(\frac{\partial lnTC}{\partial lny_2}\right)\right]$$

We use Allen partial elasticities of substitution to measure the degree of substitution among the factors of production. Equation 9 defines the partial elasticities of substitution in the translog cost function

$$(9) \qquad \sigma_{ij} = \frac{\varphi_{ij}}{s_i s_j} + 1 \text{ where } i \neq j$$

where, σ_{ij} is the elasticity of substitution, s_i and s_j are the cost shares of the different inputs, and φ_{ij} is the estimated coefficient of the interaction term for factor prices.

3. Data

The dataset used in this study was obtained from the Microfinance Information Exchange (MIX) that consists of over 1,000 MFIs across six regions of the world covering a period of nine years (2008–2015). The MFIs are divided into three categories: (1) the overall sample of MFIs jointly producing urban and rural loans, (2) Non-Deposit-MFIs jointly producing urban and rural loans but not offering deposit services, and (3) Deposit-MFIs jointly producing urban and rural loans while also offering deposit services. All regions in the sample have a significant number of MFIs jointly offering rural and urban loans.

Tables 1 and 2 summarize the regional distribution of MFIs. MFIs in East Asia incurred the highest total costs while producing the smallest number of loans. This region also has the smallest number of MFIs compared to other regions. Africa and Latin America provided \$6.35 billion and \$9.75 billion in loans, respectively, while MFIs in the Middle East and South Asia produced the largest rural loans, averaging \$524 billion.

Table 1. MFIs Offering Rural and Urban Loans

Variable	Africa	East Asia & the Pacific	Eastern Europe & Central Asia	Latin America & the Caribbean	Middle East & North Africa	South Asia
TC	8.55^{a}	9.22^{a}	8.57^{a}	7.66^{a}	1.00^{b}	1.42^{b}
	(1.00^{b})	(1.04^{b})	(9.78^{a})	(8.99^{a})	(1.02^{b})	(1.24^{b})
Y	1.22^{b}	1.06^{b}	1.32^{b}	1.39^{b}	7.24^{c}	1.56^{b}
	(2.08^{b})	(1.70^{b})	(1.97^{b})	(2.16^{b})	(7.36^{d})	(1.84^{b})
Y_1	6.35^{a}	1.79^{b}	1.24^{b}	9.77^{a}	5.24^{c}	1.84^{b}
	(8.76^{a})	(2.62^{b})	(1.84^{b})	(1.71^{b})	(5.35^{d})	(2.54^{b})
Y_2	1.03^{b}	8.45^{a}	1.12^{b}	1.20^{b}	7.21^{c}	1.23^{b}
	(1.92^{b})	(1.54^{b})	(1.84^{b})	(2.01^{b})	(7.36^{d})	(1.63^{b})
SL	0.683	0.610	0.543	0.589	0.589	0.584
	(0.064)	(0.080)	(0.111)	(0.072)	(0.073)	(0.088)
SK	0.226	0.238	0.236	0.247	0.314	0.245
	(0.049)	(0.059)	(0.065)	(0.052)	(0.058)	(0.061)
SFK	0.091	0.152	0.221	0.164	0.097	0.171
	(0.064)	(0.087)	(0.150)	(0.095)	(0.057)	(0.116)
Risk	0.090	0.058	0.069	0.065	0.050	0.054
	(0.120)	(0.098)	(0.102)	(0.084)	(0.086)	(0.090)
MFIs Obs.	266	242	531	976	109	84

Notes: TC is total cost, Y is total loan portfolio, Y_1 is total rural loans, Y_2 is total urban loans, SL share of labor expense, SK share of capital expense, SFK is the share of financial expense, Risk is the risk portfolio at 30 days. Column values assigned a letter are adjusted as follows: a:10^6, b:10^7, c:10^8 and d:10^9.

Table 2. Global and Regional Summary of MFIs Offering Rural and Urban Loans

	Sample	Africa	East Asia & the Pacific	Eastern Europe & Central Asia	Latin America & the Caribbean	Middle East & North Africa	South Asia
Overall MFIs in sample							
Observations	2,208	266	242	531	976	109	84
#MFIs	690	129	92	164	251	20	241
Non-Dep-MFIs							
Observations	934	11	18	276	549	61	19
MFIs	295	8	10	97	150	25	5
Dep-MFIs							
Observations	1,256	300	246	231	391	21	67
MFIs	530	151	100	125	118	14	22

Note: Full Sample includes both Non-Dep-MFIs and Dep-MFIs. Dep-MFIs are MFIs are those MFIs which provide deposit services and Non-Dep-MFIs are those MFIs that do not provide deposit services

Table 3. Means of Variables Used in the Estimation

Variable	Full sample	Non-Dep-MFIs	Dep-MFIs
TC	8.52^{a}	3.04^{a}	9.52^{a}
	(9.75^{a})	(2.54^{a})	(1.20^{b})
Y	4.83^{b}	7.52^{a}	2.64^{b}
	(1.64^{d})	(8.80^{a})	(4.09^{b})
Y_1	3.66^{b}	3.73^{a}	1.26^{b}
	(1.19^{d})	(5.16^{a})	(2.28^{b})
Y_2	4.63^{b}	3.79^{a}	1.38^{b}
	(1.64^{d})	(5.06^{a})	(2.55^{b})
SL	0.591	0.598	0.592
	(0.093)	(0.085)	(0.110)
SK	0.244	0.262	0.225
	(0.059)	(0.061)	(0.058)
SFK	0.165	0.140	0.184
	(0.114)	(0.104)	(0.132)
Risk	0.067	0.070	0.072
	(0.095)	(0.103)	(0.102)
MFIs	690	295	530
Obs.	2,208	934	1,256

Notes: TC is total cost, Y is total loan portfolio, Y_1 is total rural loans, Y_2 is total urban loans, SL share of labor expense, SK share of capital expense, SFK is the share of financial expense, Risk is the risk portfolio at 30 days. Column values assigned a letter are adjusted as follows: a:10^6, b:10^7, c:10^8 and d:10^9.

The share of labor expenses in total costs varies across regions, with Africa and East Asia allocating over 60%, while Eastern Europe had the lowest labor share. Administrative expenses are fairly uniform, ranging between 24% and 25% of total costs, except in Africa, where they average 22.6%, and the Middle East, where they reach 31.4%. Financial expenses are highest in Eastern Europe (22.1%) and South Asia (17.1%) and lowest in Africa (9.1%) and the Middle East (9.7%).

Regarding MFI categories, the average total cost for Dep-MFIs is $9.52 million, about three times higher than the $3.04 million average for Non-Dep-MFIs. Loan portfolios for both categories are nearly evenly distributed between rural and urban loans. Non-Dep-MFIs supplied $7.65 million in loans, divided into $3.73 million in rural loans and $3.75 million in urban loans. Dep-MFIs provided $26.4 million in loans, divided into $12.6 million in urban loans and $13.8 million in rural loans.

Labor expenses account for 59% of total costs across both categories. Administrative expenses represent 22.5% of total costs for Dep-MFIs, compared to 26.2% for Non-Dep-MFIs. Financial expenses for Non-Dep-MFIs are about 4% lower than those for Dep-MFIs. Risk exposure, measured by the percentage of loans delinquent for more than 30 days, averages 7% across both MFI types.

