

Integrated Socio-Strategic Empowerment Model Structural and Psychological Pathways with Predictive Modeling and Statistical Analysis

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Abstract: In this paper, we developed a model to measure the role of women's empowerment in rural areas considering the effects of various variables and mediator using original data. The model is based on Social Capital Theory and examines the role played by sociocultural intervention and market linkage infrastructure in the accessibility of finance by women mediated by social capital. Partial Least Squares Structural Equation Modeling (PLS-SEM) method is used to check the impact of parameters effect, mediator rule for reliability and discriminant validity through statistical results. Artificial Neural Networks (ANN) technique used to develop an optimization results such as error analysis, correlations effect, error histogram, input-output time series analysis and best gradient values for two different cases. Results confirm the model's robustness, revealing significant direct and indirect effects. WESE emerged as the strongest direct predictor of empowerment, while MLI served as a critical mediator translating structural supports into tangible outcomes. The findings underscore that sustainable entrepreneurial empowerment arises from the synergistic interaction of external enablers and internal agency. This study provides theoretical contributions by integrating structural and psychological perspectives and offers practical implications for policymakers and development agencies aiming to design effective, multi-faceted empowerment programs.

Keywords: Integrated Socio-Strategic Empowerment Model (ISSEM), Entrepreneurial self-efficacy, Social protection, Economic resources, ANN.

1. Introduction

Women's entrepreneurship in developing countries has emerged as a critical mechanism for promoting inclusive economic growth, job creation, and poverty alleviation. However, despite an observable increase in policy reforms and entrepreneurial initiatives, women particularly in rural areas continue to face multifaceted structural, institutional, and socio-cultural barriers that restrict their participation in entrepreneurial ecosystems [1,2]. The Entrepreneurial Self-efficacy of Women (WESE) refers to the self-confidence of an individual that she is able to carry out entrepreneurial activities and maintain businesses [3] and some social theories results are developed in [4,5]. Meanwhile, Social Cognitive Theory [9] situates empowerment within psychological mechanisms such as self-efficacy, confidence, and learning through social modeling [3,10]. It has been proven using empirical evidence that weak infrastructure, institutional voids, and social exclusion are major obstacles to women taking part in entrepreneurship [11,12]. In contrast, institutional scaffolds (like credit facilities, entrepreneurship training and digital enablers) have a positive impact on the entrepreneurial success and innovation of women [1,4,6]. On the same note, the institution environment can also drive the growth of the market infrastructure by legalizing women owned businesses and facilitating entry into the market [13]. However, the institutional support is still inadequate unless the social

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and cultural systems reinforcing attitudes, trust and collective action are reinforced at the same time. The Structural Resource Pathway of the ISSEM integrates institutional support and social capital as external enablers of empowerment. Institutional support refers to the policies, programs, and regulatory systems that foster women's entry into entrepreneurship by legitimizing and supporting their activities [6,14]. It is supported by empirical evidence that facilitated institutional frameworks can significantly increase the accessibility of women in the market, increase the survival rate of ventures and enhance [7,11]. Traditionally, women have challenged significant barriers to achieving equality, including limited access to education, healthcare, financial opportunities, and political contribution [15,16]. These infrastructures allow information exchange, reduce the cost of transactions, and increase the sustainability of female-owned businesses with the support of formal institutions and social networks [1,11].

Social capital (SC) is inseparably connected with formal institutional structures, since it forms the basis of networks that are based on trust, mentorship, and mutual interaction in business [8,17]. Therefore, MLI has an opportunity to take a central mediating position between structural enablers and empowerment, thus, positively impacting the business performance and increasing the economic agency of women [6]. In fact, evidence indicates that active social networks and connection network can be used to improve the role of women in business, which will positively affect their market positions and access to necessary resources [18,19]. Social capital serves as a channel through which the institutional support is relayed to the entrepreneurial performance in informal and rural contexts, specifically in Pakistan and similar developing states [20,21]. Moreover, alongside psychological empowerment, MLI use can be used to provide women with practical tools and networks that augment predictability, confidence, and control [21]. The Psychological Agency Pathway of the ISSEM builds on the role of Socio-Cultural Influences (SCI) in transforming gender norms and enhancing entrepreneurial self-belief. Cultural beliefs and social expectations continue to shape women's intentions, risk-taking behaviors, and access to opportunities [22,23]. However, community-based programs such as gender sensitization campaigns, mentorship initiatives have demonstrated effectiveness in challenging restrictive norms and increasing self-efficacy among [24,25,26]. According to empirical studies, entrepreneurial intentions, innovation, and persistence are positively correlated with high levels of self-efficacy [10,27]. The Empowerment of Rural Women construct incorporated the aspects of business autonomy and financial management and inclusion of leadership. This theoretical structure allows an evaluation of the interaction of the structural, social, and psychological processes that contribute to the sustainable entrepreneurial empowerment of women in developing environments in a rigorous manner.

This research analyzes that institutional support, social capital and socio-cultural interventions directly and indirectly affect the empowerment of rural women via managerial leadership and entrepreneurship self-efficacy. It applies the Integrated Socio-Strategic Empowerment Model (ISSEM) to examine the interrelationship between structural and psychological conditions that determine the women entrepreneurial empowerment in rural Pakistan. A two model of PLS-SEM and ANN displays both linear and nonlinear relationships, which expands the currently existing models and establishes a connection between psychological agency and structural facilitators to obtain a more comprehensive view of empowerment.

1.1 Motivation and Structure of the study

This study applies the integrated socio strategic empowerment model to examine how structural and psychological factors influence the empowerment of rural women in Pakistan. To capture these nonlinear dynamics, the study uses a hybrid method combining Smart-PLS and Artificial Neural Networks, which strengthens both confirmatory and predictive analysis. The paper is structured in the following way: Section 1 introduces the theoretical background and the research framework Section 2 presents the research design and hybrid analytical procedure, Section 3 conceptual model and statistical analysis 4 mathematical modeling and Section 5 contains discussion and theoretical and practical implications directions and Section 6 contain the conclusion with future recommendation.

