

Development of the dairy sector in Latvia: AGMEMOD scenario analysis

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Abstract. The dairy sector is one of the most important and complexly regulated agricultural sectors, making a significant contribution to the national economy, public employment, and rural development. At the same time, it is a strategically important part of the food supply system, which is influenced by political, economic, technological, social, and environmental factors. Due to these circumstances, it is essential to develop and analyze scenarios for the development of the sector, which allow for the prediction of possible future situations and the assessment of the impact of policy measures or market changes on the sustainability of the sector. This is made possible by various forecasting models that are widely used in the agricultural sector. One such model is AGMEMOD, which was developed to forecast the agricultural and food market in the European Union (EU). In this study, using the AGMEMOD, scenarios for the development of the Latvian dairy sector were analyzed based on current sector trends and expert opinions obtained during interviews. Two scenarios were developed and the results show that gradual and structured integration of technology into milk production processes can promote productivity growth and ensure more stable adaptation of the sector to political and economic challenges without increasing herd size. Overall, the introduction of technology is the most promising direction for the development of the sector, allowing the potential for innovation to be balanced with practical adaptation processes.

The aim of this study is using the AGMEMOD model to assess how different assumptions regarding technological progress and policy uncertainty may influence future milk production, herd size, and productivity.

Key words: dairy sector, scenarios, forecasting models, technologies, environmental requirements.

Introduction

Agriculture is one of the oldest and most important economic sectors, providing food and raw materials for both human consumption and industrial development. It can be described as a science and practical activity that involves growing plants and raising animals (Harris & Fuller, 2014). The sector serves as the basis for social and economic growth, while forming a close link with the use of natural resources. Today, the importance of agriculture is linked not only to food security, but also to issues of sustainable development and environmental protection, which determine its role in future global food systems (Robinson, 2024).

The agricultural sector is traditionally characterized as a combination of two interrelated subsectors - crop production and livestock farming - which provide the basis for food production for society and promote economic development (Knips, 2001). Cow's milk production is considered an important strategic

sector in many countries, as it not only promotes the development of primary agriculture, but also provides significant support to processing companies, which create jobs in various sectors of the economy (Bełdycka-Bórawska *et al.*, 2021).

Despite the fact that the dairy sector is one of the most important agricultural sectors, it is also considered one of the most strictly regulated agricultural sectors, as defined in particular by the EU's Common Agricultural Policy (CAP) (European Commission, n.d.). Accordingly, the sector needs to adapt and comply with both EU and national regulations.

This sector is also subject to the influence of various factors: economic challenges, technological developments, demographic trends, and changes in consumer demand have been significant factors that have shaped long-term changes in the dairy sector globally (Barkema *et al.*, 2015).

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In view of the above, it can be concluded that the development of the dairy sector is influenced by a set of interrelated factors covering political, economic, social, technological, and environmental aspects. The interaction of these factors shapes the direction of the sector's development and determines its ability to adapt to various challenges (Figure 1).

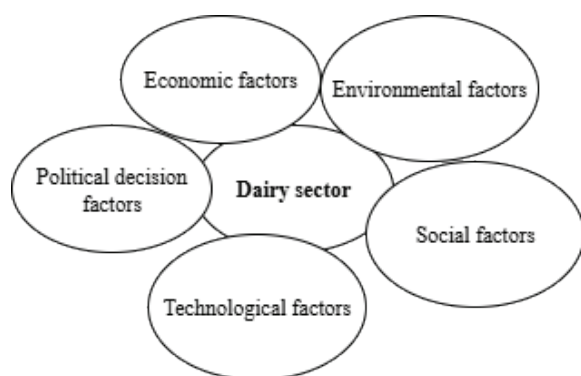


Figure 1. Groups of factors affecting dairy sector.

One of the sets of factors influencing the dairy sector is economic factors. Fluctuations in milk prices and increases in production costs (especially for feed and energy resources) can significantly affect farm income and their ability to remain competitive (Koutouzidou, 2022). Global events that affect production-related prices and demand can also have a significant impact on this sector. For example, Russia's full-scale invasion of Ukraine in 2022 caused gas and oil prices to rise, which also affected the agricultural sector as a whole (Darmayadi & Megits, 2023; Hassen & Bilali, 2022). Although energy markets partially stabilised in subsequent years, continued geopolitical uncertainty and market volatility through 2023–2025 have maintained elevated risk levels for agricultural producers. Another factor worth mentioning is the level of employee remuneration, which directly affects the dynamics and sustainability of the dairy sector (Stup, 2021; Mizik *et al.*, 2025). Additional economic factors include the cost of cultivation, farmland prices and labour wages, which determine both competitiveness and the ability of new producers to enter the sector (Tozer & Heinrichs, 2001).

