



INVESTMENT SOURCE DIVERSIFICATION AND ECONOMIC PERFORMANCE IN HORTICULTURAL FARMS: EVIDENCE FROM LATENT CLASS AND FACTOR ANALYSIS IN UZBEKISTAN

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ARTICLE INFO

Received: 06th June 2026

Accepted: 08th June 2026

Online: 10th June 2026

KEYWORDS

investment diversification, horticultural farms, economic performance, factor analysis, latent class analysis, agricultural finance, farm profitability, Uzbekistan

ABSTRACT

this study examines the relationship between investment source diversification and the economic performance of horticultural farms in Uzbekistan. Using survey data from 280 producers, the research applies Factor Analysis (FA) to construct an Investment Diversification Index and Latent Class Analysis (LCA) to identify heterogeneous investment groups. The findings reveal significant differences in income and profitability across investment classes, indicating that diversified financing structures enhance investment capacity, technological modernization, and farm competitiveness. The results highlight the strategic importance of financial diversification for sustainable development in the horticulture sector.

Introduction

Agriculture remains a key sector for economic growth, food security, and rural development, particularly in developing and transition economies. Within agriculture, horticulture has become one of the most dynamic subsectors due to its high value-added potential, export orientation, and contribution to employment and income generation [1.FAO. The State of Food and Agriculture.]. The increasing integration of agricultural markets into global value chains has intensified the need for technological modernization, efficient resource allocation, and sustainable production systems . Consequently, investment has become a critical driver of productivity growth, technological adoption, and competitiveness in horticultural production [2. Schultz, T.W. (1964)., 3. Hayami, Y., & Ruttan, V.W. (1985).].

In modern horticulture, investments support the adoption of advanced irrigation systems, greenhouse technologies, post-harvest infrastructure, cold storage facilities, and digital agricultural solutions. However, despite the recognized importance of investment, access to financial resources remains a major constraint for many agricultural producers. Small and medium-sized farms often face difficulties in obtaining external financing because of credit market imperfections, collateral limitations, and weak rural financial institutions [4. Stiglitz, J.E., & Weiss, A. (1981)]. As a result, many producers rely heavily on internal funds, limiting their capacity to invest in productivity-enhancing technologies.

Recent studies suggest that the effectiveness of investment depends not only on its volume but also on the diversification of financing sources. Investment source diversification

enables farms to combine internal funds with bank loans, government support programs, private investments, grants, and foreign capital, thereby reducing financial risks and increasing investment flexibility. According to portfolio diversification theory, reliance on multiple financing channels enhances resilience and improves long-term economic performance.

The issue of investment diversification is particularly relevant for Uzbekistan, where horticulture has been identified as a strategic sector within ongoing agricultural reforms. Government policies have focused on improving access to agricultural finance, attracting private and foreign investments, and strengthening institutional support mechanisms. Nevertheless, significant differences remain among horticultural farms in terms of access to investment resources and financing opportunities.

Although previous studies have examined the relationship between investment and agricultural growth, limited attention has been devoted to the structure of investment financing and its impact on farm-level performance. Furthermore, most studies assume that farms are homogeneous units, overlooking potential heterogeneity in investment behavior and financial capacity [5. Barrett C.B.]. Consequently, empirical evidence on the relationship between investment source diversification and economic performance in horticulture remains scarce, particularly in transition economies.

To address this gap, the present study investigates the impact of investment source diversification on the economic performance of horticultural farms in Uzbekistan. Using survey data collected from 280 horticultural producers, the study applies Factor Analysis (FA) to construct a composite investment diversification index and Latent Class Analysis (LCA) to identify hidden investment segments. The results are further used to evaluate differences in farm income and profitability across latent classes.

This study contributes to the literature in three ways. First, it develops a multidimensional measure of investment source diversification in horticulture. Second, it applies Latent Class Analysis to identify heterogeneous investment groups among agricultural producers. Third, it provides new empirical evidence from Uzbekistan, where research on agricultural finance and investment diversification remains limited. The findings offer important policy implications for improving financial inclusion, enhancing investment efficiency, and strengthening the competitiveness of the horticulture sector.