2. Materials and Methods

The current study is a quantitative, cross-sectional study design that seeks to test the Integrated Socio-Strategic Empowerment Model (ISSEM) a construct that addresses the conjoint impact of structural and psychological determinants on its effect on empowering rural women entrepreneurs in Pakistan [32] data is used to developing and modifying the new model. A random sample size of 385 rural women entrepreneurs [32] was used to collect primary data through owners and managers of micro, small and medium-sized enterprises (MSMEs) in agribusiness, handicrafts, food processing, textile, and retail. The sampling process used a two-phase probability-based random procedure; first to identify the rural cluster with high concentration of women-owned enterprises in cooperation with local development agencies and then random sample selection of participants in each cluster is used to ensure representativeness.

Data analysis that followed was a Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS 4.0, a type of variance-based data analysis that is suitable when dealing with complex theoretical models that comprise reflective and formative constructs and that are capable of delivering predictive validity and theoretical generalizability [28]. The

questionnaire tool was a structured, self-administered questionnaire based on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), whose measurement items were modified according to rigorously validated scales in order to maintain content and construct validity. The indicator of institutional Support included the quality of the training, the sufficiency of the policy, and the availability of financial and technical services [1]. Social Capital included network diversity, trust and reciprocity.

2.1 Hypothesis and Problem Formulations

H1: Institutional Support (IS) has a positive effect on Market Linkage Infrastructure (MLI).

H2: Social Capital (SC) has a positive effect on Market Linkage Infrastructure (MLI).

H3: Socio-Cultural Interventions (SCI) have a positive effect on Women's Entrepreneurial Self-Efficacy (WESE).

H4: Market Linkage Infrastructure (MLI) has a positive effect on the Empowerment of Rural Women (ERW).

H5: Women's Entrepreneurial Self-Efficacy (WESE) has a positive effect on the Empowerment of Rural Women (ERW).

H6: Market Linkage Infrastructure (MLI) has a positive effect on Women's Entrepreneurial Self-Efficacy (WESE).

2.2 Data Analysis Statistical Technique

A Quantitative approach used for data analysis by using SmartPLS 4.0 following a two-step approach: first assessing the measurement model for reliability and validity, and then testing the structural model for hypothesis evaluation. Internal consistency was confirmed through Cronbach's alpha and Composite Reliability (≥ 0.70 and ≥ 0.60), while convergent validity was established with $AVE > 0.50$. Discriminant validity was ensured using the HTMT ratio (< 0.85), and multicollinearity was ruled out with $VIF < 3.3$. The bootstrapping method (5000 resamples) generated path coefficients and significance levels, and Variance Accounted For (VAF) was used to evaluate the mediating roles of MLI and WESE. Model adequacy was assessed through R^2 , f^2 , and q^2 , where $R^2 > 0.35$ indicated strong explanatory power for MLI and $R^2 > 0.60$ for ERW, confirming the model's predictive relevance and robustness.

3. Conceptual model and Statistical Analysis

This paper demonstrates that the impacts of Institutional Support (IS), Social Capital (SC), and Socio-cultural Interventions (SCI) on Women entrepreneurial self-efficacy (WESE) are positive and SC has the strongest effect figure 1. As a result, WESE enriches Market Linkage Infrastructure (MLI) to a considerable extent, which suggests that women entrepreneurs who have a stronger self-efficacy develop stronger market relationships. In its turn, MLI has the strong positive influence on Empowerment of Rural Women (ERW), which implies the dire significance of market access in empowerment.

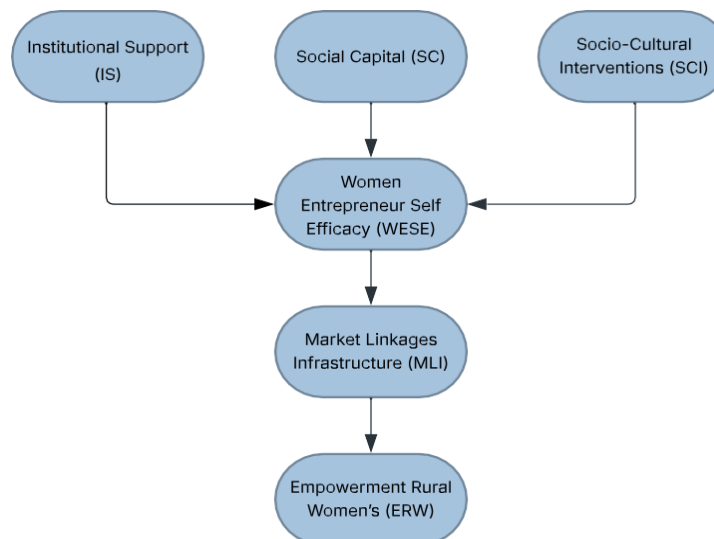


Fig. 1: Flow chart of variables and mediators' effect to output results

3.1: Indirect mediation effect

The mediation analysis shows that the indirect relations in the ISSEM model are statistically significant, which validates the mediating role of Market Linkage Infrastructure (MLI) and Women's Entrepreneurial Self-Efficacy (WESE) in transforming

structural and socio-cultural inputs into empowerment outputs. The institutional Support (IS) has positive indirect impact on both Empowerment of Rural Women (ERW) (0.092, $t = 3.677$, $p = 0.001$) and MLI (0.140, $t = 4.069$, $p = 0.001$), meaning that institutional mechanisms have a significant impact on empowerment by developing infrastructure. Similarly, Social Capital (SC) demonstrates that it is a significant mediator of ERW (0.109, $t = 4.033$, $p = 0.001$) and MLI (0.164, $t = 4.245$, $p = 0.001$), which means that network-based resources have an indirect positive influence on empowerment through enhancing market access. The effects illustrated in Table 1 through mediation indicate that Socio-Cultural Interventions (SCI) bring influence to ERW (0.058, $t = 1.947$, $p = 0.001$) and MLI (0.088, $t = 2.031$, $p = 0.001$), thus indicating that the cultural transformation only brings an insignificant impact through enhanced confidence and involvement. Lastly, WESE $\rightarrow$ ERW has a significant direct impact ($\beta = 0.338$, $t = 7.532$, $p = 0.001$), which proves that the psychological empowerment is an important conduit that conveys the external supports to the actual entrepreneurial empowerment represents in table 1.