4. Empirical Results

This section presents estimation results for all MFIs and the two subcategories MFI. Table 4 contains specifications (1) - (3) with the estimates from a translog cost function with homogeneity and symmetry restrictions imposed. Alternative estimations, with the restrictions relaxed are in the appendix, Table A1 and they show slight differences between the coefficients across models with and without restrictions. The overall R-squared statistics for models (1) - (3) in Table 4 range between 0.61-0.73. Coefficients across MFI sample (aggregate sample and non-deposit and deposit MFIs) show expected signs and magnitudes. These coefficients are not directly interpretable when they are not scaled by total costs so the interpretation of input price elasticity and outputs is relevant as well as the computed cross price elasticity and cost complementarity.

Table 4. Regression Results Models with Restrictions Imposed

Variable	Full Sample	Non-Dep MFIs	Dep-MFIs
$\ln(Y_1)$ (rural loans)	0.665***	0.372***	0.499***
	(0.105)	(0.072)	(0.052)
$\ln(Y_1)^2$	0.093***	0.080***	0.102***
	(0.010)	(0.014)	(0.010)
$\ln(Y_2)$ (urban loans)	0.333***	0.514***	0.172***
	(0.114)	(0.087)	(0.053)

$ln(Y_2)^2$	0.075***	0.097***	0.081***
	(0.010)	(0.017)	(0.011)
$ln(Y_1)$ *$Ln(Y_2)$	-0.050***	-0.025	-0.059***
	(0.009)	(0.016)	(0.010)
Ln(L) (Labor expense)	0.501***	0.612***	0.576***
	(0.020)	(0.012)	(0.011)
Ln(K) (Capital expense)	0.165***	0.220***	0.168***
	(0.010)	(0.006)	(0.006)
Ln(FK) (Financial expense)	0.334***	0.168***	0.256***
	(0.028)	(0.014)	(0.014)
$Ln(L)^2$	0.054***	0.045***	0.066***
	(0.004)	(0.006)	(0.004)
$Ln(K)^2$	0.035***	0.033***	0.032***
	(0.002)	(0.004)	(0.003)
$Ln(FK)^2$	0.061***	0.054***	0.076***
	(0.005)	(0.006)	(0.007)
Ln(L)*Ln(K)	-0.014***	-0.012***	-0.011***
	(0.002)	(0.004)	(0.003)
Ln (L)*Ln (FK)	-0.040***	-0.033***	-0.055***
	(0.005)	(0.006)	(0.005)
Ln(K)*Ln (FK)	-0.021***	-0.021***	-0.021***
	(0.001)	(0.002)	(0.003)
$Ln(Y_1)$* Ln(L)	-0.007***	-0.010***	-0.005*
	(0.002)	(0.003)	(0.003)
$Ln(Y_1)$* Ln(K)	-0.003***	-0.003**	0.000
	(0.001)	(0.002)	(0.002)
$Ln(Y_1)$* Ln(FK)	0.011***	0.013***	0.005
	(0.003)	(0.003)	(0.004)
$Ln(Y_2)$* Ln(L)	-0.012***	-0.006*	-0.024***
	(0.002)	(0.003)	(0.002)
$Ln(Y_2)$* Ln(K)	-0.003**	-0.000	-0.007***
	(0.001)	(0.002)	(0.001)
$Ln(Y_2)$* Ln(FK)	0.015***	0.006*	0.031***
	(0.003)	(0.003)	(0.003)
Time (Time index)	-0.107*	-0.145***	0.028
	(0.062)	(0.047)	(0.053)
$Time^2$	0.004	0.008*	-0.001
	(0.003)	(0.004)	(0.004)
Time*$Ln(Y_1)$	-0.003	-0.008	-0.008
	(0.005)	(0.007)	(0.005)
Time*$Ln(Y_2)$	-0.003	-0.007	-0.005
	(0.006)	(0.009)	(0.005)
Time*Ln(L)	-0.002*	-0.002	-0.003**

	(0.001)	(0.001)	(0.001)
Time*Ln(K)	0.001***	0.001	0.001
	(0.001)	(0.001)	(0.001)
Time*Ln(FK)	0.001	0.001	0.002
	(0.001)	(0.002)	(0.002)
Time*Ln(PR)	-0.003	-0.015**	0.012*
	(0.005)	(0.008)	(0.007)
Ln(PR) (Portfolio risk)	0.154	0.268***	0.072
	(0.097)	(0.080)	(0.075)
$Ln(PR)^2$	0.019***	0.020**	0.015**
	(0.006)	(0.009)	(0.006)
$Ln(PR)*Ln(Y_1)$	0.001	0.009	0.001
	(0.009)	(0.016)	(0.011)
$Ln(PR)*Ln(Y_2)$	0.009	0.026	-0.021*
	(0.011)	(0.020)	(0.011)
Ln(PR)*Ln(L)	0.005**	0.010***	0.001
	(0.002)	(0.003)	(0.002)
Ln(PR)*Ln(K)	-0.011***	-0.008***	-0.009***
	(0.001)	(0.001)	(0.001)
Ln(PR)*Ln(FK)	0.006**	-0.002	0.008**
	(0.003)	(0.003)	(0.003)
Constant	3.510***	1.159***	0.178
	(0.681)	(0.205)	(0.162)
Observations	2,208	934	1,256
R-squared	0.638	0.612	0.731

Notes: Y_1 is the total rural loans, Y_2 is the total urban loans, L is the labor expense, K is the capital expense, FK is financial expense, PR is the risk portfolio at 30 days. Full Sample includes both Non-Dep-MFIs and Dep-MFIs. Dep-MFIs are MFIs are those MFIs which provide deposit services and Non-Dep-MFIs are those MFIs that do not provide deposit services. The standard error in the parentheses are bootstrapped standard errors with ***p<0.01, **p <0.05 and *p<0.1.

Table 5 shows sample estimates of the scale economies, cost elasticities based on loan type, risk elasticities, and technological effects for each MFI category. Results from the translog cost models with restrictions show that both Non-Deposit MFIs and Deposit MFIs have increasing returns to scale with almost identical estimates of about 1.7 (measured as AC/MC) suggesting that they can reduce costs by increasing production of loan portfolios.

