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The Regulatory Framework and Policies for Advancing Green Logistics in Republic of Moldova's Agri-Food Sector

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Abstract: This study examines how green logistics strategies and decision-making models can enhance the efficiency of the agri-food supply chain in the Republic of Moldova. It identifies major challenges, including high logistical costs, environmental impact, and limited market access, while highlighting the role of European policies and digital technologies in promoting sustainability. To address these issues, the research employs a structured decision-making approach, focusing on supplier selection and strategic business choices. A multi-method framework is utilized, integrating quantitative analysis, decision modelling, and policy assessment. The Global Utility Method (GUM) is applied to evaluate suppliers based on key criteria, ensuring an objective and systematic selection process. The findings indicate that incorporating structured decision-making enhances logistical efficiency, cost management, and sustainability in the agri-food sector. Furthermore, the study underscores the importance of digital transformation, environmentally responsible logistics, and data-driven procurement decisions in achieving long-term industry growth. By demonstrating the benefits of green logistics and analytical decision-making models, the research highlights their critical role in ensuring sustainable development, supply chain resilience, and economic competitiveness within Moldova's agri-food industry.

Keywords: green logistics; agri-food supply chain; sustainable development; market competitiveness; sustainable agriculture

JEL Classification: O13; R40

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1. Introduction

The distribution of agri-food products across Europe is a complex and dynamic process influenced by economic factors, logistical challenges, and regulatory frameworks. From production and processing to transportation and retail, the supply chain operates through multiple stages, each playing a critical role in ensuring food reaches consumers efficiently and safely.

Globalization and digital advancements have reshaped the industry in recent years, prompting businesses to adopt innovative solutions to improve efficiency and sustainability. Europe boasts a well-developed logistics infrastructure, integrating road, rail, maritime, and air transport systems to facilitate smooth distribution. However, challenges persist, including high transportation costs, environmental concerns, and the need to maintain food quality throughout the supply chain.

To address these issues, companies and policymakers are focusing on greener logistics strategies. Efforts such as adopting electric-powered vehicles and using eco-friendly packaging aim to reduce the sector's environmental impact. Additionally, regulatory frameworks like the Common Agricultural Policy (CAP) and initiatives under the European Green Deal (2021) are driving changes to minimize food waste, promote sustainable farming, and enhance supply chain resilience.

Technology is also playing an increasingly vital role in modernizing agri-food distribution. Tools like blockchain and artificial intelligence are improving logistics by optimizing routes, enhancing transparency, and ensuring greater traceability from farm to fork.

Looking ahead, the industry must continue to evolve, embracing both sustainability and digital transformation. The future of agri-food distribution in Europe will depend on balancing efficiency with environmental responsibility, ensuring a resilient and forward-thinking supply chain that meets the demands of both businesses and consumers.

This article is structured into some sections that explore green logistics in Moldova's agri-food sector. The Introduction outlines the topic's significance, while Materials and Methods detail the research approach, including the Global Utility Method (GUM) for supplier selection. Results and discussion analyze green logistics strategies, digital transformation, and policy impacts. Challenges and Opportunities examine sector constraints and solutions. Conclusions summarize findings and recommendations, followed by a References section supporting the study.

2. Materials and Methods

The study employs a multi-method approach to assess the impact of green logistics strategies and decision-making models in optimizing the agri-food supply chain in

the Republic of Moldova. The research integrates quantitative analysis, decision modeling, and policy evaluation to provide a comprehensive framework for improving logistical efficiency and sustainability.

A core component of the methodology is the application of the Global Utility Method (GUM) for supplier selection. This multi-criteria decision-making (MCDM) approach enables the ranking of suppliers based on three weighted criteria: purchase price (40%), delivery time (30%), and potential sales growth (30%). The study calculates utility values for each supplier, determining the optimal choice by maximizing overall utility.

