Logistic model for forecasting the growth of Ukrainian dairy exports

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Abstract. A logistic model has been proposed for forecasting the growth of Ukrainian dairy exports. The model takes into account the growth rates of consumption, imports, and domestic production of the importing country. It can be considered a decision-making tool for operators of the Ukrainian dairy market when developing an export strategy for future periods. To evaluate the potential attractiveness of sales markets for dairy product exports, we propose an analytical toolkit based on the taxonomy method. This toolkit facilitates the assessment of the potential attractiveness of foreign markets through sequential stages. These stages include identifying key criteria for determining the prospects of countries for the supply of dairy products, forming a matrix of input indicators, standardizing key factors for assessing market prospects, and calculating the integral coefficient of potential attractiveness for importing countries. This ranking system allows for a reasonable assessment of countries importing dairy products. The analytical tools developed for assessing the potential attractiveness of foreign markets and the logistic model for forecasting the growth of Ukrainian dairy exports enable practical monitoring of the prospects of potential foreign markets on an annual basis. They also facilitate timely and informed decisions on changing the export strategy and diversifying markets.

1 Introduction

In recent years, Ukraine has been actively seeking new export destinations for dairy products. This search is particularly relevant now due to the loss of traditional markets resulting from the outbreak of a large-scale war in Ukraine in 2022 and the decline in purchasing power of the domestic market [1-3].

When entering international markets, it is important to consider both consumer preferences for dairy products in a particular market and current global trends, as well as existing national traditions in the country of export. The most common dairy products on international markets are traditional products, including butter, cheese, casein, UHT milk, yogurt, desserts, and dried dairy products, such as milk powder, whey powder, and whey-based food ingredients [4-7].

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Fermented dairy products, including ryazhenka, sour cream and kefir, are typically associated with Eastern European cuisine and have a limited market in that region. On the other hand, laban, soft white cheese, and processed cheese are widely consumed in the Middle East. Simultaneously, it is important to consider whether the product offer is intended for B2B or B2C markets. The research focuses on identifying a range of dairy products suitable for export and determining the appropriate marketing tools to promote them in each potential export country. Dairy products for the B2C market include UHT milk, UHT yogurts, packaged instant milk powder, and condensed milk. Dairy products intended for business-to-business (B2B) markets include skimmed milk powder, butter, and whey powder. To assess the potential attractiveness of Ukrainian dairy markets, it is important to consider foreign consumers' preferences, national traditions, and consumption culture. Informed management decisions should be made to adapt the export strategy to international markets and diversify sales markets [8-10]. Dry dairy products with a longer shelf life that do not require cold chains are in high demand in North African countries [11]. When planning the stages of goods movement from the producer to the end consumer, it is important to consider the limited choice of markets due to the relatively short shelf life of most dairy products and the logistics challenges posed by active hostilities in eastern Ukraine, which have extended the supply chain to Asia and Africa.

2 Related works

Assessing the actual state of Ukraine's economic complex, including its individual industries and capabilities, is crucial for a prompt and appropriate response to global challenges. This will enable domestic producers to reorient themselves towards new international markets, resulting in a further increase in the export of goods and services with high added value [9]. The modern problems of the theory of economics and marketing of industrial enterprises in terms of globalization and international economic integration are studied by scientists in different directions [12-13]. One of the areas concerns the impact of globalization and international economic integration on world markets for goods and services, which is reflected in the scientific works of leading domestic and foreign scholars, including: R. Voitovych [14], A. Filipenko [6]. The study of the development of food and processing industry exports in the context of intensification of integration and globalization processes, as well as the development of international logistics, has been explored by economists such as E.Krykavskyi [2], O. Deineha [4], P. Kupchak [8], D.Tsaruk [12].

P. Kupchak [9] highlights the importance of Ukrainian producers increasing their volume of international trade to improve Ukraine's integration into the global market. As noted by R. Voitovych in his research paper [17], globalization policy should primarily aim to realize national interests by asserting and defending its own nationally regulated position in the global world, rather than adapting to the needs of the global development system. Approaches to achieving compromise solutions for the development of international economic integration into the global arena are described in the works of A. Filipenko [6]. Filipenko focuses on the development of integration in economic spaces that are characterized by less conflict and a willingness to transfer power to international institutions. The emphasis is on contractual and legal aspects.