Table 5. Scale Economies and Elasticities

Models with Restrictions Imposed			
	Full Sample	Non-Dep MFIs	Dep-MFIs
Rural loan elasticity	0.351***	0.256***	0.406***
	(0.011)	(0.015)	(0.015)
Urban Loan Elasticity	0.221***	0.339***	0.197***
	(0.011	(0.169)	(0.014)
Economies of Scale	1.749***	1.681***	1.669***
	(0.031)	(0.047)	(0.035)
Risk Elasticity	0.033	0.104***	0.100*
	(0.024)	(0.031)	(0.07)
Technological Effect	-0.048	-0.048***	0.005
	(0.015)	(0.020)	(0.040)
Models with No Restrictions Imposed			
	Full Sample	Non-Dep MFIs	Dep-MFIs
Rural loan elasticity	0.339***	0.285***	0.416***
	(0.008)	(0.012)	(0.012)
Urban Loan Elasticity	0.390***	0.443***	0.401***
	(0.010)	(0.015)	(0.126)
Economies of Scale	1.372***	1.373***	1.224***
	(0.017)	(0.027)	(0.018)
Risk Elasticity	0.034	0.063***	0.222
	(0.017)	(0.023)	(0.187)
Technological Effect	0.000	0.006	0.097
	(0.011)	(0.016)	(0.107)

Notes: Full Sample includes both Non-Dep-MFIs and Dep-MFIs. Dep-MFIs are MFIs are those MFIs which provide deposit services and Non-Dep-MFIs are those MFIs that do not provide deposit services. The standard error in the parentheses are obtained via the delta method with ***p<0.01, **p <0.05 and *p<0.

The outputs cost elasticities are reported in Table 6. For the samples of All MFIs and for Dep-MFIs the cost elasticity of urban loans is significantly lower than that for rural loans, which is in line with the MFI literature that argues that MFIs have more cost savings in urban areas as opposed to rural areas attributed typically to higher population density. The MFI literature suggests that rural environments expose MFIs to higher transaction costs and higher rural economy (systemic) risk relative to urban areas. However, the non-deposit MFIs have an unexpected higher urban loan cost elasticity of 0.339 compared to rural loan elasticity of 0.256 in line with recent findings by Mia et al 2022.

Table 6. Allen Elasticities of Substitution

Models with Restrictions Imposed			
	Full Sample	Non-Dep MFIs	Dep MFIs
Labor-Financial	0.896***	0.920***	0.915***
	(0.013)	(0.018)	(0.019)
Labor-Capital	0.619***	0.631***	0.504***
	(0.023)	(0.035)	(0.032)
Financial-Capital	0.507***	0.460***	0.496**
	(0.034)	(0.039)	(0.048)
Models with no Restrictions Imposed			
	Full Sample	Non-Dep MFIs	Dep-MFIs
Labor-Financial	1.043***	1.247***	0.725***
	(0.201)	(0.255)	(0.278)
Labor-Capital	1.034***	1.285***	1.116***
	(0.142)	(0.189)	(0.191)
Financial-Capital	1.606***	0.695	-1.563**
	(0.465)	(0.701)	(0.609)

Notes: Full Sample includes both Non-Dep-MFIs and Dep-MFIs. Dep-MFIs are MFIs are those MFIs which provide deposit services and Non-Dep-MFIs are those MFIs that do not provide deposit services. The standard error in the parentheses are obtained via the delta method with ***p<0.01, **p <0.05 and *p<0.

Table 7. Cost Complementarities

Models with Restrictions Imposed			
	Full Sample	Non-Dep MFIs	Dep-MFIs
Sample Estimate	0.004***	0.009***	0.003***
	(0.001)	(0.001)	(0.001)
Negative	13.86%	3.20%	19.03%
Positive	58.92%	76.87%	40.53%
Models with No Restrictions Imposed			
	Full Sample	Non-Dep MFIs	Dep-MFIs
Sample Estimate	0.008***	0.011***	0.014***
	(0.000)	(0.001)	(0.001)
Negative	17.16%	13.50%	9.8%
Positive	68.84%	72.70%	74.92%

Notes: Full Sample includes both Non-Dep-MFIs and Dep-MFIs. Dep-MFIs are MFIs are those MFIs which provide deposit services and Non-Dep-MFIs are those MFIs that do not provide deposit services. The standard error in the parentheses are obtained via the delta method with ***p<0.01, **p <0.05 and *p<0.

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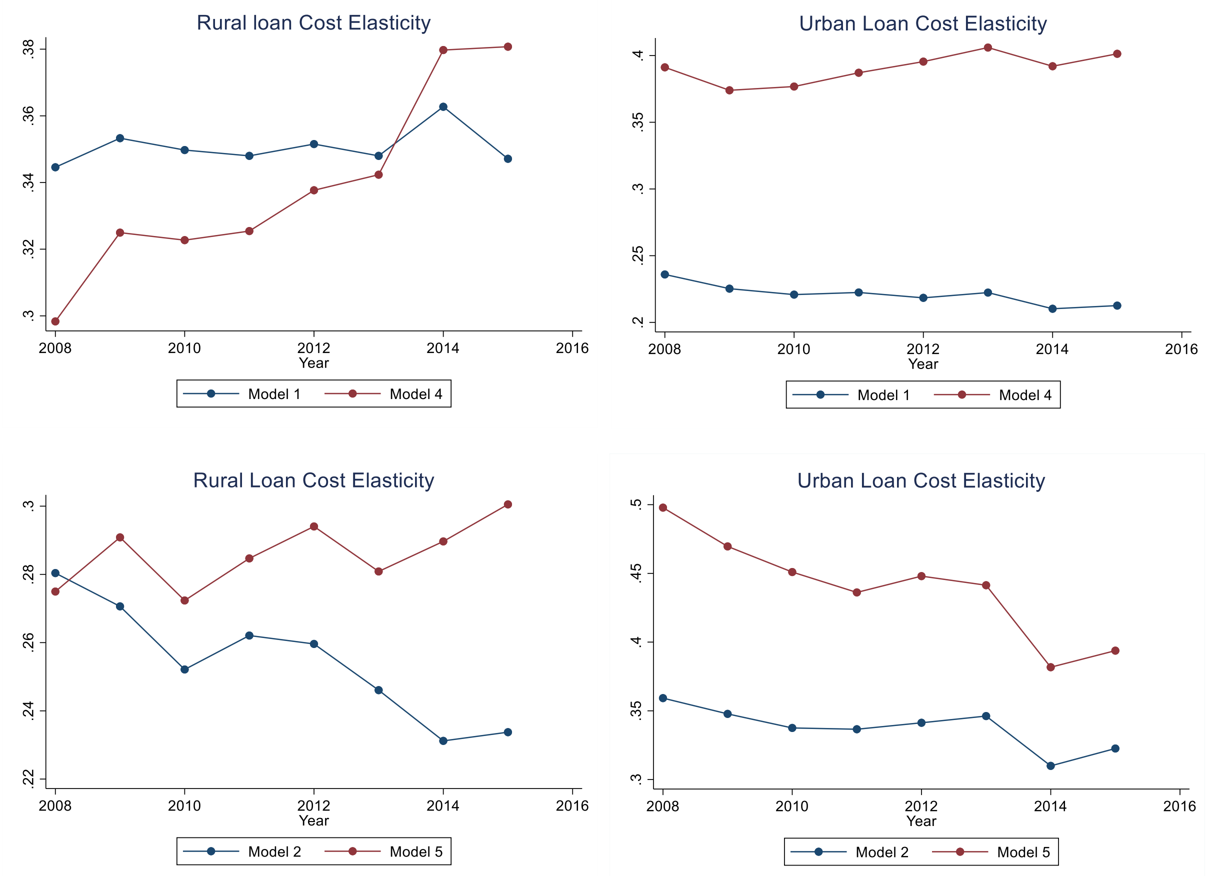
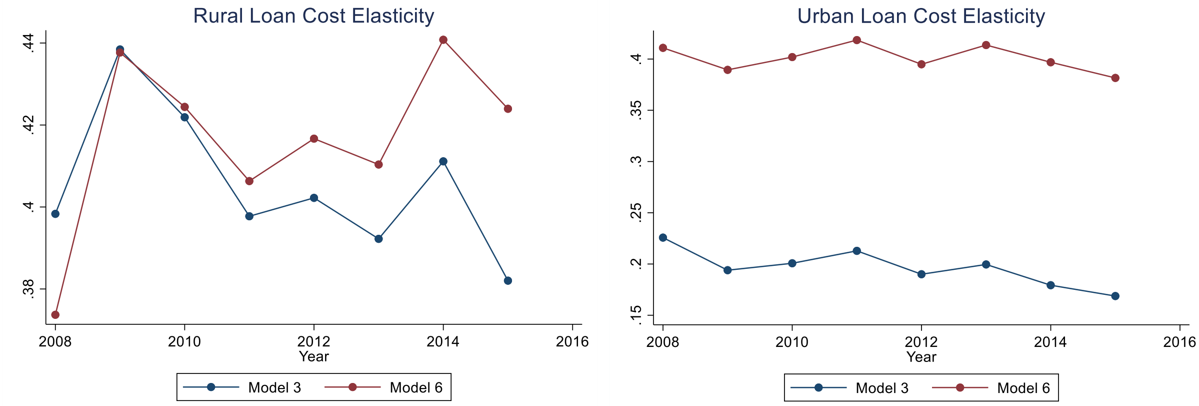
We also find that the costs had declined across all three MFIs sample types. Dep-MFIs experienced the largest drop of 26.67%, consistent with previous research on deposit-collecting MFIs finding them more cost efficient (Cosarenco et al., 2022). Non-Dep-MFIs costs fell by 18.33%, potentially affected in part by a 30% increase in urban loan elasticity. However, rural loan elasticities of the three MFI samples are slightly different, with magnitudes smaller than 10%.

