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## Article

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Comparative Economic Research. Central and Eastern Europe

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*Suggested Citation:* Klapkiv, Jurij; Putsenteilo, Petro; Karpenko, Vitalii (2023) : The convergence of factors that affect the dairy product market: A comparative analysis of European Union countries, Comparative Economic Research. Central and Eastern Europe, ISSN 2082-6737, Lodz University Press, Lodz, Vol. 26, Iss. 2, pp. 105-127, <https://doi.org/10.18778/1508-2008.26.15>

This Version is available at:

<https://hdl.handle.net/10419/289738>

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# The Convergence of Factors That Affect the Dairy Product Market: A Comparative Analysis of European Union Countries

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## Abstract

The European Union is a large producer of milk and dairy products. It is also a significant market for the consumption of dairy products, which is characterised by effective demand, and it significantly influences the markets of other food products. The main milk producers in the EU are Germany, France, Poland, the Netherlands, Italy and Spain. Intensive migration has contributed to additional demand for food products, in particular, dairy products. This provided the basis for the construction and calculation of a dynamic model of dairy production, the export of dairy products, and the coexistence with the existing population as the main consumers in the EU-27 countries and Great Britain between 2004 and 2020.

An additional research value is that based on the presentation of the analysis and modeling, the relationship between the growth in the demand for dairy products and the growth in the population is established. The reason for the large population in the countries of Central and Eastern Europe is intensive migration flows, which increase the demand for dairy products. The increase in volumes reduces the cost price, which contributes to the export of dairy products, and also contributes to the increase in the volume of production of dairy products. The resulting models made it possible to analyse the influence of population growth on the increase in production volume. At the same time, the dependence and influence of the export of dairy



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Received: 4.07.2022. Verified: 10.11.2022. Accepted: 21.03.2023

products on the increase in the volume of production of dairy products in the EU–27 and Great Britain countries is investigated.

The results of the mathematical modelling indicate unique opportunities to develop the dairy sector of individual EU–27 countries, i.e., the Czech Republic, the Netherlands, and Poland. These countries have a rational ratio of the influence of the population growth factor on the increase in the volume of dairy production and the optimal influence of the export of dairy products on the increase in the volume of dairy production.

**Keywords:** milk, dairy products, European Union, milk producers, consumers, export of dairy products, cost, price, profitability

**JEL:** F10, J11, Q11, Q17

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## Introduction

In the context of globalization, most countries around the world position themselves as open economies, the dynamics of which depend on building effective foreign economic relations between companies (Rosen et al. 2000; Robbins 2003). Economies adjust to more open markets by bringing their prices into line with global prices (Eskelinen et al. 2002). Exports and international competitiveness are crucial driving forces behind contemporary sectoral and economic development (Bojnec and Fertő 2019). National economies are embedded in a global system that generates mutual interdependence across countries. In this system, each country depends on the supply of consumer goods, intermediate products, and capital goods from its trade partners, and it relies on the trade partners to supply markets for its own products (Bayoumi, Coe, and Helpman 1996). Exports in an open economy are a tool to expand market space for branches and industries that are ready for intense international competition (Mahmood and Nishat 2004; Berger 2005; Demir, Kalayci, and Ertugan 2020; Gilpin 2020). The export base hypothesis is that a region's growth is led by export demand, given perfectly elastic factor supplies (Kilkenny and Partridge 2009). In accordance with the bilateral agreements, quotas are an additional element of trade liberalization (Putsenteilo, Klapkiv, and Kostetskyi 2018).

Given the existing natural, resource, social, economic and other factors, the agricultural sector is among the export industries in every country of the world that creates conditions for intensive integration into the world economy and food security (Mitchell 1985; Capalbo and Denny 1986; Melo and Robinson 1992; Barbier 2004; Qi and Wang 2007; Molenaar et al. 2015; Yu et al. 2017; Kyrgiakos, Vlontzos, and Pardalos 2021). Agri-food products are among the most popular on the market because they are a basic need for a person among the food ration, which is met in the first place.