Simultaneously with the strategic objective of increasing food exports, including dairy products, as outlined in scientific works [3], some authors have noted current issues facing the dairy industry in the context of the ongoing conflict. These issues include limited opportunities for exporting Ukrainian dairy products to the EU, increased production costs, loss of production capacity in the occupied territories, a reduction in the number of consumers in the domestic market, and the suspension of certain government programs.

An analysis of current perspectives on the development of exports of domestic food products, including the dairy processing industry, based on intensified marketing support for export activities of domestic operators when entering foreign markets, has highlighted the need for further research on this topic. This sentence appears to already meet the desired characteristics. No changes have been made.

3 Method

India, the EU, and China are the leading consumers of fresh dairy products, accounting for 23%, 11%, and 10% of total consumption, respectively. They are followed by Pakistan (8%) and the United States (6%). The consumption of dairy products in India and Pakistan is growing at an annual rate of 3-4%, while in the US and the EU, it is declining [5, 11]. Turkey, on the other hand, has the highest growth rate of fresh dairy consumption, averaging 9% annually. Skimmed milk powder is consumed in large volumes in the EU, the US, and Mexico, while whole milk is consumed in Brazil, China, and the EU. These countries are expected to continue increasing their consumption of both fresh and dried dairy products in the future. The EU, the US, and New Zealand account for 75% of skimmed milk powder exports, which is the product with the fastest-growing global demand, averaging 7% per year in recent years. Ukraine has also significantly increased its supplies of this export item.

The UN Population Fund's 2017 Report predicts that the world's population will reach 9.7 billion by 2050, an increase of 2 billion people. The demand for milk and dairy products will be driven by population growth, increased life expectancy, rising incomes, and accelerated urbanization. Currently, 83% of the world's population resides in Asia and Africa, with 1 billion people living in the least developed countries of Africa. As a result, the demand for food, including dairy products, will increase rapidly in these regions.

Dairy production and consumption in Asia are growing at a faster rate than in other regions. Some parts of the region have significant imports of dairy products, which are expected to continue to increase. The highest growth in demand for dairy products is anticipated in East Asia. FAO forecasts predict a 75% increase in demand in South Asia and a 50% increase in demand in Southeast Asia by 2050 [5]. Currently, Asia remains a significant net importer of dairy products, purchasing over 20 million tonnes annually. The majority of these products are imported from East and Southeast Asia, with the EU, Australia, and New Zealand being the primary suppliers. For Ukraine, the North Africa (MENA) and China markets are also crucial targets for dairy exports. Notably, China has the largest deficit in international milk trade. China's negative cash flow suggests untapped potential in this category of goods, creating opportunities for dairy-supplying countries to meet strong consumer demand from the country's population, which accounts for one-fifth of the world's 1.44 billion people. When developing a marketing strategy to enter the global dairy market, the Ukrainian dairy industry should consider several factors, such as the country's population, growth rate, GDP per capita, dairy product production and consumption, established trade relations, and net import of dairy products. The net import is determined by the difference between imports and exports, and a positive balance indicates a prevalence of imports over exports. To conduct a thorough evaluation of potential markets for dairy exports, we will use the development level method from the taxonomy methods. This method provides a level-by-level quantitative assessment of the region's state in the form of an integral indicator that combines the influence of a specific set of indicators. Fig. 1 shows the analytical tools used to comprehensively assess the potential attractiveness of markets for dairy exports.