Figure 1 shows computed mean annual urban loan and rural loan elasticitiesacross MFIs types and models (with and without restrictions), while Figure 2 shows the computed economies of scale. The results suggest that, in Non-Dep-MFIs, the rural loan cost elasticities across model types are trending downward indicating increasing cost savings from increasing rural loan production. The urban loan cost elasticities in both model types are also trending downward suggesting increasing cost savings from larger urban loan output over the sample period. These results, altogether, present evidence of declining MFI costs over time.

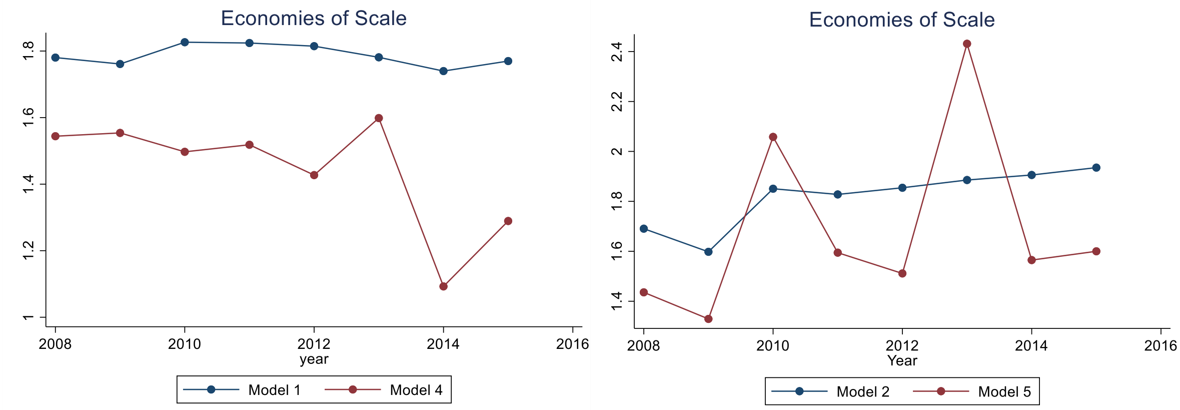


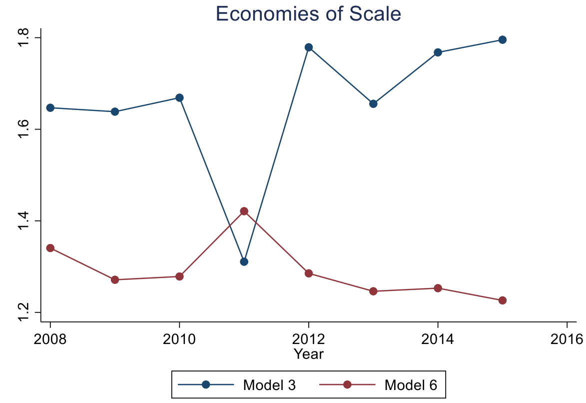


Notes: Model 1and Model 4 (Model 1-No restrictions) represent the entire MFI sample, Model 2 and Model 5 (Model 2-No restrictions) represents MFIs not offering deposits, finally Model 3 and Model 6 (Model 3-No restrictions) represents MFIs offering deposits.

Figure 1. Computed Urban Loan and Rural Loan Cost Elasticities across MFIs Types and Models

The results for the Dep-MFIs show that they compare well to non-dep-MFIs and fluctuate in similar fashion with cost of rural loans fluctuating quite a bit while that or urban loan show little variability and downward trend. The economies of scale presented in Figure 2 and shows that relative to the Non-Deposit MFI, Dep-MFIs' economies of scale fluctuate much more. However, the figure illustrates that the economies of scale are increasing overtime, indicating that scaling up has been increasing cost savings for all types of MFIs. The scale economies from the restricted model are greater than those of the unrestricted model over most of the sample time period.

