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DOES INVESTMENT SOURCE DIVERSIFICATION IMPROVE FARM PERFORMANCE? EVIDENCE FROM HORTICULTURAL PRODUCERS IN UZBEKISTAN

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Abstract. This study investigates the relationship between investment source diversification and the economic performance of horticultural farms in Uzbekistan. Using survey data from 280 producers, an Investment Source Diversification Index (ISDI) was constructed through Principal Component Factor Analysis, while Latent Class Analysis was employed to identify heterogeneous financing patterns. The results reveal two statistically distinct investment groups and show that farms with more diversified financing structures achieve significantly higher income and profitability. The findings identify investment source diversification as a key determinant of farm performance and underscore the importance of diversified financing for enhancing investment capacity and economic efficiency. The study contributes new empirical evidence to the agricultural finance literature and offers policy insights for the sustainable development of Uzbekistan’s horticultural sector.

Keywords: Investment Source Diversification; Horticultural Farms; Farm Performance; Economic Efficiency; Agricultural Finance; Latent Class Analysis; Uzbekistan

Аннотация. В данном исследовании изучается взаимосвязь между диверсификацией источников инвестиций и экономическими показателями плодоовощных хозяйств Узбекистана. На основе данных опроса 280 производителей был сформирован Индекс диверсификации источников инвестиций (ISDI) с использованием метода анализа главных компонент, а метод анализа латентных классов был применён для выявления неоднородных моделей финансирования. Результаты исследования выявили две статистически различающиеся инвестиционные группы и показали, что хозяйства с более диверсифицированной структурой финансирования достигают значительно более высоких показателей дохода и рентабельности. Полученные результаты определяют диверсификацию источников инвестиций как важный фактор эффективности хозяйств и подчёркивают значение диверсифицированного финансирования для повышения инвестиционного потенциала и экономической эффективности. Исследование вносит новый эмпирический вклад в литературу по аграрным финансам и предлагает практические рекомендации для устойчивого развития плодоовощного сектора Узбекистана.

Ключевые слова: диверсификация источников инвестиций; плодоовощные хозяйства; эффективность хозяйств; экономическая эффективность; аграрные финансы; анализ латентных классов; Узбекистан.

INTRODUCTION

Horticulture is a high-value agricultural subsector that contributes significantly to food security, rural employment, export diversification, and income generation. Its sustainable development increasingly depends on investments that enhance productivity, technological innovation, and resource-use efficiency [18; 20]. Although agricultural investment is widely recognized as a key driver of farm productivity and competitiveness, existing studies have focused primarily on investment volume, credit access, and public financial support [7]. Comparatively little attention has been devoted to investment source diversification and its implications for farm performance, particularly in developing and transition economies.

Investment source diversification involves combining multiple financing channels, including self-financing, commercial bank loans, government support, grants, private investment, and partnership financing. Portfolio theory suggests that diversified financing structures reduce financial vulnerability and improve investment sustainability under uncertain conditions [1]. This issue is particularly relevant in Uzbekistan, where agricultural reforms aim to modernize production systems and stimulate investment in high-value agricultural sectors [19]. Nevertheless, access to financial resources remains uneven among horticultural producers.

Using survey data from 280 horticultural farms in the Urgut and Taylaq districts of Samarkand Region, this study constructs an Investment Source Diversification Index (ISDI) through factor analysis and identifies latent investment groups using Latent Class Analysis (LCA). The study further evaluates whether investment source diversification is associated with differences in farm income and profitability. The findings contribute to the literature by providing empirical evidence on the role of financing diversification in shaping the economic performance of horticultural farms and offer policy implications for agricultural investment and rural financial development.

Literature Review

Investment source diversification has received increasing attention in agricultural economics because financing structures influence farms' investment capacity, technological modernization, and economic performance. Existing theoretical and empirical studies emphasize the importance of financial resources, credit accessibility, and investment activities for agricultural development (Markowitz, 1952 [1]; Penrose, 1959 [2]; Stiglitz and Weiss, 1981 [3]; Barney, 1991 [4]; Feder et al., 1990 [5]; Latruffe, 2010 [7]; Schimmelpfennig, 2016 [10]).