Table 1: Details results of each variable indirect (Mediated) Effects

Path	β	t - value	p - value	Mediation Type
IS $\rightarrow$ ERW	0.092	3.677	0.001	Supported
IS $\rightarrow$ MLI	0.140	4.069	0.001	Supported
SC $\rightarrow$ ERW	0.109	4.033	0.001	Supported
SC $\rightarrow$ MLI	0.164	4.245	0.001	Supported
SCI $\rightarrow$ ERW	0.058	1.947	0.001	Supported
SCI $\rightarrow$ MLI	0.088	2.031	0.001	Supported
WESE $\rightarrow$ ERW	0.338	7.532	0.001	Supported

The PLS-SEM structural model illustrates the interconnected relationships among the six latent constructs of the Integrated Socio-Strategic Empowerment Model (ISSEM). (IS) demonstrates a positive path ($\beta = 0.273$) toward (WESE), confirming that supportive institutional frameworks enhance entrepreneurial confidence. Similarly, (SC) exerts a stronger influence on WESE ($\beta = 0.321$), emphasizing the value of networks and trust in fostering self-belief among women entrepreneurs. (SCI) also contribute positively ($\beta = 0.172$), showing that gender norm transformation and community engagement strengthen psychological empowerment.

In Figure 2, there are intermediate relationships with the Market Linkage Index (MLI) such that the Women Entrepreneurial Self-efficacy (WESE) is a significant predictor of it ($\beta = 0.511$), which means that the confidence in any entrepreneur increases the ability to utilize resources and technology to expand the market. Moreover, MLI has a significant impact on Entrepreneurial Resilience to Work ERW (0.661) which highlights the role of digital and logistical connections in creating enterprises and independence. WESE, MLI and ERW have coefficients of determination (R^2) of 0.429, 0.262 and 0.436 respectively. The values represent a moderate to high explanatory ability, which implies that both structural and psychological processes simultaneously explain a significant percentage of the variance in the results of women empowerment.

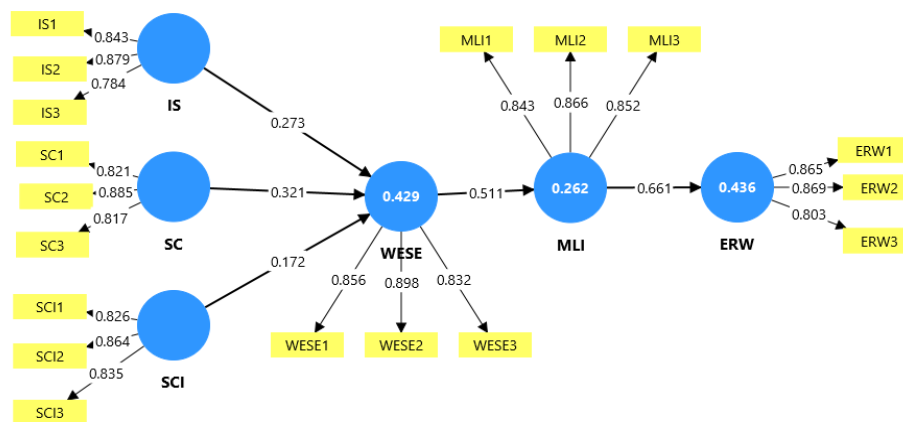


Fig. 2: Structural Model with Path Coefficients and Significance Levels

3.2: Model Reliability and Validity

The quantitative and qualitative reliability and validity of Table 2 support the strength of each of the constructs in the Integrated Structural Equation Modeling (ISEM) framework. The alpha coefficients of the Cronbach are also between 0.784 and 0.828 and are above the standard alpha of 0.70 thus portraying high internal consistency. The stability of the measurements is also supported by composite reliability (0.874 0.897). In addition, satisfactory convergent validity is supported by the Average Variance Extracted (AVE) scores that are more than 0.69. Taken together these measures indicate

that both of the constructs are always relevant and true to its theoretical construct and thus, the psychometric soundness of the model to be utilized further in structural analysis.

Table 2: Construct reliability and validity results of each variable of developed model

Construct	Cronbach'sAlpha	Pa	Pc	AVE
ERW	0.802	0.809	0.883	0.716
IS	0.784	0.791	0.874	0.699
MLI	0.814	0.814	0.890	0.729
SC	0.793	0.797	0.879	0.708
SCI	0.795	0.795	0.880	0.709
WESE	0.828	0.831	0.897	0.744

3.3: Discriminant Validity

The results of the Heterotrait-Monotrait Ratio (HTMT) confirm strong discriminant validity among all constructs. All HTMT values fall well below the conservative threshold of 0.85 [30] indicating that each construct is empirically distinct and captures a unique dimension of the ISSEM framework. The relatively moderate inter-construct correlations from 0.621 to 0.815 further demonstrate that while the variables are in the table 3 are conceptually related, they do not exhibit redundancy.