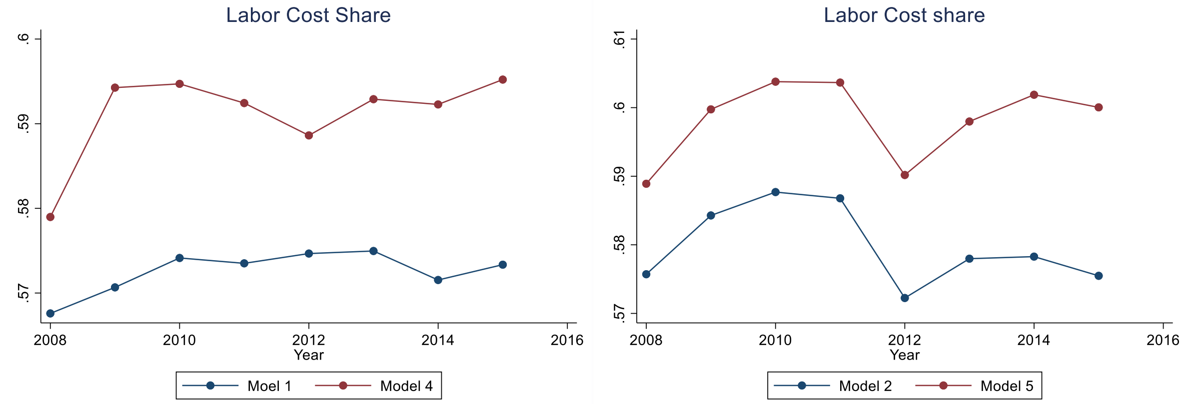


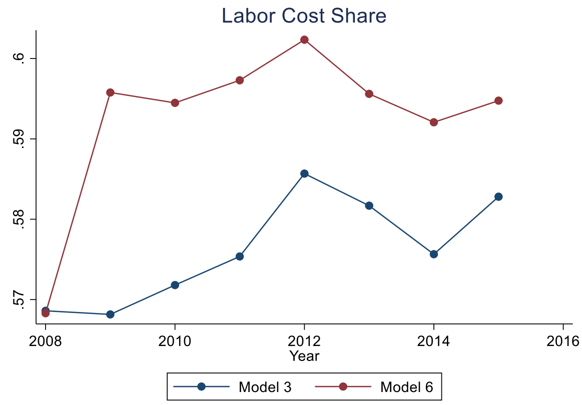


Notes: Model 1 and Model 4 (Model 1 with no restrictions) represent the entire MFI sample (upper Left quadrant), Model 2 and Model 5 (Model 2 with no restrictions) represents MFIs not offering deposits (upper right quadrant), finally Model 3 and Model 6 (Model 3 with no restrictions) represents MFIs offering deposits (lower left quadrant).

Figure 2. Computed Economies of Scale across Models and Samples

Input cost shares are computed and are presented in Figures 3 and 4. Figure 3 illustrates that while in the overall sample there little variability, in the labor cost share the upward fluctuation in Non-deposit MFIs seems to coincide with downward fluctuation in the labor cost share for Deposit-MFIs. While this could be a coincidence, it may also reflect changes in the labor market that have potentially shifts labor use across different sectors or within the MFIs which is less likely since labor tends to be localized. It may be a result of substitution due to changes in the relative costs, which is explored next.

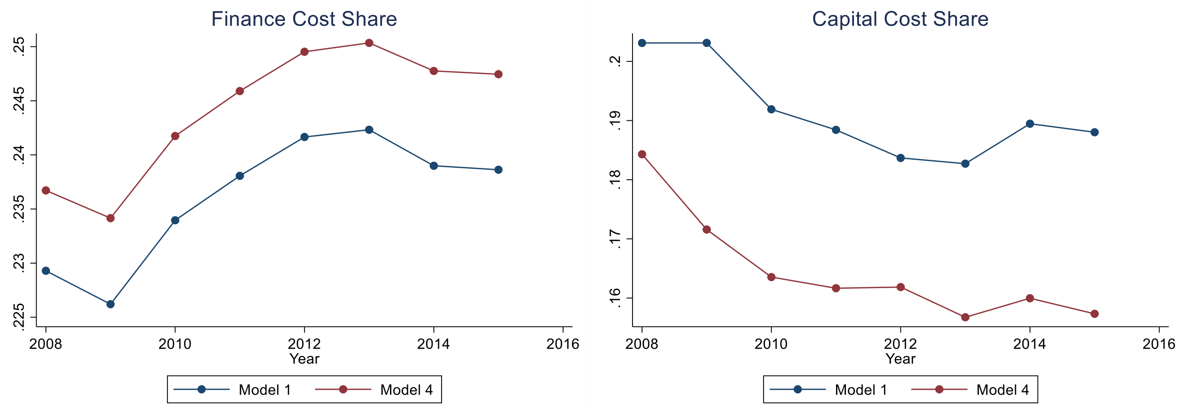




Notes: Model 1 and Model 4 (Model 1 with no restrictions) represent the entire MFI sample (upper Left quadrant), Model 2 and Model 5 (Model 2 with no restrictions) represents MFIs not offering deposits (upper right quadrant), finally Model 3 and Model 6 (Model 3 with no restrictions) represents MFIs offering deposits (lower left quadrant)

Figure 3. Predicted Labor cost Shares across Models and Samples

Figure 4 shows that financial cost share exhibits an upward trend over time for all samples, while that of capital costs share decreases during the time period. Capital cost share increases in the Non-deposit MFIs but their capital costs share is stable, suggesting that labor costs and finance costs may act as substitutes. In Dep-MFIs, there is more fluctuations in all three costs shares.



Notes: Model 1 and Model 4 (Model 1 with no restrictions) represent the entire MFI sample, Model 2 and Model 5 (Model 2 with no restrictions) represents MFIs not offering deposits, finally Model 3 and Model 6 (Model 3 with no restrictions) represents MFIs offering deposits.

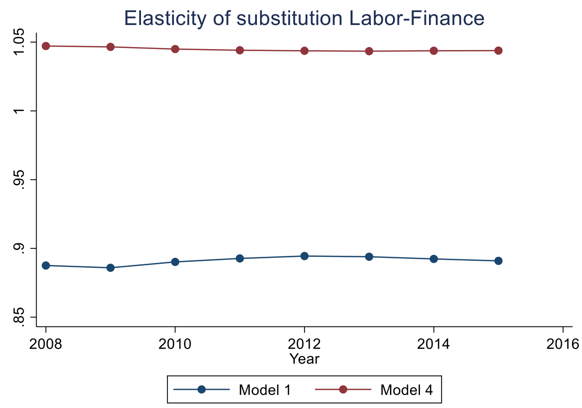
Figure 4. Predicted Finance Cost Shares and Capital Cost Shares across Models and Samples

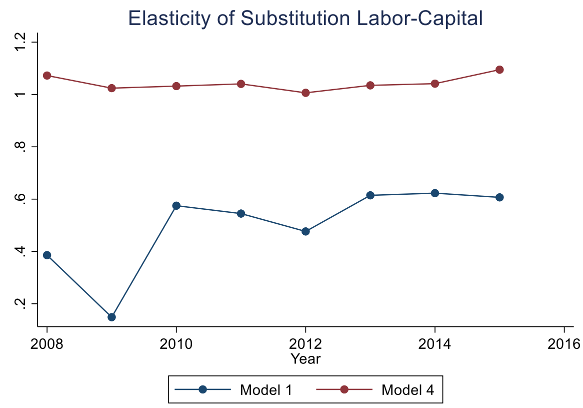
The results on the time index estimates represents a measure of technological innovation. It is statistically significant only in Non-Dep MFIs, indication that for thes MFIs, costs decrease by 4.8% annually. This index does not reflect the source of the innovation but may indicate its direction. For instance, public infrastructure, group lending technologies, or adoption of mobile and other lending technologies may have reduced both transaction and monitoring costs amongst these MFIs.