Growing public interest in environmental protection significantly determines the development directions of the dairy sector and places emphasis on setting environmental requirements. Accordingly, environmental factors have a significant impact on the dairy sector, as dairy farming generates high greenhouse gas emissions, intensive water consumption, and pollution from manure, while milk processing generates significant amounts of wastewater and by-products. These circumstances

promote the integration of sustainability principles into production and processing processes (Castillo, 2018).

Social factors also have a significant impact on the development of the dairy sector, particularly demographic changes in rural areas, where an aging generation of farmers and a lack of interest in traditional agriculture among the younger generation are causing labor shortages (Ryan, 2023). At the same time, social factors include global population growth, which increases demand for dairy products (Grout, 2020).

Another important factor is the development of technology and its implementation on farms. Nowadays, the introduction of technological innovations on farms has become an integral prerequisite for the development and competitiveness of the dairy sector. The integration of solutions such as robotic milking systems, digital monitoring tools, and animal health monitoring systems into farms can significantly improve productivity and reduce labor costs (Naglova *et al.*, 2017; Lovarelli, 2020). Technology provide opportunities to optimize herd management, use resources more efficiently, and increase animal productivity. At the same time, it ensures timely identification of problems and rapid response, thus preventing potential risks before they negatively affect animal health or production efficiency (Lovarelli, 2020; Neethirajan & Kemp, 2021; Norton & Berckmans, 2017).

The last factor evaluated in the study is the political factors that determine the development directions of the dairy sector through financial support instruments – subsidies, tax breaks, and direct payments that promote farm adaptation, innovation, and knowledge transfer. The most important component of this factor is the CAP (European Parliament, 2024).

In view of the above, it can be concluded that the development of the dairy sector is determined by a combination of political, economic, social, technological, and environmental factors, which interact to influence market dynamics, competitiveness, and sustainability. However, in order to ensure the sustainable development of the sector, it is essential to identify not only macro-level impact factors, but also the direct factors that determine the efficiency and productivity of the production process itself.

The cow milk production sector is characterized by several indicators, including the number of farms with dairy cows, the average number of cows per farm, the average milk yield per cow, and overall milk production. These indicators provide an opportunity to objectively analyze the development of production capacity, the efficiency of resource use, and the level of technological progress (Figure 2).

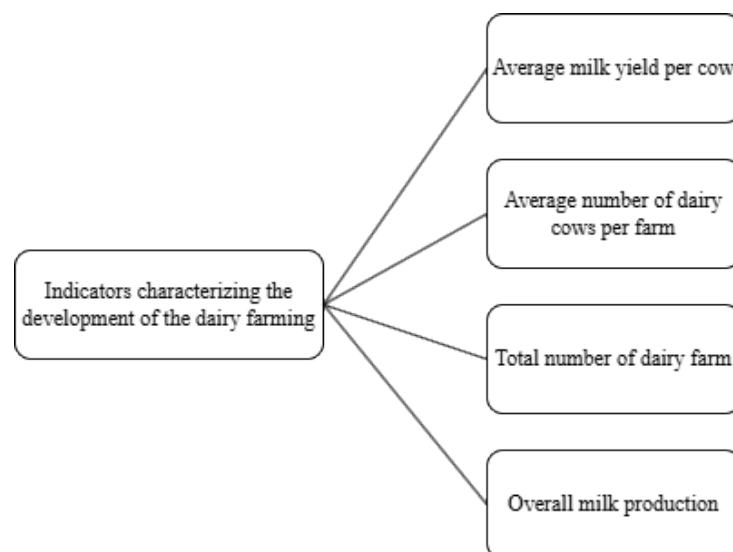


Figure 2. Indicators characterizing the development of the dairy farming.

