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DEVELOPMENT OF THE CIRCULAR BUSINESS MODEL IN THE WINE SECTOR OF THE REPUBLIC OF MOLDOVA

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CONCEPTUAL FRAMEWORK OF THE RESEARCH

Relevance of the research topic and importance of the addressed issue. In the context of the increasingly pronounced phenomenon of global warming, which is accompanied by a significant reduction of finite natural resources, the rapid degradation of air, water, and soil quality, the intensification of urbanization, and the acceleration of population growth, the transition to a circular economy is not merely an option but un imperative for enduring environmental sustainability and economic resilience .

Current data reveal that humanity has exceeded the Earth's planetary boundaries. Currently, meeting the global demand for resources would require 1.75 "Earths," or alternatively, 20.5 years to regenerate what has been depleted if the Earth were left "untouched." [1].

Despite the economic progress achieved in recent years, the Republic of Moldova's growth remains closely tied to waste generation, with its economy largely following a linear model. As of 2021, the country's ecological footprint per capita stands at 1.68 global hectares (gha), indicating an ecological deficit of 36%. [2].

The Republic of Moldova has made multiple international commitments regarding sustainable development and the transition to a circular economy. On September 25, 2015, it joined other UN member states in formally adopting the ambitious 2030 Agenda for Sustainable Development, committing to its implementation. On December 28, 2022, through Government Decision No. 953, the national monitoring framework for implementing the 2030 Development Agenda was approved, marking a significant milestone in the country's efforts to foster a more sustainable and equitable global future.

The granted EU candidate status in 2022 to the Republic of Moldova, further obliges the country to intensify efforts to align its legislation with EU standards, including fostering an economy that harmonizes with environmental sustainability. The National Development Strategy "European Moldova 2030" (NDS) serves as a cornerstone document, guiding these developmental directions, aligning national priorities and objectives with international commitments and local contexts. Key elements of the European Green Deal and the Circular Economy Action Plan "For a cleaner and more competitive Europe" are embedded within the National Development Strategy or NDS 2030, the draft Environmental

Strategy for 2024-2030, the draft Climate Action Law for 2024, and additional relevant policy frameworks.

These international commitments underscore the Republic of Moldova's determination to advancing a sustainable development model, representing an important step toward European integration.

The circular economy is not limited to a single sector or field, serving as a cross-cutting framework applicable across all sectors and areas of society. This study explores the application of the circular economy concept/principles within the wine industry, as this sector represents one of the country's key industries where adopting circular business models can yield significant economic and environmental benefits. Enterprises in the wine sector operate within both agricultural and biotechnological cycles, producing not only primary products but also by-products and waste. If left untreated/not processed, the latter can cause substantial harm to the environment/can have severe environmental consequences. On a global scale, the pollution resulting from unprocessed wine by-products is estimated to equate to the environmental impact of a population of 3 to 4 million people [3]. In Moldova, the wine industry generates approximately 60,000 tons of by-products annually, with grape pomace comprising the largest share. Without proper management, these by-products pose a substantial threat to environmental sustainability. Therefore, the relevance of researching the circular economy in this context is highlighted by the industry's potential to redefine its business model aligning with the principles of sustainability and contributing to the achievement of the Sustainable Development Goals (SDGs) and the Circular Economy Action Plan.

The purpose of this research is to develop and economically substantiate/justify a circular business model focused on the integrated, closed-loop utilization of grape pomace, a significant by-product of the wine production process. Based on the biorefinery concept, this model is designed/aims for industrial-scale implementation, thereby enhancing the long-term sustainability and resilience of the Republic of Moldova's viticulture sector.

Research Objectives:

1. To analyze and assess the current state of research on the circular economy;
2. To assess and evaluate the importance of the wine sector in the socioeconomic development of the Republic of Moldova, identifying existing gaps and evaluating opportunities for implementing the circular economy;

3. To study the European legislative framework related to the circular economy, highlighting key regulations and directives aimed at facilitating the transitioning to a circular economic model, and examining legislation related to the processing of waste and by-products from winemaking;
4. To investigate the national legislative framework of the Republic of Moldova in the field of circular economy, with a specific focus on the wine industry;
5. To analyze statistics on waste generation in the Moldovan wine sector, identifying optimal directions for utilization and recovery within the framework of the circular economy;
6. To examine international best practices in implementing circular economic models in the wine sector, aiming to identify applicable solutions for the national context of the Republic of Moldova;
7. To assess current practices in the management of winemaking by-products and estimate the level of their valorization in the Republic of Moldova;
8. To develop and economically justify a circular, closed-loop business model for the integrated recovery of grape pomace, based on the biorefinery concept, tailored to the wine sector of the Republic of Moldova.

Research hypotheses

Hypothesis 1: *The business model in the wine sector is predominantly linear, with limited emphasis on the valorization of resulting by-products.*

Hypothesis 2: *Implementing an integrated circular business model for the valorization of grape pomace in the wine sector of the Republic of Moldova at an industrial scale is feasible and will generate significant economic, social, and environmental benefits.*

The novelty and scientific originality of the research:

- Development of a comprehensive chronology detailing the evolution of the circular economy concept, providing a systematic perspective on its stages of formation and development.
- Proposals for revisions to the legal and regulatory framework of the Republic of Moldova's wine sector, specifically the redefinition of " wine by-products" in the Law on Vineyards and Wine 57/2006, along with the introduction of clear deadlines and procedures for the controlled withdrawal of secondary products, in order to promote compliance and alignment with international best practices.
- Expansion of the use of wine by-products through proposed changes to Annex 8 of Government Decision No. 356/2015.

- Conducting a study on the territorial distribution of wine by- products across the Republic of Moldova, as well as estimating the degree of processing of these by-products generated by the wine sector.
- Proposing and economically justifying, for the first time in the Republic of Moldova, a circular business model for the integrated, closed-loop valorization of grape pomace, designed for industrial-scale implementation in the wine industry of the Republic of Moldova.

The research problem addresses the economic foundation of a circular business allowing the integrated valorization, at industrial scale, of grape pomace, a major by-product of the wine production process. This model aims to support the sustainable development of the wine sector, reduce environmental impacts and create sustainable economic opportunities.

The main scientific results:

- A chronology of the formation and evolution of the circular economy concept.
- Proposals for amending the legal and regulatory framework for the Moldovan wine sector.
- A study on the geographical distribution of wine by-products in Moldova, along with an evaluation of their processing rates.
- A circular business model for the closed-loop valorization of grape pomace, tailored for the Moldovan wine industry.

The obtained result/results offers/offer a scientific and practical contribution to addressing the issue of inefficient management of grape pomace in the Moldovan wine industry, through the development and economic justification of a circular business model for the integrated industrial valorization of grape pomace, promoting sustainability and resource optimization

Synthesis of the research methodology

The methodology of this research is based on systemic research approaches/adopts a systemic approach, integrating both *inductive* and *deductive* reasoning, and combines *analysis*, *synthesis*, and *comparison* to develop a comprehensive understanding of the transition to a circular business model within the wine sector of the Republic of Moldova. This *synthesis method* is applied at various stages of the research to integrate and interpret the data collected. A deductive approach is used to validate the formulated hypotheses and to draw conclusions through the *questionnaire* results. The *graphical method* is employed to present and interpret data in a clear and informative manner. The economic viability of the proposed

circular model is demonstrated through a feasibility study, supported by *mathematical methods*.

Information Base of the research

The informational foundation/information base of this research includes specialized bibliographic resources relevant to the research topic, as well as national and international official documents such as laws, regulations, resolutions, strategies, and programs related to the circular economy and sustainable development. It also incorporates statistical data from the National Bureau of Statistics of the Republic of Moldova, the International Organization of Vine and Wine, the Vine and Wine Register of the Republic of Moldova, and databases from the OECD, Global Footprint Network, Worldometer, among other relevant sources addressing the research theme. The theoretical and scientific foundation of this dissertation is grounded in the works of globally recognized scholars in the field, such as K. Boulding, G. Reday, W. Stahel, K. Webster, R. Carson, J.T. Lyle, M. Braungart, B. MacDonough, D. Pearce, K. Turner, and J.S. Mill. Additionally, significant contributions to the study of this topic have been made by Romanian economists, including M. Popescu, M. Târțiu, V. Ștefănescu, M. Petrache, A.M. Gurău, C.R. Lupu, I. Vlăduț, F. Bonciu, D. Ciobanu, V. Nedeff, M. Leonte, and M. Macoveanu, among others.

Theoretical significance. The research makes valuable scientific contributions by expanding the theoretical and conceptual framework of the circular economy, thereby enhancing/deepening the understanding of how circular economy principles can be effectively integrated into the wine industry. It proposes a chronology for the development of the circular economy concept, along with a recommendation to replace the term "wine by-product" in legislation. Through a comprehensive analysis of the legislative framework and both international and national initiatives, the research provides theoretical support for the development of public policies and national strategies in the field of the circular economy.

The practical value of the research lies in its ability to outline concrete pathways for enhancing the management of wine by-products, thereby contributing to the sustainable development of the wine sector in the Republic of Moldova. The proposed circular business model provides a solution for closing the loop in the processing of grape pomace, significantly reducing waste generation to nearly zero.

Keywords: circular economy, sustainable development, circular business models, wine industry, grape pomace, by-products, biorefinery, cascading processes.

SYHTHESIS OF THE CHAPTERS

Chapter 1, *Theoretical Framework for Defining the Contextual and Conceptual Framework of the Circular Economy*, delves into the intricacies of the circular economy, elucidating its essence, core concepts, and fundamental principles. It emphasizes the urgent need for a transition to a sustainable economic model, particularly in light of significant global challenges such as climate change, biodiversity loss, and pollution. The chapter positions the circular economy as a fundamental solution for the efficient management of resources and for mitigating environmental impacts.

A significant role in the expansion of the circular economy concept has been played by the 1972 report „The Limits to Growth", which laid the groundwork for understanding the interconnections between global ecosystem support and the future of human civilization. This foundation was further developed by the Brundtland Report, "Our Common Future," published in 1987, which highlighted the need for compromise between economic growth and environmental sustainability, emphasizing the conservation of non-renewable resources for future generations.

With the establishment of the Ellen MacArthur Foundation, the circular economy gained political legitimacy and meaningful conceptual clarity. The theoretical analysis demonstrates that the circular economy offers an integrated solution to counteract the global challenges related to resource use and environmental sustainability. The study emphasizes the limitations of the traditional linear economic model, where natural resources are extracted, processed, consumed, and ultimately disposed of as waste. The author proposes a chronological framework for the evolution of the circular economy concept, delineating four distinct phases: the embryonic period, the intermediate period, the expansion period, and the period of political legitimacy and implementation (refer to Figure 1).

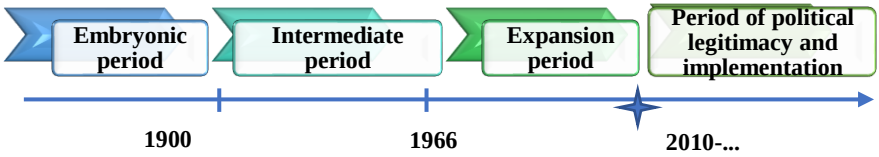

Figure 1. Evolution of the circular economy concept
Source: elaborated by the author based on [4-8]

The embryonic period (...-1900) is characterized by the emergence of various works addressing environmental issues, highlighting the necessity of protecting natural capital and raising concerns about waste management. During this period, efforts were made to design organized systems for waste

management and collection, with coal ash from brick manufacturing being one of the primary types of waste. Industrial-scale metal recycling also began to be practiced, particularly for metals such as iron and steel, marking the early stages of resource recovery and reuse.