Empirical data for the study is sourced from official statistical reports, market analyses, and prior research on logistics efficiency in Moldova's agri-food sector. The results are validated through comparative analysis, ensuring the robustness of the proposed optimization models in enhancing sustainability and supply chain resilience.

3. Results and Discussions

Green logistics has emerged as a vital element of the European supply chain, playing a key role in improving both sustainability and operational efficiency in product distribution (Carp, 2023). Research in this field presents diverse strategies for incorporating eco-friendly practices, such as biodegradable packaging and route optimization, to minimize carbon emissions and environmental impact.

Recent studies have explored the adoption of sustainable logistics strategies across various sectors. Mansi et al. (2024) analyzed the implementation of green supply chain strategies in downstream logistics, emphasizing approaches to minimizing the environmental impact of large-scale distribution operations. Similarly, Dotelli, Gallo Stampino and Simonetti (2025) analyzed the carbon footprint of different pallet types in Italy, underlining the importance of logistics efficiency in promoting sustainability.

Another perspective comes from Renkema, Hilletofth and Fobbe (2024), who investigated the role of food hubs in Sweden, emphasizing how green logistics can create added value within the supply chain. Likewise, Barbieri et al. (2024) conducted an environmental performance assessment of agri-food distribution, demonstrating the advantages of sustainable logistics solutions in reducing emissions and improving efficiency.

Digital innovation is becoming an essential part of optimizing supply chains, with a growing emphasis on sustainable solutions. Recent studies have explored various strategies to make logistics more environmentally friendly. For example, Salehi et al. (2024) examined the potential of crowd shipping as a sustainable last-mile

delivery option in urban areas, emphasizing its role in cutting transportation-related emissions. Similarly, Dujak (2025) conducted a comparative analysis of food distribution models in Europe and Croatia, highlighting the implementation of green logistics strategies aimed at reducing the industry's environmental footprint.

As globalization reshapes food production and distribution, value chain analysis becomes essential in identifying sustainable logistics solutions (Gereffi & Fernandez-Stark, 2016). The adoption of green logistics practices, such as optimized transportation routes, energy-efficient storage facilities, and reduced packaging waste, can lower operational expenses and mitigate environmental impacts. Private agri-food standards have also influenced the shift toward sustainability, compelling firms to adopt eco-conscious logistics to meet market demands and regulatory requirements (Henson & Reardon, 2005). Compliance with these standards not only enhances brand reputation but also improves efficiency through waste reduction and better resource utilization. Additionally, integrating shelf-life considerations into production planning further enhances logistics efficiency, reducing food spoilage and transportation-related emissions (Lütke Entrup, 2005).

These findings reinforce the idea that green logistics is no longer just a forward-thinking initiative but a necessary approach to minimizing environmental impact in European distribution networks. While significant progress has been made, further advancements in technology integration and infrastructure development will be crucial for building more sustainable and efficient supply chains.

3.1. The Agri-Food System in the Republic of Moldova - Challenges and Opportunities

Agri-food systems encompass a broad range of activities, including food production, agricultural input preparation, processing, distribution, accessibility, consumption, and waste management. As the industry expands in developing economies, it faces challenges related to sustainability, equity, and inclusiveness. In many cases, value creation and market benefits are concentrated among a few dominant players, potentially disadvantaging smaller stakeholders. Ensuring the long-term sustainability of the sector requires cost efficiency, competitive pricing, operational effectiveness, and fair compensation for farmers to sustain agricultural livelihoods.

In Moldova, the agri-food sector is a pillar of the national economy, contributing around 30% of GDP and providing employment for a significant portion of the workforce. The country benefits from fertile soils and a favourable climate, which have supported the industry's growth and modernization. However, several structural challenges persist, including fragmented farmland, reliance on outdated agricultural practices, and restricted access to international markets, limiting the sector's competitiveness.