Literature review

Investment is widely recognized as one of the principal drivers of agricultural modernization, productivity growth, and long-term competitiveness. Classical economic growth theories emphasize capital accumulation as a fundamental determinant of economic performance, while contemporary agricultural development literature highlights the importance of investment quality, financing structures, and institutional support mechanisms in shaping farm-level outcomes [6. Solow, R.M. (1956), 7. North, D.C. (1990)].

In horticultural production systems, investments play a particularly significant role due to the capital-intensive nature of modern production technologies. The adoption of drip irrigation systems, protected cultivation technologies, cold storage infrastructure, processing facilities, and digital farming solutions requires substantial financial resources [8. FAO].

Consequently, the availability and composition of investment resources directly influence production efficiency, value-added creation, and profitability.

Several empirical studies demonstrate that farms with greater access to diversified financing mechanisms exhibit higher levels of productivity and economic resilience. For example, studies conducted in European agricultural systems indicate that farms utilizing multiple financing sources achieve significantly higher investment efficiency than farms relying exclusively on internal funds [9. European Commission]. Similar findings have been reported in Asian and Latin American agricultural sectors, where financial diversification contributes positively to technological adoption and business expansion [10. Asian Development Bank].

From a theoretical perspective, investment diversification reduces financing constraints and enhances the flexibility of investment decision-making. According to Resource-Based Theory, access to diversified financial resources constitutes a strategic capability that strengthens competitive advantage and organizational performance [11. Barney, J. (1991)]. Likewise, Institutional Theory argues that diversified financing structures facilitate stronger integration with formal financial institutions, thereby improving access to information, innovation, and investment opportunities [12. Scott, W.R.].

Despite these theoretical arguments, empirical evidence remains inconclusive regarding the mechanisms through which investment diversification affects economic outcomes in horticulture. Most previous studies have concentrated on aggregate investment volumes while neglecting the structural composition of investment sources [13. OECD.]. Consequently, the relationship between investment source diversification and farm profitability remains insufficiently explored, particularly in transition economies.

Methodology

The multidimensional nature of investment activities presents significant methodological challenges for empirical research. Agricultural producers often utilize multiple financing sources simultaneously, including internal funds, commercial bank loans, government support programs, foreign direct investment, private sector financing, grants, and partnership investments. These financing channels are frequently interrelated, generating multicollinearity and measurement difficulties in econometric analyses [14. Hair, J.F. et al.].

To address such challenges, researchers increasingly employ Factor Analysis (FA) to identify latent dimensions underlying observed financial indicators. Factor Analysis enables the reduction of complex datasets into a smaller number of unobservable factors while preserving the majority of informational content [15. Johnson, R.A., & Wichern, D.W.].

Mathematically, the factor model can be represented as:

$$\mathbf{X_i} = \lambda_i \mathbf{F} + \epsilon_i$$

where:

($\mathbf{X_i}$) represents observed investment indicators;

($\mathbf{F}$) denotes the latent investment factor;

(λ_i) indicates factor loadings;

(ϵ_i) represents random disturbances.

In agricultural finance research, FA has been widely applied to construct composite indicators of financial inclusion, investment readiness, innovation capacity, and institutional

performance [16. OECD, Nardo, M. et al.]. The approach provides a statistically rigorous mechanism for aggregating multiple correlated indicators into a single composite index suitable for subsequent econometric analysis.

The present study adopts Principal Component Factor Analysis (PCFA) to construct a composite investment diversification index. The empirical results reported in Section 3 demonstrate that the first principal factor explains 68.31% of total variance, indicating the existence of a dominant latent investment structure among horticultural farms. This finding suggests that investment diversification can be represented as a unified latent construct encompassing various financing sources.