Milk production processes are determined by several key indicators – average milk yield per cow, average herd size, total farm size and overall milk production. Average milk yield per cow is one of the most widely used productivity indicators in dairy farms, as it characterizes production efficiency regardless of herd size (Viira *et al.*, 2015; Olini *et al.*, 2020; Song *et al.*, 2024).

It should be noted that average milk yield per cow may differ depending on the statistical source used. In Latvia, higher yield values are typically reported for milk-recorded cows, as these data represent a selected group of farms with more intensive management and higher productivity. In this study, data provided by the Central Statistical Bureau (CSB) are used, as they cover the entire population of dairy farms and therefore better reflect the overall situation and average production conditions in the Latvian dairy sector.

Another important indicator is the average number of dairy cows on the farm, which determines the farm's milk production potential (Oleggini *et al.*, 2001), while the size of the farm as a whole determines the efficiency and sustainability of the sector (Ren *et al.*, 2019).

Regarding the Latvian context, structural changes in the dairy sector are particularly significant. Between 2002 and 2023, the Latvian dairy farming sector underwent substantial restructuring, reflected in a sharp decline in the total number of dairy farms from 71.3 thousand in 2002 to 8.5 thousand in 2023. The most pronounced decline occurred among small-scale farms. The number of farms with 1–2 cows and 3–5 cows decreased by 93.28% and 87.01%, respectively, over the period 2002–2023. In contrast, the number of medium-sized and large farms

increased. The most stable growth over the 21-year period was observed among farms with 300 or more cows, whose number rose from 28 in 2002 to 52 in 2023. This development indicates that large farms have increasingly become the dominant structure in milk production in Latvia.

Total milk production is calculated as the product of the number of dairy cows and the average milk yield per cow. Therefore, while dairy cow numbers and milk yield represent primary indicators, total milk production constitutes a derived but equally important indicator of the sector's overall production capacity.

It can be concluded that the dairy sector is complex and subject to the influence of various factors, so it is essential to use tools that can assess the impact of various factors on the sector's development potential. For this reason, agricultural system models have become important tools that provide forecasting capabilities to an increasingly wide range of decision-makers in both the private and public sectors (Antle *et al.*, 2017). Various forecasting models are used in agriculture to analyze the sector's response to certain changes, mainly in policy variables (Adenauer, 2008). One of the forecasting models used in the agricultural sector is the AGMEMOD model. The aim of this model is to provide an integrated modeling approach that takes into account the significant differences between the agricultural systems of different Member States (Salamon *et al.*, 2008). The model is a multinational partial equilibrium tool designed to forecast the agricultural and food markets in the EU. It provides the opportunity not only to develop scenarios for the development of the agricultural market, but also to analyze the impact of policy measures on the sector. In this context, aspects such as the impact of the

direct payment system on the structure of the sector, the consequences of trade restrictions for different product groups, and the impact of changes caused by climate change are taken into account (Salamon *et al.*, 2017). The model uses a separate module for each country, ensuring analytical consistency between countries. At the country level, it reflects agricultural policy using historical time series data as the basis for modeling (Nehrey *et al.*, 2019). In this study, the model is applied to assess how technological progress and policy uncertainty may influence milk production, herd size, and productivity.

Materials and Methods

The study uses the AGMEMOD partial (focus on specific sectors, such as agricultural sub-sectors, and allow for a detailed analysis of supply and demand interactions as well as policy impacts within a defined market) equilibrium model, which was developed to forecast the EU agricultural and food market (Kotevska *et al.*, 2013). The model integrates endogenous and exogenous data. Before identifying and modeling scenarios, expert interviews were conducted and, based on them, a PESTEL analysis was performed to identify the main factors influencing the sector.

In developing the scenarios, qualitative expert input was incorporated through semi-structured interviews conducted in 2025. Four experts representing key organisations in the Latvian dairy sector participated in the consultations. They included:

- (1) livestock production specialist from a national farmers’ organisation,
- (2) the executive representative of a breed association,
- (3) a senior researcher and academic expert in animal science, and
- (4) the owner of a commercial dairy farm.

The aim of the interviews was to identify ongoing structural changes in the dairy sector, assess technological and economic constraints, and determine the main challenges and potential development pathways.

To ensure a systematic approach, interview guidelines were developed encompassing the following thematic areas: farm structural dynamics; technology adoption and labour efficiency; milk quality and breeding priorities; market challenges; and the impact of climate policy on the sector.