Table 1.
Gap-Oriented Summary of Previous Studies on Agricultural Investment, Financing, and Farm Performance[1]

Authors	Research Focus	Key Findings	Research Gap
Markowitz (1952)	Portfolio diversification	Diversification reduces financial risk.	Agricultural financing diversification not examined.
Penrose (1959); Barney (1991)	Resource-based advantage	Strategic resources enhance performance.	Financial diversification not explicitly addressed.
Stiglitz & Weiss (1981)	Credit constraints	Financial constraints limit investment.	Multiple financing sources not considered.
Feder et al. (1990)	Agricultural credit	Credit promotes investment and productivity.	Focuses on credit rather than financing diversification.
Latruffe (2010)	Agricultural investment	Investment improves competitiveness and productivity.	Financing structure remains underexplored.
Schimmelpfennig (2016)	Technology adoption	Investment supports technological modernization.	Financing-source diversity not examined.
Present study	Investment source diversification	Develops ISDI and identifies latent investment groups.	Addresses financing diversification and producer heterogeneity.

As shown in Table 1, previous studies have primarily focused on agricultural credit, investment intensity, and technology adoption. Despite extensive evidence on the positive role of investment in agricultural development, limited attention has been devoted to financing-source diversification, particularly as a multidimensional strategy combining internal funds, bank credit, government support, grants, and private investment. Furthermore, existing research generally treats agricultural producers as a homogeneous group and rarely investigates heterogeneity in financing behavior. Empirical evidence on how diversified financing structures affect farm income and profitability remains particularly scarce in horticultural systems of developing and transition economies.

To address these gaps, this study develops an Investment Source Diversification Index (ISDI) using Factor Analysis and applies Latent Class Analysis (LCA) to identify heterogeneous investment groups among horticultural producers. By linking financing diversification to farm economic performance, the study provides new evidence from Uzbekistan's horticultural sector.

1 Source: Compiled by the author based on previous studies [1–5; 7; 10].

RESEARCH METHODOLOGY

This study employed a quantitative research design based on survey data collected in 2026 from 280 horticultural farms in the Urgut and Taylaq districts of Samarkand Region, Uzbekistan. Data were obtained through structured interviews with farm owners and supplemented by field observations.

The analysis was conducted in three stages. First, investment source diversification was measured using eight indicators representing the main financing sources of horticultural farms. Second, Principal Component Factor Analysis (PCFA) was applied to construct the Investment Source Diversification Index (ISDI) [8; 11]:

$Xi = \lambda iF + \varepsilon i$

where Xi denotes the observed variables, F represents the latent factor, λi is the factor loading, and εi is the error term. Data adequacy was assessed using the Kaiser–Meyer–Olkin (KMO) statistic and Bartlett's test of sphericity [12; 13].

Third, Latent Class Analysis (LCA) was employed to identify heterogeneous investment patterns among farms [9; 16]. The optimal model was selected using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). All analyses were performed using Stata software [14; 15]. The combined application of PCFA and LCA enabled the construction of a composite investment diversification index and the identification of latent investment groups among horticultural producers. Participation was voluntary, and respondent confidentiality was maintained throughout the study.

ANALYSIS AND RESULTS

Table 2.
Descriptive Statistics of Investment Financing Sources among Horticultural Farms (n = 280) [21]

Investment Financing Source	Mean	Standard Deviation	Minimum	Maximum
Self-financing (Own financial resources)	**4.350**	0.733	1	5
Commercial bank loans	1.514	0.656	1	5
Government budget support	1.582	0.581	1	5
Government grants and subsidies	1.936	1.010	1	5
Borrowed funds	2.046	1.062	1	5
Private sector investment	2.100	1.011	1	5
Foreign investment	2.089	1.003	1	4
Partnership investment	1.596	0.579	1	4

Table 2 indicates that self-financing is the dominant source of investment funding among horticultural farms, recording the highest mean value (4.35). In contrast, commercial bank loans, government support, partnership financing, and grants are used to a comparatively lesser extent. The comparatively higher standard deviations for borrowed funds, private-sector investment, and foreign investment suggest considerable heterogeneity in financing behavior across farms. Overall, the results reveal a greater reliance on internal financial resources and a comparatively limited financing-source diversification. At the same time, the observed variability across external financing channels indicates the presence of underlying latent financing structures. These findings provide empirical support for applying Principal Component Factor Analysis (PCFA) to identify common latent dimensions and construct the Investment Source Diversification Index (ISDI).