Table 3: Relationship effect through Discriminant validity (HTMT) of variables

Construct	ERW	IS	MLI	SC	SCI	WESE
ERW						
IS	0.813					
MLI	0.815	0.798				
SC	0.767	0.716	0.706			
SCI	0.743	0.791	0.792	0.725		
WESE	0.622	0.694	0.621	0.707	0.651	

4. Levenberg Marquardt Neural Network (LBMNN) Approaches

This is a mathematical concept which is used in all the learning models to study and improve functions. The Artificial Neural Network was trained using the Levenberg–Marquardt (trainlm) back-propagation algorithm due to its rapid convergence and efficiency in nonlinear optimization. This algorithm is widely recognized for minimizing mean squared error in moderate-sized datasets [31, 29].

$$\nabla \delta(z_1, z_2, \dots, z_n) = \begin{bmatrix} \frac{\partial \delta}{\partial z_1}(z_1, z_2, \dots, z_n) \\ \frac{\partial \delta}{\partial z_2}(z_1, z_2, \dots, z_n) \\ \vdots \\ \frac{\partial \delta}{\partial z_n}(z_1, z_2, \dots, z_n) \end{bmatrix}$$

An ANN analysis was provided to supplement the PLS-SEM findings and to consider the possibility of complex non-linear relationships between the study constructs. The processing model was a stochastic model that utilizes Artificial Neural Networks that are trained by use of Levenberg Marquardt (ANNLMB) back-propagation. Multilayer Perceptron (MLP) network was designed that included an input layer where the nodes used the scores of five predictors on the latent variable, which included the following: Institutional Support (IS), Social Capital (SC), Socio-Cultural Interventions (SCI), Women entrepreneur self-efficacy (WESE), and Managerial Leadership (MLI). Only one hidden layer was employed and an optimization process by trial and error was done on the configuration of the network to obtain the lowest value of the prediction error on the validation data which produced an optimal number of neurons in the hidden layer of one. The dependent construct was the output neuron, which was Empowerment of Rural Women (ERW).

To facilitate a reliable and efficient training of the network all the input data were first normalized by a Min Max scaler in the range [0, 1]. The data were randomly divided into three portions; 80 per cent of the data to be used as a model, 10 per cent to be used to validate the model (to avoid overfitting and guarantee objectivity of the predictive results), and 10 per cent to be used in the ultimate testing to objectively assess the predictive power. Levenberg-Marquardt (trainlm) algorithm has been chosen because it is fast to converge and because it is stable. Mean Squared Error (MSE) was used to evaluate the

performance of the model during training, validation and testing stages and regression (R) values to measure the relationship between the predicted and the actual results. Other performance metrics as lag-0 autocorrelation, gradient steadiness and error histogram distributions were used to confirm the dependability and strength of the network and establish the fact that ANN was successful in modeling the non-linear relationships that exist between structural and psychological variables that affect women entrepreneurial empowerment as exhibited in Table 4.

Table 4: Key findings result though (ANN) Approach for developed model in different cases

Measurement of Attributes	Case 1	Case 2
Lag-0 Autocorrelation	1.90	1.60
Max Input-Error Correlation	-0.90	0.60
Error Histogram	0.05	-0.10
Max Output Error	2.90	2.50
Gradient	0.107	0.186
Mu	0.0001	0.0001
Validation	6	6
Validation Performance	3	4.5
Validation Training	0.696	0.768
Regression Validation	0.590	0.643
Test	0.494	0.393
Total Regression	0.661	0.723

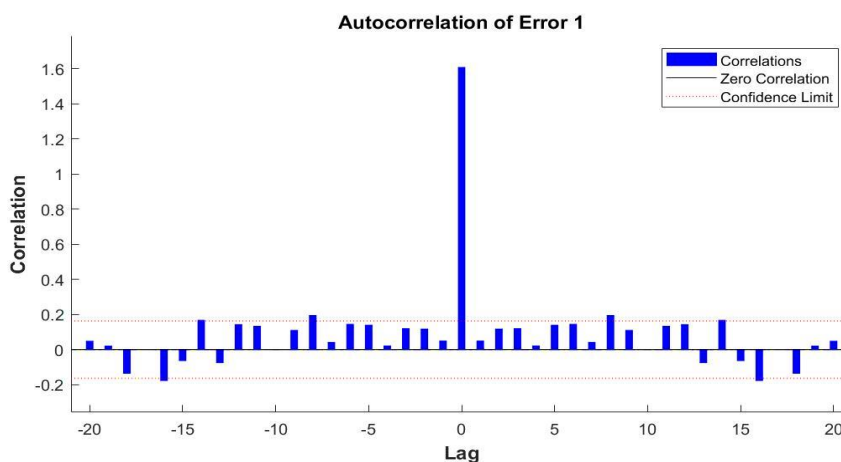
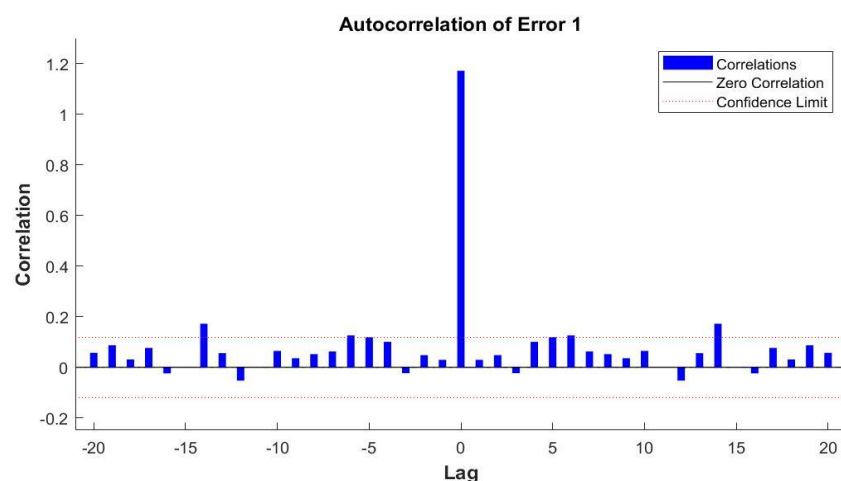