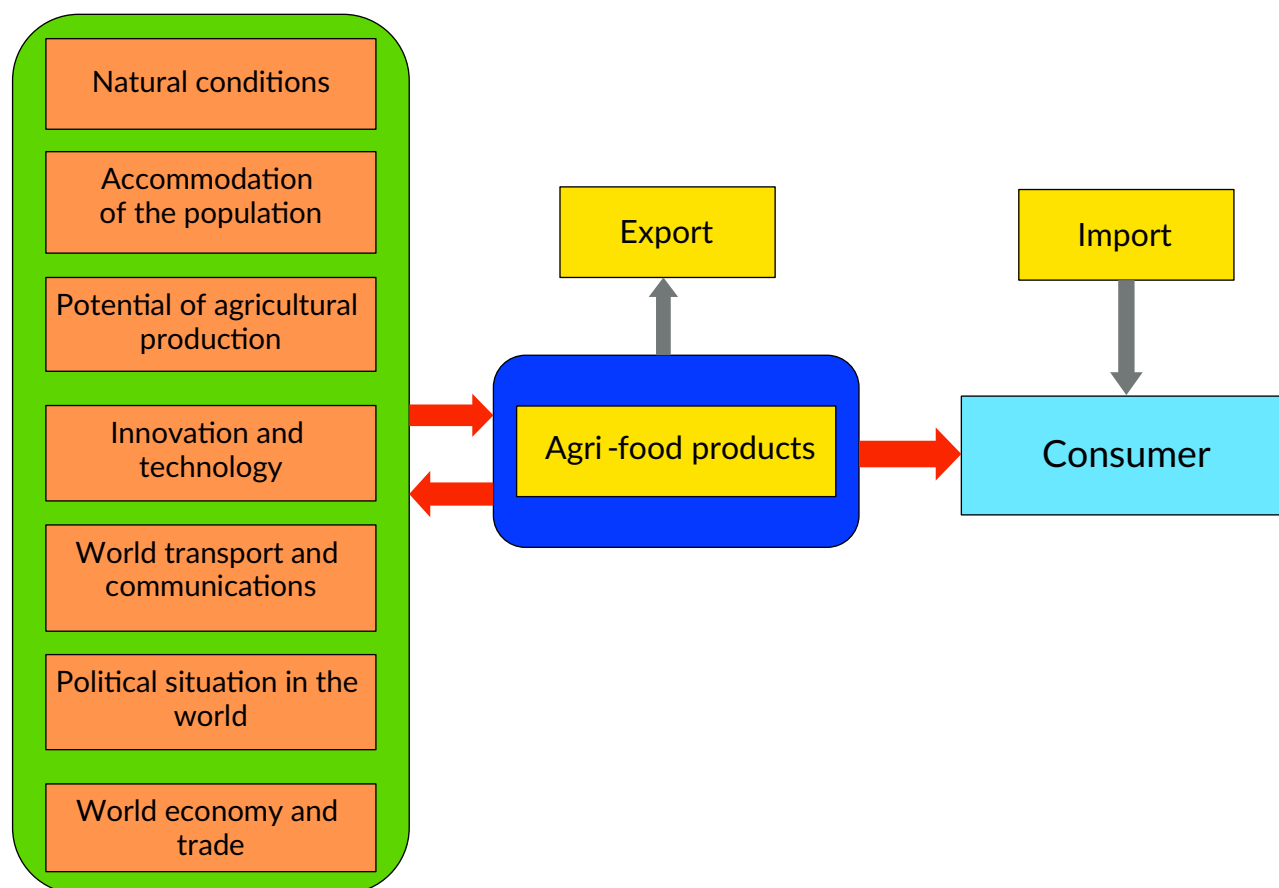
In any territory, the supply of food is formed by a country's own resources through the production of agricultural products (Marsden, Banks, and Bristow 2000). It must fully cover the needs of the entire population living there. However, the planet's pop-

ulation is constantly growing, so the demand for food is also growing rapidly. Historically, when there have been food shortages or unavailability within A country, there is an urgent need to supply or purchase food on the world market.

Food demand has always been characterised by dynamism and a large volume of consumer requests (Thiele and Weiss 2003; Wang, Mao, and Gale 2008). It is also a key factor that directly affects food price formation (Henson and Traill 1993).

All countries are involved in the global food trade, as demand is constantly growing, mainly due to population growth, income growth and diversification of ways of nutrition (Liverman and Kapadia 2012; Stephens, Jones, and Parsons 2018). Therefore, international trade is of great importance for food security (Putsenteilo 2011).

According to research, the following factors commonly influence agri-food products on a global scale (Figure 1).



**Figure 1.** The factors that influence global agri-food products relations

Source: generated by the authors.

The development of the agricultural sector of the economy and its efficient functioning are determined primarily by the development of its institutions (Putsenteilo et al. 2020).

## Material and methods

The EU is a large consumer market with more than 450 million inhabitants. It is characterised by effective demand – the average income is 1,900 euros per month (Eurostat 2001b). These factors make it very attractive to foreign companies, resulting in the intensification of competition in individual EU countries (Sadowski, Wojcieszak-Zbierska, and Beba 2021). However, companies from third countries face real challenges in entering EU agricultural markets (Chantreuil, Hanrahan, and Leeuwen 2011). Let us consider the dynamics and structure of the dairy market to better understand the competition in these markets.

Sales and market share data from all countries within the European Single Market (the European Union's 28 member states) have been included. The Euromonitor International Passport Global Market Information Database has the best available database for most of the selected countries and product markets. Euromonitor is the world's leading independent provider of strategic market research and collects volume sales databases from various sources, including trade associations, industry bodies, company financial reports, and official government statistics. These databases are validated by the food industry.

For this study, the databases were obtained for milk and dairy in the European Union (EU) at the most fine-grained level between 2004 and 2020.

The present study is secondary research mainly based on The Food and Agriculture Organization (FAO) database, Eurostat New Cronos, and the Bulletin of the IDF. Based on these data, we carry out statistical evaluations and illustrate the main tendencies in terms of production, trade and prices; finally, we analyse these trends. The FAO database provides the appropriate numbers for production, consumption, trade and prices. We have used these numbers to prepare figures and tables and analyse the changes over the years. We make relative numbers and examine the percentage changes in the different values. In addition, we try to reveal which causes contribute to the changes.

The main purpose of this study is to assess the production in the EU of butter, butter oil, cheeses, SMP (Skimmed Milk Powder), WMP (Whole Milk Powder), whey powder, casein, lactose, and cows' milk between 2004 and 2020. To achieve this goal, the Eurostat databases were selected. The advantage of these databases is their wide coverage (they cover all EU countries) and the only methodology for obtaining them. This makes it possible to compare EU countries.

Using multiple correlation analysis, we study the quantitative impact of factors on the results and establish the level of dependence of the performance indicator on each of the factors.

As the effective indicator  $Y$ , we choose “Products obtained”, and as factors that influence the effective indicator, we use factors  $x_1$ ,  $x_2$  and  $x_3$  – “Population”; “EXPORTS of Dairy Products to Third countries”; and “IMPORTS of Dairy Products from Third countries”, respectively.