In the intermediate period (1900-1966) waste management strategies intensified, and attitudes towards sanitation and environmental equity shifted positively. Recycling practices expanded to include glass and plastics, marking significant progress in waste reduction efforts. In the automotive industry, efforts to repair and refurbish vehicles became more prevalent, reflecting an early recognition of the value in reusing materials and extending product life cycles.

The expansion period (1966-2010) represents a pivotal transition in the development of the circular economy concept. This period is marked by the publication of Kenneth Boulding's seminal work, *The Economics of the Coming Spaceship Earth (1966)*, followed by the influential 1972 report *The Limits to Growth*, which laid the foundational understanding of the interconnections between global ecosystem support and the future of human civilization *[4, 6]*. Subsequently, the Brundtland Report, *Our Common Future*, published in 1987, further articulated the necessity for compromise in development and emphasized the urgent need for conservation of non-renewable resources [5]. The practical applicability of the circular economy gained momentum in the 2010s, following the establishment of the Ellen MacArthur Foundation, a key driver in accelerating the transition. Therefore, 2010 marks the beginning of a new phase in the development and global adoption of circular economy principles.

The period of political legitimacy and implementation (2010–present). With the establishment of the Ellen MacArthur Foundation, the concept of circular economy has gained significant political recognition and conceptual clarity. This period is characterized by a more critical and responsible approach to business practices and the management of natural capital. Notable milestones include the publication of the annual Towards a Circular Economy series, issued in three volumes between 2012 and 2014, which have been instrumental in shaping academic discourse and policy frameworks surrounding the circular economy. In 2015, the European Union adopted the Circular Economy Package, a comprehensive set of measures aimed at promoting sustainable economic models, followed by the European Green Deal [7] and the New Circular Economy Action Plan in 2020. Increasingly, countries around the world are integrating the circular economy concept/principles into their national policies as a basic element in fostering

sustainable global development and addressing pressing environmental challenges.

Subchapter 1.2 *Business models in a circular economy* analyzes the diversity of circular business models and their applicability across various industries. The examination of each model has led the author to conclude that there is no single universal solution or uniformly applicable model across all sectors.

Table 1 offers a comprehensive analysis of five circular business models, highlighting their distinctive characteristics, specific subtypes, examples of best practices, as well as the optimal application domains for each type of model.

Table 1. Comparative analysis of circular business models

Types of models	Distinctive characteristics	Subtypes	Examples of best practices	Areas of application
Circular consumables	Replacement of traditional materials and energy with bio-resources, recycled materials, and renewable energy	"Cradle-to-Cradle"	WeWood, TerraCycle, Allbirds, Rothes	Light industry, Food industry
Extending product lifespan	Maintaining resources in use for as long as possible	Repairing, Remanufacturing, Refurbishing, Direct Reuse, Modular Design, Upgrading	Albatross Razors, Caterpillar, Geração Ecotrônicos, Neptuno Pumps, Lindström	Electronics, Industrial equipment, Construction, Furniture, Light industry, Telecommunications
Collaborative economy / Sharing platforms	Facilitating interaction between service providers and beneficiaries	Peer-to-Peer, Crowdfunding, Couchsurfing, Ridesharing/Carsharing, Coworking	Airbnb, Rover, Uber, RVshare, Indiegogo, Kickstarter, Zipcar, HomeExchange, eBay, Craigslist	Transportation Home appliances
Product as a service	Providing services related to the use of a physical good instead of selling the good	Customer-oriented, Product-oriented, Outcome-oriented	Xerox, Rolls-Royce (Power-by-the-Hour), Atlas Copco (Contract Air Service), Epson (PaperLab)	Transportation, Electronics, Chemical industry
Resource recovery	Recovering secondary raw materials from production processes and recycling waste	Industrial Symbiosis, Recycling, Downcycling, Upcycling	Freitag, Looptworks, Eco Serv Recycle, Filgreen Recycling, Swane Design	Metallurgical Industry, Plastics, Paper, Light industry

Source: elaborated by the author based on [9, 10]

Circular business models encompass a wide range of approaches, emphasizing innovation and sustainability. However, not all models are entirely new. For example, the resource recovery business model has historical roots, particularly in the metallurgical sector. Metal recycling, which dates back to the 18th century, was primarily employed for the production of armaments. At that time, these recycling and resource recovery practices were motivated by economic or military imperatives rather than environmental considerations.

In contemporary literature, most circular business models are regarded as recent innovations. Models such as circular consumables, sharing platforms, and products-as-a-service promote/focus on the resource efficiency by optimizing consumption and reducing waste. Nevertheless, achieving entirely waste-free production remains a complex challenge from a practical standpoint. Currently, no business model can be considered 100%/fully circular.

Subchapter 1.3, *European and national legislative framework regarding the transition to a circular economy***,** analyzes the main regulations and policies that have been adopted at both European and national levels to support the transition to a sustainable economic model.

The launch of the Roadmap to a Resource Efficient Europe (COM (2011) served as a key reference point [12]. In response to the growing need for a more comprehensive approach, the Circular Economy Action Plan was adopted in 2015 [8]. This initiative was further strengthened with the adoption of the New Circular Economy Action Plan in 2020, which introduced a more extensive, integrated, and ambitious strategy aimed at fostering a sustainable economy and promoting competitive economic growth.

The European legislative framework for the circular economy has evolved significantly over the past decade as illustrated in Figure 2.

- **May 2023**

The European Commission reviewed and updated the monitoring framework for the circular economy

- **March 22, 2023**

The European Commission adopted proposals related to green claims and the right to repair

- **November 30, 2022**

The European Commission adopted the measures outlined in the action plan for the circular economy

- **April 5, 2022**

The European Commission adopted proposals to revise EU measures aimed at addressing pollution from large industrial installations

- **March 30, 2022**

The European Commission adopted a package of measures outlined in the action plan for the circular economy

- **November 17, 2021**

The European Commission adopted a proposal for new regulations regarding waste transportation

- **October 28, 2021**

The European Commission adopted a proposal to update the rules on persistent organic pollutants in waste

- **February 22, 2021**

The Global Alliance for Circular Economy and Resource Efficiency (GACERE) was established

- **December 10, 2020**

The European Commission adopted a proposal for new regulations on sustainable batteries

- **March 11, 2020**

The European Commission adopted a new action plan for the circular economy

- **December 11, 2019**

The European Commission adopted the European Green Deal

- **December 2015**

The European Commission adopted the first action plan for the circular economy

Figure 2. Timeline of European initiatives for the circular economy, 2015-2023

Source: Author's compilation, based on data from the Council of the European Union [11]

In the Republic of Moldova, the transition to a circular economy has been supported by the adoption of Law No. 209/2016 on Waste, which aligned national legislation with European Union standards [14]. This law

introduced the concept of "*extended producer responsibility*" and the environmental impact assessment tool known as "life cycle assessment" (LCA).

Law No. 57/2006 on Vine and Wine stipulates that economic agents are obliged to process wine by-products either within their own enterprises or in other specialized companies within the sector. However, certain aspects of this process remain ambiguous, leading to potential interpretative discrepancies. The Moldovan legal-regulatory framework lacks specific requirements regarding the minimum alcohol content in by-products, disposal deadlines , and clear implementation procedures - issues that are addressed in EU legislation, particularly in Commission Delegated Regulation (EU) 2019/934.

Government Decision No. 356/2015 on the Approval of the Regulation on the Organization of the Wine Market specifies both the list of wine by-products and the new products that can be derived from their valorization. However, the current list of approved products remains limited, suggesting the need for a review to include a broader range of product categories. Article 2 of Law No. 57/2006 on Vine and Wine defines wine by-products *as "waste resulting from grape processing and wine production."* However, the term "waste" may carry a negative connotation, failing to adequately reflect their potential of these materials as valuable resources within the circular economy.

To better align with this perspective, it is proposed that the definition be reformulated as follows**: "material resources derived from the processing of grapes and the production of wine products, with valuable potential for reuse in agricultural, industrial, or energy-related purposes."**

Chapter 2, *Towards a circular economy in the wine sector of the Republic of Moldova*, examines the sector's significance by identifying both the challenges and opportunities associated with the implementation of circular economy practices in this industry. The factual study on the current state of the wine sector in the Republic of Moldova highlights its strategic importance, not only for economic development but also in preserving the country's cultural and social identity. Internationally, Moldova's wine industry enjoys substantial recognition, ranking 14th globally in wine exports, 16th in vineyard area, and 20th in overall wine production, underscoring its competitive position on the global stage. At the national level, the wine industry plays a critical role in the country's economy, as illustrated by the data in Table 2.

Table 2. Evolution of indicators in the manufacturing industry and beverage production in the Republic of Moldova (2015-2022)

Indicatori	2015	2016	2017	2018	2019	2020	2021	2022
Number of enterprises in:								
C00 Manufacturing industry	4482	4535	4686	4860	4906	5024	4982	5064
C11 Beverage manufacturing	**226**	**229**	**239**	**237**	**229**	**228**	**231**	**238**
% Share in the manufacturing industry	***5,04***	***5,05***	***5,1***	***4,9***	***4,67***	***4,54***	***4,64***	***4,7***
Revenue from Sales, Current Prices, Billion Lei:								
C00 Manufacturing industry	43,13	45,94	50.02	52,96	57,06	57,05	67,09	85,31
C11 Beverage manufacturing	**5,40**	**5,73**	**5,76**	**5,64**	**6,26**	**5,50**	**6,60**	**7,21**
% Share in the manufacturing industry	*12.5*	*12.5*	*11.5*	*10.7*	*11.00*	*9.7*	*9.9*	*8.5*
Number of persons employed (Thousand persons):								
C00 Manufacturing industry	92,51	95,09	103,53	107,96	108,36	103,88	100,21	98,89
C11 Beverage manufacturing	**9,16**	**8,9**	**8,86**	**9,08**	**8,71**	**7,93**	**7,80**	**7,76**
% Share in the manufacturing industry	*9.9*	*9.4*	*8.6*	*8.4*	*8.1*	*7.6*	*7.8*	*7.9*
Value of Manufactured Industrial Production, Billion Lei:								
C00 Manufacturing industry	37,70	39,65	43,93	46,48	49,86	50,03	59,28	73,70
C11 Beverage manufacturing	4,82	4,46	4,94	5,25	5,21	4,99	5,62	6,85
% Share of C11 in the manufacturing industry	*12.0*	*11.3*	*11.3*	*11.3*	*10.5*	*10.0*	*9.5*	*9.3*
C1102 Wine Production from Grapes	**2,76**	**2,76**	**3,20**	**3,42**	**3,35**	**3,25**	**3,53**	**4,20**
Share of C1102 in Beverage Manufacturing (C11)	***57.2***	***61.9***	***64.8***	***65.1***	***64.4***	***65.2***	***62.9***	***61.30***

Source: Compiled by the author based on data from the National Bureau of Statistics (BNS) [15]

Subsection 2.2: *Statistical analysis of by-products in the wine sector of the Republic of Moldova: types, characteristics, and valorization strategies* offers a comprehensive statistical analysis of the generation and management of by-products within the wine sector, with a particular focus

on potential pathways for their utilization and valorization within the framework of a circular economy.