To formally assess the suitability of the dataset for multivariate reduction, the intercorrelation structure of variables was examined prior to Factor Analysis. The diagnostic results are presented in Table 3.

Table 3.
Diagnostic Measures for Factor Analysis Adequacy [21]

Test / Indicator	Value	Interpretation
Determinant of correlation matrix	0.001	Indicates sufficient inter-variable correlations
Bartlett's Test (p-value)	0.000	Rejects null hypothesis of identity matrix
Kaiser–Meyer–Olkin (KMO)	0.864	Meritorious sampling adequacy

The diagnostic results confirm the suitability of the dataset for factor analysis. The KMO statistic (0.864) indicates a high level of sampling adequacy, while Bartlett's test ($p < 0.001$) confirms statistically significant correlations among the financing variables. Furthermore, the low determinant value (0.001) suggests substantial shared variance across the indicators.

Collectively, these findings support the existence of a common latent structure underlying investment financing behavior and justify the application of Principal Component Factor Analysis (PCFA). Consequently, PCFA was employed to construct the Investment Source Diversification Index (ISDI), which serves as the basis for the subsequent Latent Class Analysis. The results are presented in Table 4.

Table 4.
Results of Principal Component Factor Analysis [21]

Factors	Eigenvalue	Proportion	Cumulative Proportion	Difference
Factor 1	5.46455	0.6831	0.6831	4.56110
Factor 2	0.90345	0.1129	0.7960	0.38684
Factor 3	0.51662	0.0646	0.8606	0.10702
Factor 4	0.40960	0.0512	0.9118	0.13815
Factor 5	0.27145	0.0339	0.9457	0.04951
Factor 6	0.22195	0.0277	0.9735	0.06258
Factor 7	0.15937	0.0199	0.9934	0.10636
Factor 8	0.05301	0.0066	1.0000	–

Table 4 indicates that the first principal component had an eigenvalue of 5.46 and explained 68.31% of the total variance, demonstrating strong explanatory capacity. Based on the Kaiser criterion (eigenvalue > 1), only the first factor was retained, confirming that the investment indicators are primarily driven by a single latent dimension related to investment source diversification. The substantial gap between the first and second eigenvalues further supports the unidimensional structure of the data. These results indicate a high level of internal consistency among the financing variables and provide a solid statistical foundation for constructing the Investment Source Diversification Index (ISDI). Accordingly, factor scores from the first principal component were used to generate the ISDI, which served as the key variable in subsequent latent class and economic performance analyses.

The scree plot (Figure 1) provides additional confirmation of the one-factor solution, as the eigenvalue curve declines sharply after the first component and stabilizes thereafter.