We assume that the relationship between factor indicators and performance is straightforward. To write such dependencies, one can use a linear function such as:

$$Yx = a_0 + a_1x_1 + a_2x_2 + \dots + a_nx_n.$$

In multiple correlation-regression models, even and partial correlation coefficients are calculated to measure the relationship density. Paired correlation coefficients show the density of the relationship between factors, and between factors and performance. The method of calculating and interpreting such coefficients is similar to the linear correlation coefficient for a one-factor (pair) connection. Constructing the regression equation is carried out for each study country separately.

Calculating paired correlation coefficients makes it possible to identify collinearity. Since it distorts the estimation of regression parameters, it must be eliminated. In this case, one of the factors must be excluded from the regression equation, which in a pairwise correlation gives a high linear coefficient that exceeds the absolute value of 0.7. Such a connection between two factors is called collinearity, and between several factors, it is called multicollinearity.

Determining the pairwise correlation coefficients takes into account the influence of other factors of the model. Partial correlation coefficients are calculated to abstract from their impact and to quantify the relationship between performance and factor indicators in their pure form. They show the level of influence of one factor on the result at influence of one factor at a fixed value on the result of others.

We find the calculated values of t-statistics for each pair of factors and the tabular value of t-statistics and compare them with each other.

$t_{12} > tkp$	Pair	$X_1X_2$	multicollinear
$t_{13} < tkp$	Pair	$X_1X_3$	non-multicollinear
$t_{23} > tkp$	Pair	$X_2X_3$	multicollinear
	Factor	$X_3$	excluded

Thus, as a result of the calculations, it can be concluded that it is necessary to remove factor  $X_3$  (IMPORTS of Dairy Products from Third countries) from the equation, which indicates that there is no close relationship between factors  $X_1$  and  $X_3$ , i.e. these factors are non-multicollinear. Then we build a standardised model with-



out taking into account the removed factor  $X_3$ . In order to be sure of the reliability of the connection equation and the expediency of its use for practical purposes, it is necessary to give a statistical assessment of its reliability. To do this, in addition to the coefficients of multiple correlation and determination, we use Fisher's criterion and the average error of approximation. The higher the multiple correlation coefficients, determination and Fisher's criterion, and the lower the standard error, the more accurately the relationship equation describes the relationship between the factors. When assessing the reliability of the relationship, the actual value of Fisher's test is compared with its tabular value. If the tabular value of the Fisher coefficient is greater than its actual value, this indicates that there is no relationship between the performance and factor indicators. Since  $F_{\text{calculation}} > F_{\text{tab}}$ , the reliability of the constructed mathematical model with reliability  $P = 0.95$  can be considered adequate experimental data, and based on the accepted model, it is possible to carry out the economic analysis.

The Student's criterion is used separately to assess the reliability of each parameter of the equation. The result of the calculations is the construction of a multiple regression equation for each country separately, which reflects the dependence of  $Y$  on  $X_1$  and  $X_2$ .

Analysing the parameters of the regression equation will allow us to draw a conclusion about the degree of influence of each of the two factors on the  $Y$  indicator – “Products obtained”. For visual presentation, the results will be displayed  $Y$  and  $Y_{\text{calculation}}$  in the form of charts for each EU country.

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## Results and discussion

Milk production is one of the important industries that provide the industry with raw materials and the population with biologically valuable food products (De Boer 2003; Blayney 2004; Marchand et al. 2012; Baldini, Gardoni, and Guarino 2017; Rotz et al. 2021). Milk has been known as nature's most complete food for millennia, and it currently plays an important role in people's diets across the world (Górska-Warsewicz et al. 2019). Milk and dairy products are nutrient-dense foods, supplying energy and high-quality protein with a range of essential micronutrients (especially calcium, magnesium, potassium, zinc, and phosphorus) in an easily absorbed form (Black et al. 2002; Bailey et al. 2010; Muehlhoff, Bennett, and McMahon 2013; Pfeuffer et al. 2018; Bechthold et al. 2019). Milk minerals are crucial for human health and development, as well as in dairy processes such as cheese-making and for all traits involving salt-protein interactions (Franzoi et al. 2017).

In Western countries, milk and dairy products are major components of the human diet, providing about 30% of dietary proteins and lipids and about 80% of dietary calcium (Fox 2003). Dairy products are an important part of most people's diets, and the benefits of calcium are widely advertised (Jelen and Lutz 1998; Girma, Tilahun, and Haimanot 2014). Therefore, dairy products are unlikely to be completely replaced (Maijala 2000; Bauman et al. 2006). Liquid (beverage) milk is a major food item in all developed dairy-producing countries, representing 40% of total milk production (Fox 2003). However, the concentrations and properties of milk constituents are variable. Hence, the processability of milk and the properties of dairy products are inconsistent. However, much of this variability can be eliminated by modern technology, which exploits certain features of milk constituents (Boland and Singh 2019).

Given the crucial importance of the dairy sector in providing livelihoods, equity and food security for rural populations, quantifying the contribution of various factors to milk production growth is useful for reorienting dairy programs and development priorities (Dries and Swinnen 2004; Faye and Konuspayeva 2012).

Milk has certain features that distinguish it from other agricultural products and shape its production, processing and trade. In contrast to grains, milk is a bulky and heavy commodity requiring high-cost storage and transportation as it spoils quickly without cooling (Knips 2005). The production and consumption of milk as a food product is a chain of interrelated and interdependent stages of the overall process, the course of which depends on the state of the milk market, which is part of the agricultural market (Bourlakis et al. 2014; Landes et al. 2017; Kumar et al. 2019). Strategies for sustainable rural development focus on value chain creation by establishing and constantly searching for transparency, using tools such as traceability systems to establish trust and, ultimately, consumer willingness to pay for products of a higher added value. Despite various attempts to define what sustainability means, the concept is still imprecise in its definition (Luhmann, Schaper, and Theuvsen 2016). Today, the market for milk and dairy products is one of the largest food markets because it is quite large and active, has strong trends, and significantly affects other food markets (Dawson and Hubbard 1987; Serra and Goodwin 2003; Bouamra-Mechemache, Jongeneel, and Réquillart 2008; Hill 2017).

