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Constraints to women's financial literacy in Pakistan: A Bayesian hierarchical analysis

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Abstract

This study investigates the determinants of financial literacy among women entrepreneurs in Pakistan's informal sector and its implications for their entrepreneurial success. Using data from five districts in Punjab, a Bayesian hierarchical logistics model estimated through Hamiltonian Monte Carlo (HMC) and the No-U-Turn Samplers (NUTS) was applied for robust interference. Results show that 55-59 % of respondents were financially literate, with an overall mean of 61 %. Education, access to credit, and business facilities were positively associated with financial literacy, whereas gender-related constrains and lack of formal education had negative effects. Cultural constrained showed mixed influences, and multiple roles had a slight positive impact. The findings highlight the need for targeted financial literacy programs, focusing on budgeting, financial management, and investment skills, to enhance women's entrepreneurial capacity and support inclusive economic development.

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JEL Classification: D14, C11, C25

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1. Introduction

Entrepreneurship is more than merely running a business, as it involves identifying external opportunities, aligning available resources, acquiring additional capabilities, and ultimately creating sustained value and rewards (Mishra and Zachary, 2015). It can also be understood as a process of vision, change, and creation that requires energy and passion to implement new ideas (Kuratko, 2014). Recently, women's entrepreneurship, particularly in South Asia, has attracted growing attention from academics, policymakers, and broader society (Koneru, 2017; Sastre-Castillo et al., 2015; Vossenberg, 2013). This interest stems from the recognition of entrepreneurship as a key driver of economic development and from the significant contributions women make as entrepreneurs worldwide (Global Entrepreneurship Monitor, 2020).

Women entrepreneurs promote economic growth by creating jobs, increasing productivity, and introducing distinct managerial and operational approaches that complement those of men (Safarik et al., 2003). Entrepreneurship also plays a crucial role in lifting women out of poverty (Reed et al., 2012). In contexts with limited employment opportunities, many women turn to the informal sector to earn a living (Ram et al., 2007). Within this sector, women entrepreneurs are vital contributors to wealth creation, employment generation, and broader improvements in human development, education, and health, particularly in developing countries like Pakistan (Neumeyer et al., 2019; Sajjad et al., 2020).

Women in emerging markets reinvest nearly 90 % of their earnings into household education, health, and nutrition, compared to 30–40 % for men.[1] Recognizing this, many countries, such as Canada and Germany, have implemented policies to support women entrepreneurs. In contrast, women entrepreneurship in many developing economies, including Pakistan, continues to face significant constraints, especially due to lack of access to finance (Naguib and Jamali, 2015). Despite increasing participation of women in Micro, Small, and Medium Enterprises (MSMEs) and in the labor force, financial access remains a major barrier to business growth in Pakistan (Hussain et al., 2019).

Figure 1. The Global Economy.com

[1] https://hbr.org/2013/09/global-rise-of-female-entrepreneurs

A major contributor to this barrier is low financial literacy among women entrepreneurs (Baporikar and Akino, 2020). This constraint has broader implications for economic growth, given that a large proportion of Pakistani women still lack direct access to financial services (Noor et al., 2020). More than 82 % of women remain excluded from the formal banking system (WFIDP).[2] Without adequate financial knowledge and training, women are unable to fully utilize available financial products, optimize income, or expand their businesses (Brixiova, 2010).

Financial literacy is a critical determinant of formal financial account ownership and helps overcome barriers to financial inclusion, such as documentation requirements, lack of trust, and limited awareness (Akudugu, 2013; Lotto, 2020). Improved financial knowledge also equips women entrepreneurs to identify, compare, and demand financial products that meet their needs, ultimately promoting savings and informed decision-making (Atkinson and Messy, 2011). Although women are increasingly involved in financial decision-making, significant gaps remain, particularly in developing countries characterized by high poverty and unemployment (Lotto, 2020). Many women are aware of financial products but hesitate to use them due to insufficient technical knowledge (Arora, 2016; Danes and Haberman, 2007). Research shows that financial literacy is positively correlated with wealth accumulation (Tambunan, 2009), underscoring its importance not only for business performance but also for broader economic contributions.

Women are recognized as one of the fastest-growing groups of entrepreneurs globally (Patil and Deshpande, 2018). In the informal sector, when women's entrepreneurship is paired with financial literacy, it can significantly spur economic growth by creating jobs and reducing poverty (Lotto, 2020; Williams and Martinez, 2014). Evidence from South Africa demonstrates that financial literacy among small-scale women entrepreneurs promotes employment, empowerment, investment, and business operations, and therefore entrepreneurs must possess adequate financial knowledge (Oseifuah, 2010).

Financial literacy is widely recognized as an important factor influencing financial behavior, financial inclusion, business sustainability, and economic well-being (Hasan et al., 2021; Kumar and Singh, 2015; WE-FI, 2025). Among women entrepreneurs in the informal sector, improved financial knowledge can support more effective financial management and strengthen their ability to cope with economic challenges (Bernhard, 2008; Jiyane and Zawada, 2013). Besides, enhancing women's financial capabilities may indirectly contribute to broader development objectives, including poverty reduction, gender equality, and decent work, which are reflected in several United Nations Sustainable Development Goals (Javed et al., 2021).