Latent Class Analysis and Investment Heterogeneity

Recent developments in agricultural economics emphasize the importance of accounting for heterogeneity among producers. Traditional regression approaches typically assume homogeneous behavioral responses across observations. However, growing empirical evidence indicates substantial variation in financial behavior, investment strategies, and institutional integration among farms [17. Greene, W.H.].

Latent Class Analysis (LCA) offers a powerful framework for identifying unobserved subpopulations characterized by distinct behavioral patterns. Unlike conventional clustering techniques, LCA is model-based and relies on probabilistic classification procedures that explicitly account for measurement uncertainty [18. Collins, L.M., & Lanza, S.T.].

The probability of belonging to a particular latent class can be expressed as:

$$[P(C=k|Y)]$$

where (C) denotes latent class membership and (Y) represents observed investment indicators.

LCA has gained increasing popularity in agricultural research due to its ability to uncover hidden structural segments within heterogeneous populations. Applications include farmer technology adoption, risk behavior, sustainability practices, market participation, and financial decision-making. Despite its growing use, applications of LCA in agricultural investment research remain relatively limited. Existing studies have rarely examined whether farms characterized by different investment structures exhibit systematically different economic outcomes. This limitation is particularly evident in developing and transition economies, where investment heterogeneity is likely to be substantial.

The present study addresses this gap by applying LCA to classify horticultural farms according to their investment diversification profiles. Based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), the two-class solution was identified as the optimal model specification. The results indicate the existence of two statistically distinct investment groups, confirming significant heterogeneity in investment behavior among horticultural producers.

Analysis and results

The ultimate objective of investment activity is the enhancement of economic performance. Previous studies consistently report positive associations between investment intensity and farm profitability. Nevertheless, relatively few studies investigate whether the structure of investment financing influences economic outcomes independently of investment volume. According to Financial Constraint Theory, diversified financing structures reduce

capital shortages and improve producers' ability to undertake productivity-enhancing investments. Similarly, Portfolio Diversification Theory suggests that reliance on multiple financing channels reduces financial risk and improves long-term economic stability.

Empirical evidence from the present study provides strong support for these theoretical expectations. Farms classified within the high-diversification investment segment achieved average revenues of 861.1 million UZS and profits of 277.1 million UZS, whereas farms belonging to the low-diversification segment reported substantially lower values of 394.2 million UZS and 129.4 million UZS, respectively. These differences indicate that investment diversification functions as a critical determinant of economic performance in horticultural production systems.

The observed relationship suggests that diversified investment portfolios facilitate greater access to capital, technological modernization, institutional support mechanisms, and market opportunities. Consequently, investment diversification should be regarded not merely as a financing strategy but as a strategic instrument for enhancing farm competitiveness and sustainable development.

Conceptual Framework and Hypothesis Development

Based on the theoretical and empirical literature reviewed above, this study proposes a conceptual framework linking investment source diversification to farm economic performance through latent investment structures.



Figure 1.

Proposed conceptual framework linking investment source diversification, latent investment classes, and economic performance.

Developed by the authors based on Portfolio Diversification Theory, Financial Constraint Theory, and empirical research framework. The framework assumes that:

Investment Sources → Investment Diversification Index → Latent Investment Class → Income and Profitability

Accordingly, the following hypotheses are proposed:

H1: Investment source diversification positively affects farm income.

H2: Investment source diversification positively affects farm profitability.

H3: Horticultural farms can be classified into statistically distinct latent investment groups.

H4: Farms belonging to highly diversified investment classes achieve significantly higher income and profitability than farms relying predominantly on internal financing sources.

CONCLUSION AND RECOMMENDATIONS

This study investigated the relationship between investment source diversification and the economic performance of horticultural farms in Uzbekistan. Using survey data collected from 280 horticultural producers, the research employed Factor Analysis (FA) to construct a composite Investment Diversification Index and Latent Class Analysis (LCA) to identify heterogeneous investment groups among farms. The integrated methodological framework enabled the examination of both the structural characteristics of investment behavior and their implications for farm-level economic outcomes.