Research by Ghencea and Stanciu (2024) highlights the role of small and medium-sized enterprises (SMEs) in enhancing market diversity and ensuring food security within Moldova's agri-food sector. Additionally, Sovcovici, Lopotenco and Staver (2024) assess the export competitiveness of Moldovan agri-food products, identifying high production costs and logistical barriers as key obstacles to broader market penetration.

Another critical factor influencing the sector is climate variability and economic instability, which pose risks to food security and supply chain resilience. Stratan, Lopotenco and Staver (2024) explore the vulnerabilities of Moldova's food supply chains and propose strategies to increase sustainability and adaptability in response to these challenges. Similarly, Zbancă and Cruceresсu (2024) examine the competitiveness of the fruit and berry industry, advocating for investment in modern and sustainable farming techniques to boost efficiency and profitability.

According to the National Bureau of Statistics, Moldova's agricultural production in 2023 recorded a 23.6% increase compared to 2022 (in comparable prices). While crop production grew by 35.1%, livestock production declined by 1.9%. The trend in agricultural output across different farm categories from 2017 to 2023 provides insights into the sector's development trajectory.

Overall, Moldova's agri-food sector is undergoing significant transformations, but further progress requires technological advancements, policy support, and improved market access. Strengthening these areas will be key to ensuring long-term growth, resilience, and sustainability in the industry.

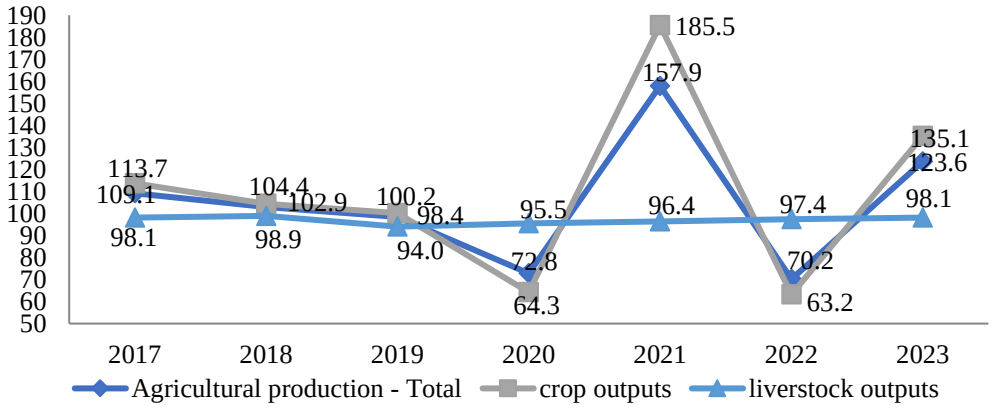

Fig.1. Dynamics of annual indices of agricultural production volume in households of all categories in the years 2017 - 2023 (previous year = 100), %

Source: National Bureau of Statistics statistica.gov.md

Between 2017 and 2019, Moldova's agricultural sector remained relatively stable, with crop and livestock production fluctuating only slightly around the average benchmark. However, 2020 brought a significant downturn, as total agricultural output dropped to 72.8%, with crop production falling even further to 64.3%. This decline was likely driven by adverse weather conditions or broader economic challenges.

The sector rebounded in 2021, particularly in crop production, which surged to 185.5%, pushing overall agricultural output to 157.9%. Despite this strong recovery, the momentum did not last, as 2022 saw another sharp decline, with crop production falling to 63.2%.

By 2023, agriculture showed renewed signs of growth, with total production increasing by 23.6%, largely due to a 35.1% rise in crop output. Meanwhile, livestock production remained relatively stable, recording only a slight decline of 1.9%.

These fluctuations underscore the volatility of Moldova's agricultural sector, particularly in crop production, which remains highly susceptible to climate shifts and economic pressures.

3.2. Application of the Global Utility Method for Optimizing Agri-Food Supply in the Republic of Moldova

The Global Utility Method (GUM) offers a structured framework for improving supply chain performance, reducing costs, and optimizing procurement processes within Moldova's agri-food sector. Utilizing a multi-criteria decision-making approach, this method enables a systematic assessment and selection of suppliers by assigning weights to key decision factors, ensuring a balanced and objective evaluation.