Despite the growing recognition of the importance of financial literacy, limited evidence exists on the factors that determine financial literacy among women entrepreneurs operating in the informal sector, particularly in developing countries such as Pakistan. Accordingly, this study treats financial literacy as the outcome variable and examines the socio-economic and demographic factors associated with women's financial literacy. The study aims to identify the key determinants of financial literacy among women microentrepreneurs in Pakistan and to highlight areas requiring policy attention to support women's entrepreneurship and financial capability development.

[2]https://data2x.org/resource-center/womens-financial-inclusion-data-partnership-partnership-principles/

Enhancing financial literacy among informal-sector entrepreneurs is crucial for addressing their lack of practical financial skills (Jiyane and Zawada, 2013). Financial literacy promotes positive financial behavior, strengthens overall financial well-being, and improves resilience during adverse economic conditions (Kumar and Singh, 2015). It also plays a significant role in tackling broader development and poverty-related challenges (Zhu et al., 2018). By improving financial knowledge, women entrepreneurs in the informal sector can gain greater access to financial services, expand their businesses, and generate employment opportunities, thereby contributing to poverty reduction in underprivileged communities. Ultimately, improved financial literacy supports a more inclusive and sustainable pathway to economic development (Dinkova et al., 2021; Taft et al., 2013).

The evidence discussed above indicates that financial literacy is closely linked to the success and growth of women entrepreneurs in the informal sector. Therefore, the primary aim of this research is to identify the factors that influence women's financial literacy and determine which areas require targeted interventions to promote women's entrepreneurship. This study makes two key contributions. First, it adopts a novel methodological approach to data analysis by employing a Bayesian hierarchical logistic model estimated using Hamiltonian Monte Carlo (HMC). HMC is an advanced Markov Chain Monte Carlo (MCMC) technique that uses the No-U-Turn Sampler (NUTS) to improve sampling efficiency (Hoffman and Gelman, 2014). This approach allows for precise estimation of posterior distributions and facilitates robust inference through Bayesian credible intervals, which are less sensitive to noise in lower-level parameters. Second, by using Bayesian credible intervals instead of traditional confidence intervals, the study provides more interpretable and reliable conclusions.

Compared to Gibbs samplers and Metropolis–Hastings algorithms, HMC and NUTS are more efficient due to their reduced susceptibility to autocorrelation within chains (Hoffman and Gelman, 2014). The findings of this research can therefore assist policymakers and government officials in designing more effective interventions for women engaged in small-scale entrepreneurship. All model estimations were conducted using the R programming language and Stan software, which integrates both HMC and NUTS.

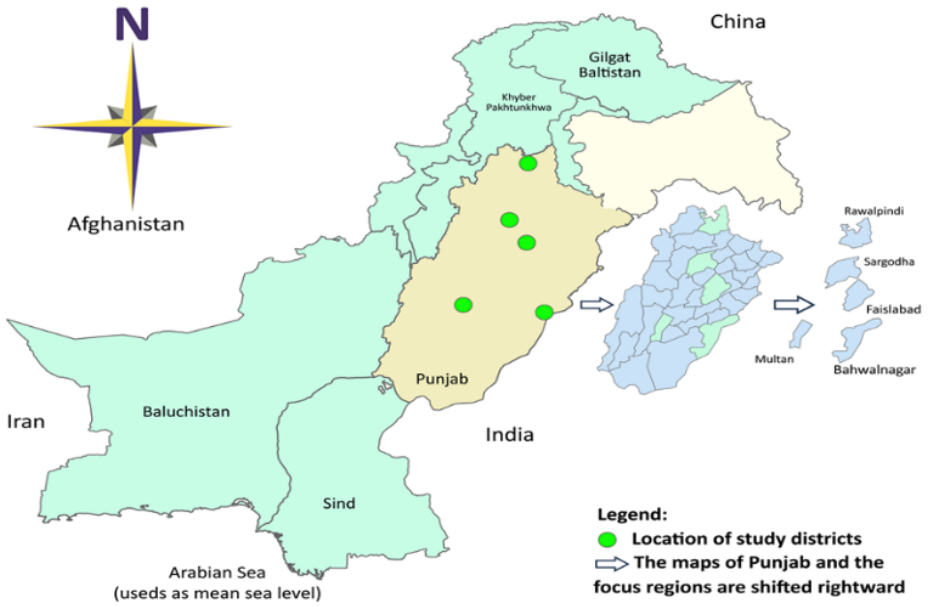
2. Study Area and Definition of Variables

The study was conducted in both urban and rural areas of five districts in the Punjab province of Pakistan, including Bahawalnagar, Faisalabad, Multan, Rawalpindi, and Sargodha (Figure 2), targeting women aged 18 to 40 who were engaged in small-scale entrepreneurship within the informal sector. Marital status was not used as an exclusion criterion; therefore, single, married, widowed, and separated women were all included. Due to budgetary and operational constraints, the research was limited to these five districts. Punjab was selected because it is the most populous and economically diverse province in Pakistan, offering an appropriate setting for examining the financial literacy of women entrepreneurs.

Given the challenges associated with accessing informal-sector women entrepreneurs, a population often dispersed, unregistered, and difficult to reach, snowball sampling was employed. This

method is particularly effective for hidden or hard-to-reach populations. The first respondent was identified based on predetermined eligibility criteria[3] and was then asked to refer other eligible women within her social and professional network. Because many women entrepreneurs in the informal sector maintain close community ties, the referral process progressed smoothly, allowing the sample to grow iteratively until the target of 500 respondents was achieved.