Based on the results obtained, possible scenarios were identified and integrated into the model. The scenario results were validated using the TOPSIS method, which allows alternatives to be compared according to several criteria (average milk yield, number of dairy cows, total milk volume).

Results and Discussion

The model uses endogenous and exogenous data (Table 1) to forecast the development of the agricultural sector and analyze the impact of policies on the market (Laquai, 2023).

Within AGMEMOD, endogenous data are calculated using historical data and the impact of other variables, while exogenous data are interpreted as external factors that are not determined within the model itself but serve as input data for the preparation of agricultural forecasts. Another important aspect is that the EU-level price or “key price” is defined in the model as the price set in the most important Member State market for a specific product group. National models are designed to reflect the specific characteristics of each country’s agriculture, taking into account the specificities of national markets and economic conditions. Although their structure is uniform, the models are adapted to the situation in each country and then integrated into the common EU AGMEMOD system (Banse *et al.*, 2011).

Within AGMEMOD, the milk model is considered one of the most complex, as it consists of several interrelated components (Kotevska *et al.*, 2013). For example, the average milk yield of a single cow in the model may depend on technological trends, milk prices, and other exogenous variables that affect productivity. In turn, the total number of dairy cows is determined by dividing the total milk production by

AGMEMOD database – exogenous and endogenous variables

Table 1

Endogenous data	Exogenous data
Calculations based on historical data or calculations based on other variables	Exogenous input data necessary for scenario projection (defined outside the model structure)
Production statistics (area, number of livestock, yield, production), supplies, prices (producer prices, wholesale prices)	Macroeconomic variables (e.g., inflation rate, population, exchange rates), policy variables (e.g., agricultural policy, trade policy), other variables (e.g., technology indicator), and world market commodity prices

Source: Laquai, 2023.

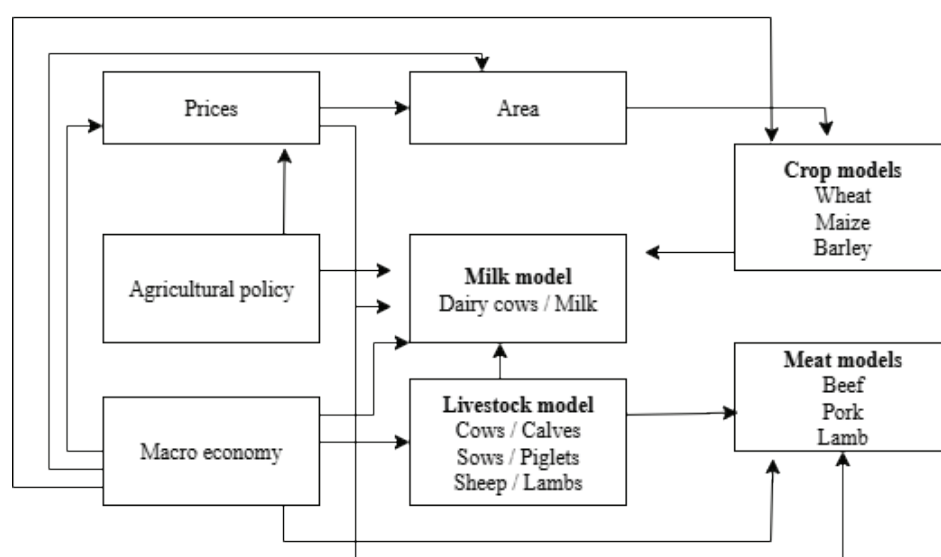


Figure 3. Interrelationships between AGMEMOD sub-models.

Source: Kotevska et al., 2013.

the average milk yield per cow (Hamulczuk & Hertel, 2009).

This model is widely used to create various scenarios to promote a better understanding of sector trends, which in turn provides clearer development directions for policymakers. AGMEMOD is mainly used to create a baseline scenario, which is a scenario for the future development of the agricultural market based on historical developments. This scenario is based on assumptions about exogenous variables that are determined outside the model (Salamon et al., 2019). However, it is important to note that the baseline scenario and the alternative scenarios are not considered to be predictions of the future, but rather possible scenarios for market development.

Given the purpose of the model, it was used to develop scenarios for the development of the Latvian dairy sector.