A distribution center seeks to identify the most suitable supplier for a widely demanded product—Milk (2.5% fat content)—by evaluating three key selection criteria:

- Purchase price (minimization criterion);
- Delivery time (minimization criterion);
- Potential sales growth (maximization criterion).

Justification of the importance coefficients (reflecting the relative weight of each criterion in the Decision-Making Process):

- Purchase price (coefficient 0.4): Represents a primary factor as it directly impacts overall product costs and pricing strategies within the retail sector.

- Delivery time (coefficient 0.3): While significant for operational efficiency, its influence on sales outcomes is comparatively lower.

- Potential sales growth (coefficient 0.3): Affects profitability but is less determinant than pricing in the supplier selection process.

By integrating the Global Utility Method, decision-makers can adopt an analytical and objective approach to supplier selection, ensuring a balance between cost-effectiveness, logistical reliability, and market responsiveness. This methodology contributes to strategic supply chain management by optimizing supplier performance in alignment with market demands and operational goals.

Table 1. Initial data for Global Utility Method

№	Criteria	Criterion type	Importance coefficient	Decision variants (Suppliers)		
				F_1	F_2	F_3
C_1	Purchase price (MDL)	Minimum	0,4	15	17	18
C_2	Delivery time (days)	Minimum	0,3	3	5	7
C_3	Sales increase (%)	Maximum	0,3	25	20	15

Source: Developed by the authors

Solution:

1. Transforming *Xij* values into utilities *Uij*.

Determining the minimum and maximum values for each criterion:

In the first step, the minimum and maximum values of the variables are determined for each criterion:

- Purchase price: Minimum – 15 MDL (Supplier 1), Maximum – 18 MDL (Supplier 3);
- Delivery time: Minimum – 3 days (Supplier 1), Maximum – 7 days (Supplier 3);
- Sales increase: Minimum – 15% (Supplier 3), Maximum – 25% (Supplier 1).

2. Calculating the utilities U_{ij} for each criterion by type:

The next step is to transform the actual values of each decision variant into utilities. Utilities are calculated based on the type of criteria: maximum or minimum.

- For minimization criteria:

$$U_{ij} = \frac{X_{imax} - X_{ij}}{X_{imax} - X_{imin}}$$

- For maximization criteria:

$$U_{ij} = \frac{X_{ij} - X_{imin}}{X_{imax} - X_{imin}}$$

Where:

- *Xij* is the value of criterion *i* for decision variant *j*;
- *Ximin* and *Ximax* are the minimum and maximum values of criterion *i*.

Table 2. Calculation of utilities for each criterion and decision variant

Criteria	Criterion type	Importance coefficient	Decision variants (Suppliers)		
			F_1	F_2	F_3
Purchase price (MDL)	Minimum	0,4	$U_{ij} = 1$	$U_{ij} = 0{,}33$	$U_{ij} = 0$
Delivery time (days)	Minimum	0,3	$U_{ij} = 1$	$U_{ij} = 0{,}5$	$U_{ij} = 0$
Sales increase (%)	Maximum	0,3	$U_{ij} = 1$	$U_{ij} = 0{,}5$	$U_{ij} = 0$

Source: Developed by the authors

Calculation of global utility:

$$U_{Gj} = \sum_{i=1}^{m} U_{ij} * \alpha_i$$

Where:

- *Uij* is the specific utility of decision variant *j* for criterion *i*;
- α_i is the importance coefficient of criterion *i*;
- *m* is the total number of criteria (in our case, 3 criteria);
- Supplier 1: $U_{G1} = 1$
- Supplier 2: $U_{G1} = 0{,}432$
- Supplier 3: $U_{G1} = 0$

Conclusion:

Based on the analysis and calculations for each supplier, the following conclusions can be drawn:

Supplier 1 emerges as the most favourable option, achieving a global utility score of 1.0. This indicates that it best meets the selection criteria by offering a competitive purchase price, a short delivery time, and a strong positive impact on sales.