The composition of dairy product consumption varies across different regions, with liquid milk being the overall most important product by volume. However, processed dairy products have become more important with increasing incomes and living standards. In developed countries, there is a growing trend for high-value functional foods that require considerable research investments and sophisticated processing (Knips 2005).

The global increase in milk sales is associated with the growth in the world's population, as well as economic development, overall human well-being, and climate change (Guzmán-Luna et al. 2021). At the same time, the milk market has undergone significant trans-



formations in recent years, taking place against the background of changing consumer preferences and the elimination of global demographic balance (Blasko 2011; Gerosa and Skoet 2012). However, while milk sales are growing in developing countries, they are declining in developed countries (Duncan et al. 2013).

According to the latest outlook from the OECD-FAO, in the ten years between 2019 and 2028, global consumption of fresh and processed dairy products is expected to increase by 2.1% and 1.5% a year, respectively (Rusk 2019). Population growth in developing countries, together with the gradual economic development that has taken place, has forced milk producers to pay close attention to these markets (Delgado 2003). At the same time, in developed countries, the opposite effect is seen. There are declines in sales amid the widespread popularization of the idea of diet and healthy eating, which sees some people giving up milk and dairy products due to the presence of sugar in their ingredients (Armstrong et al. 2005; Pothoulaki and Chryssochoidis 2009; Sääksjärvi, Holmlund, and Tanskanen 2009; Nolan-Clark et al. 2011; Grout et al. 2020).

Factors in the growth in demand for milk and dairy products include population growth in the world, urbanization, increasing incomes in developing countries, and a high share of young people, among others. These demand factors will continue over the next 10–20 years. It will increase the demand for dairy products and, therefore, result in large volumes of milk being produced. This production, in turn, depends on two main factors: the number of cows and their productivity.

Prices for milk and dairy products on the world market, as well as any other product market under normal circumstances, are usually determined by domestic prices of major exporting countries, which, in turn, depend on production costs, government support for exports, and the season of the year (Cox and Chavas 2001). Thus, the market for milk and dairy products is a complex interconnected system of national markets in different stages of formation. At present, the way it functions is complicated by factors related to lower prices and intensified competition between exporters of dairy products.

The EU is a major producer of milk and dairy products, and they are integrated into a single market organization. Milk is produced in all EU countries and accounts for 12% of total agricultural output, estimated at around 155 million tonnes per year. The main producers are Germany, France, Poland, the Netherlands, Italy and Spain, which account for almost 70% of the production. While milk is produced in all member states, farm and herd sizes, yields, and types of farming vary widely across Europe, from free-range farming in Alpine areas to large specialised dairy farms in the north-west and centre of Europe (Augère-Granier 2018). The number of dairy cattle in the EU has been declining in recent years, as milk yield per cow has increased.

.As the dairy sector develops across the EU, differences in productivity, as well as technical factors, have diminished – less developed dairy producers are rapidly catching up

with those who were the first to restructure and modernize (Pappa, Illiopoulos, and Mas-souras 2019).

The EU is a major exporter of dairy products and the world's largest exporter of cheese and SMP. Exports of dairy products under certain quotas opened by third countries are carried out based on an export license issued. The European dairy industry processes about 135 million tons of raw milk into a wide range of products for both consumption and use in the production of many foods, feeds and pharmaceuticals. The dairy industry accounts for about 15% of the food industry in Europe (and about 13% of the total EU workforce). Various dairy products produced by the European dairy industry, such as liquid milk, cheese, fresh dairy products and butter, are an important contribution to the diet of EU consumers (Eurostat 2001b).

Part of the common agricultural policy, the EU's dairy policy consists of a range of instruments designed to support farmers and address market imbalances. In particular, it includes common market organisation, public intervention and private storage provisions, direct payments and rural development measures (Augère-Granier 2018). The growth of the world's population, as well as the popularity of dairy products, will be the main factors that will contribute to the export of dairy products from the EU-27 and maintain commodity prices. Cheese and skimmed milk powder will show the best export performance.

The study revealed a number of global trends in the dairy industry, such as the demand for dairy ingredients has higher growth compared to the demand for standard dairy products; in most countries, including the EU, profits from milk production do not exceed costs; the tendency to increase the demand for "non-dairy" products based on plant substitutes has led to the introduction of large enterprises that produces these lines of products. Some specific trends have also been identified. In particular, China's policy is aimed at increasing imports of the dairy industry, although the increase in national production is insignificant.

The largest producer of milk and dairy products in the EU is Germany, where the number of dairy herds exceeds 4 million cows. In terms of gross milk production, Germany ranks fifth in the world. It has 2% of the world's dairy cows and provides 5% of the world's milk. Germany's share of EU milk production is 20%. On average, there are 55.5 cows per farm in the country. Almost 70% of the dairy herd is represented by purebred breeds; the average annual yield per cow is 7352 kg (Eurostat 2001b).

The dairy industry accounts for a significant share of the total output of most countries. The last few years have seen an increase in milk production every year, despite the restraining policies of some countries in this direction. The trend of the world milk market will continue to grow. However, global trends in international trade in dairy products include a decrease in the number of large ex-

porters with an increase in the number of importing countries, as well as an increase in freshly exported products. EU policies on milk and dairy products, as in the United States, are aimed at balancing the interests of commodity producers and supporting exports.