According to data provided by the National Office for Vine and Wine (ONVV), the following quantities of wine by-products were generated from 2019 to 2023 (see Table 3):

Table 3. Evolution of wine by-products generated by Moldova's wine industry (2019-2023)

Wine by-products	2019	2020	2021	2022	2023
Grape pomace (tonnes)	39 253	27 415	38 568	41 000	41 841
Yeast, (hectoliters)	94 652	60 389	87 977	N/A	N/A
Grape Skins (tonnes)	12 144	22 721	11 883	14 000	12 077

Source: National Office of Vine and Wine (ONVV) [16].

During the period analyzed (2019-2023), fluctuations in the generation of wine by-products were observed, closely correlated with the volume of grapes processed. Given the focus of this research on grape pomace, it is essential to analyze its distribution across the Republic of Moldova, including the Transnistrian region (Table 4).

The analysis includes data from 2019, prior to the declaration of the red alert regarding COVID-19 infections, and from 2021, following the pandemic. Data for 2020, a year marked by severe restrictions and economic disruptions due to the COVID-19 pandemic- which significantly affected production processes as well as market demand and supply in the wine sector- has been excluded from the analysis to ensure consistency and reliability of the findings.

The study on the territorial distribution of grape pomace in the Republic of Moldova reveals that the southern and central regions of the country are predominant areas for grape processing, resulting in a significant generation of by-products, with pomace being the most prevalent. Pomace accounts for approximately 15% of the processed raw material, a predominance attributed to the favorable climatic conditions and well-developed processing capacities in these regions. In 2021, the wine sector in the Republic of Moldova processed approximately 255,000 tons of grapes, yielding 38,568 tons of pomace. The largest quantities of pomace were recorded in Cahul district (17%), followed by Causeni district, UTA Gagauzia, and Tiraspol (in the Transnistrian region) with 16.33%, 12.26%, and 8.48%, respectively. The findings of this study emphasize that managing

grape pomace, as the dominant by-product, represents a significant challenge for wine enterprises in these regions.

Table 4. Distribution of Grape Pomace in the Republic of Moldova by Region in 2019 and 2021

Region/district	2019, tonnes	Structure, %	2021, tonnes	Structure, %
Cahul	9170.9	*23.36*	6383.9	*16.55*
Causeni	1279.4	*3.26*	6299.5	*16.33*
UTA Gagauzia	7.396	*18.84*	4727.3	*12.26*
Tiraspol	4373	*11.14*	3269	*8.48*
Ialoveni	1980.1	*5.04*	2518.2	*6.53*
Straseni	2109.4	*5.37*	2323	*6.02*
Cantemir	1933.8	*4.93*	2202	*5.71*
Calarasi	2162.4	*5.51*	2034.3	*5.27*
Taraclia	500.6	*1.28*	1797.2	*4.66*
Chisinau	2476.6	*6.31*	1259.4	*3.27*
Anenii Noi	524.9	*1.34*	1256	*3.26*
Nisporeni	526.2	*1.34*	1046.8	*2.71*
Cimislia	307	*0.78*	913.8	*2.37*
Stefan Voda	1889.5	*4.81*	669	*1.73*
Hancesti	296.9	*0.76*	582.2	*1.51*
Orhei	376.2	*0.96*	504.1	*1.31*
Basarabeasca	357.5	*0.91*	313.1	*0.81*
Leova	930.4	*2.37*	166.6	*0.43*
Falesti	644.7	*1.64*	76.3	*0.20*
Ungheni, Soroca, and others	17.6	*0.04*	226.3	*0.59*
Total	39253.1	*100*	38567.7	*100*

Source: elaborated by author based on data provided by the National Office for Vine and Wine [16]

Subchapter 2.3**,** *Best practice models in the global wine industry* examines international best practices within the wine industry, focusing on the valorization of wine by-products and waste management. Relevant examples, such as Caviro EXTRA in Italy, Grap'SUD in France, and Tarac Technologies in Australia, demonstrate the effectiveness of circular business models that are both environmentally sustainable and economically viable. These models transform wine by-products into a wide range of products, including alcohol, tartaric acid, natural fertilizers, renewable energy,

polyphenols, liquid tannin, oenocyanin, essential oils, grape seed oil, organic amendments, among others.

An essential component of these practices is the recycling of wastewater from the production process. This wastewater is treated and reused, primarily for crop irrigation, contributing to water conservation and reducing environmental impact. These business models offer valuable insights and promising directions for a more sustainable wine industry. By adapting these best practices to local contexts, the wine sector can stimulate the transition toward innovation that addresses contemporary challenges, improving resource management and mitigating environmental impact.

Subchapter 2.4, *Current practices and the contribution of the wine sector to circular economy objectives* aims to address several fundamental concerns regarding the integration of circular economy principles within the wine sector of the Republic of Moldova. Specifically, it seeks to answer the following questions:

- To what extent are the opportunities presented by the circular economy understood within the wine sector of the Republic of Moldova?
- How do businesses in the wine sector manage waste and by-products?
- How is the relevance and effectiveness of current waste and by-product management practices perceived within the wine industry?

The study revealed that the majority of wineries in the Republic of Moldova participating in the survey (75%) acknowledge the strong connection between the linear business model and climate change. This finding suggests an awareness among businesses that the linear model has reached its limits and that the circular economy offers a viable solution for the sustainable development of the sector. Additionally, the study shows that although 45% of wineries process by-products, the majority (66.6%) only valorize less than 50% of the total by-product volume generated (Figure 3).

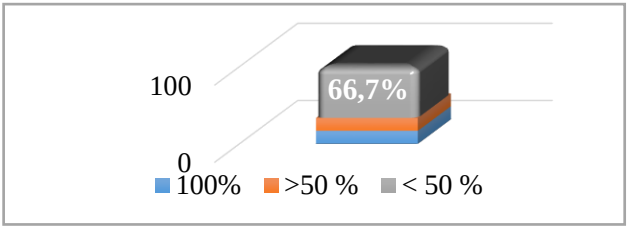

Figure 3. Degree of valorization of by-products, %
Source: Developed by the author based on survey results

For unprocessed by-products, two primary disposal methods are identified:

a) transportation and disposal to an authorized landfill (55%);
b) commercialization (45%).

The survey results indicate that one of the key challenges wineries face in transitioning to and implementing a circular economy is the lack of technological solutions, as reported by 65% of respondents.

Chapter 3, titled *Economic rationale for the circular business model in the wine sector of the Republic of Moldova*, focuses on the development of an industrial-scale circular business model aimed at the comprehensive valorization of grape pomace generated by the winemaking sector in the Republic of Moldova. Centered on the biorefinery concept, the research presents a detailed economic analysis and justification for the implementation of/adopting this innovative model. The study examines/evaluates three distinct investment scenarios for grape pomace processing, each designed to optimize resource utilization and maximize economic and environmental benefits: **Scenario 1:** establishment of a company dedicated to processing pomace exclusively for the production of grape seed oil; **Scenario 2:** establishment of a company produces both grape seed oil and polyphenols from grape pomace ; **Scenario 3:** establishment of a company implementing an integrated, closed-loop processing system for grape pomace valorization, resulting in the generation of three value-added products: grape seed oil, polyphenols, and biochar.

The economic argumentation study is systematically structured into three phases, illustrated in Figure 4

1. **Data collection**: gathering comprehensive data on the territorial distribution of grape pomace to understand its availability, volume, and logistical considerations across different regions;
2. **Evaluating various pomace processing options:** providing a comparative analysis to select the most viable strategy based on economic feasibility, resource efficiency, and market potential;
3. **Economic rationale of the circular business model:** conducting a detailed economic assessment of the selected option, analyzing investment, operational costs, revenue projections, and profitability to provide a solid economic rationale.

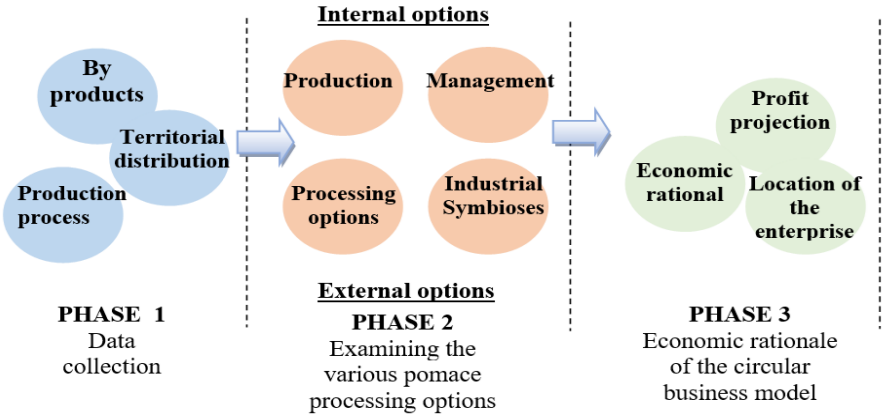

Figure 4: Economic feasibility path/approach

Source: elaborated by author

1. **Gathering information on the territorial distribution of grape pomace**

The first step/initial phase consisted in analyzing production declarations from wineries on the generation of wine by-products and their regional distribution. This territorial distribution, detailed in Chapter 2 for the years 2019 and 2021, also included an analysis of the ratio between pomace from red and white grapes to inform decision-making on potential utilization strategies

2. **Identification and analysis of potential valorization options for pomace**

Several pomace processing methods were evaluated, considering their environmental, social, and economic impacts. The integrated valorization approach, which involves transforming grape pomace into three distinct products, was selected. The analysis took into account factors such as market potential, consumer demand, and the economic benefits associated with the selected recovery option.

3. **Economic justification of the circular business model for industrial-scale grape pomace valorization**

The final stage involved an in-depth economic feasibility analysis for the selected grape pomace processing approach. This analysis considered operational costs, revenue projections, and key financial performance indicators to determine the financial viability of the chosen method. A comparative study of various pomace processing methods (Table 5) was

carried out, highlighting the advantages and disadvantages of each approach. The findings confirmed that an integrated cascade processing method optimizes resource efficiency, minimizes waste generation, offers a more sustainable and economically viable solution.