Expert interviews indicate clear structural changes in the Latvian dairy sector, characterized by a continued decline in smaller and less productive farms, while larger, modernized farms are becoming increasingly productive and competitive. These farms actively adopt advanced technologies, such as automated milking systems, which significantly improve labor productivity. In contrast, smaller farms often face knowledge and investment constraints that limit technology adoption.

Experts also highlighted structural characteristics of the dairy processing sector, noting a relatively fragmented structure with a large number of small-scale processors alongside several large enterprises. As a result, a substantial share of raw milk is exported,

which influences production strategies at the farm level and encourages a focus on high milk yields rather than milk composition.

Regarding future development, experts emphasized the need to shift from maximizing milk yield per cow toward more balanced and sustainable production. An optimal achievable milk yield of approximately 12,000 kg per cow was identified as consistent with animal health, reproduction, and long-term farm sustainability. Large farms were noted as more actively engaged in breeding programs, supported by greater technological capacity.

Finally, experts pointed to uncertainty related to EU climate and emission policies in Latvia, including the lack of a clear national implementation framework. This uncertainty, together with administrative burden, negatively affects long-term investment decisions.

Based on the results of the expert interviews, a PESTEL analysis was then carried out to identify the main influencing external factors (Table 2).

This PESTEL framework allows important conclusions to be drawn about trends in the development of Latvia's dairy sector and the impact of the external environment, for example, uncertainty in climate regulation affects the rate of financial resource utilization. Based on the results of the PESTEL, two scenarios were identified, which were developed and integrated into the AGMEMOD model: A "Targeted and Intensive Modernisation of Farms" and A2 "Limited Modernisation of Farms".

Scenario A "Targeted and Intensive Modernisation of Farms" envisages a situation where stable support for farm modernization is maintained and most farms

Table 2

PESTEL factors affecting the dairy sector in Latvia

Factor	Description	Impact on the sector
P – Political	No clear strategy for reducing GHG emissions has been defined in the sector; Compliance with regulatory requirements creates a significant administrative burden.	Promotes uncertainty and limits long-term investment opportunities.
E – Economic	Structural changes continue in the sector – the number of small farms is decreasing, while larger farms are becoming more competitive.	The country's potential for creating added value is declining; The competitiveness of small farms is gradually weakening.
S – Social	There is growing demand in society for higher animal welfare standards; The structure of the workforce is changing as a result of robotization, with an increasing need for digital skills.	A reorientation of production strategy is needed; Demand for employee training is growing.
T – Technological	Robotic milking systems and precision farming can significantly improve productivity.	Increases production efficiency and reorients the workforce.
E – Environmental	Possible tightening of regulations may apply to methane emission control.	Additional investments in emissions management.
L – Legal	Uncertainty in climate regulation.	Availability of financial resources is ensured with a delay.

are able to implement gradual technology adoption, while scenario A2 “Limited Modernisation of Farms” envisages a situation where the implementation of sustainability goals is hampered by an unclear regulatory framework, which in turn hinders the attraction of investment in farms.

The introduction of new technologies on farms is a trend that can be observed in the Latvian dairy sector. Technologies such as automated milking systems, animal health and feed monitoring systems provide opportunities for continuous production monitoring and data flow analysis. At the same time, these solutions promote sustainable agriculture and can also reduce the impact on the environment (Hassoun *et al.*, 2023; Abiri *et al.*, 2023; Méndez-Zambrano *et al.*, 2023).

Various EU reports also emphasize that future growth in the dairy sector will be based more on increasing the productivity of existing animals, which is directly linked to the introduction of new technologies, rather than on increasing herd numbers (European Commission, 2024; OECD-FAO Agricultural Outlook 2023-2032, 2024).

According to expert assessments, a similar trend is expected in Latvia, where further development of the dairy sector is likely to be driven primarily by

increases in average milk yield rather than by growth in dairy cow numbers.

Taking the above into account, as well as what experts said in interviews that a trend of technological development is observed in the agricultural sector in Latvia, scenario A, “Targeted and Intensive Modernisation of Farms” modeled the gradual integration of technology into production, emphasizing its importance in promoting long-term productivity growth.