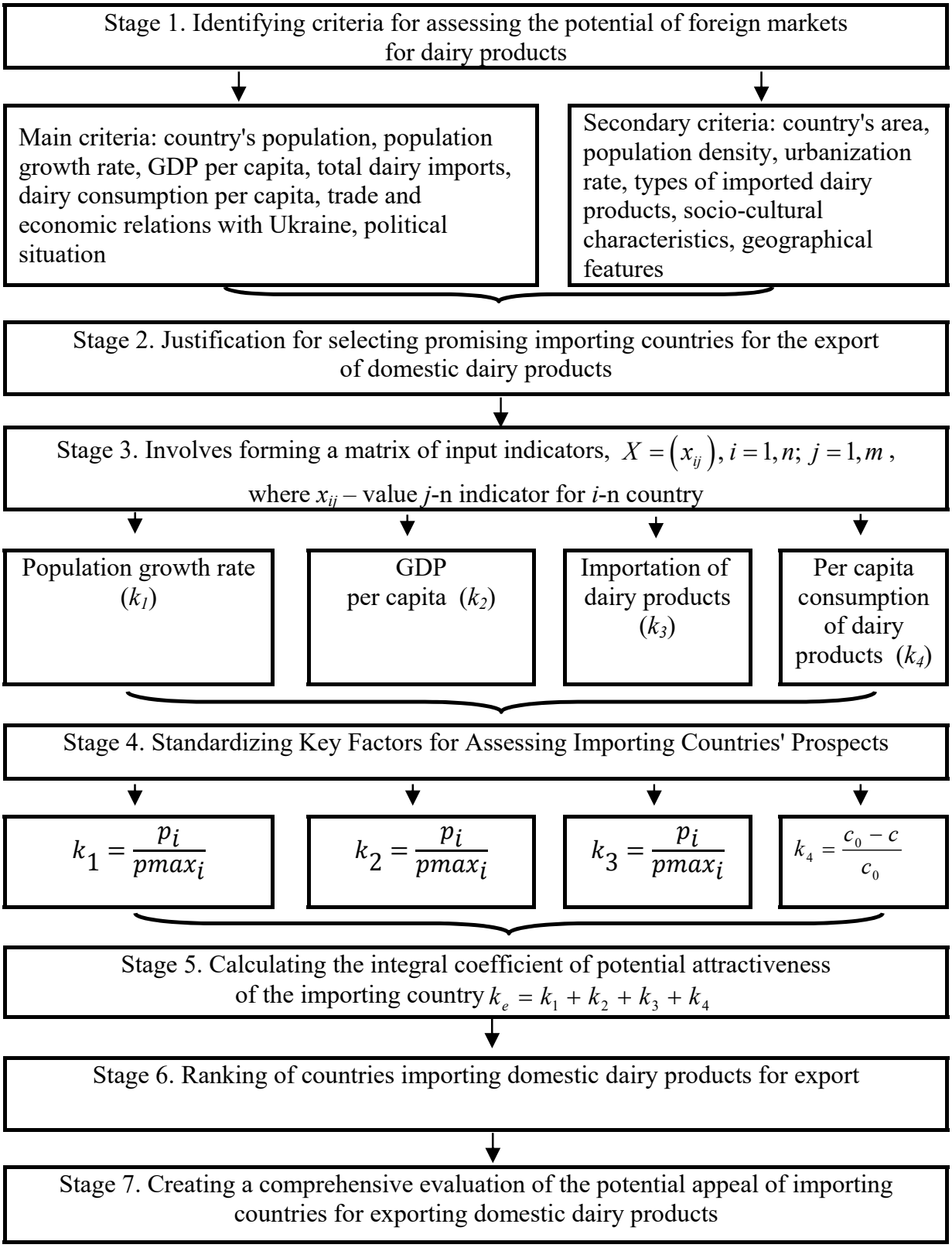


Fig. 1. Analytical tools for assessing the potential attractiveness of markets for dairy exports.

The selection of countries for dairy exports is based on main and secondary factors. The following indicators have been identified as key factors: k_1 - population growth rate, k_2 - GDP per capita, k_3 - dairy imports, k_4 - per capita consumption of dairy products.

The integral indicator ranges from 0 to $П_{max}$, where $П_{max}$ is a small positive number.

The resulting scores are easy to rank and interpret economically. In this case, the country's prospects are reflected by the potential volume of dairy exports to a particular country.

The following step involves creating a matrix of input indicators.

$$X = \left(x_{ij}\right), i = 1, n;\ j = 1, m,$$

where x_{ij} - value j -n value для i -n country.

During the fourth stage of the algorithm, a standardization procedure is applied to the initial indicators. This is necessary because the indicators may be specified in different units of measurement. To standardize the indicators, the maximum value of p_{maxi} is first determined. Then, all other values of p_i are divided by the maximum value:

$$k_i = \frac{p_i}{p_{\max i}}. \quad (1)$$

The maximum values ($p_{max\ i}$) When discussing countries with potential for dairy exports, India has a population growth rate of 19381 persons per year. Japan has a GDP per capita of 39,312 USD/person. China imports 931 thousand tonnes of dairy products, while the Philippines has a dairy consumption rate of 183.13 kg/person per year. The use of a standardized indicator is convenient because it is dimensionless, with values ranging from 0 to 1.