Figure 2. The Study area in Punjab province, Pakistan



Because the dependent variable, financial literacy, is binary in nature, a logistic regression framework was considered appropriate for the analysis. Furthermore, the respondents were drawn from five different districts of Punjab province, indicating a hierarchical data structure in which individuals are nested within districts. Women entrepreneurs operating within the same district may share similar socio-economic conditions, institutional environments, cultural norms, and access to financial resources. To account for this potential district-level heterogeneity, the study employed a Bayesian hierarchical logistic regression model.

Compared with conventional logistic regression approaches, the hierarchical specification allows for district-specific variation and reduces potential bias arising from correlated observations within districts. Furthermore, the Bayesian framework provides full posterior distributions and credible intervals for parameter estimation, offering greater flexibility and robustness in analyzing complex hierarchical relationships.

The survey included one dependent variable (DV)—Financial Literacy—and 22 explanatory variables, as summarized in Table 1. These explanatory variables capture a wide range of contextual and socio-economic factors relevant to women entrepreneurs in the informal sector and are

[3]Eligibility criteria for selecting the first respondent is to prioritize a well-informed individual, who can provide valuable insights about the study, is well-connected within the target population, facilitates the recruitment of additional participants, and contributes to the overall success of the study.

used to assess their relationship with financial literacy. The key explanatory variables of interest include place of business, access to credit, availability of business facilities, social acceptance, social capital, working environment, marketing training, cultural constraints, gender-related constraints, and the multiple roles women are required to fulfill.

Additionally, several socio-demographic characteristics were collected, including age, education, marital status, and household size. The study hypothesizes that access to information sources positively influences financial literacy among women engaged in small-scale entrepreneurship, as these sources serve as essential channels through which financial knowledge is disseminated.

Prior to model estimation, diagnostic tests were conducted to assess potential multicollinearity among the explanatory variables. Variance Inflation Factor (VIF) values were examined, and the results indicated no serious multicollinearity concerns, as all VIF values remained below the commonly accepted threshold levels. To avoid the dummy variable trap, one education category was treated as the reference category in the regression model, and the remaining education categories were interpreted relative to this baseline group.

Table 1
Definition of Variables

Variable Name	Variable Description
Dependent Variable	
Financial Literacy[4]	Financial literacy of respondent; equal 1 if yes, 0 otherwise
Explanatory Variable	
Age	Age of the respondent in years
No Education	Respondent received no formal education, equal to 1 if yes, 0 otherwise
Primary	Highest level of education is primary, equal to 1 if yes, 0 otherwise
Middle	Highest level of education is middle, equal to 1 if yes, 0 otherwise
Matric	Highest level of education is matric, equal to 1 if yes, 0 otherwise
Inter	Highest level of education is intermediate, equal to 1 if yes, 0 otherwise
Graduation	Highest level of education is graduation and above, equal to 1 if yes, 0 otherwise
Marital Status	Marital status of the respondent, equal to 1 if married, 0 if unmarried
HH. Size	Number of members in a household
Place Business	Place of business of respondent, equal to 1 if personal property, 0 if rented
Region	Location of the respondent, equal to 1 if rural, 0 if urban
Family Type	Type of family of the respondent, equal to 1 if nuclear, 0 if joint
Access Credit	Respondent has access to credit, equal to 1 if yes, 0 otherwise
Business Facilities	Respondent has access to business facilities, equal to 1 if yes, 0 otherwise
Social Acceptance	Respondent's business has social acceptance, equal to 1 if yes, 0 otherwise
Social Capital	Respondent has access to social capital, equal to 1 if yes, 0 otherwise
Marketing Training	Respondent has received marketing training, equal to 1 if yes, 0 otherwise
Cultural Constraints	Respondent has faced cultural constraints to training, equal to 1 if yes, 0 otherwise
Gender Constraints	Respondent has faced gender constraints, equal to 1 if yes, 0 otherwise
Multiple Role	Respondent has multiple roles, equal to 1 if yes, 0 otherwise
Districts	
Bahawalnagar	Respondent located in Bahawalnagar; equal to 1 if yes, 0 otherwise
Faisalabad	Respondent located in Faisalabad; equal to 1 if yes, 0 otherwise
Multan	Respondent located in Multan; equal to 1 if yes, 0 otherwise
Rawalpindi	Respondent located in Rawalpindi; equal to 1 if yes, 0 otherwise
Sargodha	Respondent located in Sargodha; equal to 1 if yes, 0 otherwise

[4]We constructed a binary variable to determine whether women exhibit financial literacy, considering factors such as proficiency in budgeting and money management, savings and investment, debt management, financial planning, risk management, understanding of financial products and services, and knowledge of consumer rights and responsibilities.

2.1 Descriptive Analysis

Appendix Table 3 presents the descriptive statistics for the sample. Across the five districts surveyed, between 55 % and 59 % of respondents were classified as financially literate, meaning they demonstrated the ability to understand and effectively use financial skills such as personal financial management, budgeting, and investment planning. The overall mean financial literacy score across all districts is 61 %, indicating that a relatively high proportion of women in the sample possess foundational financial knowledge.