As discussed earlier, milk yield levels may differ depending on the statistical source used. In 2024, the average milk yield per cow in Latvia was 8,239 kg according to data from the CSB, while in milk-recorded farms it reached 9,355 kg (Lauksaimniecības datu centrs, n.d.), illustrating the structural differences between the two data sources. Milk-recorded farms represent a more intensive and technologically advanced subset of producers, rather than the overall structure of the dairy sector. Therefore, for the purposes of this analysis, CSB data are used to ensure representativeness at the sector level.

Figure 4 shows that the “Baseline” scenario for 2032 predicted an average milk yield of 9295 kg, while in the gradual technology adoption scenario this value reached 9769 kg. This means that, compared

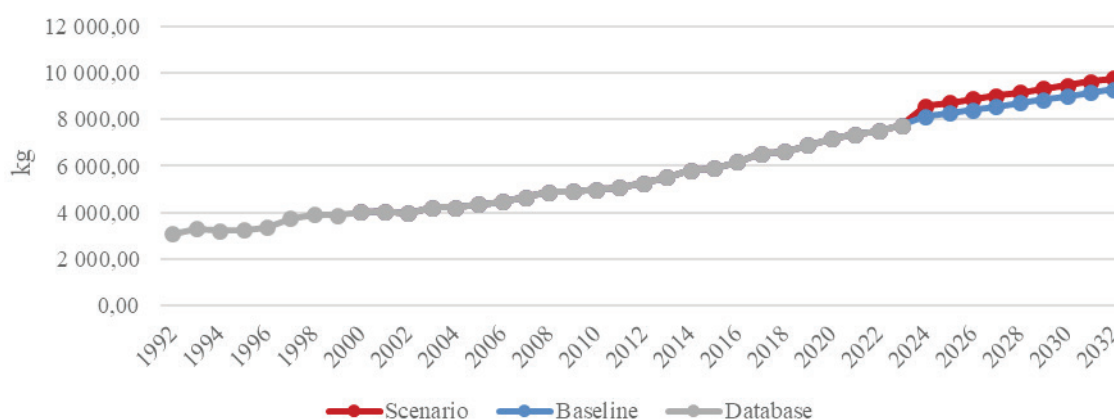


Figure 4. Results of Scenario A “Gradual technology adoption”.

Source: AGMEMOD results.

to the initial development trajectory, the projected milk yield increases by 474 kg, or approximately 5.1%. This difference confirms the significant role of technological progress in increasing the efficiency of milk production.

Other fundamental indicators related to the dairy sector were also affected by this scenario. One such indicator is the number of dairy cows.

The data in Table 3 show that in the technology adoption scenario, the number of dairy cows throughout the forecast period remains approximately 5.0–5.4% lower than in the baseline scenario, and this difference gradually decreases (from -5.24% in 2024 to -5.03% in 2032). This means that the reduction in herd size is slightly faster than in the baseline scenario, but slows down over time. This trend is consistent with the assumption that the increase in milk yield per cow allows total milk production to be maintained with a smaller herd, while contributing to the continuation of structural change in the sector.

Taking into account the case modeled in scenario A “Targeted and Intensive Modernisation of Farms” an alternative development scenario was also developed, which envisages the restriction or gradual prohibition of environmentally unfriendly agricultural systems. The EU and its Member States

are tightening requirements in the area of emission reduction and environmental compliance. For example, the European Green Deal sets a climate neutrality target for 2050, while the EU Methane Strategy emphasizes the need to use technologies that reduce emissions without sacrificing production. Such policy trends point to possible restrictions on farms with an intensive production approach, particularly with regard to animal density, feed composition and fertilizer management. Moderate and stimulating regulations can encourage the introduction of new technologies, while strict or punitive requirements without adequate support mechanisms or inconsistent policies may hinder innovation and complicate its practical implementation (Long *et al.*, 2016; Sun, 2022; Dibbern *et al.*, 2024). It is also important to mention that there is a time lag between policy decisions and the implementation of investment cycles in Latvia. For example, the Recovery and Resilience Facility funding period ends in 2026, while discussions on methane regulation continue and the clarifications provided for in the National Energy and Climate Plan are being implemented gradually. In addition, the high administrative burden in the process of attracting funding hinders farmers’ ability to make effective use of available resources and, in some cases, leads to a

Table 3
Relative difference between scenario A “Targeted and Intensive Modernisation of Farms”
and scenario “Baseline”, %

Indicator	2024	2025	2026	2027	2028	2029	2030	2031	2032
Number of dairy cows	-5.24	-5.38	-5.33	-5.28	-5.23	-5.18	-5.13	-5.08	-5.03

Source: AGMEMOD results.