Table 5. Comparative analysis of grape pomace processing methods

Methods	Advantages	Disadvantages
Distillation	Valuable products, such as grappa.	Expensive equipment – distillation column; high energy consumption; only a portion of components are recovered; requires additional treatment; requires large storage capacity; not suitable for small wineries.
Tartaric Acid	Valuable product with applications in food and beverages.	Disposal of sulfite sludge.
Composting	Relatively inexpensive and convenient, low cost, low energy consumption.	Long storage period, risk of soil pollution, greenhouse gas emissions if the process is not managed properly.
Vermicomposting	Ecological process, relatively inexpensive and convenient, low cost, low energy consumption. Compared to other methods, vermicomposting emits fewer greenhouse gases.	Long processing period, risk of soil pollution, worms are sensitive to environmental conditions and can be affected by extreme temperatures, excessive humidity, or inadequate aeration.
Direct Spreading	The simplest method for managing pomace.	Must be used cautiously and only in small quantities to prevent erosion; risk of phytotoxicity; fresh pomace is acidic and can alter soil pH. Requires large spaces and accessibility; no more than 3 tons of dry matter per hectare can be applied annually.
Methods	**Advantages**	**Disadvantages**

Polyphenol Recovery	Valuable products with multiple applications in industry, food, and health.	High scaling costs, need for solvent removal, process complexity.
Combustion	Complete waste treatment, full energy recovery.	Requires pre-treatment (drying of pomace); high energy consumption for drying pomace.
Gasification	Production of synthesis gas, with options for gas turbines or internal combustion engines. Generation of electricity, which can be reused for refrigeration.	Expensive equipment; requires pre-treatment (drying of pomace), reducing process efficiency; requires additional supply (water or oxygen).
Pyrolysis	Products such as biochar, bio-oil, and biogas can be obtained. Simple feedstock system, energy recovery, offering multiple options for further utilization.	High equipment costs; high energy consumption; requires pre-treatment, as bio-oil and biogas are used to generate energy to support the pyrolysis process and dry the raw material.
Cascade (Integrated) Utilization with the Production of a Set of Products	Produces multiple high-value-added products. The profitability of the process is higher due to the variety of products generated.	High capital costs; high process complexity; not cost-effective for small enterprises.

Source: Developed by the author based on Meadows, D.H., Meadows, D.L., Randers, J., & Behrens, W.W.; Mill, J.; Qing Jin [17, 18, 19]

The current technological processes for grape pomace valorization tipically focus on specific applications such as alcohol recovery, oil production, animal feed, composting, grape seed production, and enological colorant extraction . However, many enterprises limit these processes to a single product, resulting in significant waste requiring additional management. This approach is both economically and ecologically inefficient. Contrarily, adopting an integrated utilization strategy based on the biorefinery concept offers a transformative alternative by minimizing waste generation and maximizing the efficient use of raw materials through the production of multiple value-added products. In the wine industry, the biorefinery concept represents a modern sustainable and innovative solution

for valorizing/managing waste streams, enabling the production of various high-value products and enhancing overall resource efficiency [20].

As a result, this study identified and selected a complex technological process for grape pomace valorization, tailored to the national context and based on the biorefinery concept, aimed at producing three distinct products: grape seed oil, polyphenols, and biochar. Developed by a research team from the Department of Food Science and Technology at the Polytechnic Institute and the State University of Virginia, the integrated process comprises three combined/sequential steps: oil extraction from grape seeds, ethanol solvent extraction to obtain polyphenols, and pyrolysis process to convert the remaining solid residues into biochar [17]. Figure 5 provides a schematic representation of the integrated process for grape pomace valorization.

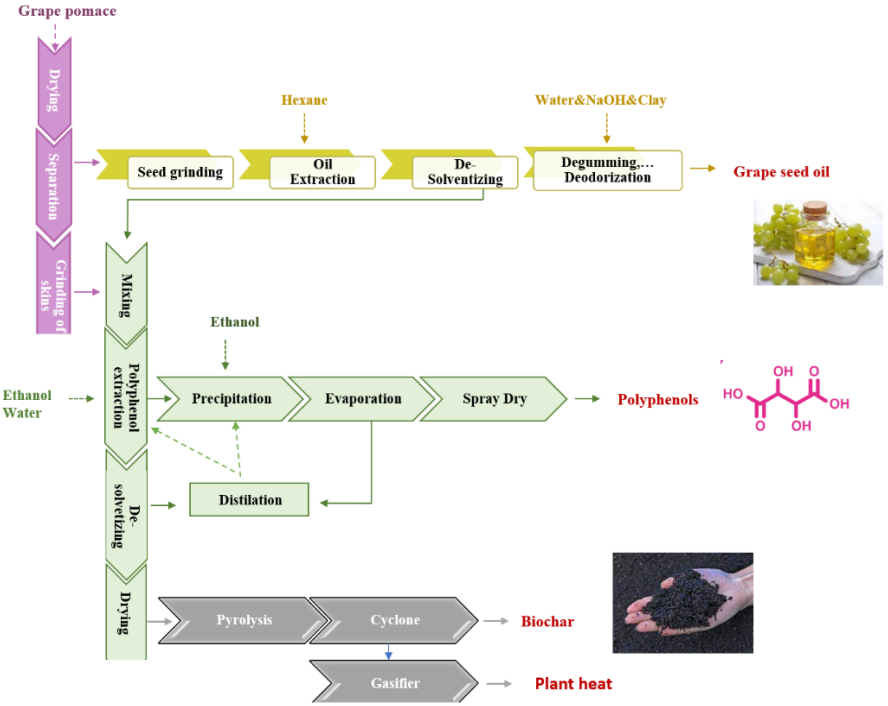

Figure 5. Block diagram of complex/comprehensive valorization process of grape pomace

Source: developed by the author based on Qing Jin [17]

Economic justification for the closed-loop circular model for complex valorization of grape pomace at an industrial scale

This model assumes the enterprise will operate continuously throughout the year, despite winemaking being a seasonal activity. Since winemaking is a seasonal activity, certain handling processes for grape pomace- including collection, transportation, drying, and the separation of seeds and skins—occur within a roughly 120-day period each year, typically aligning with the grape processing season in September and October. In contrast, downstream processes such as grinding, grape seed oil production, polyphenol extraction, and biochar production are carried out year-round to maximize resource utilization. The handling of grape pomace—such as collection, transportation, drying, and the separation of seeds and skins—occurs over a 120-day period, typically during the grape processing season in September and October. In contrast, downstream processes including grinding, grape seed oil production, polyphenol extraction, and biochar production are conducted year-round to optimize resource utilization and ensure a continuous flow of value-added products.

The process begins with the collection of grape marc from winemaking facilities, which is subsequently transported to a processing facility. To ensure efficient and secure transport, specialized airtight containers (trailers) with a capacity of approximately 25 tons are provided to the wineries. Upon arrival at the processing site, the grape marc is conveyed to a drum dryer, where its moisture content is significantly reduced through thermal drying, typically powered by natural gas. Once dried, the pomace is mechanically separated its constituent components — into grape seeds and skins — for further processing [17].

Location

The center of gravity method was used to determine the optimal location for the grape pomace biorefinery. This technique applies an (X-Y) coordinate system to map the geographical areas under analysis, identifying the x and y coordinates of a "center of gravity" that minimizes total transportation costs [21]. The calculation involves a weighted approach, where the formula for determining the center of gravity for a set of points in a two-dimensional plane is [22]:

$$C_X = \frac{\sum D_{ix}.W_i}{\sum W_i} \qquad C_Y = \frac{\sum D_{iy}.W_i}{\sum W_i} \tag{1.1}$$

where:

$\mathbf{C_x}$, $\mathbf{C_y}$ – coordinates of the center of gravity;

$\mathbf{D_{ix}}$, $\mathbf{D_{iy}}$ – x and y coordinates of supply center i;

$\mathbf{W_i}$ – volume of products transported from the supply center to i.

Table 6 presents detailed information on the geographic distribution of grape pomace quantities, including the geographic coordinates associated with each district.

Table 6. Initial data for determining the optimal location of the plant (Year 2019)

District	**Geographic coordinates, Latitude D_{ix}**	**Geographic coordinates, Longitude D_{iy}**	**Quantity of grape marc, tons W_i**
Cahul	45.916667	28.183611	9170.9
UTA Gagauzia	46.300278	28.657222	7396.2
Tiraspol	46.840278	29.643333	4373.0
Chisinau	47.026389	28.840278	2476.6
Straseni	47.133333	28.600000	2109.4
Ialoveni	46.950000	28.783333	1980.1
Calarasi	47.250000	28.300000	2162.4
Cantemir	46.276667	28.196389	1933.8
Stefan Voda	46.515278	29.663056	1889.5
Causeni	46.633333	29.400000	1279.4
Leova	46.483333	28.250000	930.4
Falesti	47.573611	27.709167	644.7
Nisporeni	47.083333	28.183333	526.2
Taraclia	45.900000	28.666667	500.6
Anenii Noi	46.881389	29.232222	524.9
Orhei	47.383333	28.816667	376.2
Basarabeasca	46.333056	28.972222	357.5
Hancesti	46.828333	28.594167	296.9
Cimislia	46.500000	28.800000	307.0
Soroca	48.155833	28.297500	13.0
Ungheni	47.187500	27.795833	4.6
Total			**39253.2**

Source: elaborated by the author on the bases of data provided by [16, 23]

By inputting the relevant data into the formula, the calculated coordinates of the center of gravity are Cx and Cy. These coordinates represent the optimal location for the biorefinery, balancing the distribution of grape pomace sources to minimize overall transportation costs/ These represent the x and y coordinates of the weighted center of gravity, indicating the most cost-efficient position for the biorefinery.

$$Cx = \frac{(45.916667*9170.9)+(46.300278*7396.2)+\cdots+(47.187500*4.6)}{39253.2} = 46.52201266 \text{ N.}$$

$$Cy = \frac{(28.183611*9170.9)+(28.657222*7396.2)+\cdots+(27.795833*4.6)}{39253.2} = 28.68263232 \text{ E.}$$

Using the center of gravity (centroid) method, the potential coordinates for the plant's location, based on the quantity of grape pomace generated by district in 2019, were determined to be 28.68263232° E and 46.52201266° N. coordinates indicate a potential site within Cimislia district [24]. The same methodology was subsequently applied to determine the optimal location using aggregated data on grape pomace production by district in 2021. The results from both datasets—2019 and 2021—consistently identify the Cimislia district as the optimal location for establishing the plant.

Subchapter 3.2, *Economic Justification for the closed-loop circular model of complex grape pomace valorization at an industrial scale*, demonstrates the economic feasibility of fully utilizing grape pomace through a circular model. This subchapter demonstrates the economic feasibility of fully utilizing grape pomace through a circular processing model. It presents an analysis and comparison of three distinct scenarios for implementing this model:

- **Scenario 1**: The investment project involves establishing a grape pomace processing plant focused on producing a single product: grape seed oil.
- **Scenario 2**: The investment project involves establishing a grape pomace processing enterprise focused on producing two products: grape seed oil and polyphenols.
- **Scenario 3**: The investment project involves establishing a comprehensive, closed-loop grape pomace processing enterprise, generating three value-added products: grape seed oil, polyphenols, and biochar.

Scenario 1: Feasibility analysis of the grape pomace processing enterprise for grape seed oil production

To determine the transportation costs for the grape pomace (the raw material), the total distance required to transport the entire quantity of grape pomace to the processing enterprise was initially calculated. Based on fuel consumption norms per 100 kilometers and the cost of diesel, the transportation cost per ton of grape pomace transported was determined.