Fig. 3: Lag-0 autocorrelation of error 1

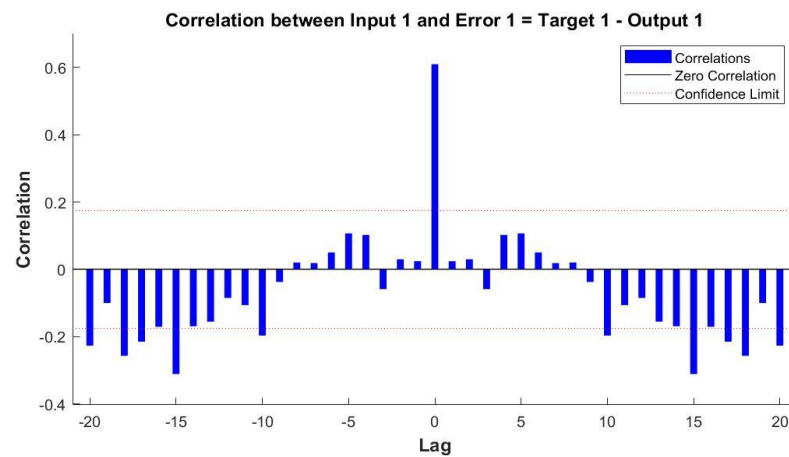
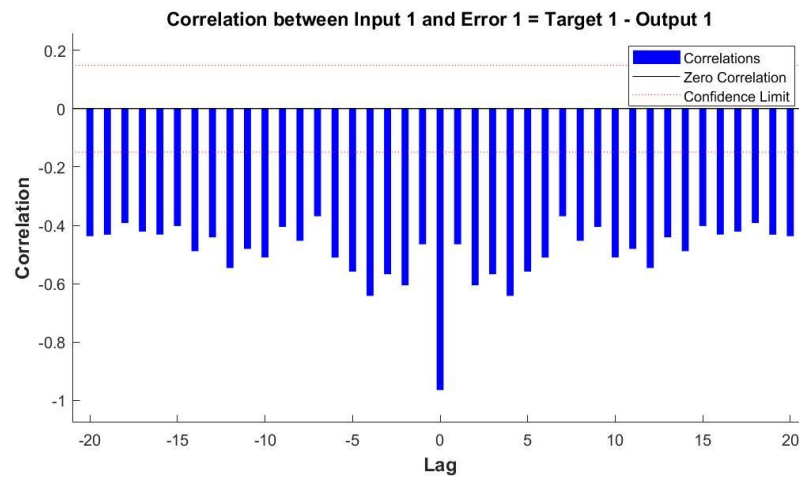
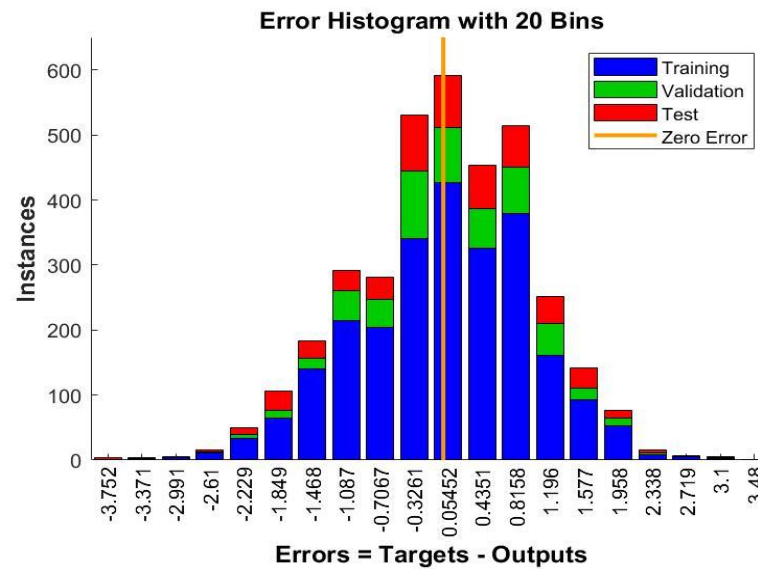
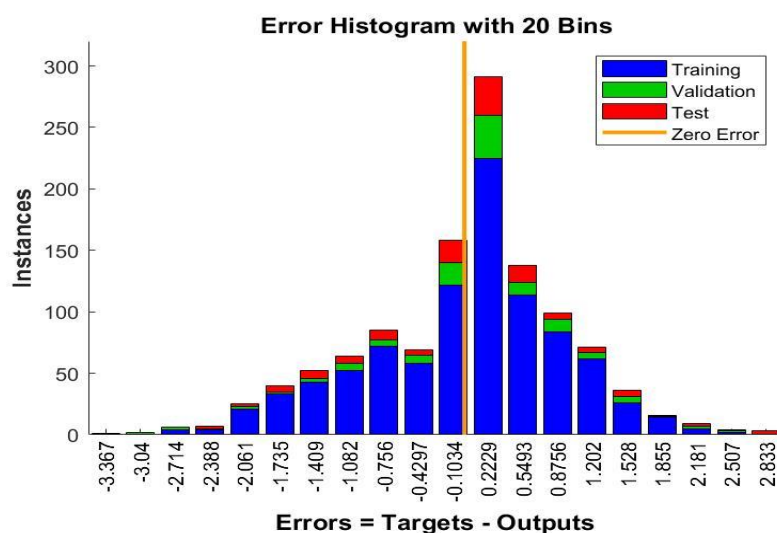
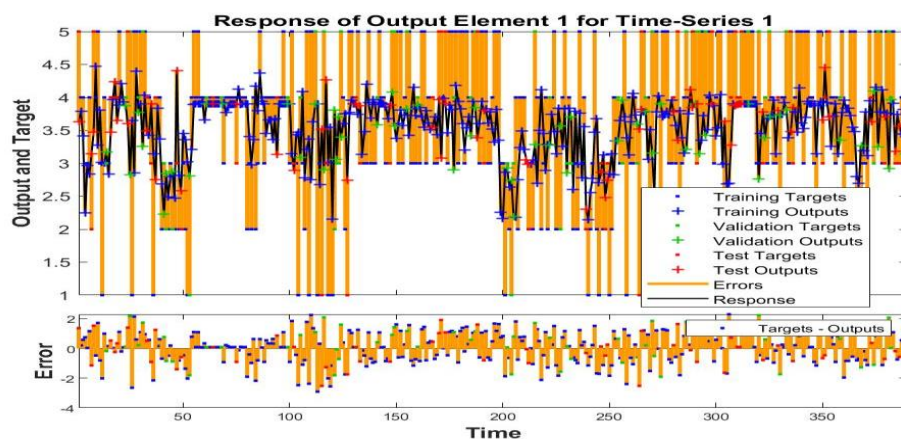