The empirical findings reveal that investment source diversification constitutes a significant determinant of economic performance in horticultural production systems. The Factor Analysis results confirmed that various financing sources can be aggregated into a unified latent construct reflecting the degree of investment diversification. Furthermore, the Latent Class Analysis identified two statistically distinct investment segments characterized by different financing structures and investment capacities.

A key finding of the study is the substantial economic advantage enjoyed by farms belonging to the highly diversified investment class. These farms generated average annual revenues of 861.1 million UZS and profits of 277.1 million UZS, compared with 394.2 million UZS and 129.4 million UZS, respectively, among farms classified within the low-diversification segment. The results indicate that diversified farms achieved approximately 2.18 times higher revenues and 2.14 times higher profits than their less diversified counterparts. This evidence suggests that access to multiple financing channels enhances investment capacity, facilitates technological modernization, and strengthens overall farm competitiveness.

The findings also contribute to the broader literature on agricultural finance and investment behavior by demonstrating that horticultural producers should not be treated as a homogeneous population. Significant heterogeneity exists in terms of financing strategies, resource accessibility, and investment decision-making. Consequently, policies designed under the assumption of uniform producer behavior may fail to achieve their intended outcomes. The application of Latent Class Analysis provides new insights into hidden investment structures and offers a useful analytical framework for future agricultural finance research.

From a theoretical perspective, the results support the assumptions of Financial Constraint Theory and Portfolio Diversification Theory. Farms utilizing diversified financing portfolios appear better equipped to overcome capital constraints, manage financial risks, and exploit growth opportunities. Thus, investment diversification should be viewed not merely as a financing mechanism but as a strategic tool for improving farm performance and ensuring sustainable sectoral development. Based on the empirical findings, several policy recommendations can be proposed:

First, policymakers should prioritize the expansion of diversified agricultural financing mechanisms. Improving farmers' access to commercial bank loans, leasing instruments, investment funds, grants, and partnership financing schemes would reduce excessive dependence on internal financial resources and strengthen investment capacity.

Second, government support programs should be designed to encourage the simultaneous utilization of multiple financing sources. Rather than focusing exclusively on subsidized credit, agricultural support policies should promote integrated financing packages combining public and private investment instruments.

Third, greater efforts should be directed toward attracting foreign direct investment (FDI) into the horticulture sector. Foreign investments can provide not only financial resources but also technological innovations, managerial expertise, and access to international markets, thereby enhancing sectoral competitiveness.

Fourth, institutional mechanisms facilitating cooperation between farmers, financial institutions, agricultural clusters, and private investors should be strengthened. Such cooperation can improve information flows, reduce transaction costs, and increase the efficiency of investment allocation.

Fifth, financial literacy and investment management training programs should be expanded among horticultural producers. Enhancing farmers' knowledge of available financing opportunities and investment planning techniques may increase the effectiveness of resource utilization and improve long-term economic outcomes.

Despite its contributions, this study has several limitations. The analysis was based on cross-sectional survey data and therefore does not fully capture the dynamic nature of investment behavior over time. Future studies could employ longitudinal datasets to examine how changes in financing structures influence farm performance across different stages of development.

In addition, the research focused exclusively on horticultural farms in Uzbekistan. Comparative analyses involving other agricultural subsectors or countries could provide a broader understanding of investment diversification patterns and their economic implications. Future research may also integrate advanced econometric approaches, such as Structural Equation Modeling (SEM), multilevel models, or causal inference techniques, to explore the mechanisms through which investment diversification affects productivity, innovation adoption, and long-term farm sustainability.

Overall, the study demonstrates that investment source diversification represents a critical pathway for improving the economic performance of horticultural farms. Expanding access to diversified financing structures can contribute significantly to agricultural modernization, income growth, and the sustainable development of Uzbekistan's horticulture sector.

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