According to the calculations, transporting 39,253 tons of grape pomace to the processing enterprise in Cimislia would require a total travel

distance of 262,939 kilometers. The average fuel consumption rate for trucks with a payload exceeding 25 tons was sourced from the official report *"Real-world fuel economy of heavy trucks"* [25]. The diesel price was obtained from the official website of the National Agency for Energy Regulation of Republic of Moldova (ANRE) [26]. The rental price for trucks was determined based on quotations from various transportation and logistics companies operating in the Republic of Moldova. Social insurance contributions were calculated in accordance with Law No. 489/1999 on the Public Social Insurance System, which establishes a rate of 24% for 2023 [27]. Based on data from the National Bureau of Statistics of the Republic of Moldova, the average gross monthly wage earnings in the transportation sector in 2023 was 10 833 MDL, while the estimated salary for a truck driver was set at 19 000 MDL [28]. The references for the prices of specific materials (hexane, NaOH, phosphoric acid, etc.) were sourced from the commercial platforms of chemical product suppliers. The rates for water, natural gas, and electricity were retrieved from the official ANRE website, using values valid for 2023 [29].

Workforce planning for the three scenarios was conducted based on data from source [30], taking into account the necessary adjustments for processing a volume of 35,000 tons of pomace, as well as potential variations in labor efficiency and productivity between locations. Maintenance and repair expenses were estimated at 3% of the total value of the installed equipment [31]. Equipment depreciation was calculated using the straight-line method over 10 years, with a depreciation rate of 10% [32]. Additionally, building depreciation was set at 3.3%, corresponding to a useful life of 30 years, as per the Fixed Assets Catalog included in Government Decision No. 941/2020 [33].

General and administrative expenses, as well as distribution costs, were each estimated at 7% of the production cost for each scenario [31, 34]. Additionally, the salary fund for the management staff, along with social insurance contributions—calculated at 24%— was incorporated into the overall cost structure. The information regarding the price and type of equipment for all three anticipated scenarios was derived from the study *Techno-economic analysis of a grape pomace biorefinery: Production of seed oil, polyphenols, and biochar* [17]. Equipment prices were converted from U.S. dollars to Moldovan lei using the exchange rate provided by the National Bank of Moldova as of December 6, 2023 (1 USD = 17.7574 MDL). These values were further adjusted by the cumulative annual inflation rate for 2020-2023, which was approximately 12% [35].

The fixed assets required for producing grape seed oil include machinery and equipment for collecting pomace, machinery for handling raw materials, technological equipment for the direct production of grape seed oil, machinery for storing the finished product, and a CIP (Clean-in-place) system. Pomace collection equipment consists of special containers (trailers) with a capacity of 25 tons, which will be provided to enterprises. Approximately 80 units will be used, a number justified by the number of enterprises producing more than 25 tons of pomace. The price of each container was determined using data from Machineseeker [36] and adjusted according to capacity variations through an exponential scaling expression.

Furthermore, the total capital expenditures for establishing the grape pomace biorefinery were estimated using the factorial method of H.J. Lang, which calculates the overall investment costs based on a standard formula (1.2):

$$C_{\mathrm{TDC}} = F_{\mathrm{L}} \cdot \sum_{k=1}^{n} E_{\mathrm{k}} \tag{1.2}$$

where:

F_L – lang factor;

E_k – equipment cost.

The Lang factor (**F_L**) values vary depending on the type of industry. The research of H.J. Lang, Peters and Timmerhaus, and Sinnott and Towler is primarily focused d on the chemical and petrochemical industries. In the food industry, however, the **F_L** was estimated by Z.B. Maroulis and G.D. Saravacos in their 2003 book *Food Process Design*. They proposed that the **F_L** ranges between 1.5÷2.5, depending on the complexity of the technology and specialized equipment to meet high quality and efficiency standards [37]. Later, in 2005, A.Z. Marouli and Z.B. Maroulis, in their article *Cost data analysis for the food industry*, published in *Journal of Food Engineering*, suggested that the **F_L** for the food industry can be approximated as 2 [38]. However, more recent studies on the value of the **F_L** in the food industry are not readily available.

In the feasibility study, total capital expenditures were calculated using a **F_L** of 2.5, justified by the complexity of the technological process involved in grape pomace processing. On average, one ton of pomace yields approximately 45 liters of oil. Therefore, processing 35,000 tons of pomace would result in the extraction of about 1.575 million liters of oil. The price of grape seed oil varies significantly, ranging from 80 to 550 MDL per liter [39]. Considering that solvent extraction method is used in this study — a

more cost-efficient process, though resulting in oil of lower quality compared to other methods — the minimum of 80 lei per liter was selected for the calculations. With this price, the estimated revenue from oil sales would amount to approximately 126 million MDL. To reach the breakeven point, the enterprise would need to sell about 50% of the total production, which corresponds to over 760,000 liters of oil. The detailed projections for Scenario 1 are provided in the profit and loss statement in Table 7.

Table 7. Planned profit and loss statement under scenario 1

Indicators	Code	Value, MDL
Sales revenue	10	126,000,000.00
Cost of sales	20	69,651,022.03
Gross profit (gross loss) (line 010 - line 020)	30	56,348,977.97
Distribution expenses	40	513,5971.54
Administrative expenses	50	6,809,971.54
Operating result: profit (loss) (line 030 - line 040 - line 050)	60	44,403,034.89
Profit (loss) before tax (line 060)	70	44,403,034.89
Income tax expenses, 12%	80	5,328,364.19
Net profit (net loss) for the period (line 070 - line 080)	90	39,074,670.70

Source: developed by the author based on economic calculations from subsection 3.2

The projections in the profit and loss statement for Scenario 1 indicate an estimated **gross margin** of approximately **44%**, derived from the ratio of **gross profit** to **sales revenue**. This suggests that for every leu earned from sales, 44% constitutes gross profit before accounting for period expenses and other costs. The **estimated net profit** for this scenario exceeds **39 million MDL,** which reflects the profitability after deducting all operating expenses, taxes, and other costs. The **net margin**, calculated as the ratio of **net profit** to **total sales revenue**, stands at approximately **31%**. This implies that, for every MDL generated in sales, roughly 31 (or 31% of each leu) bani represents the **net profit,** showcasing a strong level of profitability after all expenses have been accounted for. This result reflects the business's efficient management of costs and its ability to generate profit from sales.

Scenario 2: Feasibility analysis of the grape pomace processing enterprise for the production of grape seed oil and polyphenols

The selling price of polyphenol extracts can vary significantly, generally ranging from 5 and 100 USD per kilogram, or even higher, depending on various factors such as product's purity, extraction method, purchase quantity, and the specific composition of active compounds in the

extract [40]. Additionally, price fluctuations are influenced by market demand, regional conditions, and other external factors. For feasibility this study, a conservative price of 450 MDL per kilogram has been selected to reflect potential risks associated with market volatility, unforeseen expenses, challenges in customer acquisition, and the desire to avoid overestimating potential sales revenue.

In terms of extraction yield, approximately 36.8 kg of polyphenols can be obtained per ton of grape pomace after oil extraction, total estimated sales revenue from polyphenols would be approximately 173.88 million MDL. To determine the break even, at the selected selling price of 450 MDL per kilogram, the company would need to generate a minimum sales revenue of 72.1 million MDL to cover its total fixed and variable costs. This means that the company would need to sell more than 42% of its total polyphenol production, which equates to over 160 thousand kg, to reach the break-even point. Table 8 presents the projected profit and loss estimates for the grape pomace processing enterprise specializing in the production of grape seed oil and polyphenol extracts under Scenario 2 of this research. In this scenario, the total sales revenue is projected at 299.88 million MDL. The net margin, calculated as the ratio of net profit to sales revenue, is estimated at 23.8%. The cost of goods sold per each Leu of sales revenue is 0.63 MDL, meaning that 37 bani per Leu of sales revenue represents the contribution margin.

Table 8 Planned profit and loss statement under scenario 2

Indicators	Code	Value, MDL
Sales revenue	10	299 880 000,00
Cost of sales	20	189 028 515,24
Gross profit (gross loss) (line 010 - line 020)	**30**	110 851 484,76
Distribution expenses	40	13 752 796,07
Administrative expenses	50	15 947 596,07
Operating result: profit (loss) (line 030 - line 040 - line 050)	**60**	81 151 092,63
Profit (loss) before tax (line 060)	70	81 151 092,63
Income tax expenses, 12%	80	97 38 131,12
Net profit (net loss) for the period (line 070 - line 080)	**90**	71 412 961,51

Source: elaborated by the author based on economic calculations from subsection 3.2

Scenario 3: Feasibility analysis of the grape pomace processing plant in a closed-loop system with the production of grape seed oil, polyphenol extracts, and biochar

Scenario 3 examines the economic potential of implementing a closed-loop circular business model in the wine industry, focusing on the industrial processing of grape pomace. In this model, grape pomace serves as the primary raw material for producing three distinct types of products—grape seed oil, polyphenol extracts, and biochar—through a cascade of processing stages. Biochar is produced through a pyrolysis process, a thermochemical process that decomposes organic materials in the absence of oxygen at high temperatures. During the pyrolysis process, the grape pomace undergoes thermal treatment, producing a vapor flow containing gases and oils. This vapor is subsequently combusted to generate the energy required to sustain the pyrolysis process. The energy released from burning 1 kg of pomace residue- can not only meet the energy requirements of the pyrolysis process itself but also generate an additional 2.7 MJ of energy [17]. This closed-loop process contributes significantly to resource efficiency and waste management, promoting a more sustainable and circular approach. Table 9 presents the projected profit and loss statement for Scenario 3, offering detailed financial insights into the viability and profitability of this closed-loop system for grape pomace processing.

Table 9. Planned profit and loss statement under scenario 3

Indicators	**Code**	**Value, MDL**
Sales revenue	10	361 494 000.00
Cost of sales	20	204 184 472.91
Gross profit (gross loss) (line 010 - line 020)	**30**	157 309 527.09
Distribution expenses	40	15 074 113.10
Administrative expenses	50	18 050 113.10
Operating result: profit (loss) (line 030 - line 040 - line 050)	**60**	124 185 300.88
Profit (loss) before tax (line 060)	70	124 185 300.88
Income tax expenses, 12%	80	14 902 236.11
Net profit (net loss) for the period (line 070 - line 080)	**90**	**109 283 064.78**

Source: elaborated by the author based on economic calculations from subsection 3.2

In this scenario, total sales revenues amount to 361.49 million MDL. The estimated net margin, calculated as the ratio of net profit to sales revenue, is 30.2%, meaning that for every 1 MDL earned in sales revenue, 30.2 bani constitutes net profit, after covering all expenses, including cost of sales, distribution and administrative expenses, and taxes.

Table 10 presents a comparative analysis of the financial performance across three different production scenarios: processing grape

pomace into a single product (oil), processing grape pomace into two products (oil and polyphenol extracts), and processing grape marc into three products (oil, polyphenol extracts, and biochar). The evaluated indicators include investment expenditures, net profit (expressed in both MDL and EURO), return on investment (ROI), and the payback period.