Fig. 4: Max error correlation between Input 1 and error 1= target 1- output 1

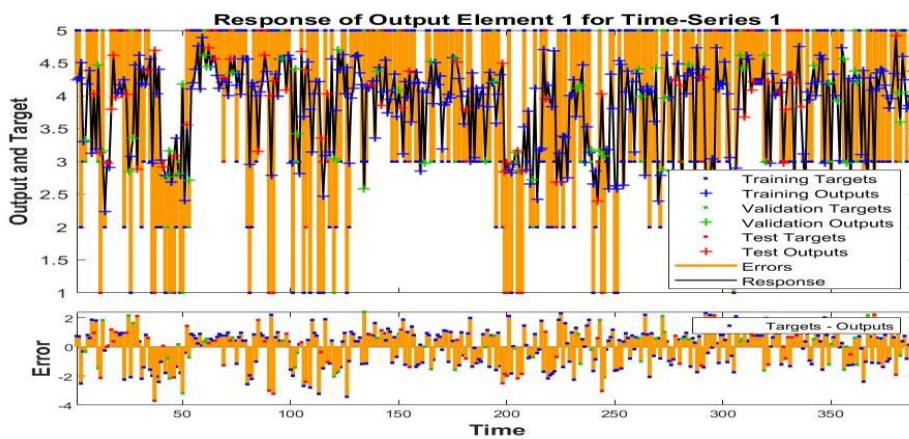




(b) Case II

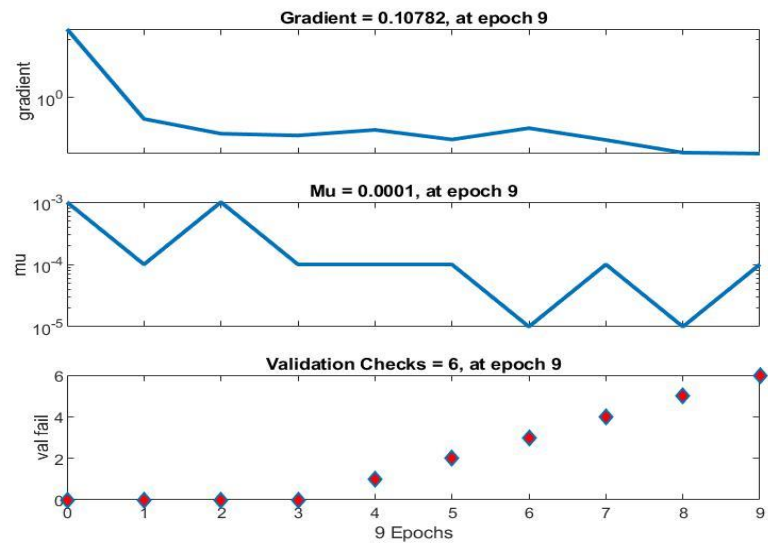
Fig. 5: Error histogram with targets and outputs