To standardize the consumption ratio, we applied a slightly modified procedure. It is recommended to consider the normative level of consumption, which we suggest can be set at $C_0=100$. To normalize the consumption coefficient, use the following ratio: kg per individual.

$$k_4 = \frac{c_0 - c}{c_0}. \quad (2)$$

The integral coefficient of the potential attractiveness of the importing country is the final coefficient. This is determined by the sum of all individual coefficients, using an additive model.

$$k_e = k_1 + k_2 + k_3 + k_4, \quad (3)$$

where k_1 – population growth rate, k_2 –coefficient k_1 reflects the country's GDP, while k_3 represents the volume of dairy imports to the country, and k_4 is the coefficient for dairy consumption.

The integral coefficient values for the potential attractiveness of importing countries are listed in the last column of Table 1, with a graphical representation shown in Fig. 2. Based on this analysis, China, Japan, Indonesia, Bangladesh, Malaysia, the Philippines, Nigeria, India, and Vietnam are potential partners for the growth of dairy exports from Ukraine. As depicted in Fig. 2, China has the greatest potential for dairy imports. Its dominant position is maintained by the high level of imports, consumption of dairy products, and growing population dynamics [7].

Table 1. Standardized coefficients for the main factors affecting domestic dairy exports.

No.	Country	k_1	k_2	k_3	k_4	Coefficient of potential market attractiveness
1	Japan	0.000	1.000	0.441	0.279	1.720
2	China	0.331	0.241	1.000	0.673	2.245
3	India	1.000	0.050	0.012	0.155	1.218
4	Indonesia	0.129	0.097	0.360	0.852	1.438
5	Malaysia	0.033	0.276	0.273	0.747	1.329
6	Pakistan	0.154	0.036	0.079	0.000	0.269
7	Philippines	0.072	0.077	0.324	0.843	1.316
8	Vietnam	0.043	0.065	0.178	0.836	1.123
9	Egypt	0.079	0.062	0.197	0.405	0.743
10	Nigeria	0.274	0.049	0.066	0.921	1.310
11	Tanzania	0.073	0.024	0.039	0.597	0.733
12	Bangladesh	0.076	0.042	0.460	0.781	1.359

China is currently the third largest country in the world in terms of milk production and consumption. According to Rabobank, several factors have contributed to the recent increase in dairy consumption in China. These factors include increased demand for high-quality food due to increased disposable income, increased consumption of dairy products in line with national guidelines, government funding for the national school milk program, and efforts by the trade to increase innovation and product range while improving the quality of dairy products [7]. In terms of the key factors that determine a country's dairy supply prospects, the cities of Shanghai, Beijing, Shenzhen, and Guangzhou are the primary retail consumption markets in China. These cities have an urban population share of approximately 55%, which is continuously increasing [13].

The demographic situation in China is marked by an aging population resulting from increased life expectancy and a declining birth rate. Additionally, food consumption accounts for 31% of the annual expenditure of urban families in China [13]. China's milk production is expected to grow by 3.3% annually in the coming years, indicating slower growth than in the past decade. The focus will shift from quantity to quality. It is worth noting that by 2020, per capita consumption of dairy products in China reached 32.66 kg.

