

SUSTAINABILITY AND INNOVATION AS VECTORS OF ECONOMIC PERFORMANCE IN THE WINE SECTOR IN THE REPUBLIC OF MOLDOVA

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Abstract: *The wine sector is a strategic pillar of the Moldovan economy, exerting a multidimensional impact on export earnings, employment and sustainable rural development. In the current context, defined by heightened climate volatility and competition on the EU market, sustainability and innovation are no longer simple competitive options, but are becoming essential structural imperatives for strengthening the economic resilience of the sector. The study aims to analyze the impact of these dimensions on the sector's performance in the period 2014–2023, highlighting the role of subsidy mechanisms and external financing, including programs supported by the European Investment Bank, in facilitating the transition to a value-added model. The methodology used is of a mixed type and integrates documentary analysis of public policies, a systemic approach and the processing of statistical data provided by relevant institutions, such as the Ministry of Agriculture and Food Industry, the Agency for Intervention and Payments for Agriculture and the reports of the International Organization of Vine and Wine. The research results reveal an increase in average productivity by 2.67%, simultaneously with a significant consolidation of the Premium wine segment, which came to represent approximately 6% of total national merchandise exports. This dynamic confirms that investments directed towards post-harvest infrastructure and the rigorous adoption of quality standards have increased the sector's ability to adapt to external shocks. The study supports the need to implement a "Twin Transition" strategy based on digitalization and sustainability. This double transition is essential for aligning with Green Deal standards and maintaining competitiveness on international markets.*

Keywords: *Wine sector, innovation, sustainability, economic performance, subsidies, competitiveness.*

JEL classification: *Q13, Q18, G11.*

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1. Introducere

The vitivinicultural sector is a strategic branch of the national economy of the Republic of Moldova, exerting a direct influence on the Gross Domestic Product (GDP) and the maintenance of social balance in rural areas. This sector serves as Moldova's calling card, defining its identity and competitiveness on the global market. Over the last decade, following the implementation of the Association Agreement with the European Union (Association Agreement with the Republic of Moldova, 2014), the wine industry has undergone a radical transformation, shifting from a model based on quantity and extensive land cultivation to one focused on quality and high added value. This paradigm shift represented a maturation process that enabled the sector to adapt to the rigorous demands of global markets.

The importance of the vitivinicultural sector in the Republic of Moldova is characterized by key fundamental indicators:

- **Contribution to Gross Domestic Product:** Viticulture and winemaking play a major role in generating national value added. The wine sector generates approximately 3% of the GDP and accounts for around 7–8% of the total exports of the Republic of Moldova (BNS, 2024). Unlike other agricultural branches, viticulture delivers high added value by processing

raw materials into finished goods (wines, divins), thereby stimulating related industries such as glassware, logistics, and tourism.

• **Export Performance and Strategic Reorientation:** Following the signing of the Association Agreement (2014), exports to the EU have grown steadily, currently representing over 50% of the total volume of bottled wines. Analyses indicate a clear transition from bulk wine exports (high volume, low profit) to bottled wine (lower volume, higher profitability), consolidating the Republic of Moldova's position as the most awarded wine producer in Eastern Europe (BNS, 2024).

• **Social Impact and Employment:** The wine sector provides employment opportunities both in rural areas and within processing industries, helping mitigate outward migration and ensuring the continuity of local economic activities.

• **Modernization of Wine Grape Vineyards:** The Republic of Moldova has one of the highest vineyard densities in the world relative to its total land area, encompassing about 120,000 hectares. Although the total area remains large, a restructuring process is underway: removing hybrid varieties and replacing them with European and indigenous grape varieties such as Fetească Albă, Fetească Regală, and Rară Neagră, which yield better returns. These native varieties serve as Moldova's passport to foreign markets, offering distinct authenticity (ONVV, 2024).

• **Rural Development and Agritourism:** The modernization of vineyards and the rise of boutique wineries have boosted rural infrastructure and enogastronomic tourism, turning villages into attractive destinations for investments and visitors.

Taken together, these indicators reveal a sector undergoing profound structural maturation. Although vulnerable to geopolitical and climate shocks, the industry demonstrates strong resilience driven by quality, moving away from its historical dependence on traditional Eastern markets toward competitive integration into premium global networks. In the face of contemporary global challenges such as climate change, market volatility, and rising consumer demand for "green" products, sustainability and innovation are no longer just strategic alternatives, but vital drivers of economic resilience. The "Twin Transition," which leverages the synergy between digitization and sustainability, is becoming the new benchmark for competitiveness. This research aims to analyze how the adoption of modern technologies and sustainable practices influences the economic performance indicators of the Moldovan wine sector, providing an overview of the financing mechanisms and structural barriers that shape the success of this transition during the 2014–2024 period.