Table 10. Determining efficiency indicators of the investment project

Indicators	Oil production	Oil and polyphenol extracts production	Grape seed oil, polyphenol extracts, and biochar production
Investment Expenditures (MDL)	291 176 030	366 176 031	**496 124 031**
Investment Expenditures (EUR)	15 157 602	19 061 839	**25 826 476**
Net Profit (MDL)	390 74 670	71 412 962	**109 283 065**
Net Profit, EUR, 1 EUR=19.2099 MDL	2 034 090	3 717 508	**5 688 892**
Return on Investment (ROI), *%, Net profit/ Investment Expenditures *100%*	13.42	19.50	**22.03**
Payback Period (Years) *Investment Expenditures / Net Profit*	7.45	5.13	**4.54**

Source: elaborated by the author based on economic calculations from subsection 3.2

The capital expenditures for the investment project aimed at establishing a company for processing grape pomace into oil are estimated at approximately **€15 million**. In this scenario, the **rate of return (ROI)** is **13.42%**, and the **payback period** is estimated to be around **7.45 years**.

The second scenario involves establishing a grape pomace processing plant that produces two products: **oil and polyphenol extracts**, requiring investments of approximately **€19 million**. In this case, the **ROI** increases to **19.5%**, and the **payback period** decreases to **5.13 years**.

The most promising investment project is the establishment of a **complex closed-loop processing plant**, producing three products: **oil, polyphenol extracts, and biochar**. With a capital investment of about **€25.8 million**, this project would generate an **ROI** of **22%** and a **payback period** of **4.54 years**. This project represents the most financially advantageous

option, yielding the highest profitability and the shortest payback period among the alternatives.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. The evolution of the circular economy concept reflects a paradigm shift in the utilization of natural resources over time. Early thinkers such as John Stuart Mill and Thorstein Veblen were among the first to recognize the detrimental impact of uncontrolled consumption, laying the groundwork for resource conservation studies. Alexander von Humboldt and Henry David Thoreau contributed significantly/made significant contributions to understanding the interplay between economic practices and environmental sustainability, highlighting the need for a balance between economic development and the preservation of natural resources. In the early 20th century, recycling efforts were limited, primarily driven by military imperatives. It wasn't until the late 20th century that influential reports, such as the 1987 Brundtland Report (Our Common Future) promoted the idea of reconsidering waste as valuable resources. The concept of a circular economy began to solidify during this period, gaining practical significance in 2010 with the establishment of the Ellen MacArthur Foundation in the United Kingdom, thus transforming from an abstract notion into a sustainable economic model. (Subchapter 1.1)
2. The theoretical analysis highlights the inherent limitations of the linear economic model, characterized by the extraction, processing, consumption, and subsequent disposal of resources as waste. This unsustainable practice/approach has led to an alarming depletion of natural resources. Projections suggest that if the "produce-consume-dispose" linear model continues, the global demand for resources could reach the equivalent of three Earths by 2050. These findings emphasize the urgent/pressing need for a paradigm shift toward a circular economy, which prioritizes resource efficiency, waste minimization, and the restoration of economic and environmental equilibrium. (Subchapter 1.1)
3. The diversity of circular business models presented in this research highlights the variability and complexity of approaches required to integrate circular economy principles across different sectors. A comparative analysis reveals that there is no universally applicable economic model suited to all industries. Each circular business model provides tailored solutions designed to address the unique needs and contextual challenges of specific industries, thereby supporting a more effective and sustainable transition toward a circular economy. (Subchapter 1.2)

4. In the Republic of Moldova, the transition to a circular economy in the wine sector has been supported by Law No. 209/2016 on waste, which aligns national legislation with European Union standards. This law introduced *extended producer responsibility* (EPR) and *life cycle assessment* (LCA) as tools for evaluating environmental impact. Additionally, the Wine and Vine Law No. 57/2006 mandates that economic agents process by-products either within the company or through specialized enterprises. However, the legal framework in the Republic of Moldova lacks specific requirements regarding the minimum alcohol content in by-products, deadlines for disposal, and clear implementation procedures. In contrast, Delegated Regulation (EU) 2019/934 of the European Commission provides more detailed guidelines on these matters. Government Decision No. 356/2015, which approves the Regulation on the Organization of the Wine Market, includes a list of by-products and new products that can be obtained through their valorization. It is important to note that the current list of permissible products derived from the processing of wine by-products is limited and requires revision to include a broader range of product categories, along with the establishment of quality standards for these new products. (Subchapter 1.3)

5. The factual study of the wine sector in the Republic of Moldova highlights the strategic importance of this industry for both economic development and the preservation of the country's cultural and social identity. The southern and central regions are the primary hubs for grape processing, generating significant quantities of by-products, especially pomace. Annually, the wine sector in the Republic of Moldova produces between 35,000 and 40,000 tons of grape pomace, with the largest quantities coming from Cahul district (17%), followed by Causeni, UTA Gagauzia, and Tiraspol (16.33%, 12.26%, and 8.48%, respectively). Managing pomace represents a major challenge for winemaking enterprises, making the adoption of a circular and sustainable approach essential to addressing this issue. (Subchapter 2.3)

6. The results of the study reveal that, although 45% of enterprises process wine by-products, most of them (66.6%) utilize less than 50% of the total quantity generated, resulting in significant amounts of waste. When by-products are not processed, their management is handled in two ways: a) Transport and disposal to an authorized landfill (53% of responses); b) Commercialization (46% of responses).

7. The survey results validate Hypothesis 1: *the business model in the wine sector is predominantly linear and places little emphasis on the*

valorization of resulting by-products. (Subchapter 1.4) The study of circular models in the global wine industry, such as Caviro EXTRA in Italy, Grap'SUD in France, and Tarac Technologies in Australia, demonstrates the effectiveness of circular business models, which are not only economically viable but also socially and environmentally sustainable. By adapting these best practices to the local context, Moldova could foster the transition toward an innovative wine sector, better equipped to address contemporary challenges, thereby contributing to improved resource management and reduced environmental impact. (Subchapter 2.3)

8. The research proposes a circular model for the integrated valorization of pomace through cascade processes, which generates three products: grape seed oil, extracted polyphenols, and biochar.

Three distinct investment scenarios are economically argued and evaluated:

Scenario 1: Establishment of a plant that processes pomace to exclusively produce grape seed oil.

Scenario 2: Establishment of a plant that produces two products from pomace: grape seed oil and polyphenols.

Scenario 3: Establishment of a plant that implements an integrated closed-loop pomace valorization process, generating three value-added products: grape seed oil, polyphenols, and biochar.

The results of the economic analysis demonstrate that the circular model, based on the integrated valorization of pomace, is the most viable and promising option. Thus, Hypothesis 2 is confirmed: the implementation of a circular business model in the wine sector of the Republic of Moldova at an industrial scale is feasible and will generate significant economic, social, and environmental benefits. According to the analysis and calculations performed, the establishment of an integrated closed-loop pomace processing enterprise, based on the biorefinery concept, indicates Cimislia district as the most optimal location from both an economic and logistical standpoint. (Subchapter 3.2)

9. The valorization of grape pomace based on the biorefinery concept requires significant investment expenditures. To address this financial challenge, a public-private business model could be a viable solution, enabling both public and private sectors to share the costs and risks. Alternatively, the cooperative model, successfully applied in countries like France and Italy (e.g., GRAP'SUD, CAVIRO), could be adapted. In this model, multiple stakeholders, such as wine producers and small enterprises, could collaborate to process pomace collectively. Another option would be

to operate on the basis of an independent commercial enterprise model, which would provide by-product collection and management services, a relevant example being TARAC, Australia. (Subchapter 2.2)

Based on the comprehensive research conducted and the results obtained, we propose the following recommendations:

- ***To the Ministry of Agriculture and Food Industry:***

To amend Government Decision No. 356/2015 by revising Annex 8 to expand the list of products that can be derived from vinicultural/winemaking/wine industry by-products, accompanied by the development of corresponding quality standards, enabling the diversification of products and fostering innovation within the sector. (Subchapter 1.3);

To draft a legislative proposal to amend and supplement the Vine and Wine Law No. 57/2006, establishing clear requirements for the controlled withdrawal of by-products, including exemptions for small-scale producers, minimum criteria for potential alcohol strength in fresh pomace, specific compliance deadlines, and detailed withdrawal procedures to ensure transparency and accountability. *(Subchapter 1.3)*

To update the definition of vinicultural/winemaking/wine industry by-products in the Vine and Wine Law No. 57/2006 (Article 2), emphasizing their value as essential resources within the circular economy and their contribution to the sustainable development of the sector. *(Subchapter 1.3)*

- ***To the National Office of Vine and Wine:***

To develop and disseminate a comprehensive national guide for wine enterprises, showcasing international best practices and diverse technological approaches for sustainable processing of grape pomace. *(Subchapter 3.1)*

To promote the adoption of circular business models among winemaking enterprises, encouraging the integrated use of grape pomace to produce a wide range of high-value-added products, such as oils, polyphenol extracts, and biochar. *(Subchapter 3.2)*

- ***To relevant higher education institutions with technological and economic profiles:***

To intergrate courses and research modules on the circular economy and the valorization of wine industry by-products into study programmes, fostering the development of specialists in this emerging yet vital field, contributing to the sustainable growth of the wine industry.

BIBLIOGRAPHY

[1] Global Footprint Network. ©2003 [citat 28.06.2020]. Disponibil: https://www.footprintnetwork.org/

[2] **Global Footprint Network.** *Ecological Footprint Explorer: Country Trends*. [citat 28.06.2022]. Disponibil: https://data.footprintnetwork.org/?_ga=2.222088664.1728191766.1728568731-1074303417.1725445350#/countryTrends?type=BCtot,EFCtot&cn=146

[3] MACOVEANU, M., CIOBANU, D., NEDEFF, V., LEONTE, M. *Minimizarea scăzămintelor tehnologice în industria alimentară prin valorificarea subproduselor și deșeurilor*. Iași, Romania: Tehnica-Info. Vol. I., 2005, p.246. ISBN: 973-86847-8-1.

[4] MEADOWS, D.H., MEADOWS, D.L., RANDERS, J., BEHRENS, W.W. III. *Limits to growth*. United Kingdom: Universe Books, 1972. 33 p. ISBN 978-0-87663-901-5.

[5] World Commission on Environment and Development. *Our common future*. Oxford University Press, 1987. 400 p. ISBN 978-0195531916

[6] KENNETH, B. The economics of the coming Spaceship Earth. In: Jarrett, H., Ed., *Environmental Quality in a Growing Economy, Resources for the Future*. Johns Hopkins University Press, Baltimore [online], 1966 [citat 07.08.2021]. Disponibil: http://arachnid.biosci.utexas.edu/courses/THOC/Readings/Boulding_SpaceshipEarth.pdf

[7] Comisia Europeană. *Pactul ecologic european, 2020.* [citat 05.07.2022]. Disponibil: https://ec.europa.eu/commission/presscorner/detail/ro/ip_19_6691

[8] European Parliament. New Circular Economy Action Plan. 2020 [citat 22.01.2022]. Disponibil: https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-new-circular-economy-action-plan

[9] OECD, Business Models for the Circular Economy, *Opportunities and Challenges for Policy* [online]. 2019 [citat 10.12.2021]. Disponibil: https://www.oecd-ilibrary.org/sites/g2g9dd62-en/1/2/2/index.html?itemId=/content/publication/g2g9dd62-en&_csp_=f6c52d6e498bc965ab3e449882b5af7b&itemIGO=oecd&itemContentType=book#countryli_container4

[10] Larisa BUGAIAN, Maria GHEORGHIȚA, Rafael CILOCI, Cornelia CRUCERESCU, Iuliu ȚURCAN, Cristina DIACONU. Economie circulară: Note de curs. Chișinău, 2023, Editura ”Tehnica-UTM”, ISBN 978-9975-45-992-1.