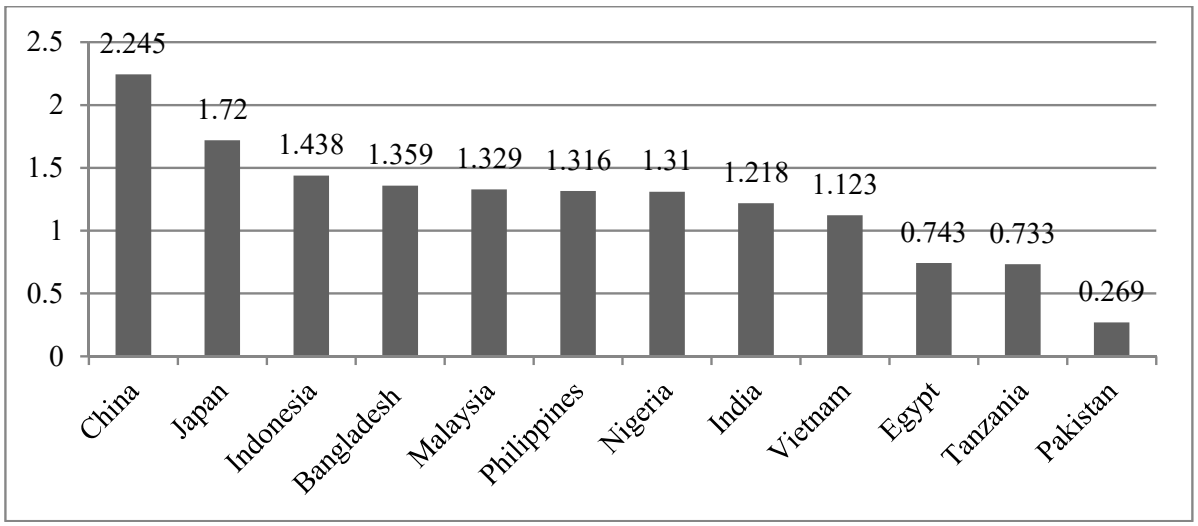


Fig. 2. Ranking of countries importing domestic dairy products for export

According to [5, 7, 13], dairy exports to China have great prospects as the country's dairy consumption has been growing at an annual rate of 2.7% from 2013 to 2020, while domestic milk production is only increasing by 2.1% annually. It is important to note that the language used in this text is clear, objective, and value-neutral, adhering to a formal register and avoiding biased or emotional language. The text also follows conventional structure and employs precise word choice, subject-specific vocabulary, and consistent technical terms. The grammar, spelling, and punctuation are correct, and the text adheres to the desired characteristics without introducing new content. According to sources [5, 7], dairy exports to China have great prospects as the country's dairy consumption has been growing at an annual rate of 2.7% from 2013 to 2020, while domestic milk production is only increasing by 2.1% annually. This is happening despite stagnant growth in domestic dairy production in China, which is driving the demand for dairy exports. Based on the most recent data from China's customs authorities, dried dairy products make up a substantial proportion of imports, accounting for approximately 70% of the total value of all dairy imports. These products primarily consist of milk powder, whey powder, and whey concentrates, which are utilized in the production of baby and functional food [10].

Logistic (S-shaped) curves can often describe the dynamics of economic processes, including consumption. The initial stage involves gathering information about a new product and recognizing the need to purchase it. Advertising and word-of-mouth from satisfied customers reinforce these processes. This is followed by a sharp increase in demand for the product. Over time, this process can lead to a saturation of demand, a loss of novelty in the product, and a subsequent decrease in consumer interest. This can result in a slowing down of the growth rate of purchases, ultimately stabilizing at a level that meets the needs of the population and corresponds to their purchasing power.

To create a model for the growth of dairy production and consumption in China, it is essential to estimate the growth rate coefficient k. The coefficient will vary depending on the process. To calculate the growth factor, we consider the following information. Rabobank predicts an 8% increase in demand for dairy products in China from 2019 to 2024, while the growth rate of imports is 2%. This growth corresponds to an 8% increase in demand, given that per capita consumption was only 30 kg of dairy products in 2019. However, according to our calculations based on existing trends, the growth rate of dairy consumption is projected to be 3%, while the growth rate of imports is expected to be 2.1%. We used these estimates to develop a logistic model of dairy consumption in China. Our calculations, based on the logistic growth model, indicate that in order to increase consumption from 30 kg/person to 44 kg/person, the current consumption growth rate should be 15% in the first year. Subsequently, the growth rate of consumption will decrease until it reaches saturation. It is unlikely that such high growth rates can be achieved. Our calculations indicate that the planned growth can be attained by 2029. The growth rate starts at 10% annually and decreases by 1.5% to 2% each year. The model was built using the following parameters: the initial value of consumption $Y0$ is the growth rate of 42.12 million tons and $k = 0.40$.

Increased imports are necessary for the rapid growth in consumption. Rabobank estimated an import deficit of 11.9 million tonnes of liquid milk equivalent (LME) in 2023. As demand in China grows faster than domestic supply, the import deficit is expected to increase over the next ten years [7]. Therefore, China's dairy product imports will remain significant, even if the import volume decreases.