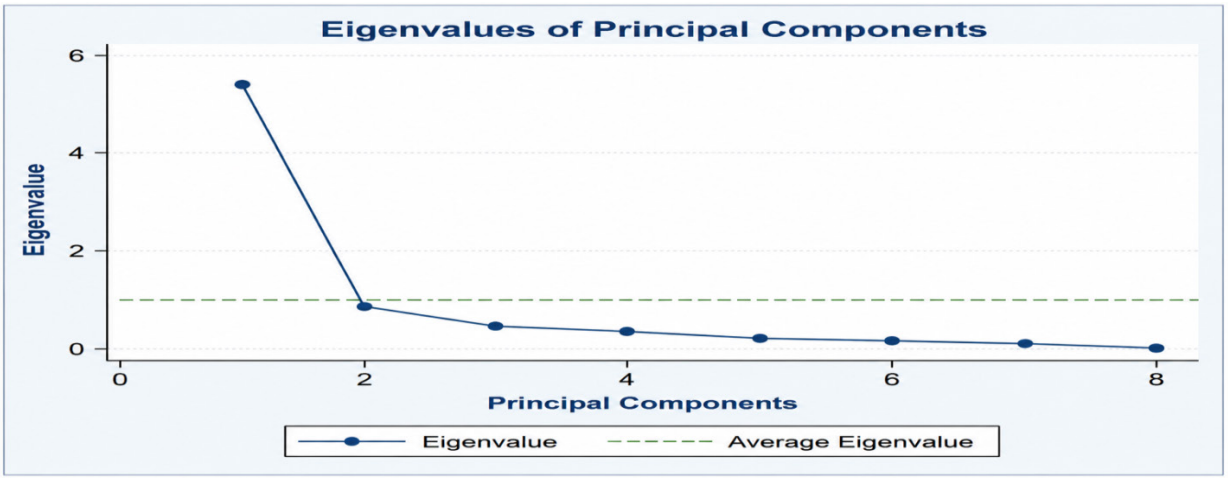

Figure 1. Scree Plot of Factor Eigenvalues [21]

The scree plot confirms a dominant latent factor underlying the investment activity indicators. The first principal component is the only factor exceeding the Kaiser criterion (eigenvalue > 1), indicating that investment source diversification can be represented by a single latent construct. The pronounced elbow point further supports the unidimensional structure of the data and justifies the construction of the Investment Source

Diversification Index (ISDI). The validity of the factor model was further confirmed by the likelihood-ratio test ($\chi^2(28) = 2084.65$, $p < 0.001$), demonstrating significant correlations among the variables and supporting the application of factor analysis. Overall, these results provide a robust empirical basis for constructing the ISDI and examining heterogeneity in investment behavior among horticultural producers.

Table 5.
Factor Loadings and Uniqueness Estimates of Investment Financing Sources **[21]**

Investment Financing Sources	Factor 1	Uniqueness
Self-financing (Own financial resources)	-0.7358	0.4587
Commercial bank loans	-0.5832	0.6598
Borrowed funds	-0.8506	0.2765
Government budget support	0.7862	0.3818
Private sector investment	0.9210	0.1517
Foreign investment	0.9459	0.1052
Partnership investment	0.8857	0.2156
Government grants and subsidies	0.8449	0.2861

Note: *Absolute factor loadings above 0.50 indicate a strong relationship with the latent factor, while lower uniqueness values imply that a greater share of variance is explained by the common factor.*

The factor loading results provide strong evidence of a unidimensional latent structure underlying investment financing sources. All variables exceeded the recommended loading threshold ($|\lambda| > 0.50$), confirming their substantial contribution to the extracted factor. The highest loadings were observed for foreign investment (0.9459), private-sector investment (0.9210), and partnership investment (0.8857), highlighting their central role in explaining investment source diversification. Although several indicators exhibited negative loadings, the sign reflects only the direction of association and does not affect explanatory relevance. Therefore, interpretation is based on loading magnitude rather than polarity.

The generally low uniqueness values, particularly for foreign investment (0.1052), private-sector investment (0.1517), and partnership investment (0.2156), indicate that most of their variance is captured by the common latent factor. Overall, the results confirm strong internal consistency among the financing indicators and support the construction of a composite Investment Source Diversification Index (ISDI). The derived factor scores were subsequently used for latent class segmentation and economic performance analysis. Factor analysis further demonstrated that investment financing indicators were highly concentrated around a single latent dimension, providing econometric justification for aggregating them into the ISDI. The descriptive properties of the index are presented in Table 6.

Table 6
Descriptive Statistics of the Investment Source Diversification Index (ISDI) **[21]**

Variable	Mean	Standard Deviation	Minimum	Maximum
Investment Source Diversification Index (ISDI)	0.352	0.280	0.000	1.000

Note: *ISDI is a composite index constructed from multiple investment financing sources.*

The average ISDI value (0.352) indicates a moderate level of financing-source diversification among horticultural farms. The relatively high standard deviation (0.280) reveals considerable heterogeneity in investment capacity and financing strategies across producers. These results suggest that the index effectively captures variations in investment behavior and provides a reliable basis for identifying latent financing groups. Accordingly, Latent Class Analysis (LCA) was applied, and the optimal number of classes was determined using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) (Table 7).