[11] Council of the European Union. Circular economy [citat 10.08.2023]. Disponibil: https://www.consilium.europa.eu/en/policies/circular-economy/

[12] European Commission. *Roadmap to a resource efficient Europe* (COM(2011) 571 final). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee

of the Regions. [citat 20.12.2022]. Disponibil: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52011DC0571
[13] Comisia Europeană. *Închiderea buclei - un plan de acțiune al UE pentru economia circulară* (COM/2015/0614 final). [citat 20.12.2022]. Disponibil:https://eur-lex.europa.eu/legal-content/RO/TXT/?uri=CELEX%3A52015DC0614
[14] Legea nr. 209/2016 privind deșeurile. In: *Monitorul Oficial al Republicii Moldova*, 2016, nr. 459-471, art. 916. Disponibil: https://www.legis.md/cautare/getResults?doc_id=105806&lang=ro#
[15] Biroul Național de Statistică al Republicii Moldova. *Statistici pe domenii* [citat 10.01.2023]. Disponibil la: https://statistica.gov.md/ro/statistic_domains
[16] Oficiul Național al Viei și Vinului.
[17] JIN, Q. *Integrated Process Design and Techno-Economic Analysis of a Grape Pomace Biorefinery:* doctoral dissertation. Virginia, 2020. 161 p.
[18] TAIFOURIS, M., EL-HALWAGI, M., & MARTIN, M. Evaluation of the Economic, Environmental, and Social Impact of the Valorization of Grape Pomace from the Wine Industry. In: *ACS Sustainable Chemistry & Engineering* [online]. *2023*, 11, 13718−13728. [citat 10.09.2023]. ISSN 2168-0485. Disponibil: https://doi.org/10.1021/acssuschemeng.3c02592.
[19] GÓMEZ-BRANDÓN, M., LORES, M. & DOMÍNGUEZ, J. Recycling and valorization of distilled grape marc through vermicomposting: a pilot-scale study. *In: Material Cycles Waste Management* [online]. *2023, Vol.* 25, pp. 1509–1518. [citat 10.09.2023]. ISSN: 1438-4957. Disponibil: https://doi.org/10.1007/s10163-023-01627-6
[20] CHOJNACKA, K. *Valorization of biorefinery residues for sustainable fertilizer production: a comprehensive review*. In: Biomass Conversion and Biorefinery [online]. *2023*,**13**, 14359–14388. 768 [citat 02.10.2023]. ISSN 2190-6823. Disponibil: https://doi.org/10.1007/s13399-023-04639-2
[21] HEIZER, J. *Production and Operations Management*. Needham Heights, Massachusetts: Allyn and Bacon, 1991., 353 p. ISBN: 0205127231.
[22] ANIL KUMAR, N. SURESH. *Production and Operational Management, Second Edition*. New Delhi: New Age International (P) Ltd, 2008, 55 p. ISBN: 978-81-224-2425-6.
[23] Google. (2024). Google Maps. [citat 25.11.2023]. Disponibil: www.google.com/maps
[24] Google. (2024). *46°31'19.3"N 28°40'57.5"E*. Google Maps. [citat 25.11.2023]. Disponibil: https://www.google.com/maps/place/46%C2%B031'19.3%22N+28%C2%B040'57.5%22E/@46.5352859,28.3482536,10.75z/data=!4m4!3m3!8m2!3d46.5220127!4d28.6826323
[25] WANG, H., MCGLINCHY, I., SAMUELSON, R. Real-world fuel economy of heavy trucks [online]. New Zealand, Ministry of Transport, Transport Knowledge Conference 2019 [citat 10.01.2023]. Disponibil:

https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2019/Real-world-fuel-economy-of-heavy-trucks.pdf.
[26] Agenția Națională pentru Reglementare în Energetică a Republicii Moldova [citat 10.07.2024]. Disponibil: https://www.anre.md/motorina-3-3
[27] Legea nr. 489/1999 privind sistemul public de asigurări sociale. In: *Monitorul Oficial al Republicii Moldova*, 2000, nr. 1-4, art. 2.
[28] Diez, © 2023 [citat 10.07.2024]. Disponibil:https://diez.md/2023/05/08/care-sunt-cele-mai-platite-joburi-din-domeniul-transporturilor-din-moldova-afla-cum-sa-le-obtii/.
[29] Agenția Națională pentru Reglementare în Energetică a Republicii Moldova [citat 10.07.2024]. Disponibil: https://www.anre.md/
[30] JIN, Q. *Integrated process design and techno-economic analysis of a grape pomace biorefinery*: Doctoral dissertation, Virginia Polytechnic Institute and State University. Blacksburg, 2020. 161 p.
[31] PETERS, M.S., TIMMERHAUS, K.D. *Plant Design and Economics for Chemical Engineers* (4th ed.). New York: McGraw-Hill, 1991, 203 p. ISBN 0-07-049613-7.
[32] TODD, R., BAROUTIAN, S. *A techno-economic comparison ofsubcritical water, supercritical CO2and organic solventextraction of bioactives from grape marc*. In: Elsevier, J. Clean. Prod. [online]. 2017, 158, pp. 349–358 [citat 10.09.2023]. ISSN: 1879-1786. Disponibil: https://www.sciencedirect.com/science/article/abs/pii/S0959652617309691?via%3Dihub
[33] Hotărârea Guvernului nr. 941/2020 cu privire la aprobarea Catalogului mijloacelor fixe. In: *Monitorul Oficial al Republicii Moldova*, 2020, nr. 372-382, art. 1141.
[34] PETERS, M.S., TIMMERHAUS, K.D., WEST, R.E. *Plant Design and Economics for Chemical Engineers* (5th ed.). New York: McGraw-Hill, 2003, 274 p. ISBN: 0-07-239266-5.
[35] Eurostat. *European Commission* [citat 10.09.2023]. Disponibil: https://ec.europa.eu/eurostat/databrowser/view/PRC_HICP_MANR__custom_3761882/bookmark/table?lang=en&bookmarkId=4ad27e6f-358a-4a3d-82a0-587d69a833eb
[36] Machineseeker [citat 10.05.2024]. Disponibil: https://www.machineseeker.md/meusburger-mpa2+baustoff+7%2C3+m+verzinkt+bpw+alufelgen/i-16935466
[37] MAROULIS, Z.B., SARAVACOS, G.D. *Food process design*. CRC Press, 2003. 47 p. ISBN:9780203912010.
[38] MAROULI, A.Z., MAROULIS, Z.B. Cost data analysis for the food industry. In: *Journal of Food Engineering* [online]. 2005, 67, 289–299, p.299 [citat 10.09.2023]. ISSN: 1873-5770. Disponibil: https://doi.org/10.1016/j.jfoodeng.2004.04.031.

[39] Tridge. *Grapeseed Oil Price* [citat 10.09.2023]. Disponibil: https://www.tridge.com/intelligences/grapeseed-oil/price.
[40] Alibaba [citat 10.12.2023]. Disponibil: https://www.alibaba.com/trade/search?spm=a2700.7724857.the-new-header_fy23_pc_search_bar.keydown__Enter&tab=all&SearchText=grape+seed+polyphenol

LIST OF SCIENTIFIC PAPERS PUBLISHED ON THE TOPIC OF DOCTORAL THESIS
Author Cristina DIACONU, PhD student of the Doctoral School, Technical University of Moldova

2. Papers in scientific journals

2.1 in internationally recognized journals

2.1.1 BUGAIAN, Larisa, **DIACONU, Cristina.** Quantifying the sustainability of the wine sector through life cycle assessment (LCA). In: *Economia Contemporană*, 2022, vol. 7, nr. 4, pp. 63-69. ISSN 2537-4222. https://ibn.idsi.md/ro/vizualizare_articol/199545

2.1.2 **DIACONU, Cristina,** BUGAIAN, Larisa. Valorization of winery waste. case of the Republic of Moldova. In: *European Journal of Accounting, Finance and Business*, 2021, vol. 16, pp. 1-8. ISSN 2344-102X.

2.1.3 **DIACONU, C.,** BUGAIAN, L. The Legislative Framework for Circular Economy in the Wine Industry of the Republic of Moldova. In: European Journal of Accounting, Finance & Business, Vol. 12, nr.2, pp. 3-9 ISSN: 2344 - 102X https://www.accounting-management.ro/index.php?pag=showarticle&issue=35&year=2024&brief=352

2.1.4 Cristina DIACONU, Larisa BUGAIAN. Circular Economy: Perception among wineries of the Republic of Moldova. In: The USV annals of Economics and Public Administration, Vol. 22, Issue 1(35), 2022. http://repository.utm.md/bitstream/handle/5014/28109/USV-Annals-Economics-Public-Admin-2022-V22-N1-p26-36.pdf?sequence=1&isAllowed=y

2.2 in journals from the National Register of professional journals, category B

2.2.1 BUGAIAN, Larisa, **DIACONU, Cristina.** Circular economy: concepts and principles. In: *Journal of Social Sciences*, 2020, vol. 3, nr. 2, pp. 5-12. ISSN 2587-3490. DOI: https://doi.org/10.5281/zenodo.3871301

2.2.2 **DIACONU, Cristina.** Assesment of progress indicators for achieving sustainability in the wine industry. In: Journal of Social Science, 2024 (în curs de publicare)

3. Papers in the proceedings of conferences and other scientific events

3.2 in the proceedings of scientific events abroad included in databases accepted by ANACEC

3.2.1 **DIACONU, C.,** BUGAIAN, L. Understanding circular economy and sustainable development awareness. Міжнародна науково-методична конференція. 2021, pp 29-32. https://repo.btu.kharkov.ua/bitstream/123456789/17840/1/universytetska_osvita_nauka_2021_29_32.pdf

3.3 in the proceedings of international scientific conferences (Republic of Moldova)

3.3.1 BUGAIAN, Larisa; ARPENTIN, Gheorghe; **DIACONU, Cristina**. Perceperea economiei circulare de către sectorul vinicol al Republicii Moldova. Conference Proceedings „Competitiveness And Sustainable Development in the Context of European Integration", 2021, pp 95-101. http://repository.utm.md/handle/5014/18379

3.3.2 **DIACONU, Cristina.** Measuring the progress towards sustainability in the wine sector of the Republic of Moldova. In: Smart Life Sciences and Technology for Sustainable Development, Ed. Ediția 13, 28 iunie 2023, Chișinău. Editura „Tehnica-UTM", 2023, p 29, ISBN 978-9975-64-363-4.