2. Data sources and methods

The methodological objective of this research consists in evaluating the impact of innovation and sustainability on the economic performance of the wine sector in the Republic of Korea / Republic of Moldova. For a comprehensive analysis, a mixed methodology was adopted; thus, the research was based on the processing of statistical data for the 2014–2023 period. The data sources utilized are: the database of the National Bureau of Statistics (NBS) for indicators such as vineyard areas, total grape production, and yield per hectare; the UN Comtrade database for monitoring exports of wine (code 2204) and table grapes (code 080610); and the reports of the Agency for Intervention and Payments in Agriculture (AIPA) to analyze subsidies directed toward post-harvest modernization and winery technology upgrades. Additionally, reports from the National Office of Vine and Wine (ONVV) were used to determine average export prices and the penetration rate into premium markets, while

reports from the European Investment Bank (EIB) and USAID served to assess the impact of external assistance. For data interpretation, the following methods were applied: comparative analysis, to highlight price and performance discrepancies between traditional markets (CIS) and high-value ones (EU, Asia, North America); and quantitative method (statistical analysis), calculating the Compound Annual Growth Rate (CAGR) to evaluate the long-term dynamics of the indicators, using the formula:

$$CAGR = \left(\frac{V_{final}}{V_{initial}} \right)^{\frac{1}{n}} - 1$$

where V_{final} is the value in 2023, $V_{initial}$ is the value in 2014, and n represents the number of years.

diagnostic analysis: identifying critical points and the sector's resilience capacity. The analysis focuses on the post-Association Agreement period (2014–2024). The data for the year 2024 are partial, based on quarterly estimates and operational reports from the ONVV, and are utilized to foreshadow current market trends within the context of the EU pre-accession process.

3. Results and discussion

3.1. Dimensions of economic performance and innovation in sustainable agriculture

Economic performance in sustainable agriculture marks a fundamental transition from short-term profit maximization to a business model anchored in stability, efficiency, and resilience. This implies an optimal management of natural capital, ensuring a balance between productivity, ecosystem conservation, and social responsibility. According to the Food and Agriculture Organization of the United Nations (FAO), economic success depends on the capacity to produce "more with less," optimizing flows without degrading the resource base (FAO, 2014). Complementarily, the Organisation for Economic Co-operation and Development (OECD) emphasizes that performance evaluation must integrate efficiency indicators for input utilization, such as water, fertilizers, and energy. Consequently, economic performance is considered the direct result of technological precision. Thus, modern economic performance transcends the productivist paradigm, becoming an indicator of the equilibrium between operational efficiency, ecosystem protection, and social equity, thereby ensuring food security and commercial success for future generations (Agricultural Policy Monitoring and Evaluation, 2024).

The transition toward this production model represents a genuine paradigm shift in agricultural management, wherein innovation and modern technologies become the bridge connecting economic efficiency and ecological responsibility. Precision agriculture redefines the way agricultural holdings are managed, providing farmers with the opportunity to make data-driven decisions. Through the use of GPS systems, soil sensors, drones, and digital monitoring platforms, agricultural processes are optimized in real time. This technological advancement allows for the maximization of yield per hectare and profitability, while simultaneously reducing the consumption of inputs such as seeds, water, fertilizers, or fuel. In this context, competitiveness is no longer defined solely by productivity, but also by the enterprises' capacity to respond to global challenges, such as food security for a continually growing population and adaptation to climatic and demographic shifts (Agro BASF, 2024; Iaşişin, Ciobanu & Timuş, 2023).

The modernization of the wine sector through precision agriculture configures an integrated, digitalized, and efficient operational model, in which agricultural processes are monitored and managed based on data collected in real time. The actions undertaken within the wine sector are executed in a timely manner and with maximum precision, being supported by sensors, satellite imagery, weather stations, and data analysis systems. This approach enables viticulturists to optimize resources, increase productivity, and maintain a balance between economic performance and environmental protection, as illustrated in Figure 1.