Table 7.
Comparative Fit Statistics of Latent Class Models [21]

Model	AIC	BIC
One-class model	5406.596	5464.752
Two-class model	3116.337	3207.206

Note: *The optimal model was selected based on the lowest AIC and BIC values.*

The two-class model exhibited substantially lower AIC and BIC values than the one-class specification, indicating superior model fit and confirming the presence of statistically distinct latent groups among horticultural farms. This result highlights significant heterogeneity in investment capacity and financing strategies across producers. Accordingly, the two-class solution was retained as the optimal specification, and posterior membership probabilities were estimated for each respondent. The findings suggest that investment source diversification is characterized by differentiated financing patterns rather than a homogeneous structure. To further examine these differences, predictive margins analysis was performed based on the selected latent class model (Table 8).

Table 8.
Predicted Class Membership Probabilities Based on the Latent Class Model (Predictive Margins) **[21]**

Class	Probability	Standard Error	z-statistic	p-value	95% Confidence Interval
Class 1	0.4625	0.0299	15.45	0.000	0.4039–0.5212
Class 2	0.5375	0.0299	17.96	0.000	0.4788–0.5961

Note: *Predicted class membership probabilities were estimated from the optimal two-class latent class model.*

Table 8 confirms significant heterogeneity in investment financing behavior among horticultural farms. The predictive margins estimates indicate that 46.25% of respondents belong to Class 1, while 53.75% are assigned to Class 2, demonstrating the existence of two distinct financing segments. Class 1 is characterized by relatively limited financing diversification, whereas Class 2 exhibits greater diversification and stronger participation in institutional financing mechanisms. The low standard errors, high z-statistics, and statistically significant coefficients ($p < 0.001$) confirm the robustness of the classification results. Moreover, entropy statistics indicate high classification accuracy, supporting the use of latent class membership probabilities for further analysis of investment behavior heterogeneity (Figure 2).

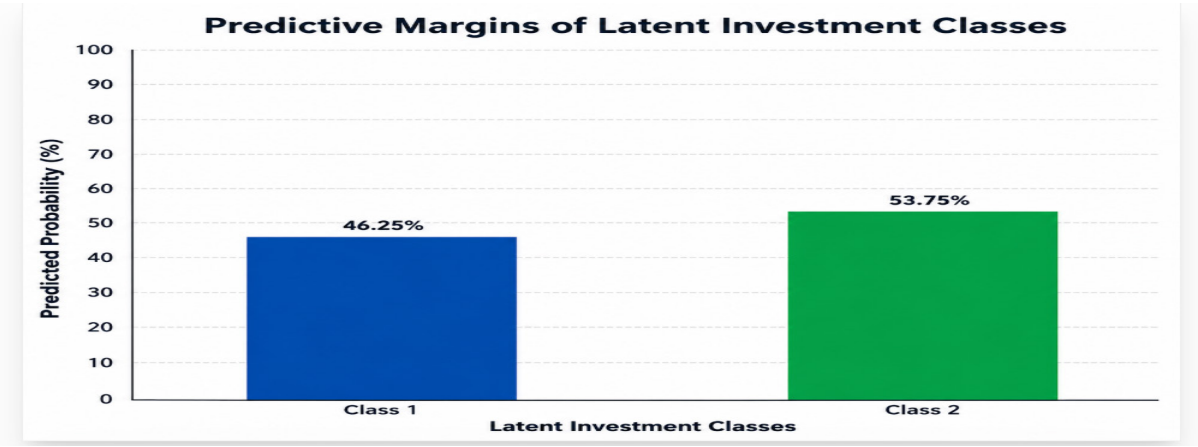

Figure 2. Predictive Margins of Respondents across Latent Classes [21]

The results in Figure 2 confirm significant heterogeneity in investment activity among horticultural farms. Predictive margins estimates show that 46.25% of respondents belong to the first latent class and 53.75%

to the second, indicating distinct financing patterns across producers. The first class is characterized by a stronger reliance on internal financing, whereas the second exhibits greater investment source diversification and stronger integration into institutional financing channels. The predominance of the second class suggests increasing financial diversification within the horticultural sector. The low standard errors and highly significant estimates ($p < 0.001$) confirm the robustness of the classification.

Overall, the findings demonstrate that investment source diversification is an important determinant of farm investment activity and economic performance. The latent class framework effectively captures heterogeneity in financing behavior and investment structures among horticultural producers.