The analysis shows that 53 % of the respondents had received marketing-related training. The average age of participants was approximately 34 years, and they reported an average of 10.5 years of business experience. In terms of education, most respondents were distributed evenly across the matriculation, intermediate, and graduation levels, while only 5 % had completed primary education.

Regarding business-related characteristics, 67 % of the women operated their enterprises from personal property, 65 % had access to credit, and 62 % reported having access to essential business facilities. Social acceptance emerged as an important factor, with 75 % indicating that they received social support in running their small-scale businesses. Additionally, 76 % reported access to social capital, and 69 % described their working environment as conducive to their business activities.

The findings also indicate that 53 % of respondents had participated in marketing training, while 51 % encountered cultural constraints that restrict their access to training opportunities. Gender-based constraints were reported by 68 % of respondents, reflecting persistent structural barriers in the entrepreneurial landscape. Finally, 46 % of the women reported managing multiple roles, indicating that they were responsible for various daily household or caregiving tasks in addition to operating their businesses.

2.2 Empirical Model (Materials and Methods)

The study uses the Bayesian hierarchical logistic model (BHL) to analyse the financial literacy of women entrepreneurs in the informal sector. In the logistic model, the dependent variable is x_{ij}, which follows the Bernoulli distribution with parameter $(1, p)$, where p is the probability of success and $i = 1, 2, \ldots, N_j$ represents individual-level indicators. The model assumes that y is a vector of exogenous predictor variables. Then the logistic model is

$$x_{ij} = p_{ij} + \xi_{ij}, \tag{1}$$

where ξ_{ij} are error terms at the individual level with zero mean and

$$Var(\xi_{ij}) = p_{ij}(1 - p_{ij}).$$

The logit function is

$$logit(p_{ij}) = \log\left(\frac{p_{ij}}{1 - p_{ij}}\right) = \alpha + \beta' y_{ij}, \tag{2}$$

$$p_{ij}(y;\alpha,\beta) = \frac{e^{\alpha+\beta' y_{ij}}}{1+e^{\alpha+\beta' y_{ij}}} = \frac{1}{1+e^{-(\alpha+\beta' y_{ij})}}. \tag{3}$$

Since the logistic model predicts probabilities instead of classes, it can be estimated using maximum likelihood. Specifically, for each data point y and binary outcome x_{ij} with probabilities p_{ij} if $x = 1$ and $1 - p_{ij}$ if $x = 0$, the likelihood function of the logit model is

$$p(y_{ij} \mid \varphi) = L(\alpha,\beta,\sigma_\xi^2) = \prod_{i=1}^{n} p_{ij}(y)^x \left(1 - p_{ij}(y)\right)^{1-x}, \qquad x = 0,1. \tag{4}$$

In the classical approach, the likelihood function of Equation (4) can be maximized over the given sample to estimate the value of parameters α and β. However, the Bayesian hierarchical logistic (BHL) model takes a different approach, estimating the posterior distribution of the model parameters from both the prior distributions and data (Gill, 2014). The BHL modeling approach involves the following steps, i.e., 1) Defining a vector of parameters as $\varphi = [\alpha, \beta]$, where α and β are the model parameters to be estimated. 2) Using the likelihood function in Equation (4) in combination with prior distributions to obtain the respective parameters of the posterior distribution. The posterior distribution of φ is then determined as

$$p(\varphi \mid x_{ij}) \propto p(x_{ij} \mid \varphi)\, p(\varphi). \tag{5}$$

According to Bayes' rule, $p(\varphi \mid y_{ij})$ presents the posterior distributions of the model parameters, $p(x_{ij} \mid \varphi)$ is the likelihood function as given in Equation (4), and $p(\varphi)$ is the prior distribution for φ. In a BHL modeling framework, the prior distribution depends on its lower-level hyperparameters, ρ. Therefore, the likelihood function will also change. Thus, Equation (5) becomes

$$p(\varphi,\rho \mid x_{ij}) \propto p(x_{ij} \mid \varphi)\, p(\varphi \mid \rho)\, p(\rho), \tag{6}$$

where $g(\rho)$ are hyper-priors for the prior distribution stated in $p(\varphi \mid \rho)$.

The factors affecting the financial literacy of women working in the small informal sector have been modeled while keeping the district and sectoral heterogeneity in women's responses. Since women belong to small, unregistered, private, unincorporated enterprises in urban and rural areas of five districts with varying challenging conditions. Therefore, a varying-intercept BHL model has been utilized according to the district. So, the empirical specification model is

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \alpha_{0j} + \sum \beta_j y_{ij}, \tag{7}$$

$$\alpha_{0j} = \alpha_0 + \varepsilon_j$$

$$\beta_j \sim N(0,10), \qquad \alpha_0 \sim N(0,10), \qquad \sigma_\varepsilon \sim N(0,10)$$

Here α_{0j} is the varying intercept parameter, which shows that the model intercept would vary by α_0, while the between-district variation would be captured by the between-intercept

stochastic disturbances ε_j. The β_j is the jth predictor variable and y_{ij} is the jth predictor of the ith women entrepreneurs in the sample. The weakly informative priors have been employed on β_j, α_0 and σ_ε to ensure the proper posterior distribution because they can take either positive or negative values, and the null hypothesis would be equal to zero. Although these priors give little information about the parameters, these priors' standard deviation of the posterior distribution is 10 % less than the standard deviation of the corresponding prior distribution, which is consistent with (Gelman et al., 2013).