Supplier 2 ranks second, with a global utility score of 0.432. While it remains a viable alternative, it is not as advantageous as Supplier 1.

Supplier 3 does not meet the expected standards for any of the assessed criteria, resulting in a global utility score of 0, making it an unsuitable choice.

Considering these results, Supplier 1 is the most suitable option for the distribution network.

Implementation and monitoring strategies need to include:

- Negotiating agreements with the selected suppliers to establish favourable terms.
- Tracking deliveries and making necessary adjustments based on supplier performance.

Advantages of using the Global Utility Method in agri-food supply include:

- Objective decision-making – reduces the influence of personal bias in supplier selection.
- Cost-effectiveness – helps identify suppliers offering the best value for money.
- Improved logistics efficiency – minimizes delays and reduces waste.
- Support for local businesses – enables prioritization of Moldovan suppliers by adjusting evaluation weights.
- Enhanced sustainability – incorporates environmental and economic impact considerations.

The Global Utility Method is a versatile and robust tool that facilitates structured decision-making, enhances strategic planning, and supports the development of sustainable and efficient solutions in complex environments. In the context of agri-food supply chain management, GUM can be particularly useful for selecting suppliers based on factors like cost-effectiveness, product quality, delivery reliability, and sustainability practices. This ensures optimized procurement strategies, reduced operational risks, and improved long-term performance.

Based on the study's findings, several policy measures can be implemented to enhance green logistics in Moldova's agri-food sector, such as: establishment of national sustainability benchmarks for agri-food logistics, aligning with EU policies like the European Green Deal and Farm to Fork Strategy; encouraging the use of structured decision-making models, such as the Global Utility Method (GUM), in public procurement and supply chain management to ensure cost-effectiveness and

sustainability; fostering collaboration between the government, businesses, and research institutions to develop and implement innovative green logistics solutions.

While this study provides valuable insights into green logistics and decision-making in Moldova's agri-food sector, certain limitations must be acknowledged. The analysis relies on available statistical reports and market studies, which may not fully reflect real-time industry dynamics, posing data constraints. Additionally, the effectiveness of the proposed policies is contingent on government adoption and their alignment with broader economic and trade frameworks, introducing regulatory uncertainty. Furthermore, while green logistics enhances sustainability, its implementation entails significant initial costs, which may present financial challenges, particularly for small and medium enterprises (SMEs). The feasibility of these investments depends on the availability of financial support mechanisms, market conditions, and long-term cost-benefit considerations. Further research is necessary to evaluate the economic viability and scalability of green logistics solutions across different business models and supply chain structures.

4. Conclusions

The integration of eco-friendly logistics strategies, such as optimized transportation routes and biodegradable packaging, plays a crucial role in reducing costs and minimizing environmental impact in the agri-food supply chain. European regulations, including the Common Agricultural Policy (CAP) and the European Green Deal, provide a framework for enhancing sustainability.

The agri-food sector in Moldova faces structural challenges but holds significant potential – Despite contributing 30% of GDP and being a major employer, the sector struggles with fragmented farmland, outdated practices, and limited international market access. Addressing these challenges through technological advancements and improved logistics can increase competitiveness and sustainability.

The Global Utility Method (GUM) enhances supplier selection and procurement efficiency – By evaluating key criteria such as purchase price, delivery time, and potential sales growth, GUM provides an objective and structured decision-making approach. The study identified Supplier 1 as the most efficient choice based on a balanced utility score.

Sustainable logistics and decision-making frameworks are key to long-term sector growth – The findings highlight the need for policy support, digitalization, and modern supply chain strategies to ensure the resilience and sustainability of Moldova's agri-food sector. Investing in logistics infrastructure and supplier evaluation models will drive efficiency, reduce operational risks, and support local businesses.

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