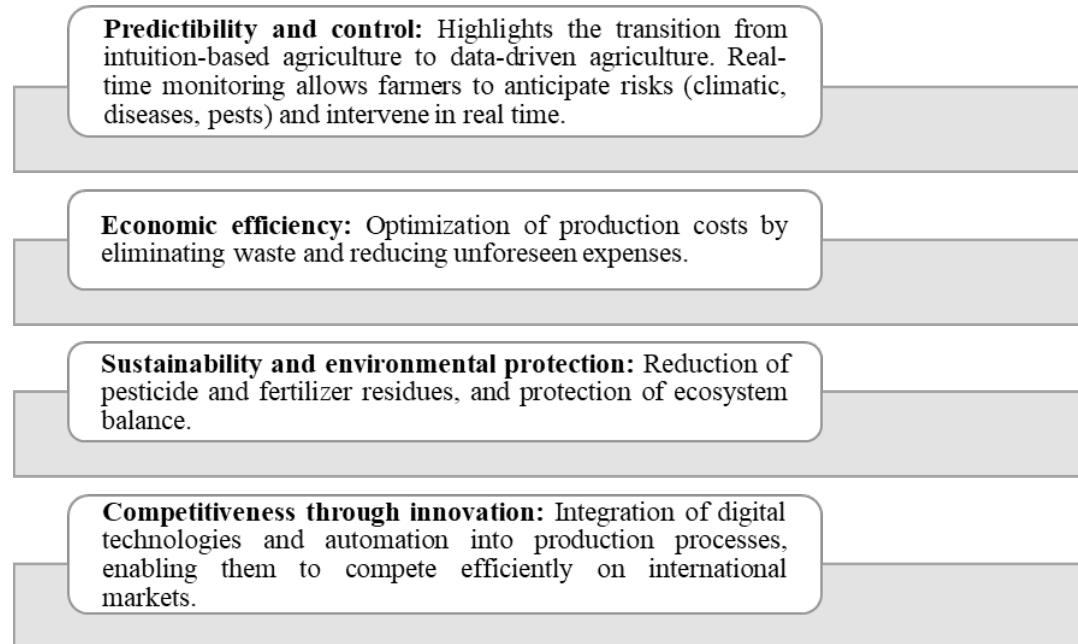


Figure 1. Model of the strategic advantages of advanced technology implementation

Source: Developed by the author, based on (Iatisin T., 2022, Timuş A., Iaţişin T., 2024)

To achieve global market competitiveness, the wine sector must integrate innovation and digitalization. Consequently, the modernization of the viticultural sector becomes an essential driver for sustainable growth and the consolidation of its competitive position worldwide.

The implementation of integrated agricultural management systems demonstrates the transition from conventional farm management to Data-Driven Agriculture. Yield analysis indicates that optimized fertilization, executed via sensors and computational algorithms, can generate considerable economic benefits. Specifically, increasing nitrogen use efficiency and reducing the losses associated with non-uniform fertilizer application lead to an estimated value-added of approximately 185 €/ha. This outcome confirms that precision technologies contribute not only to enhancing productivity but also to improving the profitability of agricultural activities. The digital ecosystem (see Figure 2) highlights the interconnection between modern technologies used in agriculture, such as weather stations, soil sensors, and GPS systems. All collected data are integrated into an analytical and monitoring platform capable of providing actionable insights regarding crop development and environmental conditions.

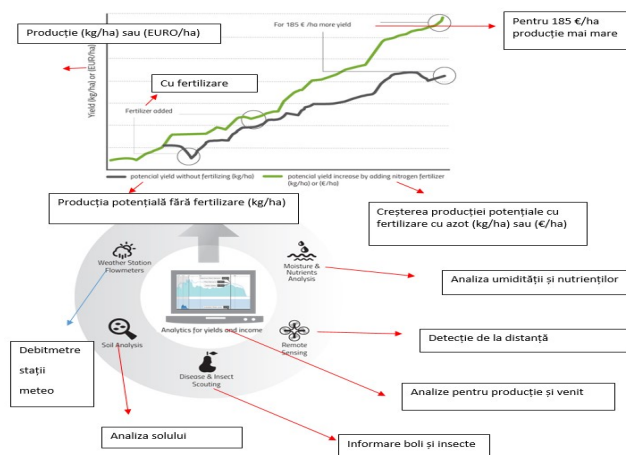


Figure 2. The precision agriculture ecosystem and the impact of input optimization on economic performance. (Adapted from digital agricultural management models).