For simulation, Hamiltonian Monte Carlo (HMC) and its extension with the No-U-Turn Sampler (NUTS) have been utilized to generate the posterior samples of the parameter estimates given Equation (7). A detailed description is given in the introduction section. The HMC has involved 2 chains with a burn-in phase of 5,000 to enable the Markov chains with total iterations of 10,000 per chain as given in Figures 3, 4 and 5. In Bayesian analysis, there is a need to check whether MCMC chains have successfully converged to their targeted posterior distributions or not. This can be done by conducting convergence diagnostics using graphical methods or formal tests. A good mixing of MCMC chains indicates successful convergence; otherwise, poor convergence. Similarly, the autocorrelation plot indicates the extinction of correlation as the lag increases, indicating successful convergence or otherwise poor convergence (Gelman et al., 2013).

Due to numerous predictors, density plots, trace plots, and autocorrelation plots for only three variables—access to credit, business facilities, and cultural constraints—are presented in Figures 3, 4 and 5, respectively. The density plots and trace plots show that the MCMC chains associated with the parameters of all three variables demonstrate good mixing, while autocorrelation diminishes as higher lags are considered, indicating successful convergence of the MCMC chains. The Gelman–Rubin test for all parameters also indicates results consistent with the graphical diagnostics, as the test statistic is less than 1.059, which provides additional evidence of MCMC chain convergence.

Figure 3. Post burn-in iteration densities of Access to Credit, Business Facilities and Cultural Constraints

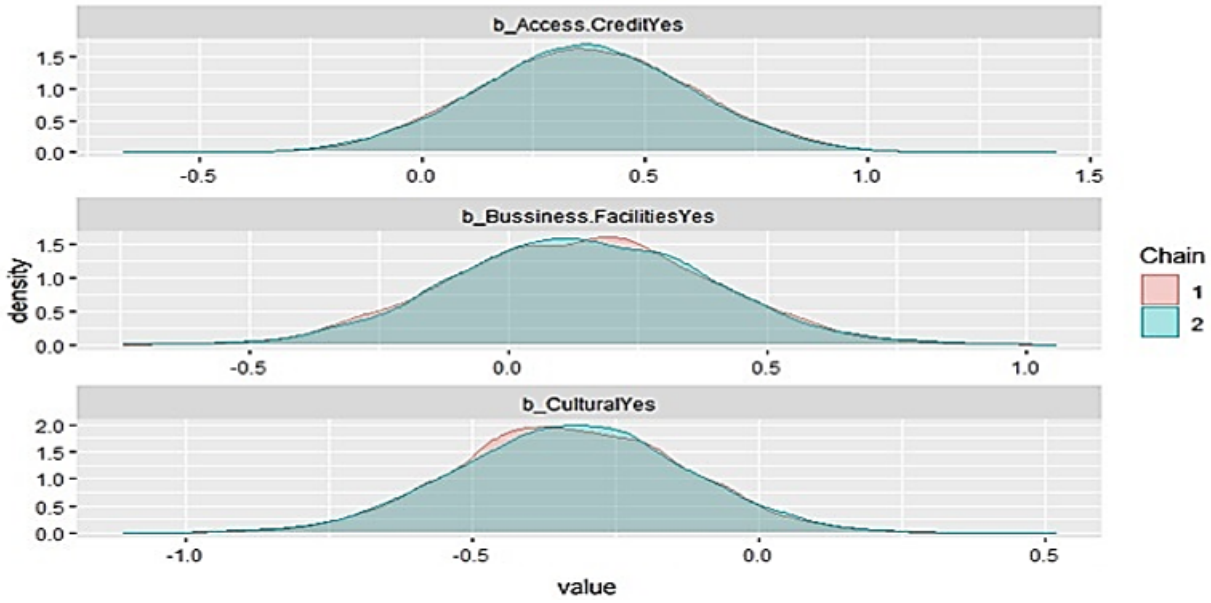


Figure 4. Post burn-in iteration posterior values of Access to Credit, Business Facilities and Cultural Constraints