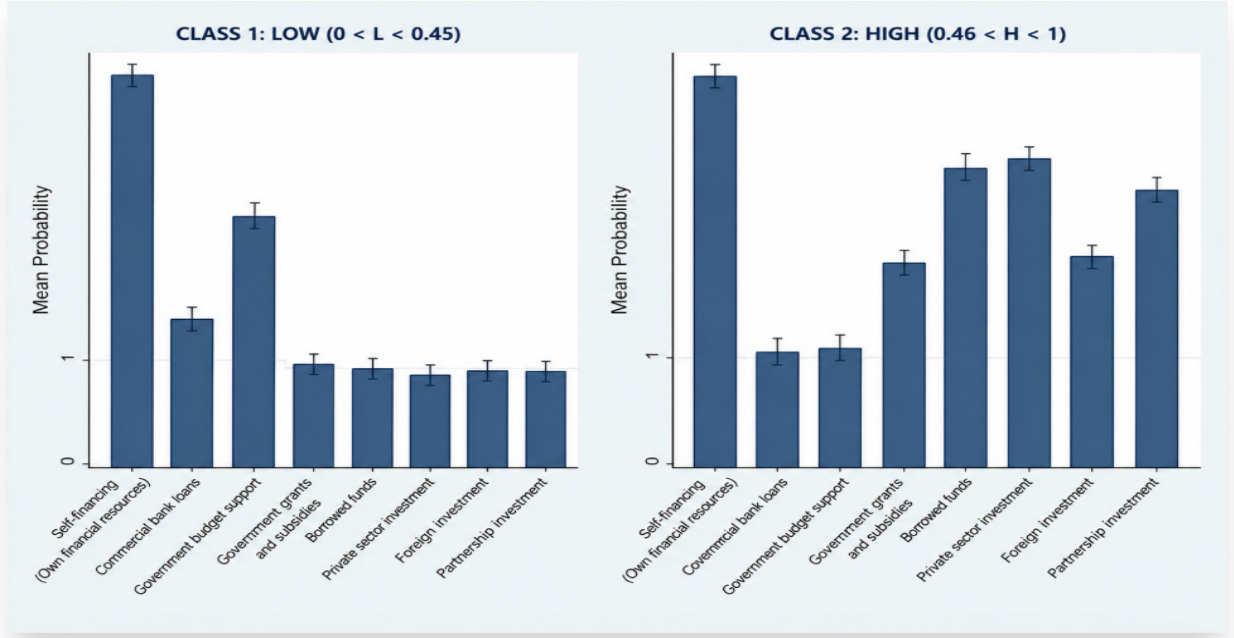

Figure 3. Predicted Values of Investment Sources across Latent Classes [21]

The results in Figure 3 reveal two statistically distinct investment segments among horticultural farms. The first latent class is characterized by a greater reliance on self-financing and relatively constrained access to external funding, whereas the second exhibits greater financing diversification through increased use of private investment, foreign capital, and government support mechanisms. Although self-financing remains the primary funding source in both groups, the more-diversified investment class demonstrates stronger integration into external financing channels. This pattern reflects ongoing financial diversification and the growing institutionalization of investment activities within the horticultural sector.

Overall, the findings corroborate the factor and latent class analyses, highlighting significant heterogeneity in investment capacity and financing access among producers. The results further identify investment source diversification as a key determinant of investment activity and economic performance. The descriptive statistics of the Investment Source Diversification Index (ISDI) and latent class distribution are presented in Table 9.

Table 9.
Descriptive Statistics of the Investment Source Diversification Index and Latent Classes [21]

Variable	Mean	Std. Dev.	Minimum	Maximum
Investment Source Diversification Index (ISDI)	0.352	0.280	0	1
Latent Investment Group	0.536	0.500	0	1

The results in Table 9 indicate considerable heterogeneity in investment source diversification among horticultural farms. The mean ISDI value (0.352) and its standard deviation (0.280) reflect substantial variation in financing structures and investment capacity across producers. The average value of the latent group variable (0.536) suggests a relatively balanced distribution between the two investment segments, confirming the presence of distinct financing strategies. The first group relies mainly on internal funding, whereas the second exhibits greater financing diversification and stronger utilization of external resources.

These findings underscore the importance of investment source diversification in shaping farm investment behavior. To further assess its economic implications, income and profitability indicators were compared across latent classes (Figure 4).