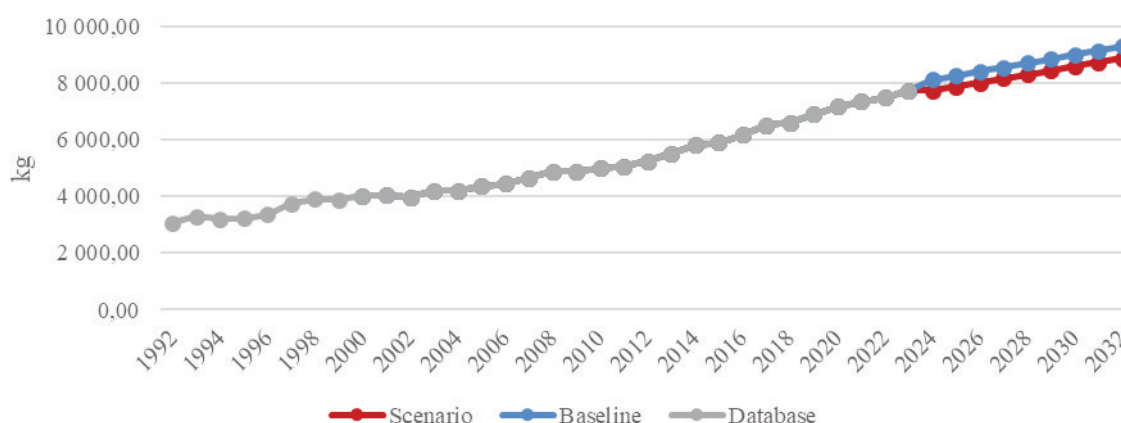


Figure 5. Results of scenario A2 “Limited Modernisation of Farms”, kg.

Source: AGMEMOD results.

situation where some of the available funds are not used at all (Zemkopības ministrija, 2024).

Taking into account the above considerations and expert indications that uncertainty in EU policy on emission reduction has a negative impact on farmers’ decisions, scenario A2 “Limited Modernisation of Farms” was developed.

Figure 5 shows that in the event of technological stagnation caused by environmental requirements and regulatory uncertainty, the average milk yield per cow increases more slowly than in the baseline scenario. Although the curve maintains its historical upward trend, its slope is smaller, which means a flattened growth rate. The baseline scenario for 2032 predicted an average milk yield of 9,295 kg, while in the A2 scenario it reached only 8,878 kg. The number of dairy cows also changed in this case, but it increased compared to the baseline scenario.

The Table 4 shows that by 2029, the herd is at least 5% larger than in the baseline scenario, but by 2032, the difference decreases to 4.89%. This indicates that with slower productivity growth, the sector maintains a larger herd to compensate for production volume, unless additional measures are introduced at EU or national level that could accelerate the decline in the number of smaller farms. This result reflects the structural pattern observed in Latvia over recent decades, where increases in average milk yield

have been associated with herd reduction and farm consolidation, supporting the internal consistency of the scenario assumptions.

A comparison of the three modeled scenarios illustrates how different rates of technology adoption affect productivity. In scenario A, by 2032, the average milk yield per cow reaches 9,769 kg, which is 4.85% more than in the baseline scenario and 9.12% more than in scenario A2, where technological development is slower. This difference develops gradually over several years, rather than suddenly. Farms that continue to invest and integrate automated solutions are able to increase milk yield per animal while reducing their dependence on herd size.

To test the scenarios obtained, they were analyzed using the TOPSIS method. This is one of the most widely used multi-criteria decision-making methods and is particularly suitable for situations where it is necessary to evaluate several alternatives, taking into account both quantitative and qualitative criteria. The basic principle of the method is based on the assumption that the optimal alternative is the one that is closest to the ideal positive solution and furthest from the ideal negative solution (Tzeng & Huang, 2011; Durbach & Stewart, 2012; Zavadskas *et al.*, 2016). In conducting this assessment, criteria such as the number of dairy cows, average yield per cow, and total milk production were analyzed. The assessment

Table 4
Relative difference between scenario A2 “Limited Modernisation of Farms” and scenario “Baseline”, %

Indicator	2024	2025	2026	2027	2028	2029	2030	2031	2032
Number of dairy cows	5.09	5.24	5.19	5.14	5.09	5.04	4.99	4.94	4.89

Source: AGMEMOD results.