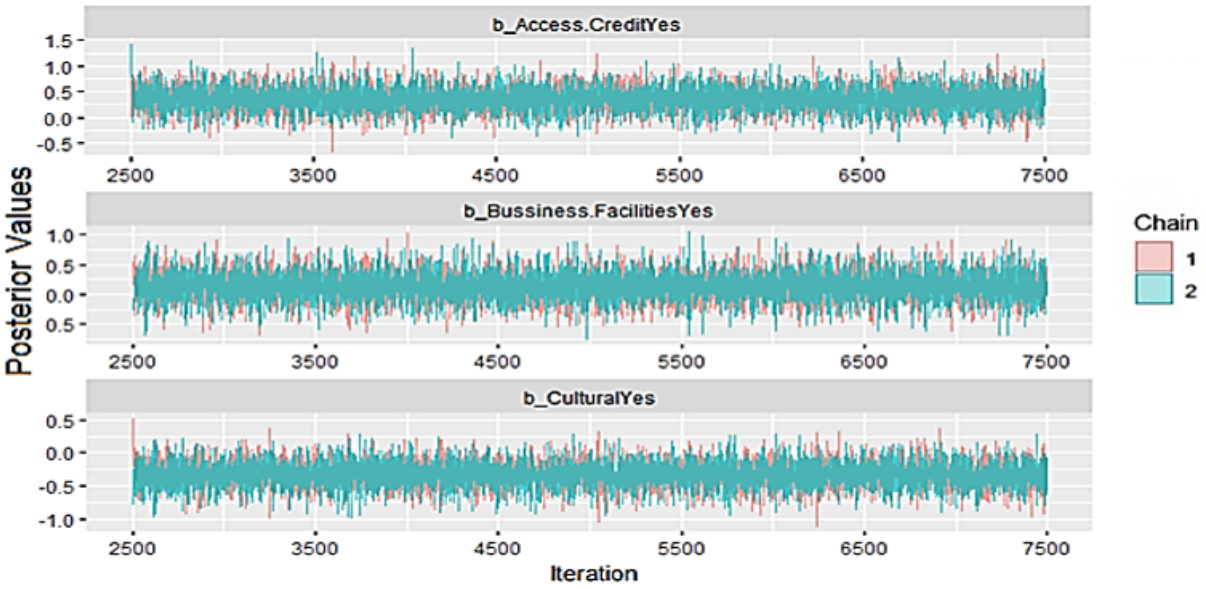
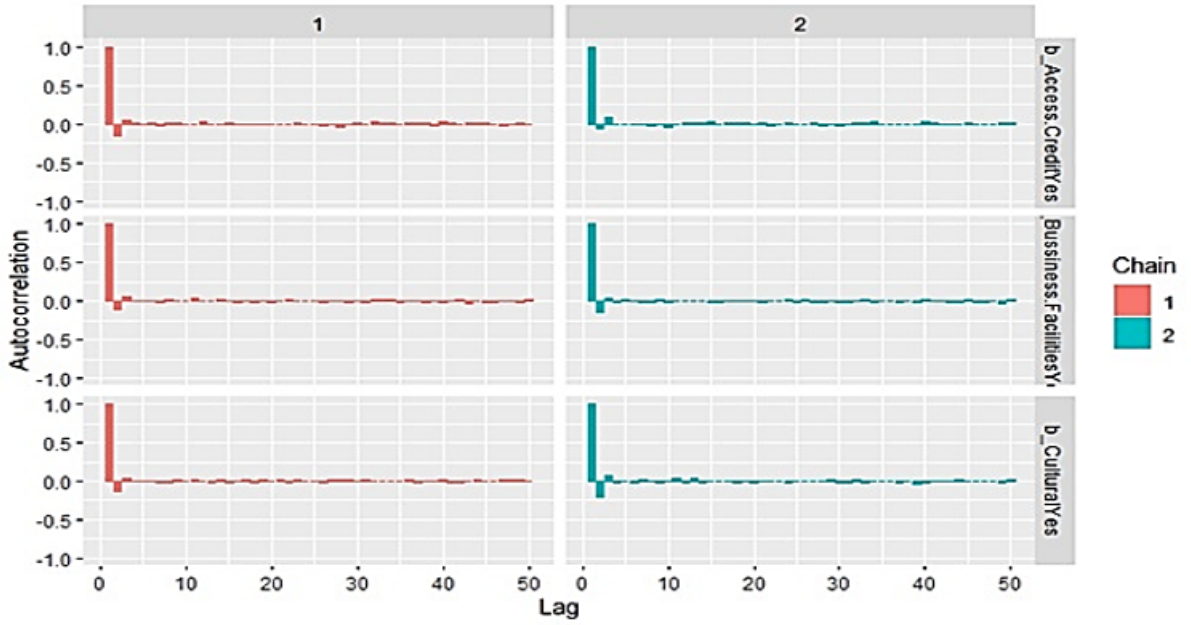


Figure 5. Post-burn-in iteration Autocorrelations of Access to Credit, Business Facilities, and Cultural Constraints



3. Results and Discussion

Table 2 the estimated odds ratios, posterior standard deviations, Monte Carlo standard errors (MCSE), and 95 % highest posterior density (HPD) credible intervals obtained from the Bayesian hierarchical logistic regression model. Financial literacy was treated as the dependent variable, while socio-demographic and business-related characteristics were included as explanatory variables. An odds ratio greater than one indicates a positive association with financial literacy, whereas an odds ratio below one indicates a negative association. Statistical significance was assessed using the HPD 95 % credible intervals, where variables were considered statistically significant when the interval did not include one.

The odds ratios are obtained as the exponential posterior means, whereas the actual posterior means can be found in Appendix Table 4. The reference value for interpreting odds ratios is one. An odds ratio greater than one indicates an increase in the likelihood of a particular factor affecting financial literacy, while a value less than one signifies a decrease in the probability of that constraint influencing financial literacy.

Regarding statistical significance, the odds ratios are considered statistically significant if the HPD 95 % credible intervals do not encompass the value of one. Similarly, the posterior means provided in Appendix Table 4 are deemed statistically significant if the HPD 95 % credible interval does not include the value zero.

The intercept reported in Table 2 represents the baseline odds of financial literacy when all explanatory variables are held at their reference categories. The estimated odds ratio for the intercept is 0.92122, with a 95 % HPD credible interval of [0.6742, 1.2126], indicating the baseline level of financial literacy in the model.