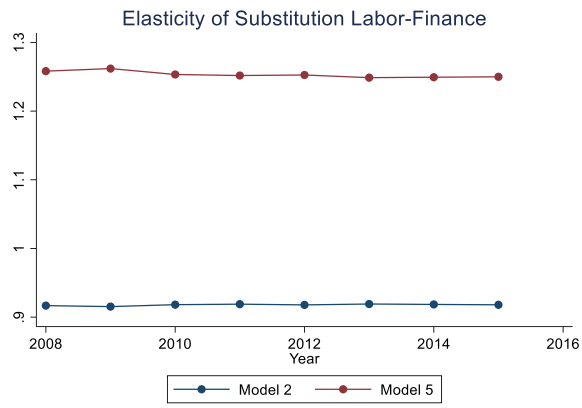
The role of risk is measured through the portfolio at risk-30 days (percentage rate of loans outstanding for >30 days). The risk elasticity for Non-Dep MFIS is 0.104 while that of Dep-MFIs is 0.100 meaning that a 1% increase in the percentage share of delinquent loans increases total costs by 0.1% across both MFI types. However, this does not necessarily mean that this interaction between MFIs' delinquent loans and costs is attributable to loan defaults. It is possible that the MFIs were implementing both ex-ante and ex-post credit policies to minimize non-performing loan levels.

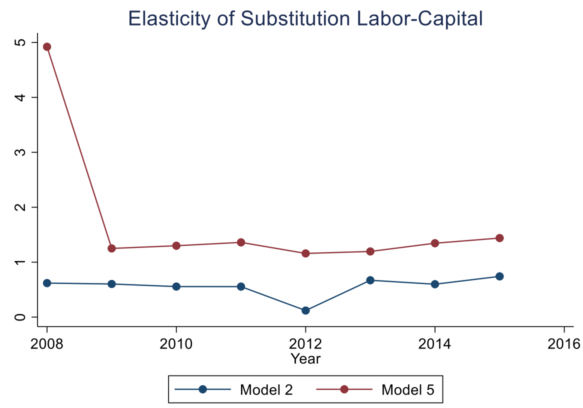
Table 6 shows the Allen-Uzawa elasticities of substitution measuring percentage change in factor proportions due to change in relative prices. Non-Dep-MFIs and Dep-MFIs show almost equal labor / financial elasticities of substitution of about 0.920. Yet, Non-Dep-MFIs show much larger labor-capital elasticities of substitution of 0.631 compared to 0.504 amongst Dep-MFIs. Moreover, for both MFI categories, financial and real capital elasticities of substitution are the smallest compared to the other input combinations. Non-Dep-MFIs and Dep-MFIs reported 0.496 and 0.460 financial - real capital elasticities of substitution.

The annual mean elasticities of substitution are presented graphically in Figures 5 and 6. Three things are worth noting. First, across both MFIs categories and model types, there are no upward nor downward trends over the sample period. Second, there is minimal to no variability. Third, the majority of the computed elasticities of substitution from the restricted model are smaller than those of the unrestricted model, as expected.









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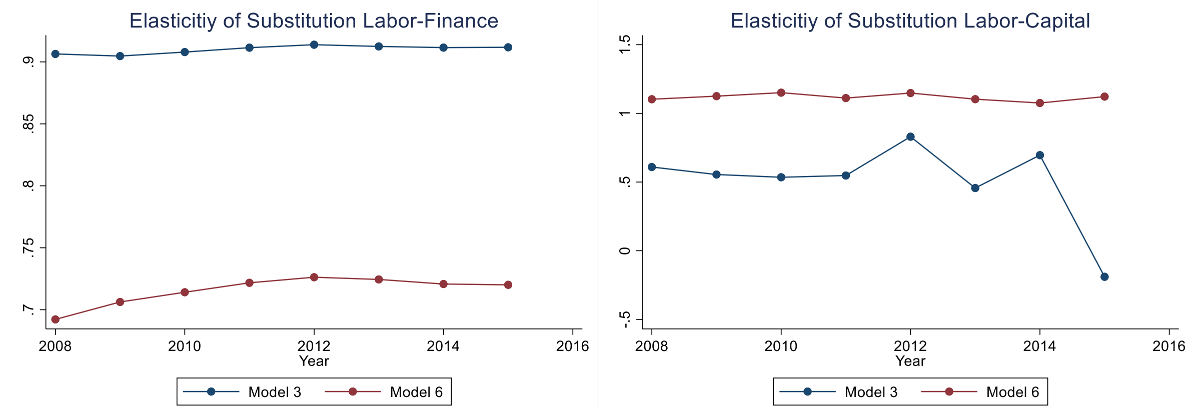
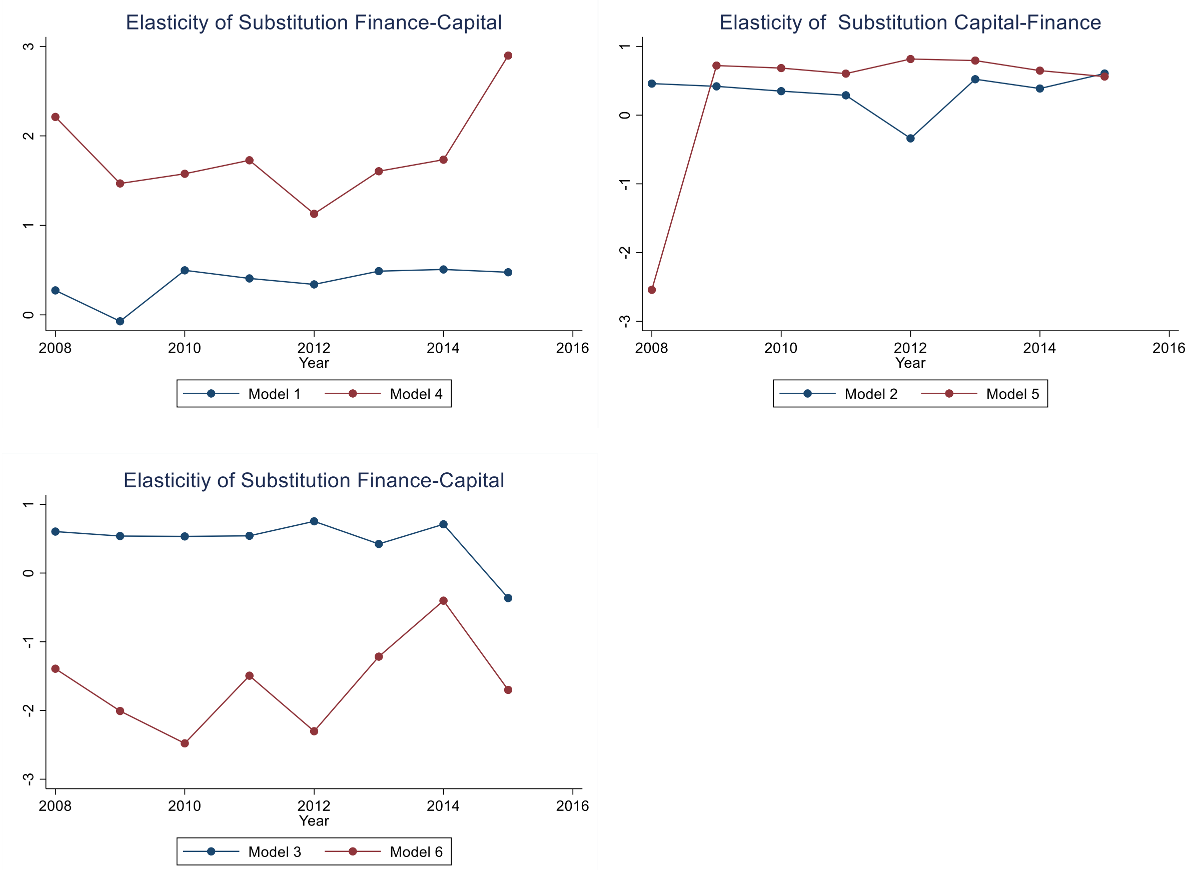


Notes: Model 1 and Model 4 (Model 1 with no restrictions) represent the entire MFI sample, Model 2 and Model 5 (Model 2 with no restrictions) represents MFIs not offering deposits, finally Model 3 and Model 6 (Model 3 with no restrictions) represents MFIs offering deposits.

