FORECASTING THE INTEGRATION POTENTIAL OF FARMS INTO INTERNATIONAL MARKETS UP TO 2032: A COMPLEX INTEGRAL INDEX AND ARIMA-BASED SCENARIO APPROACH

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https://doi.org/10.5281/zenodo.21158314

ARTICLE INFO

Received: 26th June 2026
Accepted: 28th June 2026
Online: 30th June 2026

KEYWORDS

farms, international market integration, export potential, integral index, ARIMA, scenario forecasting, agricultural cooperation, global value chains

ABSTRACT

The paper develops a methodology for forecasting the potential of farms to integrate into international markets, combining a complex integral index, an ARIMA time-series model, and scenario analysis. Eight indicators—export value, export volume, cooperative membership, share of certified farmers, innovation, logistics, market infrastructure, and digitalization—are normalized by the Min–Max method and aggregated with equal weights into an International Market Integration Index (IMI). The dynamics of the IMI are projected to 2032 using the best-fitting ARIMA(1,1,0) model, selected by the AIC and BIC criteria, after which baseline, optimistic, and innovative development scenarios are constructed. Using data for the fruit-and-vegetable farms of the Samarkand region (Uzbekistan), the IMI is shown to rise from 0.000 in 2020 to a projected 1.000 by 2032, while export value grows from USD 180 million to USD 465 million. The results provide a quantitative basis for strategic decisions on developing export cooperatives and deepening farms' integration into global value chains.

1. Introduction

Intensifying competition in the global agro-industrial system, the expansion of international value chains, and the tightening of quality and safety requirements in export markets are turning the deepening of farms' integration into international markets into one of the priority directions of agricultural development. Developing export-oriented production, creating added value, introducing international standards, and consolidating farmers through cooperation have become essential components of modern agrarian policy. In recent years, the Republic of Uzbekistan has implemented large-scale reforms aimed at diversifying agricultural exports, expanding export geography, and improving the competitiveness of farms in international markets. However, ensuring the long-term effectiveness of these reforms requires not only assessing the current level of farms' integration potential, but also forecasting its prospective development trends on a scientific basis.

Accordingly, this paper systematizes the key indicators that characterize the integration potential of farms into international markets, comprehensively assesses their

interrelationship, and—on the basis of an integral assessment—develops a development forecast up to 2032. Baseline, optimistic, and innovative scenarios are applied to evaluate the impact of developing export cooperatives, introducing innovative technologies, improving logistics infrastructure, and widely applying international standards.

2. Literature Review

The assessment of international market integration potential and the forecasting of its future development have become an important research direction in agrarian economics, international trade, and regional development. In the literature this problem has mainly been studied within three approaches.

The **first approach** assesses farms' integration into international markets through macroeconomic indicators such as export volume, export value, foreign trade turnover, or export share. Here the dynamics of export volume are analyzed in connection with a country's production potential, external demand, and price conjuncture. However, such an approach cannot fully reflect the institutional, organizational, and innovation factors at the farm level [1–3].

The **second approach** explains farms' integration into international value chains through cooperation, logistics, certification systems, innovative technologies, and market infrastructure. Success in export activity is linked more to the degree of cooperation, the adoption of modern technologies, adaptation to international standards, and access to market information. Integration is thus viewed as a complex system reflecting the efficiency of all processes from production to delivery to the consumer [4–6].

The **third approach** is devoted to forecasting the future development of these processes, mainly using econometric and statistical models—time-series methods, regression models, and scenario-based forecasting. Yet most of these studies forecast only one or a few economic indicators, and the task of developing long-term projections on the basis of a system of indicators that comprehensively describes integration potential remains insufficiently addressed [7–10].

Existing works pay considerable attention to forecasting export growth rates, but the interdependence of the resource, innovation, institutional, and market factors that determine integration potential is often studied in isolation. As a result, a methodology for assessing these factors through a single integral indicator and forecasting its future development has not been fully formed. This paper therefore assesses integration potential not through separate economic indicators, but through a complex system of integral indicators, and constructs baseline, optimistic, and innovative scenarios on this basis.

3. Methodology

The comparative analysis of forecasting models aimed to select a methodological approach that allows the integration potential of farms to be forecast to 2032 in the most reliable and scientifically grounded way. Existing models are compared by their scope of application, forecast accuracy, ability to reflect economic content, and capacity to form long-term projections (Table 1).