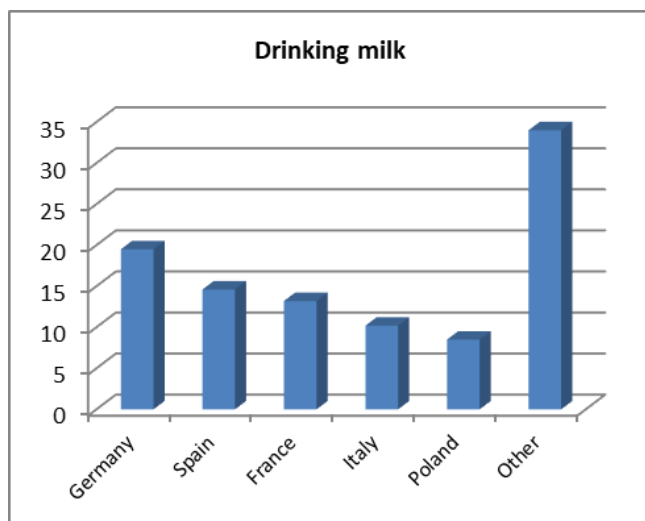
The study of the experience of the dairy sector in developed countries allows us to identify the main development factors, which are expressed in the implementation of a comprehensive agricultural policy. It aims to consolidate dairy corporations through the pooling of assets and the acquisition of shares; improving the production, organizational and economic infrastructure of the milk and dairy products market; ensuring the balance of interests of the subjects of the dairy sector, i.e., milk producers, milk processors, trade, and consumers; introducing innovative technologies for dairy farms; providing marketing support and providing support for the organic dairy market.

In the coming years, growing EU and global demand are expected to support world dairy markets without hindering price fluctuations and market imbalances. Resilience and sustainability are keywords for the future of the sector. They can be achieved with innovation as a way to reconcile the need for farmers to earn a decent living, consumer demand for affordable and quality dairy products, and environmental/animal health requirements (Augère-Granier 2018). The EU dairy sector is characterised by unique market conditions, with a record gap between very high butter prices and prices at the level of interventions for skimmed milk powder. High demand for cheese, butter, cream and powders supports the price of milk.

The EU produces an average of about 164 million tonnes of milk annually, of which 153 million tonnes are supplied to milk processing plants. Until 2015, milk production in the EU was regulated by quotas. However, after renouncing the quotas, they returned to them, but in a different, voluntary form (Eurostat 2001b).

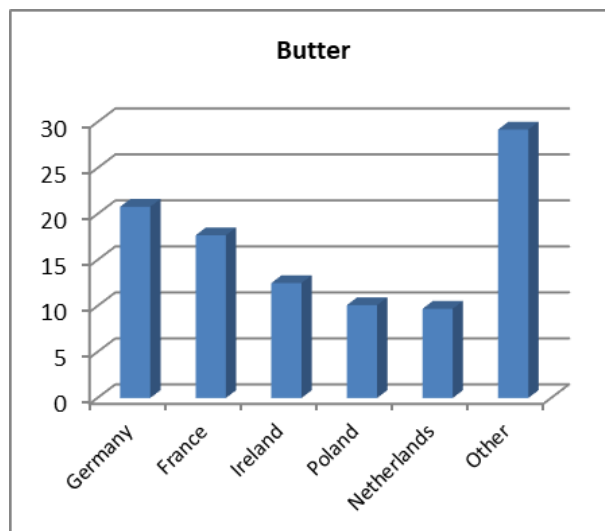
In 2020, EU farms produced 160.1 million tons of raw milk, which is 1.1% more than in 2019. It is estimated that 149.9 million tons were used by dairies together with skimmed milk to produce a variety of dairy products, as well as fresh products (Eurostat 2001b). Among other products, dairies produced 1.6 million tons of skimmed milk powder, 2.3 million tons of butter, 7.7 million tons of fermented milk products, such as yoghurt, 10.3 million tons of cheese, 24.0 million tons of drinking milk and by-product cheese production, 55.5 million tons of whey in 2020. EU dairy companies produced more of these products in 2020 than in 2019, and, with the exception of fresh products, more than in 2018. In 2020, 1.7% more butter was produced than in 2019, 2.6% more fresh drinking milk, and 3.0% more cheese (Eurostat 2001b).

Top dairy producers in the EU in 2020 (Figures 2–5).



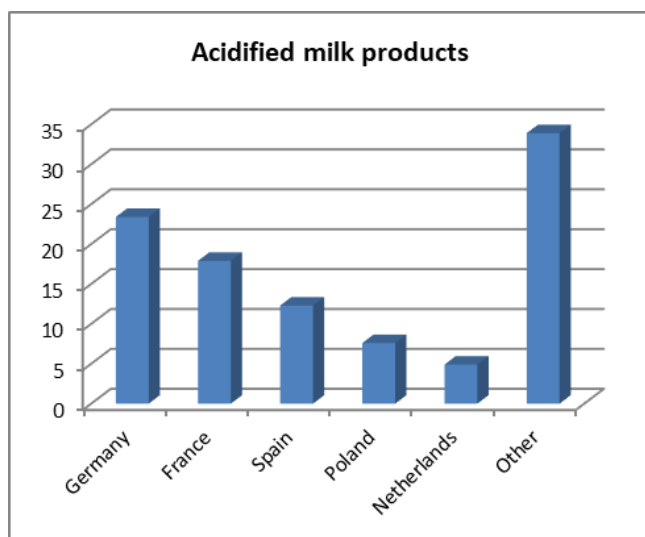
**Figure 2.** Producers of drinking milk in the EU, 2020

Source: Eurostat (2021a).