Source: (Datalab Agro, 2024).

The integration of modern technologies into the management of the wine sector is no longer a mere option, but a strategic necessity. The predictability of production processes, generated by complex data analysis, provides guarantees for sustainability and competitiveness, transforming innovation into the primary vector of economic performance within the viticultural sector (Datalab Agro, 2024).

3.2 Diagnostic analysis of the wine sector

For the diagnostic analysis of the wine sector in the Republic of Moldova, the evolution of the main economic indicators during the 2014–2023 period was examined, including production dynamics and export trends. These indicators allow for the assessment of the effectiveness of support policies and the sector's capacity to respond to the demands of the international market (Table 1).

Table 1. Evolution of indicators assessing economic growth in the wine sector in the Republic of Moldova (in all types of households)

The indicator	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	CAGR, %
Share of vineyards in production, as a percentage of total vineyards, %	95,2	95	95,4	93,1	95,4	94,1	94,1	88,9	89	88,8	-0,77
Productivity of vineyards in production, q/ha	43,7	45,6	46,9	54	57	54,8	39,2	45,4	49,1	55,4	2,67
Total grape harvest obtained from vineyards in production, mii/tonne	593,9	599,3	615,7	675	730	659	462	491	531	571	-0,44
Exports of table grapes, thousand tons (according to the code 080610)	50,4	47,5	51,4	80,2	48,2	62,7	41,3	57,8	61,7	69,9	3,69
Volume of grape wine exports, million	102	113	133	141	139	152	134	116	97	108	0,63

liters, (according to the code 2204)											
Revenue from alcoholic beverage exports, million USD dollars	111,9	97,7	107,9	128,4	137,9	139,6	134,3	141,3	126,7	137,5	2,29

Source: Calculated and compiled by the author based on data from the National Bureau of Statistics (NBS) and reports from the National Office of Vine and Wine (ONVV) and the Customs Service of the Republic of Moldova (2014–2023).

The diagnostic analysis of the wine sector in the Republic of Moldova for the 2014–2023 period highlights a trajectory of structural maturation, marking the transition from a quantity-based production model to one defined by value added and technological resilience. Although vineyard areas underwent a process of optimization and uprooting of unproductive plantations—reflected by the decrease in the share of productive vineyards from 95.2% to 88.8%—the viticultural sector achieved a qualitative leap in productivity. During the analyzed period, the yield increased from 43.7 q/ha in 2014 to 55 q/ha in 2023 (CAGR +2.67%). This evolution indicates the success of investments in modern technologies and certified planting material, demonstrating the sector's capacity to achieve superior yields on smaller land areas.

In the context of geopolitical shocks and regional economic transformations, the wine sector demonstrated adaptability, as well as a successful reorientation of external trade flows. The national economy has displayed remarkable resilience. The EU became the country's primary trading partner, with Romania consolidating its strategic role as the main market for Moldovan exports (NBS, 2024). The evolution of commercial relations with EU member states reflects not only the diversification of foreign markets but also the gradual integration of the Republic of Moldova into the European economic circuit. During the analyzed period, export revenues recorded steady growth, with a compound annual growth rate of CAGR +2.29%. This dynamic highlights the capacity of Moldovan exporters to leverage higher value-added markets and to adapt to new trade requirements and European quality standards.

Concurrently, the wine sector was affected by several crises, which acted as catalysts for innovation and modernization processes. The 2020 climate crisis, which reduced grape production to 39.2 q/ha, accelerated the need for investments in smart irrigation systems and digital technologies for vineyard monitoring (Figure 2). Subsequently, the 2022 regional and energy crisis caused by the war in Ukraine disrupted logistical chains and transport costs. Nevertheless, export revenues continued to rise, reaching 137 million USD, which confirms the resilience and adaptive capacity of the sector. The table grapes sector also recorded a positive trend during this period, with a compound annual growth rate of CAGR 3.69% for exports. The increase in exported volumes from 50.4 thousand tons in 2014 to 69.9 thousand tons in 2023 demonstrates enhanced competitiveness and growing external demand for this fresh product. In this context, the adoption of the "Twin Transition" model (Blum, S., 2022) confirms that digitalization and sustainability are no longer secondary strategic options, but essential standards for the competitiveness of the wine sector on the global market. Integrating digital technologies, utilizing smart solutions, and shifting toward sustainable practices are becoming decisive factors for increasing value added, streamlining processes, and consolidating the position of the Republic of Moldova in international wine trade.