(a) Case 1

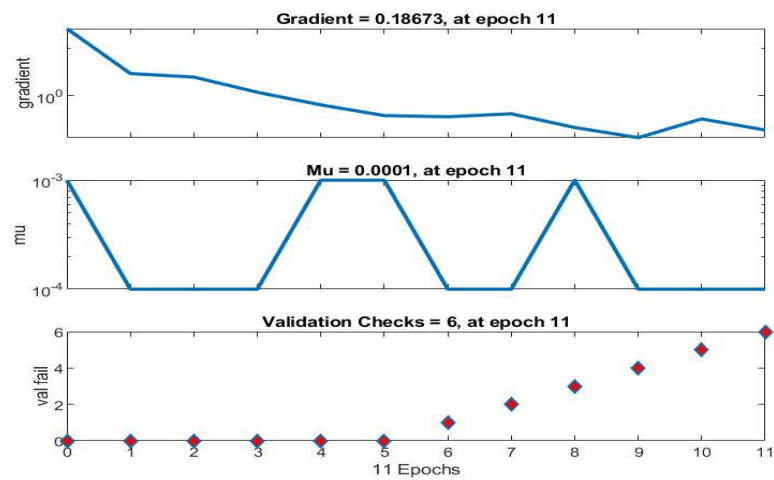


(b) Case II

Fig. 6: Maximum output element response of time-series

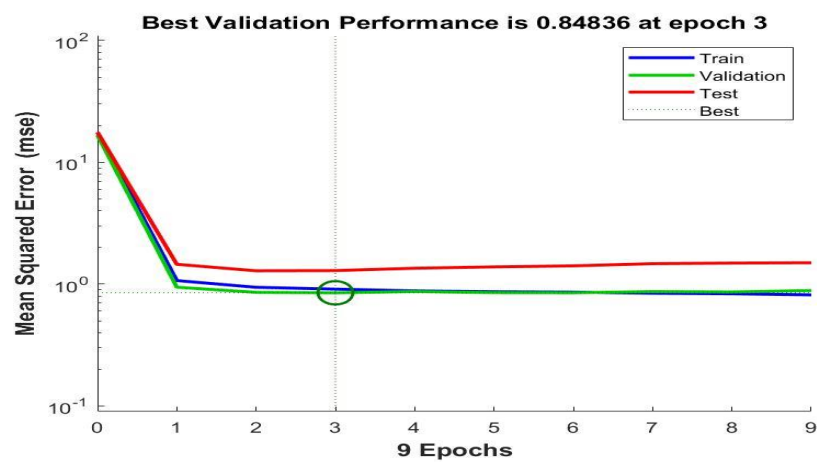


(a) Case 1

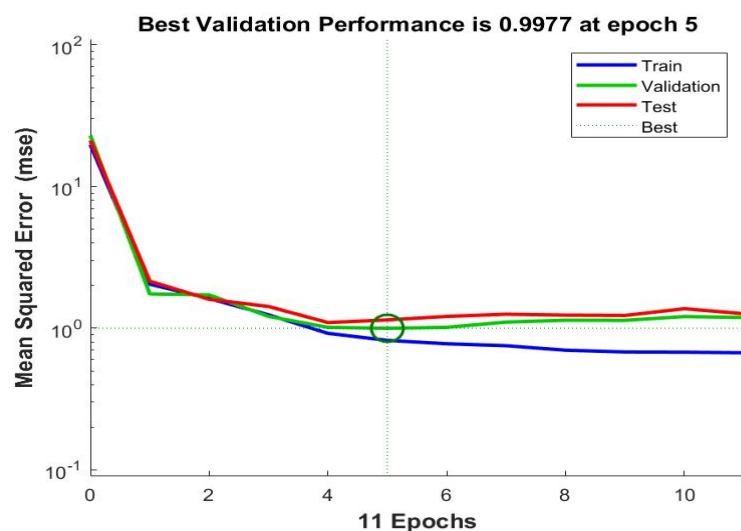


(b) Case II

Fig. 7: Validation checks of the data at different iteration

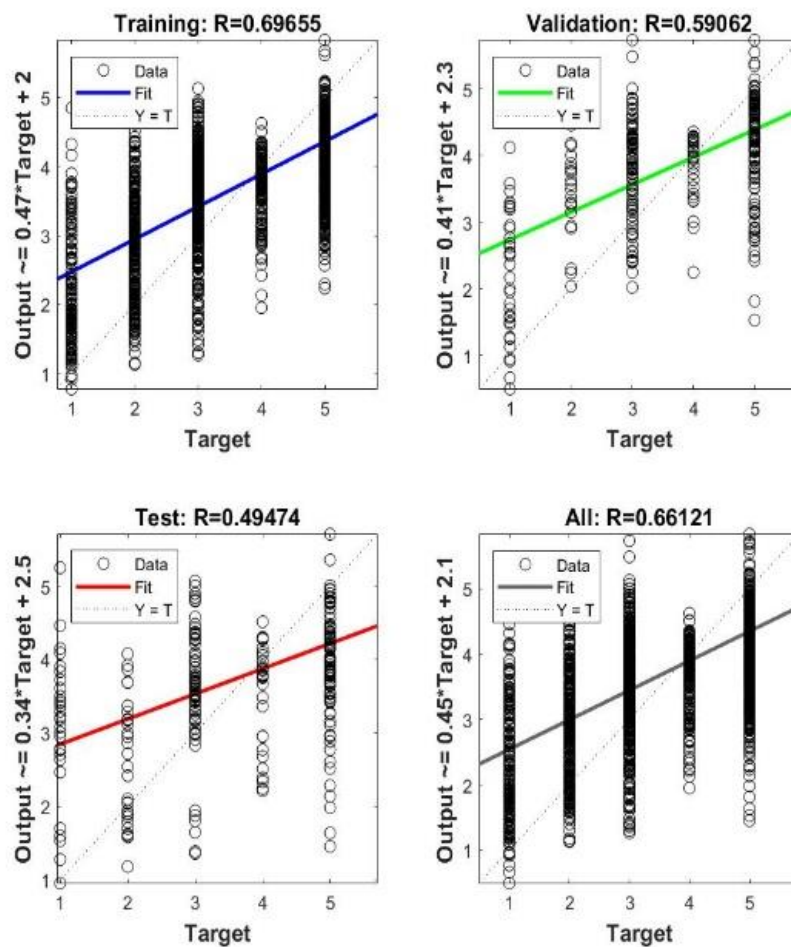


(a) Case 1

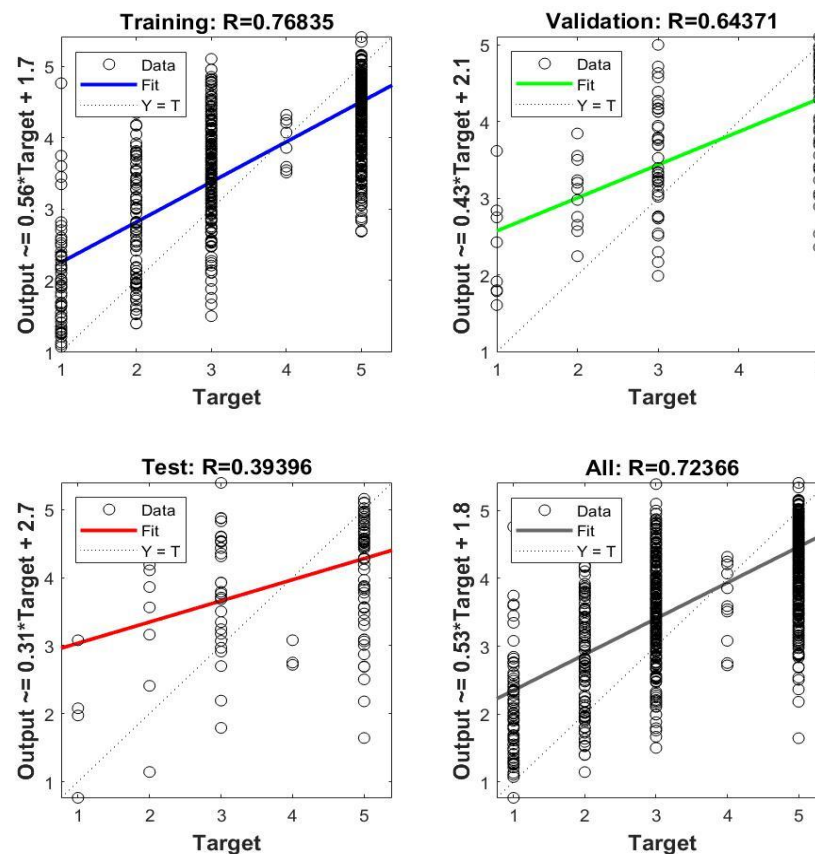


(b) Case II

Fig. 8: Validation performance of the data at different iteration



(a) Case 1



(b) Case II

Fig. 9: Regression validation of the data at different iteration

5. Results and Discussion

The analysis across the five cases demonstrates how institutional support, social capital, socio cultural interventions, women's entrepreneurial self-efficacy and managerial leadership collectively contribute to the empowerment of rural women. In the first case IS, SC, SCI and WESE directly influence ERW and the model maintains acceptable performance as shown by figure 3 lag-0 autocorrelation (1.30), in figure 5 a low error histogram (-0.04), while in the figure 7 stable gradient (0.233) and strong total regression (0.806) shown in figure 9 Case 2 evaluates the effect of WESE and MLI on ERW and the model continues to learn effectively, reflected through the validation training value (0.867). Results are developed for two different cases which are shown in figures 3 (lag-0 autocorrelation of error), figure 4 (max error correlation), figure 5 (error histogram), figure 6 (input-output with time series analysis), figure 7 (validations check), figures 8 (performance measures) and figures 9 (regression analysis). Overall, the results of all two cases reveal that empowerment is influenced through direct and indirect mechanisms where structural support, social ties and leadership qualities interact closely with women's self-efficacy to shape their entrepreneurial empowerment.

The aggregate results of ANN and PLS-SEM analysis suggest that the empirical effect of the entrepreneurial empowerment (ERW) of women is present and is built upon a synergistic interplay of the institutional, social, and psychological aspects. The results of PLS-SEM show that the direct effect of entrepreneurial self-efficacy of women (WESE) has the greatest impact on empowerment, institutional support and social capital have significant but relatively weak impacts. Managerial leadership (MLI) comes out as a powerful mediator through which structural supports relate to personal efficacy in achieving empowerment. ANN diagnostics supports these patterns by showing that total regression values of 0.661 to 0.806 and constant gradients (0.107–0.233) indicate the model is able to capture nonlinear dependencies. The combination of the two strategies confirms that the idea of empowerment is not an immediate result of the institutional systems, but a multi-