The socio-demographic characteristic variables such as age and education level provide insights into their impact on financial literacy. The odds ratio for age is 1.00180, suggesting a negligible effect on financial literacy. The standard deviation of 0.0084 indicates a small amount of variability in the estimate. The MCSE of 0.001 reflects the precision of the estimate. The HPD 95 % credible interval of [0.3848, 1.0164] includes 1, implying a minimal impact on financial literacy. The percentage effect of 0.1821 further supports the idea of a minimal influence of age on financial literacy.

Among the socio-demographic variables, education level plays a significant role in financial literacy. The odds ratios for education levels like "No Education," "Primary," "Middle," "Matric," "Inter," and "Graduation" provide insights into their effects. For instance, the odds ratio of "No Education" is 0.81489, indicating lower odds of financial literacy. The standard deviations and MCSEs associated with these variables reflect the variability and precision of the estimates. The HPD 95 % credible intervals suggest some uncertainty but generally support the negative impact on financial literacy. The percentage effects further illustrate the magnitude of the influence of each education level on financial literacy.

The variables related to socio-demographic factors such as marital status, household size, place of business, region, and family type also affect financial literacy. The odds ratios, standard deviations, MCSEs, and HPD 95 % credible intervals provide insights into their impacts. For example, the odds ratio of marital status is 0.90285, suggesting a slight decrease in the odds of financial literacy. The standard deviations and MCSEs indicate variability and precision in the estimates. The HPD 95 % credible intervals provide the range within which the true odds ratios are likely to fall. The percentage effects highlight the magnitude of the influence of each socio-demographic factor on financial literacy.

Factors associated with financial literacy such as access to credit, business facilities, social acceptance, social capital, and marketing training. Additionally, cultural constraints such as restrictive gender roles, limited mobility, male-dominated markets, and lack of family support pose significant challenges. Gender-related issues, including limited decision-making power and societal expectations that prioritize domestic roles for women, further impact financial literacy. Women often face multiple responsibilities, which also play a critical role in their entrepreneurial pursuits. The odds ratios, standard deviations, MCSEs, and HPD 95 % credible intervals provide insights into their impacts. For instance, the odds ratio for access to credit is 2.01053, indicating a substantial increase in the odds of financial literacy. The standard deviations and MCSEs reflect the variability and precision of the estimates. The HPD 95 % credible intervals provide the range within which the true odds ratios are likely to fall. The percentage effects highlight the magnitude of the influence of each factor on financial literacy.

Examining the variables related to factors related to financial literacy, we find interesting insights. The odds ratio for access to credit is 2.01053, indicating a significant positive association with financial literacy. This suggests that individuals with better access to credit are more likely to have higher financial literacy. Similarly, business facilities also show a positive effect, with an odds ratio of 1.78729. This implies that individuals who have access to adequate business facilities are more likely to possess higher financial literacy skills. On the other hand, social acceptance,

social capital, and marketing training have odds ratios close to 1, indicating minimal effects on financial literacy. Cultural constraints, with an odds ratio of 1.96012, suggest a relatively higher positive impact, while gender constraints exhibit a negative impact, with an odds ratio of 1.48374. Multiple roles, with an odds ratio of 1.42716, also show a slight positive influence on financial literacy. The standard deviations, MCSEs, and HPD 95 % credible intervals provide additional information about the variability, precision, and confidence in these estimates.

Overall, the analysis indicates that several independent variables have varying effects on financial literacy. Socio-demographic characteristics such as education level, marital status, household size, and region play a role in determining financial literacy levels. Higher levels of education, larger household sizes, and certain regions show positive associations with financial literacy, while factors such as marital status and certain education levels exhibit negative effects. Additionally, factors associated with financial literacy, including access to credit, business facilities, cultural constraints, and gender constraints, contribute to individuals' financial literacy levels. These findings provide valuable insights for policymakers, educators, and financial literacy programs to identify key areas of focus to promote financial literacy among individuals and tailor interventions accordingly. The odds ratios, standard deviations, MCSEs, HPD 95 % credible intervals, and percentage effects collectively contribute to a comprehensive understanding of the factors influencing financial literacy and their relative impacts.

Table 2
Odds ratios, standard deviations, HPD 95 % credible interval, and Percentage Effect

Variables	Odds Ratios	Std. Deviation	MCSE[5]	HPD[6] 95 % Credible Interval	Percentage Effect (%)
Dependent Variable					
Financial literacy					
Explanatory Variables					
Intercept	0.92122	0.1399	0.0124	[0.6742, 1.2126]	-7.8783
Socio Demographic Characteristics					
Age	1.00180	0.0084	0.001	[0.3848, 1.0164]	0.1821
No Education	0.81489	0.194	0.0367	[0.7319, 1.4952]	-18.511
Primary	0.87040	0.2001	0.0335	[0.7763, 1.3462]	-12.961
Middle	1.10164	0.0551	0.0206	[0.6135, 1.2185]	10.164
Matric	1.23825	0.1361	0.0187	[0.8875, 1.4954]	23.825
Inter	1.36383	0.0933	0.0072	[1.1612, 1.7147]	36.383
Graduation	1.51877	0.1341	0.0224	[0.6309, 1.7444]	51.877
Marital Status	0.90285	0.1678	0.0493	[0.6201, 1.2253]	-9.7152
HH. Size	0.80905	0.0315	0.0048	[0.9505, 1.0711]	-19.095
Place of Business	0.86979	0.1587	0.0611	[0.8478, 1.4643]	-13.021
Region	0.82852	0.1556	0.0183	[0.7318, 1.3350]	-17.148
Family Type	0.89664	0.1029	0.0169	[0.6927, 1.0946]	-10.336
Factors associated with Financial Literacy					
Access to Credit	2.01053	0.134	0.0559	[1.7803, 2.4797]	101.053
Business Facilities	1.78729	0.1779	0.0575	[1.2983, 1.8820]	78.7291
Social Acceptance	1.29927	0.221	0.0372	[0.9791, 1.6062]	29.9271
Social Capital	0.94309	0.143	0.0494	[1.0055, 1.5452]	-5.6913
Marketing Training	0.76894	0.0747	0.0091	[0.7097, 1.6903]	-23.1061
Cultural Constraints	1.96012	0.1217	0.0178	[0.7490, 1.4992]	96.0124
Gender Constraints	1.48374	0.1716	0.0429	[0.2306, 0.8323]	48.3742
Multiple Role	1.42716	0.1142	0.009	[0.1031, 0.7260]	42.7163