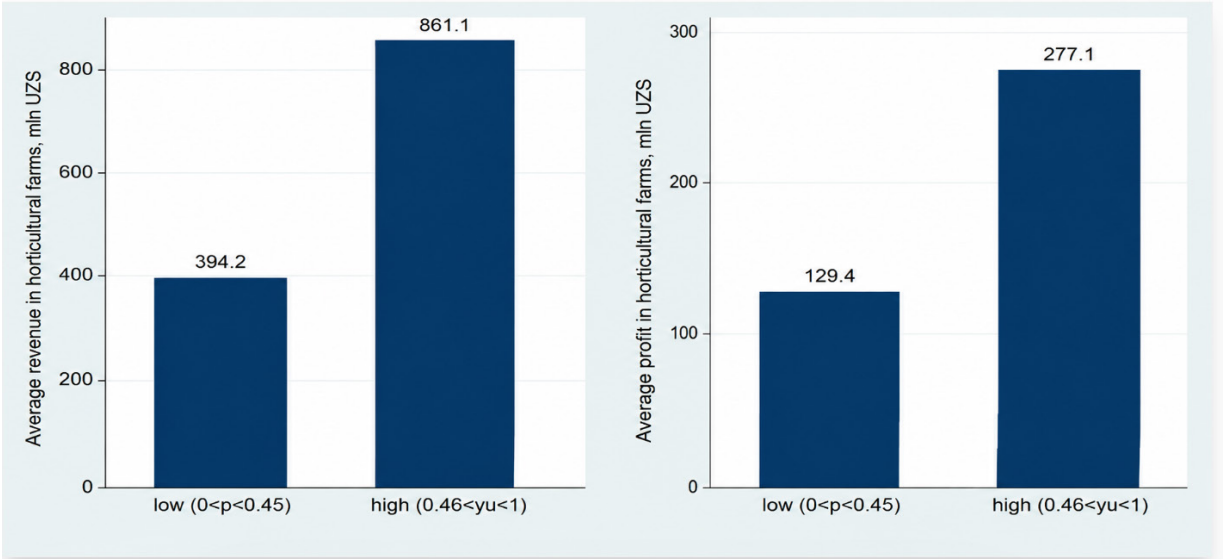

Figure 4. Average Farm Income and Profit by Investment Activity Class [21]

The results in Figure 4 demonstrate a strong positive relationship between investment source diversification and farm economic performance. Farms in the more-diversified investment group achieved substantially higher average income (UZS 861.1 million) and profit (UZS 277.1 million) than those in the less-diversified investment group (UZS 394.2 million and UZS 129.4 million, respectively). This finding suggests that broader access to diversified financing sources, including private investment, foreign capital, and government support, contributes significantly to improved economic outcomes. Factor and latent class analyses further identified two statistically distinct investment segments among horticultural producers. The AIC, BIC, entropy, and predictive margins statistics confirmed satisfactory model fit and classification accuracy, highlighting investment source diversification as a key determinant of farm profitability and economic efficiency.

Accordingly, the principal contribution of this study is the empirical evidence that diversified financing structures significantly enhance the profitability and economic performance of horticultural farms.

CONCLUSION AND SUGGESTIONS

This study examined the relationship between investment source diversification and the economic performance of horticultural farms in the Urgut and Taylaq districts of the Samarkand region. Using Principal Component Factor Analysis (PCFA) and Latent Class Analysis (LCA), an Investment Source Diversification Index (ISDI) was developed and two statistically distinct financing groups were identified. The results indicate that investment financing indicators are largely explained by a single latent factor, while the latent class model reveals substantial heterogeneity in financing behavior among producers. Farms with more diversified financing structures achieved significantly higher income and profit levels, highlighting the positive role of financing diversification in enhancing investment capacity, technological modernization, and competitiveness.

From a policy perspective, expanding access to commercial credit, government support programs, private capital, and foreign investment may be prioritized to strengthen financing diversification. In addition, improving institutional support and promoting public–private partnerships can facilitate sustainable investment and long-term development in the horticultural sector. Overall, the findings provide strong empirical evidence that investment source diversification is a key driver of farm profitability and economic efficiency, offering important implications for agricultural investment policy and rural development in Uzbekistan.

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