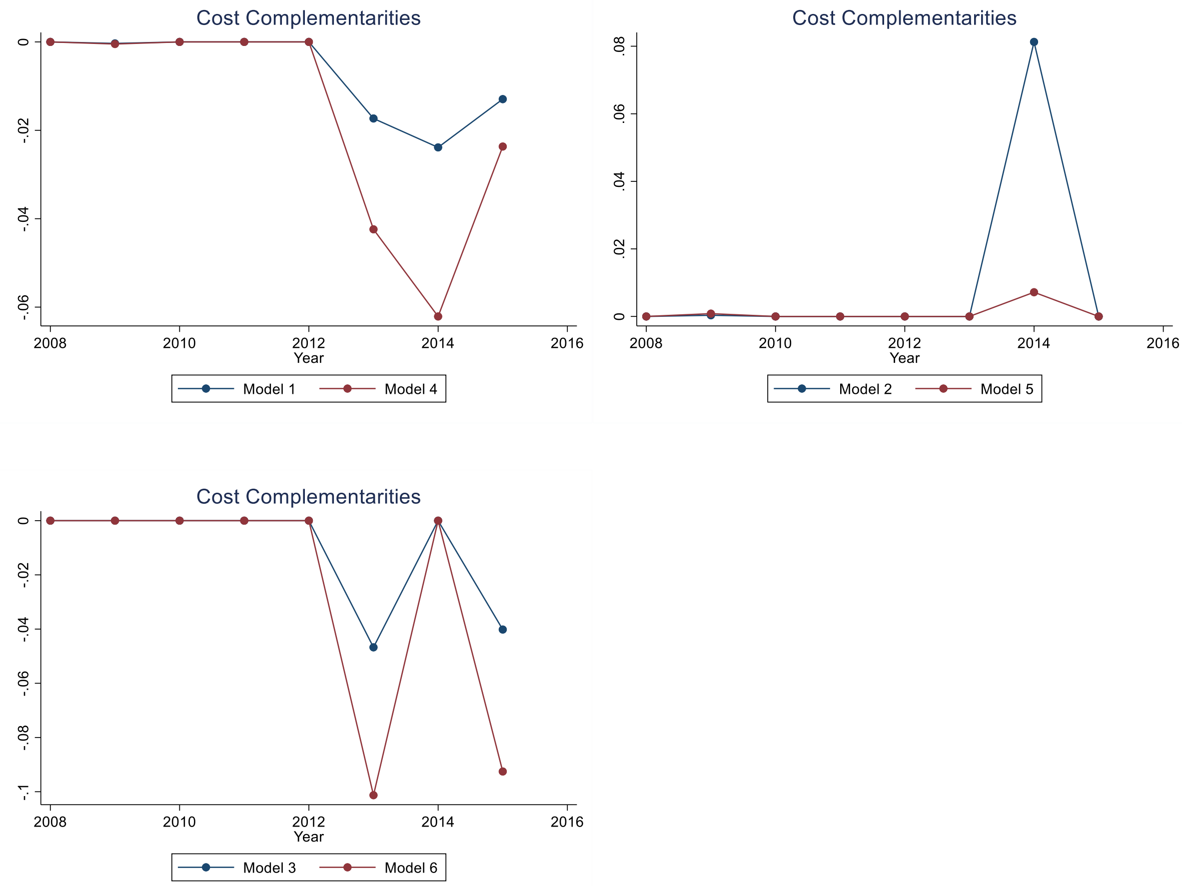
Figure 5. Computed Elasticity of Substitution Labor-Finance and Labor-Capital across Models and Samples



Notes: Model 1 and Model 4 (Model 1 with no restrictions) represent the entire MFI sample (upper Left quadrant), Model 2 and Model 5 (Model 2 with no restrictions) represents MFIs not offering deposits (upper right quadrant), finally Model 3 and Model 6 (Model 3 with no restrictions) represents MFIs offering deposits (lower left quadrant)

Figure 6. Computed Elasticity of Substitution Finance-Capital and Cost Complementarities across Models and Samples

The final and most important result is that on cost complementarities shown in Table 9. They provide information on how marginal costs of rural vs. urban loan production were affected by the increase in the production of urban/rural loans. The estimates of less than zero suggest learning across rural and urban microfinance products.



Notes: Model 1 and Model 4 (Model 1 with no restrictions) represent the entire MFI sample (upper Left quadrant), Model 2 and Model 5 (Model 2 with no restrictions) represents MFIs not offering deposits (upper right quadrant), finally Model 3 and Model 6 (Model 3 with no restrictions) represents MFIs offering deposits (lower left quadrant)

Figure 7. Cost Complementarities across Models and Samples

Across the three samples, cost complementarity estimates are positive and statistically significant although very small in magnitude, suggesting that rural and urban loans are not complementary and that serving both markets may be costly. For the sample of all MFIs, the cost complementarity average estimate is 0.004, while point estimates that are statistically significant and negative were only 13.86%. This is not very different from the sample estimate of 0.009 for Non-Dep-MFIs. However, the percentage of statistically significant cost complementarity estimates of less than zero dropped to only 3.20%. Yet, the sample of Dep-MFIs yielded the highest percentage of negative cost complementarity. Despite the overall positive and statistically significant estimate of 0.003, as much as 19.03% of the Dep-MFIs sample were experiencing negative cost complementarities indicating that when MFGI offer both savings and loans, learning across rural and urban products occur and can lower the cost of providing both in at least one fifth of the institutions. This is the largest change across different MFIs samples. Figure 7 shows these cost complementarity estimates. The blue lines show no visible trend in the first few years, mimicking the sample estimates that were very close to zero. However, the cost complementarity began fluctuating after 2012 and were negative for the Dep-MFIs at least in 2013 and 2015.

5. Conclusion

This paper analyzes cost dynamics of Microfinance Institutions (MFIs) jointly producing rural and urban loans. Using seemingly unrelated regression methods with a system of equations consisting of a translog cost function and cost share equations, the study examines three MFI samples: the aggregate sample, Non-Dep-MFIs, and Dep-MFIs. The objective was to compute and interpret economies of scale, elasticities of substitution, and cost complementarities from offering two distinct loan products.