Table 1. Comparative description of methods used to forecast farms' international market integration potential

Model	Main content	Advantages	Limitations

Model	Main content	Advantages	Limitations
Trend extrapolation	Extends past growth rates into the future	Simple to compute; needs little data	Ignores structural changes and external factors
Linear regression	Estimates a linear link between the outcome and factors	Identifies the effect of factors	Does not fully capture time-series features
VAR	Forecasts interrelations among several time series	Jointly assesses many indicators	Requires large volumes of time-series data
ARIMA	Forecasts from the variable's own time dynamics	High accuracy for short/medium-term forecasts	Based only on past trends; ignores institutional and innovation factors
ARIMAX	Adds external factors to the ARIMA model	Higher forecast accuracy	Requires much external data
Complex integral index	Combines export, cooperation, logistics, innovation, and institutional factors into one index	Comprehensively assesses integration potential	Limited dynamic-forecasting capability
Integral index + ARIMA + scenario (proposed model)	Forecasts the integral-index dynamics with ARIMA and forms baseline, optimistic, and innovative scenarios	Complex assessment, high accuracy, accounts for scenarios, convenient for strategy	More complex computation

Source: compiled by the author on the basis of monographic research.

The proposed model consists of three stages. In the first stage, the indicators describing integration potential are normalized and, on the basis of their weight coefficients, the complex International Market Integration Index (IMI) is computed. In the second stage, the time dynamics of this index are forecast using an ARIMA(p,d,q) model. In the third stage, correction coefficients for the baseline, optimistic, and innovative scenarios are applied to determine the forecast parameters up to 2032.

Stage 1. Computing the complex integral index of international market integration

The integration potential of farms is determined through the following integral index:

$$IMI_t = \sum_{i=1}^{n} w_i Z_{it}$$

where IMI_t is the international market integration index in year t; w_i is the weight coefficient of indicator i; Z_{it} is the normalized value of indicator i; and n is the number of indicators.

For positive-impact indicators:

$$Z_{it} = \frac{X_{it} - X_i^{min}}{X_i^{max} - X_i^{min}}$$

For negative-impact indicators:

$$Z_{it} = \frac{X_i^{max} - X_{it}}{X_i^{max} - X_i^{min}}$$

Stage 2. ARIMA model

The time dynamics of the integral index are forecast using the following ARIMA model:

$$\Phi(B)(1-B)^d IMI_t = \Theta(B)\varepsilon_t$$

or, in full form:

$$IMI_t = c + \sum_{i=1}^{p} \phi_i \, IMI_{t-i} + \sum_{j=1}^{q} \theta_j \, \varepsilon_{t-j} + \varepsilon_t$$

where IMI_t is the integration index; c is a constant; p is the autoregression order; d is the order of differencing; q is the moving-average order; and ε_t is a random error.

Stage 3. Scenario forecast

The forecast value is determined as follows:

$$IMI_t^S = IMI_t(1 + \delta_s)$$

where IMI_t^S is the scenario-based forecast and δ_s is the scenario coefficient, with:

$$\delta_s = \begin{cases} 0, & \text{Baseline} \\ 0.10 - 0.15, & \text{Optimistic} \\ 0.20 - 0.30, & \text{Innovative} \end{cases}$$

Thus, the overall forecasting model takes the following form:

$$IMI_{2032}^S = \left[\Phi(B)(1-B)^d \left(\sum_{i=1}^{n} w_i \, Z_i\right)\right](1 + \delta_s)$$

4. Results and Discussion

In line with Stage 1, the complex integral index (IMI) describing the integration potential of farms shows a steady upward trend over 2020–2032. Eight key indicators were selected and normalized by the Min–Max method, and equal weights (w_i = 0.125) were assigned to all of them. Each indicator's contribution to the integral index was then determined, and their sum yields the complex IMI (Table 2).

Table 2. Results of computing the complex integral index of farms' international market integration potential

Indicator	Notation	Weight (wi)	Normalized value (Zi)	wi×Zi

Indicator	Notation	Weight (wi)	Normalized value (Zi)	wi×Zi
Export value	Z_1	0.125	0.887	0.111
Export volume	Z_2	0.125	0.842	0.105
Cooperative membership	Z_3	0.125	0.771	0.096
Share of certified farmers	Z_4	0.125	0.750	0.094
Innovation index	Z_5	0.125	0.823	0.103
Logistics index	Z_6	0.125	0.798	0.100
Market infrastructure index	Z_7	0.125	0.746	0.093
Digitalization index	Z_8	0.125	0.810	0.101
Complex integral index (IMI)		1		0.803

Source: author's calculations based on survey data.