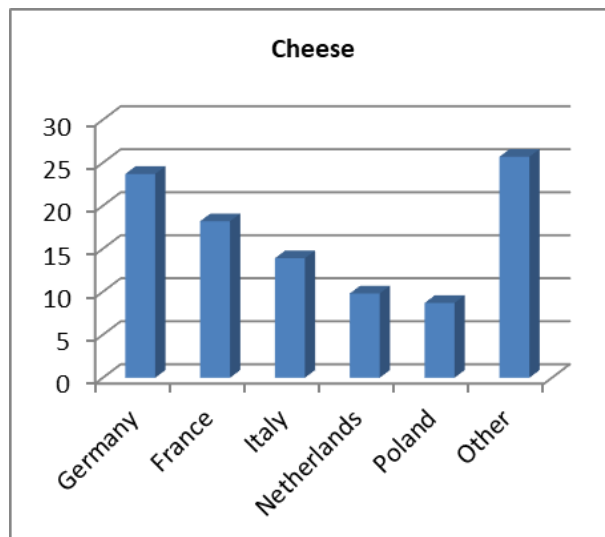
**Figure 3.** Producers of butter in the EU, 2020

Source: Eurostat (2021a).



**Figure 4.** Producers of acidified milk products in the EU, 2020

Source: Eurostat (2021a).



**Figure 5.** Producers of cheese in the EU, 2020

Source: Eurostat (2021a).

German dairies account for the highest share of EU production of all major fresh and manufactured dairy products, including drinking milk (19.3%), butter (21.0%), cheese (22.9%) and fermented milk products (23.7%) (Eurostat 2001b). The highest levels of dairy production were recorded in the most densely populated EU member states, although there were some exceptions. For example, Ireland ranks third in the amount of butter produced (12.4%), and the Netherlands is in fourth place in terms of cheese (9.7%) (Eurostat 2001b).

With the help of multiple correlation analysis, it is advisable to study the quantitative impact of factors on the results and establish the level of dependence of the per-

formance indicator on each factor. The analysis was conducted on the indicators of 28 countries of the EU between 2004 and 2020. As the effective indicator  $Y$ , we choose “Products obtained”, and as factors that influence the effective indicator, we chose factors  $x_1$ ,  $x_2$  and  $x_3$  – “Population”, “EXPORTS of Dairy Products to Third countries”, and “IMPORTS of Dairy Products from Third countries”, respectively (Annex).

We assume that the relationship between factor indicators and performance is straightforward. To write such dependencies, one can use a linear function such as:

$$Yx = a_0 + a_1x_1 + a_2x_2 + \dots + a_nx_n.$$

The construction of the regression equation was carried out for each study country separately. All calculations below use the population of each of the 28 countries of the EU from 2004–2020.

As a result of the calculations, it was concluded that factor  $X_3$  should be removed from the equation (IMPORTS of Dairy Products from Third countries), which indicates that there is no close relationship between factors  $X_1$  and  $X_3$ , i.e. these factors are non-multicollinear.

Next, we built a standardised model without taking into account the removed factor  $X_3$ . To be sure of the reliability of the connection equation and the expediency of its use for practical purposes, it is necessary to give a statistical assessment of the reliability of the connection. To do this, in addition to the coefficients of multiple correlation and determination ( $R^2 = 73\% - 83\%$  range for the 28 countries of the EU), we used Fisher’s criterion and the average error of approximation. Analysis of the parameters of the regression equation allows us to conclude about the degree of influence of each of the two factors on the indicator  $Y$  – “Products obtained”. Studying the impact of milk production, milk exports, and population (growth), and their relationship between 2004 and 2020, allowed us to establish the following findings (Annex).

For example, the analysis of factor  $X_1$  (population growth) by 1% leads to an increase in production in Sweden of 2.78%, in Greece – 2.81%, in Hungary – 2.95%, in Croatia – 2.96%, in Denmark – 3.43%, in Portugal – 3.65%, in Austria – 4.16%, in the Netherlands – 5.42%, in Poland – 16.11%, and in Slovakia – 22.17%. Population growth by 1% in some EU countries has a minimum output (< 1.0%): Belgium, Bulgaria, Germany, Estonia, Ireland, France, Lithuania, Romania, Spain and Finland.

The analysis of partial coefficients of elasticity shows that factor  $X_2$  has the greatest impact on the volume of dairy production: an increase in dairy exports by 1% gives an increase in production by 0.01% (Malta), 0.06% (Luxembourg), 0.09% (Croatia), 0.12% (Denmark), 0.16% (Cyprus), 0.19% (Estonia), 0.38% (Latvia), and 0.5% (Lithuania), but



11.83% (Germany). At the same time, an increase in production of more than 2% is observed in the following countries: Poland – 2.72%, Romania – 3.06%, UK – 5.39%, Spain – 6.78%, France – 8.14%, Italy – 8.78%, Germany – 11.83%.

To illustrate the results, we display  $Y$  and  $Y_{\text{calculation}}$  in the form of charts for each EU country and the United Kingdom. The same dynamics were observed in all countries. As a result of the calculations, factor  $X_3$  was excluded from the study of multicollinearity.

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## Conclusions

In the context of globalization, most countries position themselves as open economies. Their dynamics depend on building effective foreign economic relations between firms. Exports in an open economy are a tool to expand the market space for industries and manufacturers ready for intense international competition. In today's international trade relations, export-oriented firms and industries, by saturating domestic markets and filling certain segments of foreign markets, have the opportunity to compete not only through factors of intensive use but also through cost reductions due to scale, i.e. exports are a tool for efficiency economy and integration into the global food sector. As a result, both firms and national economies receive a growing economic effect.

The EU is a large consumer market with more than 450 million inhabitants, and it is characterised by effective demand. However, recent intensive migration has contributed to additional demand for food, including dairy products. This provided the basis for building and calculating a dynamic model of dairy production, dairy exports, and coherence with the existing population as the main consumer in the EU-27 and Great Britain between 2004 and 2020.