The computed economies of scale show that MFIs that collected deposits (Dep-MFIs) and those that did not collect deposits (Non-Dep-MFIs) experienced increasing returns to scale. The results indicate a larger cost elasticity in the production of urban loans compared to rural loans in Non-Dep-MFIs indicating that urban loans are more expensive for Non-Dep-MFIs. Even if unusual, this result is in line with a recent work by Mia et al. 2022. However, in the overall MFIs sample and Dep-MFIs, the rural loan elasticity was larger than urban loan cost elasticity making rural loans more expensive for those groups, consistent with previous findings in the literature. In addition, the results show that in Non-Dep-MFIs, both urban loan and rural loan elasticities declined over time, indicating that these MFIs lowered their costs overtime. The results show that the Non-Dep-MFIs also had larger labor / financial and labor / capital elasticities of substitution compared to Dep-MFIs. Finally, the main finding on cost complementarities show that the majority of MFIs were experiencing positive cost complementarities, suggesting that offering both urban and rural loans is costly even if the added costs are very small in magnitude. However, for about one fifth of the Dep-MFIs, we find cost complementarities from offering both urban and rural loans.

This paper contributes to the microfinance scale and scope economies literature because it offers estimates of the cost dynamics and structure for Dep-MFI and Non-Dep MFIs for MFIs that offer both rural and urban loans. It reaffirms previous findings for scale economies, the relative cost of rural and urban loans, and presents new results on cost complementarities by MFIs type. A limitation of this study is that results apply only to the group of MFIs serving all areas by offering urban and rural loans. Moreover, the estimated cost complementarities are only one aspect of the scope economies that relates to the learning-by-doing aspect of microfinance activities. Full estimates of scope economies entail estimating how in addition to cost complementarity, spreading of fixed costs between rural and urban loans affects costs. Future work should explore these issues in more detail.

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Appendix

Table A1. Regression Results: Models with no Restrictions Imposed

Variable	Full Sample	Non-Dep MFIs	Dep-MFIs
$\ln(Y_1)$ (rural loans)	0.580***	0.421***	0.427***
	(0.121)	(0.061)	(0.039)
$\ln(Y_1)^2$	0.103***	0.106***	0.110***
	(0.011)	(0.013)	(0.009)
$\ln(Y_2)$ (urban loans)	0.661***	0.713***	0.457***
	(0.146)	(0.088)	(0.051)
$\ln(Y_2)^2$	0.123***	0.136***	0.140***
	(0.013)	(0.017)	(0.011)
$\ln(Y_1)$ *$\ln(Y_2)$	-0.074***	-0.047**	-0.071***
	(0.014)	(0.019)	(0.009)
Ln(L) (Labor expense)	0.182	0.031	0.056
	(0.293)	(0.132)	(0.087)
Ln(K) (Capital expense)	-0.211	0.089	-0.150
	(0.160)	(0.126)	(0.112)
Ln(FK) (Financial expense)	0.884***	0.361***	0.427***
	(0.139)	(0.067)	(0.101)
$\ln(L)^2$	0.048	0.100**	0.193***
	(0.049)	(0.045)	(0.041)
$\ln(K)^2$	-0.021	-0.223***	-0.062
	(0.054)	(0.070)	(0.070)
$\ln(FK)^2$	0.104***	0.091***	0.126***
	(0.018)	(0.023)	(0.038)
Ln(L)*Ln(K)	0.006	0.039	-0.037
	(0.041)	(0.043)	(0.041)
Ln (L)*Ln (FK)	0.003	0.023	0.012
	(0.021)	(0.022)	(0.036)
Ln(K)*Ln (FK)	0.023	-0.011	-0.102**
	(0.027)	(0.041)	(0.049)
$\ln(Y_1)$* Ln(L)	0.011	-0.028	-0.040***
	(0.023)	(0.024)	(0.014)
$\ln(Y_1)$* Ln(K)	-0.049***	-0.031	-0.013
	(0.016)	(0.024)	(0.023)
$\ln(Y_1)$* Ln(FK)	0.057***	0.042**	0.004
	(0.013)	(0.017)	(0.023)
$\ln(Y_2)$* Ln(L)	-0.010	-0.030	-0.085***
	(0.026)	(0.021)	(0.016)
$\ln(Y_2)$* Ln(K)	0.034*	0.057**	0.009
	(0.020)	(0.027)	(0.028)

$Ln(Y_2)$* Ln(FK)	0.023	0.026	0.045*
	(0.015)	(0.019)	(0.024)
Time (Time index)	0.027	-0.065*	0.116
	(0.053)	(0.038)	(0.134)
$Time^2$	0.005**	0.004	0.005*
	(0.002)	(0.003)	(0.003)
Time*$Ln(Y_1)$	0.010***	0.003	0.005
	(0.004)	(0.005)	(0.004)
Time*$Ln(Y_2)$	-0.001	-0.018**	-0.000
	(0.006)	(0.008)	(0.005)
Time*Ln(L)	-0.031***	-0.013	-0.014
	(0.011)	(0.011)	(0.010)
Time*Ln(K)	0.015*	0.016	0.005
	(0.008)	(0.013)	(0.013)
Time*Ln(FK)	-0.015***	-0.009	-0.009
	(0.006)	(0.008)	(0.009)
Time*Ln(PR)	0.003	-0.010	0.014***
	(0.004)	(0.007)	(0.005)
Ln(PR) (Portfolio risk)	0.262***	0.191***	0.151
	(0.087)	(0.069)	(0.266)
$Ln(PR)^2$	0.011**	0.013*	-0.000
	(0.004)	(0.007)	(0.005)
Ln(PR)*$Ln(Y_1)$	0.014**	0.027*	0.003
	(0.006)	(0.015)	(0.008)
Ln(PR)*$Ln(Y_2)$	0.024**	0.034*	-0.001
	(0.010)	(0.019)	(0.011)
Ln(PR)*Ln(L)	-0.038**	-0.034	-0.040**
	(0.016)	(0.029)	(0.019)
Ln(PR)*Ln(K)	0.035*	0.025	0.041*
	(0.018)	(0.030)	(0.025)
Ln(PR)*Ln(FK)	0.014	-0.007	0.025
	(0.013)	(0.017)	(0.018)
Constant	3.914***	0.717***	-0.015
	(0.758)	(0.188)	(0.122)
Observations	2,208	934	1,256
R-squared	0.794	0.761	0.851

Notes: Y_1 is the total rural loans, Y_2 is the total urban loans, L is the labor expense, K is the capital expense, FK is financial expense, PR is the risk portfolio at 30 days. Full Sample includes both Non-Dep-MFIs and Dep-MFIs. Dep-MFIs are MFIs are those MFIs which provide deposit services and Non-Dep-MFIs are those MFIs that do not provide deposit services. The standard error in the parentheses are bootstrapped standard errors with ***p<0.01, **p <0.05 and *p<0.

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Authors contributions

Dr. Machatha was responsible for organizing the data, concept refinement, estimating the empirical models and drafting the first draft. Dr Hartarska was responsible for model development, data acquisition, empirical work supervision and draft editing. Dr Nadolnyak was responsible for method and empirical work supervision and editing the manuscript.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.