dimensional concept that develops as a result of mutual reinforcement between the leadership, self-belief, and communal resources.

The present results on the remarkable indirect impacts of institutional and social capital are consistent with those reported by [6,8] who found that institutional scaffolds and social networks worked synergistically to improve market access and market sustainability in female entrepreneurs. Moreover, the mediation aspect among digital and infrastructural connections within the frameworks of the present study resonates with the output of [1] highlighting the increased significance of technological platforms in converting the structural supports to the outcomes of empowerment. The dual-method evidence extends entrepreneurial empowerment theory by demonstrating that self-efficacy acts as a central psychological pathway linking institutional and social support to empowerment outcomes.

6. Conclusion

The combined outcomes of the PLS-SEM and ANN analysis all demonstrate that women entrepreneurial empowerment (ERW) is a complex construct that is developed both at the structural and psychological levels. The results of the PLS-SEM apprehend strong construct validity (AVE values of 0.699 through 0.744; Cronbach's α of over 0.78) and important direct impacts, with the entrepreneurial self-efficacy of women (0.338, p less than 0.001) as the most significant predictor. Institutional support (0.092, $p = 0.001$), social capital (0.109, $p = 0.001$), and socio-cultural interventions (0.058, $p = 0.001$) also have significant effects, which are mediated by managerial leadership, and thus, support the dependent nature of individual and structural determinants. These nonlinear diagnostics suggest that the model is successful in capturing complex interaction among institutional structures, social networks and psychological empowerment. The integrated approach to the methodology is important to provide greater accuracy and interpretability of the empowerment process since sustainable entrepreneurial development by rural women is the result of the active interaction of capability, confidence, and contextual support systems. Future studies could extend the dual-method approach (PLS-SEM and ANN) across larger, cross-cultural samples to validate the generalizability of empowerment determinants in diverse rural contexts. Researchers may incorporate longitudinal and policy-intervention data to examine how evolving institutional ecosystems and leadership training programs influence women's self-efficacy and sustained entrepreneurial outcomes over time.

Conflicts of Interest Statement

Authors has no conflict of interest

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