3.3 Economic analysis: Strategic reorientation and competitiveness of the wine sector

For the wine sector, the year 2014 represented a turning point regarding the external competitiveness of the Republic of Moldova. The signing of the Association Agreement with the EU and the implementation of the Deep and Comprehensive Free Trade Area (DCFTA) acted as a catalyst for a radical reorientation of the export model. Prior to 2014, wine exports were highly dependent on CIS markets (particularly the Russian Federation), which absorbed approximately 60% of total export volumes. This dependence rendered the wine sector vulnerable to trade restrictions and geopolitical instability. Following the agreement with the EU, wine producers initiated a profound process of redirecting exports toward more stable and competitive markets. Consequently, the EU market gradually became the primary destination, absorbing over 55% of the export value of bottled wines (tariff code 2204 for wines) (Figure 2) (Customs Service of the Republic of Moldova, 2024; UN Comtrade, 2024). This shift involved not only the redirection of trade flows but also the adaptation of the entire sector to stricter European standards regarding quality, food safety, labeling, and product competitiveness. The integration process of the wine sector into the European market stimulated its modernization, prompting producers to invest in modern technologies and quality standards. Concurrently, this integration contributed to strengthening the international image of Moldovan wine, enhancing its visibility in global markets. As a result, the viticultural sector has become more resilient to shocks and more competitive on the global stage.

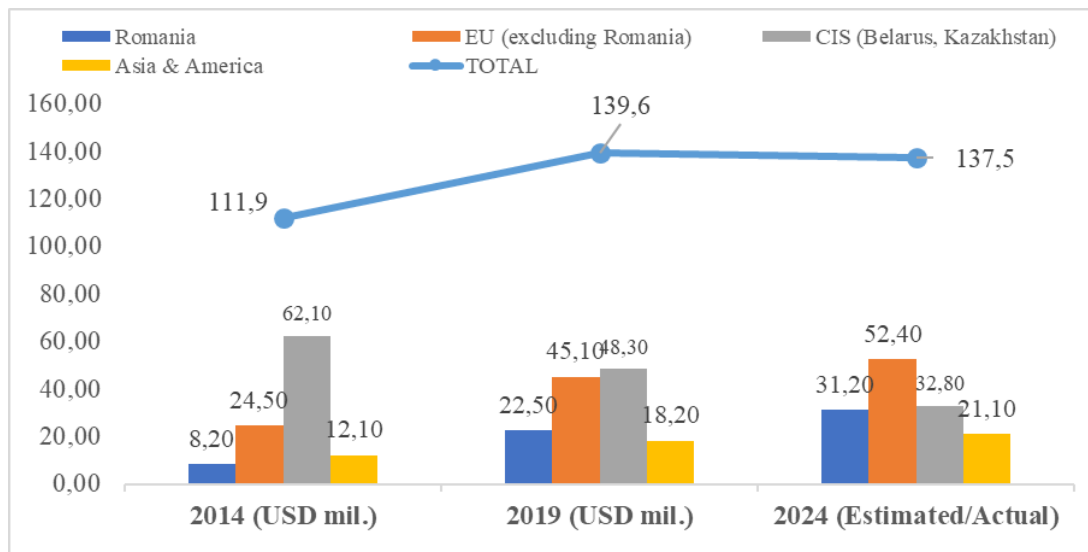


Figure 2. Reconfiguration of geographic export flows for alcoholic beverages (wine Code 2204) across main outlets (2014–2024)

Source: Customs Service of the Republic of Moldova, 2024; National Office of Vine and Wine (ONVV): "Wine of Moldova" annual reports on market developments and average export prices.

The geographic and value distribution of alcoholic beverage exports during the analyzed 2014–2024 period registers a reversal of market shares between the CIS and the European Union.

In 2014, wine exports were dominated by CIS markets (primarily Belarus and Kazakhstan), which accounted for approximately 62.1 million USD, representing the largest share of total exports. Conversely, exports to the EU (excluding Romania) amounted to about 24.5 million USD. The total export value of alcoholic beverages stood at 111.9 million USD (Colesnicova et al., 2024).