The value of the IMI rose from 0.000 in 2020 to 0.441 in 2026 (see Appendix). This reflects the growth of export volume and value, the rising share of farmers belonging to export cooperatives, the introduction of international certification systems, improvements in logistics and market infrastructure, and the wide adoption of digital technologies. According to the forecast, over 2027–2032 the growth of integration potential accelerates further, and the IMI is expected to reach 1.000 by 2032, confirming the high potential for deeper integration of farms into global value chains.

Among the ARIMA models, ARIMA(1,1,0) was selected as the most suitable by the AIC and BIC criteria (Table 3). Lower AIC and BIC values indicate a better fit and higher forecast accuracy; ARIMA(1,1,0) has the smallest values (AIC = −37.607; BIC = −38.231) and therefore minimizes forecast errors. The forecasts for 2027–2032 were computed on the basis of this model.

Table 3. ARIMA model selection results

Model	AIC	BIC
ARIMA(0,1,0)	−36.668	−37.084
ARIMA(1,1,0)	−37.607	−38.231
ARIMA(0,1,1)	−37.039	−37.663
ARIMA(1,1,1)	−35.540	−36.373

Source: author's calculations.

The forecast indicates that over 2020–2032 the integration potential of Samarkand-region farms rises step by step. Cooperative membership is projected to grow from 32% in 2020 to 77% by 2032 (+45 percentage points); the share of farmers holding export certificates rises from 12% to 60%; the innovation index from 0.42 to 0.88; the logistics index from 0.46 to 0.88; the marketing-infrastructure index from 0.50 to 0.85; and the digitalization

index from 0.31 to 0.91. As a result, the international marketing-integration index is projected to increase from 0.39 in 2020 to 0.93 in 2032 (Table 4).

Table 4. Projected change in key integration indicators, 2020 vs. 2032

Indicator	2020	2032
Cooperative membership share, %	32	77
Share of certified farmers, %	12	60
Innovation index	0.42	0.88
Logistics index	0.46	0.88
Marketing-infrastructure index	0.50	0.85
Digitalization index	0.31	0.91
International marketing-integration index	0.39	0.93
Export value, USD million	180	465
Export volume, thousand tonnes	145	286

Source: author's calculations.

Export activity likewise shows a stable upward trend. Export value is projected to grow from USD 180 million in 2020 to USD 465 million in 2032—an increase of USD 285 million, or 2.58 times—with annual increments of USD 20–35 million after 2026. Export volume rises from 145 thousand tonnes in 2020 to 286 thousand tonnes in 2032 (+141 thousand tonnes, about 97.2%). Because export value grows faster than export volume, the share of higher value-added products in the export mix increases, and the international competitiveness of farms improves markedly by 2032.

Finally, the forecast was examined under three development scenarios for 2027–2032 (Table 5). Under the **baseline** scenario—computed with the ARIMA model assuming that current trends persist—the integration index rises from 0.677 in 2027 to 0.888 in 2032. Under the **optimistic** scenario, in which export cooperatives, logistics modernization, international certification, and state support are strengthened, the index is 15% above the baseline, reaching 1.021 in 2032. Under the **innovative** scenario, reflecting full implementation of the mechanisms proposed within the FEKOM model (export cooperatives, digital technologies, modern logistics, international marketing platforms, and innovative management), the index grows fastest and reaches 1.154 by 2032.

Table 5. Scenario-based forecast of farms' international market integration potential up to 2032

Year	ARIMA (Baseline)	Optimistic (+15%)	Innovative (+30%)
2027	**0.677**	**0.779**	**0.880**
2028	**0.721**	**0.829**	**0.937**
2029	**0.764**	**0.879**	**0.993**

Year	ARIMA (Baseline)	Optimistic (+15%)	Innovative (+30%)
2030	**0.806**	**0.927**	**1.048**
2031	**0.847**	**0.974**	**1.101**
2032	**0.888**	**1.021**	**1.154**

Source: author's calculations.

5. Conclusion

The paper proposed and applied a three-stage methodology—combining a complex integral index, an ARIMA model, and scenario forecasting—for evaluating and projecting the potential of farms to integrate into international markets. Unlike approaches based on the dynamics of a single time series, the method accounts for the combined effect of the resource, innovation, institutional, and market factors that determine integration potential, so that the results carry economic meaning as well as statistical accuracy.

For the fruit-and-vegetable farms of the Samarkand region, the results show steady development of export potential: the balanced growth of export volume and value confirms the economic soundness of the proposed development model and forecast parameters. The findings provide a practical basis for strategic decisions on developing export cooperatives, improving state support mechanisms, and ensuring the effective integration of farms into international value chains.

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