Table 5

Decision matrix with real input data (before normalization)

Alternative	Average milk yield, kg	Total milk volume, thousand tons	Average number of dairy cows, thousands
Baseline	9295.7	836.6	90
A	9769	835.9	85.5
A	8878	838.2	94.4

Source: AGMEMOD results.

Table 6

Interim results of TOPSIS method calculations by scenario

Alternative	V_{k1}	V_{k2}	V_{k3}	S_i^+	S_i^-	C_i^*
Baseline	0.192	0.192	0.192	0.014	0.013	0.482
A	0.202	0.192	0.183	0.001	0.026	0.980
A2	0.183	0.193	0.202	0.026	0.001	0.020

Source: author's calculations.

 V_{k1} - weighted normalized criterion values for average milk yield per cow; V_{k2} - weighted normalized criterion values for total milk production; V_{k3} - weighted normalized criterion values for average number of dairy cows; S_i^+ distance of alternative i from the ideal (best) solution; S_i^- distance of alternative i from the anti-ideal (worst) solution; C_i^* closeness coefficient, indicating the relative proximity of alternative i to the ideal solution.

was carried out for all three scenarios – Baseline, A, and A2 – and the calculations used the scenario scores for 2032.

At the initial stage of applying the TOPSIS method, a decision matrix (Table 5) was created with the initial (non-normalized) data on the selected alternatives, and this matrix served as the basis for further data normalization and criterion weighting procedures.

Weights were assigned to the criteria, and in the base case, equal distributions (1/3) were used, subject to the condition that the weights cannot be negative and their sum is equal to 1. This approach is considered methodologically sound and widely used, as it provides a neutral reference point for further sensitivity analysis (Zhou, 2006).

The results of calculations using the TOPSIS method show that scenario A “Gradual technology adoption” (0.980), which confirms its maximum similarity to the ideal solution and its dominant position among the analyzed alternatives. The “Baseline” scenario obtained an average value (0.482), while scenario A2 “Limited Modernisation of Farms” obtained the lowest proximity coefficient (0.020), reflecting a significant difference from the ideal solution.

The results show that scenario A “Targeted and Intensive Modernisation of Farms” is closest to the ideal solution, confirming its balanced performance across all evaluation criteria and its dominant position compared to the other alternatives.

Scenario A, “Targeted and Intensive Modernisation of Farms” which provides for the structured and gradual integration of technology into production processes, can be considered a promising direction for development. This approach allows farms to gradually adapt to change, while the planned introduction of innovations ensures a more stable transition and more efficient use of resources.

Conclusions

The development of the dairy sector is determined by a wide range of factors, including political, economic, social, technological, and environmental aspects. The interaction of these elements determines both the competitiveness and long-term sustainability of the sector. The PESTEL showed that the sector in Latvia faces significant challenges – regulatory requirements and political uncertainty create risks in investment planning, and structural changes continue, with a decline in the number of small farms. Despite

these challenges, there is a noticeable trend towards the integration of technology in farms.

Scenario analysis showed different directions of development. Scenario A “Targeted and Intensive Modernisation of Farms” confirms that the gradual and systematic integration of new technological solutions (for example, milking technologies, feeding and automation technologies, animal health monitoring sensors) into farms increases productivity, reduces dependence on herd size, and ensures more efficient use of resources. This development direction allows farms to better adapt to market fluctuations and political requirements.

In contrast, scenario A2 “Limited Modernisation of Farms” indicates that policy inconsistency and the introduction of stricter requirements without sufficient support mechanisms create risks for innovation, reduce production efficiency, and hinder the competitiveness of the sector. In such a situation, the development of the sector is based on maintaining larger herds, which puts additional pressure on the environment and reduces the efficiency of resource use.

The application of the TOPSIS method confirmed that scenario A is closest to the ideal solution, ensuring balanced performance according to the selected criteria. This means that the gradual introduction of technology is the most promising development path, combining innovation potential with a practically feasible adaptation process. This approach ensures more stable sustainability of the sector and greater flexibility in the face of external challenges.

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