Assuming a domestic production level of 39.2 million tonnes in 2022, it can be concluded that imports of dairy products are expected to increase from 10.1 million tonnes in 2019 to 29.8 million tonnes in 2029. However, it would be more realistic to estimate export growth by considering the increase in China's own dairy production. This increase is driven by significant investments in the sector aimed at improving domestic food security.

When constructing an economic and mathematical model for import growth, it is important to consider that the upper limit of imports will decrease over time according to a linear law. This decrease should be factored into the model.

$$M = M_0 - at, \tag{4}$$

where M_0 - The import ceiling's initial value was 29.8 million tonnes.

a – the initial boundary's reduction coefficient (or domestic production's growth coefficient) will be used to model the growth of dairy imports, considering domestic production. The economic and mathematical model is as follows:

$$dx / dt = kx - \frac{kx^2}{M - at}, \tag{5}$$

where k=0.4 is import growth coefficient, M=29.8 is assuming stable domestic production, the maximum value of imports in millions of tonnes, α=0.44 is own production growth rate.

The growth rate was selected based on objective considerations. According to international experts, milk production in China can increase by 2.1% annually, which would result in a rise from the initial level of 32 million tonnes in 2019 to 39 million tonnes in 2029. However, considering the high production costs, we believe that a more realistic annual growth rate would be 1.2%. Simultaneously, domestic production is projected to reach 36 million tonnes, while dairy product imports are expected to rise from 10.12 million tonnes in 2019 to 25.8 million tonnes in 2029. Figure 3 illustrates the economic and mathematical modeling of the growth of dairy imports, considering China's domestic production.

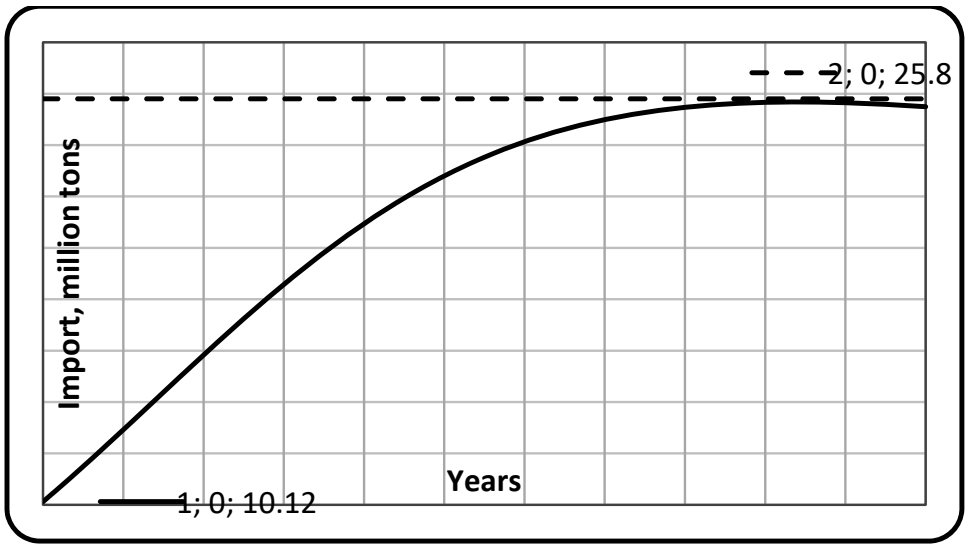


Fig. 3. The logistic model of dairy import growth in relation to the growth of domestic production in China.

Due to the rapid growth of dairy imports, it is expected that there will be an increase in imports of whey powder and whey-based dry concentrates, which are the primary dairy products imported to China. Based on the share of whey powder in total imports, whey imports may increase from 450 thousand tonnes in 2019 to 1500 thousand tonnes in 2029.

It is worth noting that whey is a significant component of Ukraine's exports to China. Despite a decrease in Ukrainian whey exports in 2022, there is potential for growth due to increasing demand from China.

If Ukraine can maintain its average share in global whey exports to China, it may be possible to expand exports of whey-based dry concentrates as well. The growth of Ukrainian whey imports is expected to follow a logistic curve similar to the one described above. Figure 4 shows the results of modeling potential whey exports to China.