3.4 in the proceedings of national scientific conferences with international participation

3.4.1 **DIACONU, C.** Modele de afaceri în economia circulară. Exemple de bune practici. In: *Conferința tehnico-științifică a studenților, masteranzilor și doctoranzilor*, 23-25 martie 2021, Chișinău. Chișinău, Republica Moldova: Tehnica-UTM, 2021, Vol.2, pp. 130-133. ISBN 978-9975-45-701-9 (Vol. II). https://ibn.idsi.md/vizualizare_articol/134781

5. Other scientific works

5.1 Course notes: Topic 5. Developing the circular economy model at the enterprise level. pp.93-121

BUGAIAN, Larisa; GHEORGHIȚA, Maria; CILOCI, Rafael; CRUCERESCU, Cornelia; ȚURCAN, Iuliu; **DIACONU, Cristina.** Publishing house "Tehnica UTM", 2023, 155 p. ISBN 978-9975-45-992-1. http://repository.utm.md/bitstream/handle/5014/25094/Economie-circulara-Note-curs_DS.pdf?sequence=1&isAllowed=y

ADNOTARE

Diaconu Cristina "Dezvoltarea modelului de afaceri circular în sectorul vitivinicol al Republicii Moldova", teză de doctor în științe economice. Chișinău, 2025.

Structura lucrării: introducere, trei capitole, concluzii generale și recomandări, bibliografie din 172 titluri, 10 anexe, 135 pagini, 38 figuri, 48 tabele.

Rezultatele obținute sunt publicate în 11 lucrări.

Cuvinte cheie: economie circulară, dezvoltare durabilă, modele circulare de afaceri, industria vinicolă, tescovină, produse secundare, biorafinărie, procese în cascadă.

Scopul cercetării constă în dezvoltarea și argumentarea economică a un model de afaceri circular pentru valorificarea integrată, în buclă închisă, a tescovinei de struguri, un produs secundar major aferent procesului de producere a vinului. Modelul propus se fundamentează pe conceptul de biorafinărie și vizează implementarea la scară industrială, contribuind astfel la creșterea durabilității sectorului vitivinicol din Republica Moldova.

Obiectivele lucrării: analiza și determinarea stadiului actual al economiei circulare, identificând practici, modele și provocări specifice; analiza și evaluarea importanței sectorului vitivinicol în dezvoltarea socio-economică a Republicii Moldova, efectuarea unui studiu referitor la cadrul legislativ european și național privind economia circulară cu accent pe industria vinicolă; analiza și evaluarea bunelor practici internaționale în implementarea modelului economic circular în sectorul vitivinicol; evaluarea practicilor actuale de gestionare a produselor secundare vinicole și estimare a gradului de valorificare a acestora în Republica Moldova; evaluarea fezabilității unei întreprinderi industriale de valorificare integrată, în buclă închisă a tescovinei de struguri, bazată pe conceptul de biorafinărie, pentru sectorul vitivinicol din Republica Moldova.

Noutatea și originalitatea științifică a lucrării. Teza aduce contribuții semnificative prin propunerea și argumentarea economică a unui model de afaceri circular, aplicabil la scară industrială, bazat pe conceptul de biorafinărie, pentru industria vinicolă din R.Moldova.

Rezultatul obținut aduce o contribuție cu caracter științifico-practic la soluționarea problemei de gestionare ineficiente a tescovinei în industria vinicolă a Republica Moldova, prin dezvoltarea și argumentarea economică a unui model de afaceri circular de valorificare integrată la scară industrială a tescovinei de struguri.

Importanța teoretică. Teza aduce contribuții științifice care extind cadrul teoretic și conceptual al economiei circulare și contribuie la înțelegerea modului în care principiile economiei circulare pot fi integrate eficient în industria vinicolă. Este propusă o cronologie de formare a conceptului economiei circulare, și o substituire a termenului de „produs secundar vinicol" din legislație. Prin analiza detaliată a cadrului legislativ și a inițiativelor internaționale și naționale, teza oferă un suport teoretic pentru fundamentarea politicilor publice și a strategiilor naționale în domeniul economiei circulare.

Valoarea aplicativă a cercetării se manifestă prin faptul că rezultatele cercetării permit conturarea unor direcții concrete de ameliorare a situației cu privire la gestionarea produselor secundare vinicole contribuind astfel la dezvoltarea sustenabilă a sectorului vitivinicol din Republica Moldova. Modelul propus oferă o soluție pentru închiderea buclei în procesul de prelucrare a tescovinei, reducând practic la zero generarea deșeurilor.

Implementarea rezultatelor științifice. Rezultatele au fost acceptate spre implementare de către MAIA, ONVV, Întreprinderea Mixtă „Vinăria Purcari" S.R.L. Rezultatele importante din lucrare vor fi utilizate în procesul didactic la Facultatea Inginerie Economică și Business, precum și în acțiunile de proiectare-dezvoltare în domeniu.

АДНОТАЦИЯ

Diaconu Cristina"Развитие циркулярной бизнес-модели в винодельческом секторе Республики Молдова", Докторская диссертация по экономике. Кишинев, 2025.

Структура диссертации: введение, три главы, общие выводы и рекомендации, библиографию из 172 наименований, 10 приложений, 135 страниц, 38 рисунков, 48 таблиц.

Результаты опубликованы в 11 научных работ.

Ключевые слова: циркулярная экономика, устойчивое развитие, циркулярные бизнес-модели, винодельческая промышленность, тесковина, побочные продукты, биопереработка, замкнутый процессы.

Цель диссертации - разработать и экономически обосновать модель циркулярного бизнеса для интегрированной, замкнутой модели использования виноградной кожицы, основного побочного продукта процесса производства вина. Данная модель основана на концепции биоперерабатывающих заводов и направлена на ее внедрение в промышленных масштабах, способствуя тем самым устойчивому развитию винодельческого сектора в Республике Молдова.

Задачи исследования состояли в: проанализировать и определить текущее состояние циркулярной экономики, выявить конкретные практики, модели и проблемы; проанализировать и оценить значение винодельческого сектора в социально-экономическом развитии Республики Молдова, провести исследование европейской и национальной законодательной базы по циркулярной экономике с акцентом на винодельческую отрасль; проанализировать и оценить лучшие международные практики внедрения модели циркулярной экономики в винодельческом секторе; оценить текущие практики управления побочными продуктами виноделия и степень их валоризации в Республике Молдова. Оценка целесообразности создания промышленного предприятия интегрированной замкнутой валоризации виноградной косточки, основанного на концепции биопереработки, для винодельческого сектора в Республике Молдова.

Оригинальность и научная новизна диссертации: Диссертация вносит значительный вклад в исследовательскую область работы, предлагая и экономически аргументируя циркулярную бизнес-модель, применимую в промышленном масштабе, на основе концепции биопереработки, для винодельческой промышленности в Республике Молдова., предлагая и экономически аргументируя модель циркулярного бизнеса, применимую в промышленных масштабах, основанную на концепции биопереработки, для винодельческой отрасли Республики Молдова.

Полученный результат вносит научно-практический вклад в решение проблемы неэффективного управления виноградным сырьем в винодельческой отрасли Республики Молдова путем разработки и экономического обоснования круговой бизнес-модели комплексной валоризации виноградного сырья в промышленных масштабах.

Теоретическая значение. Диссертация вносит научный вклад, расширяющий теоретическую и концептуальную базу циркулярной экономики и способствующий пониманию того, как принципы циркулярной экономики могут быть эффективно интегрированы в винодельческую отрасль. Предложена хронология становления концепции циркулярной экономики, а также замена термина «побочный продукт виноделия» в соответствующем законодательстве. Подробно анализируя законодательную базу, международные и национальные инициативы, диссертация

обеспечивает теоретическую поддержку для обоснования государственной политики и национальных стратегий в области циркулярной экономики.

Прикладная ценность исследования проявляется в том, что его результаты позволяют наметить конкретные направления для улучшения ситуации с управлением побочными продуктами виноделия, способствуя тем самым устойчивому развитию винодельческого сектора в Республике Молдова. Предложенная модель предлагает решение, позволяющее замкнуть цикл в процессе переработки тесковины, сведя образование отходов практически к нулю.

Результаты исследования были приняты к внедрению MAIA, ONVV, „Винария Пуркари" ООО. Важные результаты работы будут использованы в учебном процессе на факультете экономической инженерии и бизнеса, а также в проектно-конструкторских работах в данной области.

ANNOTATION

DIACONU Cristina „Development of the circular business model in the wine sector of the Republic of Moldova", doctoral thesis in Economic Sciences, Chisinău 2025.

Structure of the Thesis: the thesis comprises an introduction, three chapters, general conclusions and recommendations, a bibliography of 172 titles, and includes 10 appendices, 135 pages, 38 figures, and 48 tables. The results obtained are published in 11 papers.

Keywords: circular economy, sustainable development, circular business models, wine industry, pomace, secondary products, biorefinery, cascading processes.

The purpose of the research: to develop and economically justify a circular business model for the integrated closed-loop valorization of grape pomace in the wine sector of the Republic of Moldova. This model is based on the concept of biorefinery and aims for its implementation on an industrial scale, thereby contributing to the sustainability of the viticulture sector in the Republic of Moldova.

The objectives of research: analyzing and determining the current state of the circular economy, identifying specific practices, models, and challenges; analyzing and assessing the importance of the viticulture and wine sector in the socio-economic development of the Republic of Moldova; conducting a study on the European and national legislative framework regarding the circular economy, with a focus on the wine industry; analyzing and evaluating international best practices in implementing the circular economy model in the viticulture and wine sector; assessing current practices in managing wine by-products and estimating the degree of their utilization in the Republic of Moldova; evaluating the feasibility of an industrial enterprise for the integrated, closed-loop valorization of grape pomace, based on the biorefinery concept, for the wine sector in the Republic of Moldova.

The scientific novelty and originality. The research provides significant contributions by proposing and economically justifying a circular business model applicable on an industrial scale, based on the concept of biorefinery, for the wine industry in the Republic of Moldova.

The obtained results: it provides a scientific and practical contribution to addressing the inefficient management of grape pomace in the wine industry of the Republic of Moldova by developing and economically justifying a circular business model for the integrated valorization of grape pomace on an industrial scale.

Theoretical significance. The research provides scientific contributions that broaden the theoretical and conceptual framework of the circular economy and deepen the understanding of how the principles of the circular economy can be effectively integrated into the wine industry. It proposes a timeline for the development of the circular economy concept, as well as a replacement of the term "wine by-product" in the legislation. By providing a detailed analysis of the legislative framework and international and national initiatives, the thesis offers theoretical support for the development of public policies and national strategies in the field of the circular economy.

The applicative value of the research is manifested in the fact that the results of the research allow outlining concrete directions to improve the situation regarding the management of wine by-products, thus contributing to the sustainable development of the wine sector in the Republic of Moldova. The proposed model offers a solution for closing the loop in the process of processing of grape marc, reducing waste generation practically to zero.

Implementation of Scientific Results. The research results were accepted for implementation by MAIA, ONVV, Joint Venture "Vinăria Purcari". Important results from the work will be used in the teaching process at the Faculty of Economic Engineering and Business, as well as in design-development actions in the field.

CRISTINA DIACONU

DEVELOPMENT OF THE CIRCULAR BUSINESS MODEL IN THE WINE SECTOR OF THE REPUBLIC OF MOLDOVA

Scientific Speciality: 521.03 - ECONOMICS AND MANAGEMENT IN THE FIELD

(Social and economic sciences)

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