By 2019, alcoholic beverage exports followed an upward trend, reaching a value of 139.6 million USD. Exports to the EU increased considerably, amounting to 45.1 million USD, with Romania consolidating its position as the primary trading partner. Although CIS markets continued to hold a significant share, dependence on them began to decrease gradually. Consequently, by 2024, the European Union became the primary trading partner, offsetting declines in traditional markets through higher average prices per liter. Additionally, during the analyzed period, a strategic expansion was achieved in high-purchasing-power markets such as Japan, South Korea, the USA, and Canada, where the average price per liter is higher than in traditional markets (see Table 2).

Table 2. Comparative analysis of the average export price per liter of wine, by selected destinations (USD/Liter estimates)

Export Destination	Average price 2014 (USD/L)	Average price 2024* (USD/L)	Increase (%)	Market Segment
Japan	2,10	3,85	+83%	Premium / Super-Premium
South Korea	1,95	3,60	+85%	Premium / Varieties
USA	2,40	4,10	+71%	Premium / Wine of Moldova
Canada	2,25	3,95	+75%	Premium / Boutique
UE (Media)	1,45	2,35	+62%	Mid-to-High / Retail & HoReCa
Romania	1,60	2,80	+75%	Premium Brands / Retail
Traditional Markets (CIS)	0,95	1,25	+32%	Low-cost / Econom

** Note: For the year 2024, data are estimates based on operational reports from the National Office of Vine and Wine (ONVV) and market trends from the first three quarters of 2024.*

Source: Author's own calculations based on data from the National Office of Vine and Wine (ONVV) and the Customs Service regarding the value and volume of exports (2014–2024).

The analysis of the average export price during the investigated period (2014–2024) reveals a significant increase. While the average price in the CIS markets grew moderately, reaching up to 1.25 USD/liter, it doubled in the Asian and North American markets. Consequently, the USA recorded the highest average price, approximately 4.10 USD/liter in 2024, positioning Moldovan wines within the Premium segment. Similar trends were

observed in Japan, South Korea, and Canada, where consumers are willing to pay a premium for quality products with a distinct identity and origin.

This transformation reflects a shift in the sector's competitiveness model. While the emphasis was previously placed on low prices, competitiveness is currently driven by quality, authenticity, and added value. The growing share of wines with Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) has enabled the wine sector to move beyond the export model focused on cheap raw materials. Indigenous varieties, such as Fetească Neagră and Rară Neagră, have become pivotal elements in the international promotion of Moldovan wines. The accolades received at prestigious competitions, such as Mundus Vini and Decanter (ONVV, 2024), have consolidated the image of the "Wine of Moldova" country brand and contributed to increasing the value of exported products.

In the context of current European requirements, the modernization of the wine sector extends beyond simple re-engineering; it is heavily influenced by the concept of the "Twin Transition," which entails the integration of digitalization and sustainability. Implementing modern technologies within the wine sector transforms traditional vineyard management into a model based on data and predictive analytics, thereby optimizing resources and ensuring product traceability an essential aspect for Premium markets. Concurrently, sustainability is becoming a strategic factor, as eco-friendly practices and climate change adaptation enhance the image of Moldovan wines and boost their competitiveness in foreign markets (Timuş A., Iaşişin T., 2024; Blum, S., 2022).

3.3 Economic analysis: The impact of funds and technology transfer

The acceleration of technology transfer and the increased competitiveness of the wine sector were primarily driven by support from European funds and foreign assistance programs (Table 3). Consequently, during the investigated period (2014–2024), the EU financed the modernization of the sector through programs such as ENPARD and EU4Business. According to official data, within the framework of the ENPARD program (2014–2020), over 64 million euros were allocated for agriculture and rural development, with a significant portion directed toward modernizing the wine sector (European Neighbourhood Policy, n.d., 2013). These funds enabled investments in modern winemaking equipment, temperature control technologies, and traceability systems. Furthermore, projects implemented by USAID, such as the "Agriculture Competitiveness Project," supported over 100 wine enterprises in adopting modern technologies and international quality standards. According to USAID reports (2020), these interventions contributed to increasing productivity and improving the export capacities of wine companies. Additionally, a major role was played by the European Bank for Reconstruction and Development (EBRD), which, in partnership with other financial institutions, provided credit lines and grants for investments worth over 25 million euros in Moldova's agrifood sector, including viticulture (EBRD, 2022). These investments facilitated the implementation of modern processing and bottling technologies (Timuş A., Iaşişin T., 2024). Data from the National Office of Vine and Wine (ONVV) show that the share of bottled wines in total exports increased from approximately 30% in 2014 to over 60% in 2023, indicating a clear orientation toward products with higher added value. At the same time, the average export price rose significantly in Western markets, in some cases exceeding a 70% growth, which reflects the success of investments in quality and branding (ONVV, 2023). Beyond investments in modernizing the wine sector, external assistance played a pivotal role in know-how transfer. Training programs, consultancy, and the exchange

of best practices enabled local producers to align with international standards, thereby facilitating access to demanding markets such as Germany, the United Kingdom, or China.