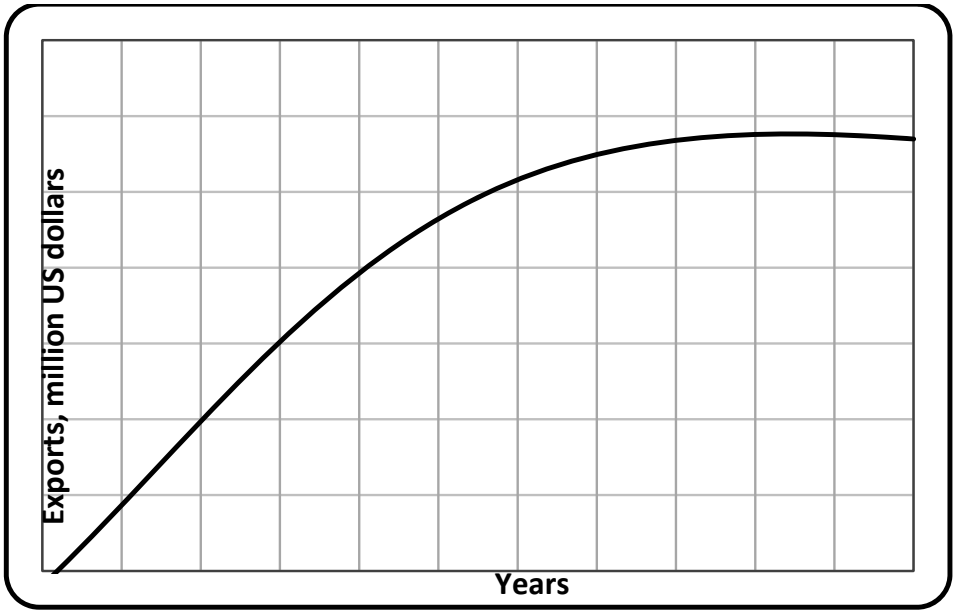


Fig. **4**. The logistic model for the valuation of Ukrainian whey exports to China.

Let us analyze whether this optimistic outlook is justified. It should be noted that due to the decline in the number of cattle in Ukraine, exports of dairy products will also decline, despite some improvement in the quality of the cow population. However, while the overall volume of dairy exports will decline, certain export items will continue to maintain a positive foreign trade balance. The State Customs Service of Ukraine provided statistical information for 2023, indicating an increase in the export of three items: whey, fermented dairy products, and ice cream [13]. Although China is currently the primary importer of Ukrainian whey, it is essential to consider the export of Ukrainian whey to other Asian countries that have significantly increased their imports of dairy products in recent years. The growth of national economies and the welfare of their populations have driven this trend. An analysis of whey exports from Ukraine to Asian countries reveals that Vietnam, Malaysia, Pakistan, and the Philippines collectively import almost as much whey as China. Assuming that the growth rate of dairy imports in these countries will be the same as in China, Ukraine has the opportunity to significantly increase whey exports.

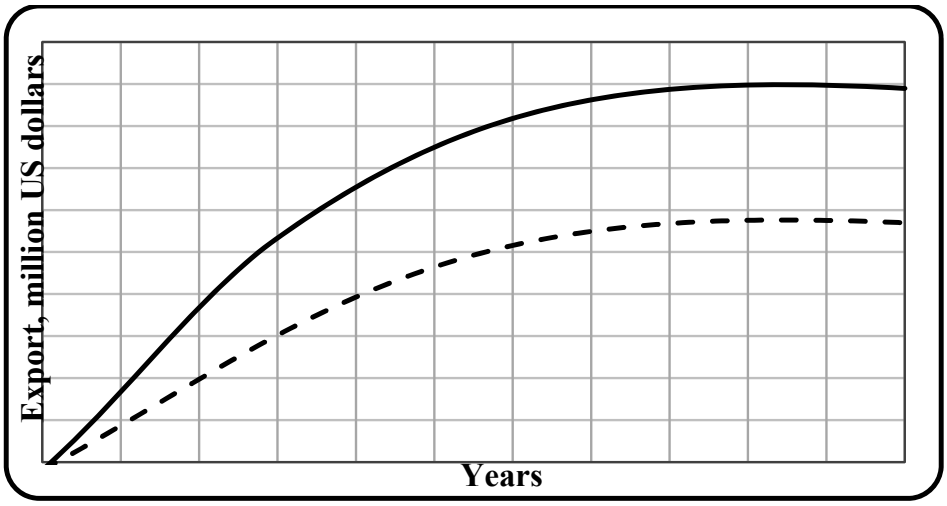
The dairy market is a rapidly growing and highly dynamic industry. There is a particular demand for new high-tech products that are designed for specific consumer groups. Deep processing of whey enables the production of valuable and high-margin dairy products, such as milk proteins (used in the food industry, baby, dietary, and sports nutrition), lactose (milk sugar, used in the food and pharmaceutical industries), and lactulose (a well-known probiotic). Whey protein hydrolysate (WPH) is a new product in the dairy ingredients market. It is used in baby food and is relatively expensive. For instance, from 1 tonne of whey, 3.6 kg of fat, 8.9 kg of protein, and 45 kg of lactose can be produced. Domestic dairy market operators can increase their profits by deeply processing whey to create innovative functional dairy products instead of drying it [10].