In summary, the table provides a detailed interpretation of the odds ratios, standard deviations, MCSEs, HPD 95 % credible intervals, and percentage effects for each variable. The analysis reveals the effects of different independent variables on financial literacy. It highlights the significant impacts of education levels, socio-demographic factors, and factors related to financial literacy on financial literacy.

The findings should be interpreted as associations rather than causal relationships because the analysis is based on cross-sectional observational data. Although the identified factors are associated with financial literacy among women entrepreneurs, the results do not imply that im-

provements in these variables will automatically translate into enhanced business performance, higher income, or broader economic well-being. Nevertheless, the findings may assist policymakers in designing targeted interventions aimed at strengthening financial literacy and financial capability among women operating microenterprises in the informal sector.

4. Conclusion

This study employed a Bayesian hierarchical logistic model to examine the constraints faced by women entrepreneurs in Pakistan and to assess the factors influencing their financial literacy. The results indicate that financial literacy levels among women entrepreneurs in the surveyed districts of Punjab are relatively high, ranging from 55 % to 59 %, with an overall mean of 61 %. These findings suggest that a considerable proportion of women operating in the informal sector possess essential financial skills.

The analysis identified several socio-demographic and contextual factors that significantly shape financial literacy. Education emerged as a particularly important determinant, as higher levels of education were associated with increased odds of financial literacy, while respondents with no formal education were significantly less likely to be financially literate. Some marital status categories and specific education levels also showed negative associations, indicating nuanced socio-demographic dynamics.

Access to credit and availability of business facilities were among the strongest predictors of financial literacy. Women who had access to credit or operated in environments with adequate business facilities demonstrated higher levels of financial knowledge. Cultural constraints, somewhat unexpectedly, exhibited a positive relationship with financial literacy, potentially suggesting that women facing such constraints actively seek financial empowerment as a coping or advancement strategy. Conversely, gender-related constraints had a negative effect, highlighting persistent structural barriers. The role of multiple responsibilities, representing the diverse tasks women perform alongside business management, showed a small positive association with financial literacy.

These findings carry important implications for policymakers, practitioners, and educators. Targeted interventions aimed at improving financial education, expanding access to credit, and strengthening business support infrastructure can help alleviate the constraints identified in this study. Financial literacy programs should be tailored to the needs of informal-sector women entrepreneurs and focus on practical skills such as budgeting, financial planning, bookkeeping, and investment decision-making. Enhancing women's financial literacy can facilitate their economic empowerment, promote business growth, and contribute to broader socio-economic development.

Hence, this Bayesian analysis highlights both the strengthens and gaps in financial literacy among women entrepreneurs in Pakistan. By addressing key determinants, including education, access to credit, business facilities, and gender-related barriers, stakeholders can play a pivotal role in improving women's entrepreneurial outcomes. Strengthening financial literacy is not only vital for individual women's economic empowerment but also for promoting inclusive economic growth.

This study also provides opportunities for future research. Analyses using richer datasets, such as panel or longitudinal data across a wider geographic scope, would deepen understanding of the evolving constraints faced by women entrepreneurs. Furthermore, the Bayesian hierarchical framework applied here helps account for uncertainty in both parameters and data, making the findings broadly relevant to policymakers and scholars interested in women's empowerment worldwide.

1. Appendix

Table 3

Descriptive statistics of variables used in the study with a sample size of 500 respondents

Variable Name	Mean	Std. Dev
Dependent Variable		
Financial literacy	0.61	0.487
Explanatory Variable		
Socio-Demographic Characteristics		
Age	33.58	10.653
No Education	0.08	0.272
Primary	0.05	0.226
Middle	0.12	0.323
Matric	0.26	0.437
Inter	0.25	0.431
Graduation	0.24	0.430
Marital Status	0.64	0.482
HH. Size	8.05	2.431
Place of Business	0.67	0.470
Region	0.48	0.500
Family Type	0.68	0.468
Factors Associated with Financial Literacy		
Access to Credit	0.65	0.477
Business Facilities	0.62	0.486
Social Acceptance	0.75	0.431
Social Capital	0.76	0.428
Marketing Training	0.53	0.500
Cultural Constraints	0.51	0.500
Gender Constraints	0.68	0.465
Multiple Role	0.46	0.499

Table 4
Descriptive statistics of variables used in the study with a sample size of 500 respondents

Variable Name	Mean	Std. Dev
Dependent Variable		
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