Table 3. The impact of external assistance programs on technology transfer in the wine sector (2014–2024), EUR million

Program / Funding Institution	Period	Allocated amount, EUR million (estimate)	Type of action	Technology transfer impact
UE- ENPARD	2014-2020	64,0	Grants for agriculture and rural development.	Modernization of equipment, quality control systems, and traceability.
EIB - "Livada Moldovei" Project	2016-2024	120,0*	Credit lines and tax incentives.	Restructuring of vineyards, investments in laboratories and post-harvest infrastructure.
USAID (PCR/RCRA)	2016-2024	25,0	Grants and technical assistance.	Nation branding (Wine of Moldova), market access to Asia, and digitalization of marketing.
EBRD and Partners	2014-2024	25,0	Credit lines (EBRD credit lines).	Production line modernization, bottling, and energy efficiency.
National Fund for Agricultural and Rural Development (AIPA)	At present	tens of millions EUR/year	EU co-financed national subsidies.	Replanting of vineyards, mechanization, and agricultural technologies.

Note: "Livada Moldovei" funding covers the entire horticultural sector, with viticulture serving as the primary beneficiary.

Source: Author's elaboration based on MAIA (2014-2024), EU Delegation, and USAID reports; Timuş A., Iaţişin T., 2024.

Thus, the research findings indicate that external financing for the viticultural sector is structured along three main dimensions:

- Technological capital (hard) – modern equipment, processing lines, and controlled fermentation technologies;
- Human capital (soft) – training, consultancy, and international know-how;
- Market capital (branding) – external promotion and quality certifications.

Therefore, European funds and external assistance have acted as a catalyst for technology transfer within the wine sector, driving infrastructure modernization, enhancing product quality, and diversifying export markets. Empirical data confirm that these interventions have sustained the transition toward a value-added economic model, thereby

consolidating the international standing of Moldovan wines. The correlation between investment and the growth of export value demonstrates that technology + branding = sustainable competitive advantage in the viticultural industry.

4. Conclusion

The research highlights that the wine sector of the Republic of Moldova underwent a process of transformation and consolidation during the analyzed period of 2014–2024. Throughout this timeframe, the wine industry successfully reduced its dependence on CIS markets and strengthened its presence in high value-added markets, such as the European Union, the USA, and Japan. This strategic reorientation contributed to increased export revenues and enhanced the external competitiveness of Moldovan wines.

The sectoral analysis demonstrates that technological modernization played an essential role in driving efficiency. Although vineyard areas underwent an optimization process—with unproductive plantations being eliminated—productivity recorded a positive trend. The increase in yield per hectare reflects the investments made in modern technologies, high-performance management systems, and quality planting material.

During this period, the wine sector demonstrated a high capacity to adapt to economic and geopolitical changes. Reorienting exports toward European and international markets reduced vulnerability to traditional markets and enabled the consolidation of the Republic of Moldova's image as a quality wine producer. The promotion strategy under the "Wine of Moldova" national brand contributed to increasing the value of exported products and positioning them within the premium segment.

Furthermore, another important aspect is the integration of the "Twin Transition" concept, which is based on digitalization and sustainability. The implementation of modern technologies and sustainable agricultural practices enabled resource consumption optimization, cost reduction, and more efficient climate risk management. At the same time, the focus on sustainability has become a significant competitive advantage in foreign markets, where quality and environmental protection standards are increasingly stringent.

Nevertheless, the sector continues to face certain vulnerabilities, particularly those related to climate change and rural labor shortages. These challenges underscore the necessity of continued investment in digitalization, modernization, and climate adaptation to ensure the sustainable development of the industry.

In conclusion, the wine sector represents one of the most dynamic and modernized branches of the Republic of Moldova's economy. Its capacity to integrate innovation, modern technologies, and sustainability principles demonstrates not only the maturation of the industry but also its potential to serve as a development model for the entire agricultural sector in the process of European integration.

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