The economic impact of replacing whey powder with high-margin processed products when exporting dairy products to China can be calculated.

The total cost of high-margin products resulting from secondary processing of 1 tonne of whey is USD 61.75, which is 33% higher than the cost of whey powder obtained from the same amount of raw materials (USD 46.54) [10].

These data were used to calculate the increase in the monetary value of dairy exports to China when whey powder is replaced by high-margin processed dairy products. The effect of changing the export structure will be gradual. Figure 5 illustrates the dynamics of the monetary value of exports of high-margin dairy products to China compared to whey powder exports.

These data were used to calculate the increase in the monetary value of dairy exports to China when high-margin processed dairy products replaced whey powder. The effect of changing the export structure will be gradual. Figure 5 illustrates the dynamics of the monetary value of high-margin dairy product exports to China compared to whey powder exports.



Notes: The dashed line represents revenues from whey powder exports,while the solid line represents revenues from exports of high-margin products.

Fig. 5. Logistic model used to forecast the growth of domestic exports of high-margin dairy products to China.

As demonstrated, altering the export structure has the potential to generate an extra $6 million in annual income by 2030.

Additionally, the COVID-19 pandemic in 2020 has led to an increase in milk and dairy consumption in China due to the emphasis on strengthening immunity at the state level. Additionally, the COVI

D-19 pandemic in 2020 has led to an increase in milk and dairy consumption in China due to the emphasis on strengthening immunity at the state level. Scientific and medical researchers are involved in this effort and their findings are used to develop nutritional recommendations. The recommendations focus heavily on milk and dairy products. It is safe to assume that the Chinese will follow these recommendations, leading to an increase in the consumption of milk and dairy products, including high-margin dairy products. It is safe to assume that the Chinese will follow these recommendations, leading to an increase in the consumption of milk and dairy products, including high-margin dairy products. The rise in imports of whey, lactose, and infant formula is due to the increase in births following the pandemic [13].

As part of our foreign trade cooperation with China, it is advisable to promote domestic dairy products, including high-margin ones, to other global markets in Southeast Asia such as Singapore, Vietnam, Malaysia, Indonesia, Pakistan, and the Philippines.

4 Conclusions

To evaluate the potential attractiveness of markets for dairy product exports, this article proposes an analytical toolkit based on the taxonomy method. The method involves seven consecutive stages, which allow for a level-by-level quantitative assessment of the potential attractiveness of foreign markets. This assessment was used to rank the countries that import dairy products, and the most promising ones were identified as China, Japan, Indonesia, Bangladesh, Malaysia, the Philippines, Nigeria, India, and Vietnam.

Considering the global demand for dairy products, this article proposes a logistic model to forecast the growth of domestic exports of high-margin dairy products. The model allows for a comparison of the cash income dynamics between the export of whey powder and high-margin dairy products, using China as an example. The article presents calculations showing that the total cost of high-margin products obtained through secondary processing of 1 tonne of whey is USD 61.75, which is 33% higher than the cost of whey powder obtained from the same amount of raw materials (USD 46.54). This change in export structure can provide additional annual income for domestic dairy market operators.

The analytical tools developed for assessing the potential attractiveness of foreign markets and the logistic model for forecasting the growth of domestic exports of high-margin dairy products enable practical monitoring of the prospects of potential foreign markets. This allows for timely and informed decisions on changing the export strategy and diversifying markets. The tools can be recommended for other sectors of the food and processing industry.

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