The models made it possible to analyse the influence of population growth on the increase in production. The dependence and impact of dairy exports on the growth of dairy production in the EU-27 and Great Britain were also studied. The empirical results indicate the unique opportunities for the development of the Czech Republic, the Netherlands and Poland in the indicators of the models. These countries have a rational ratio of the impact of population growth on the increase in dairy production and the optimal impact of dairy exports on the growth of dairy production.

The leaders in the production of drinking milk, butter, acidified milk, and cheese in Europe are Germany, France and Poland. Meanwhile, 8 of the top 10 world exporters of dairy products are in Europe: Germany, the Netherlands, France, Belgium, Italy, Denmark, Poland, and Ireland.



Thus, the world market of milk and dairy products in recent years has significantly expanded and diversified due to growing needs, geographical changes in trade flows, new consumers, and consumers' food preferences. The growth and change in trade in the world dairy market significantly depend on the level of the difference between domestic production of milk and dairy products and demand in individual countries, where there is a deficit against the background of rapid growth in consumption and population growth. The rapid demand for dairy products in countries with milk shortages is forcing exporting countries to re-evaluate and transform the capabilities of international markets. The export potential of the dairy industry is determined by domestic demand, raw materials and production base, market prices and the level of state support for production and export operations.

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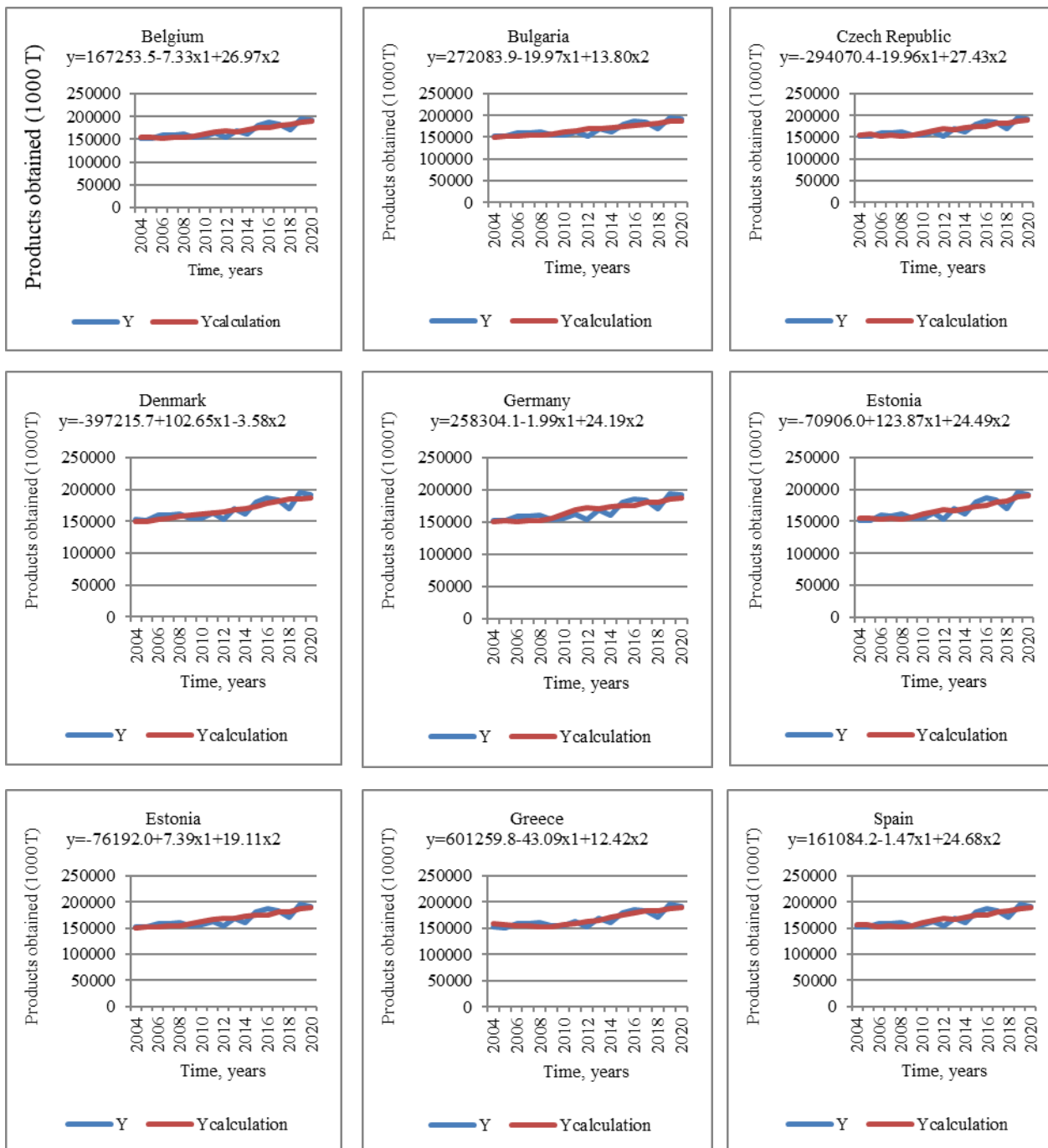
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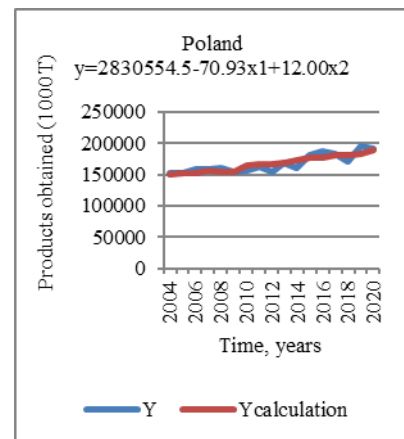
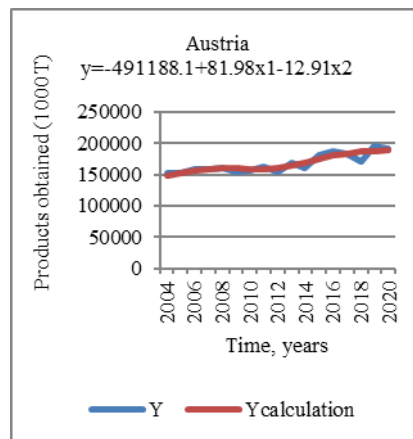
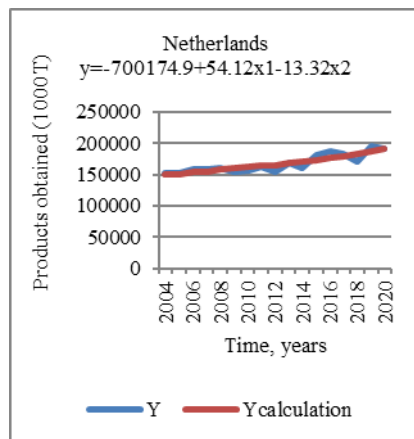
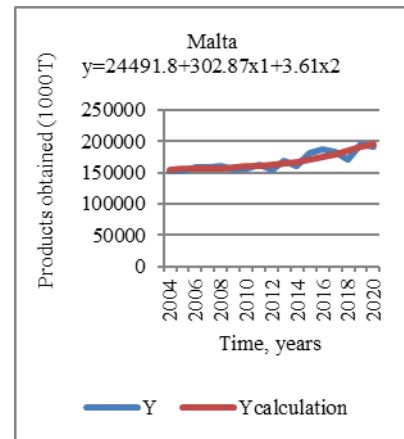
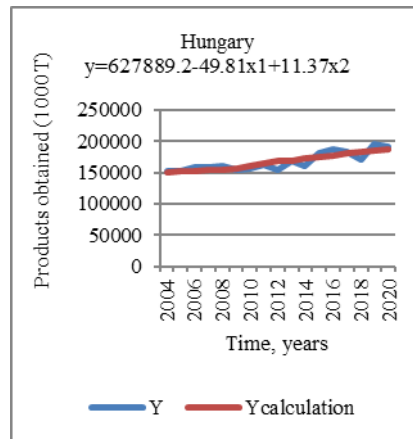
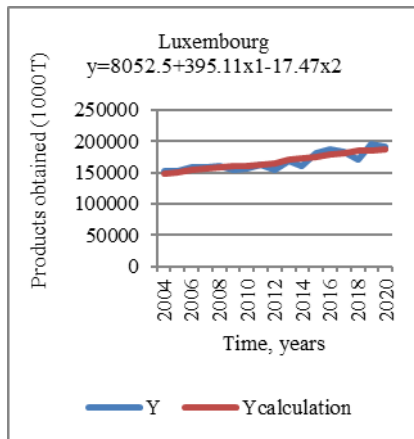
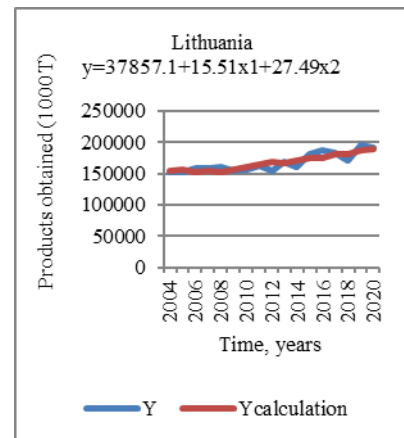
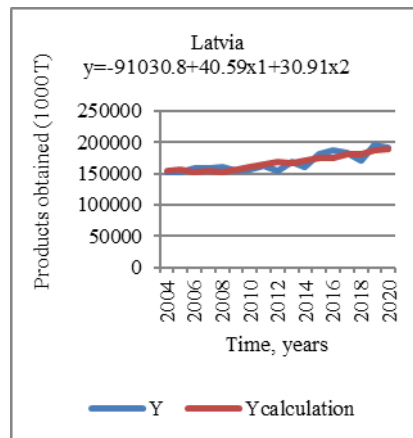
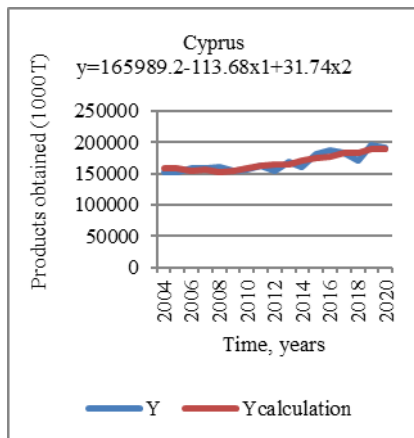
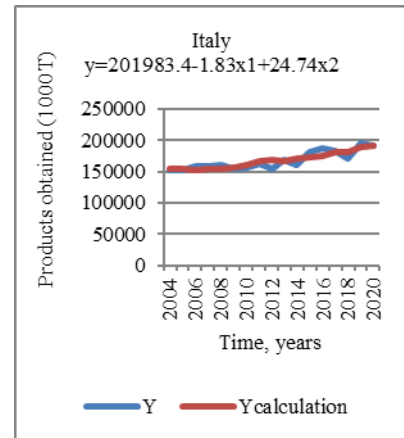
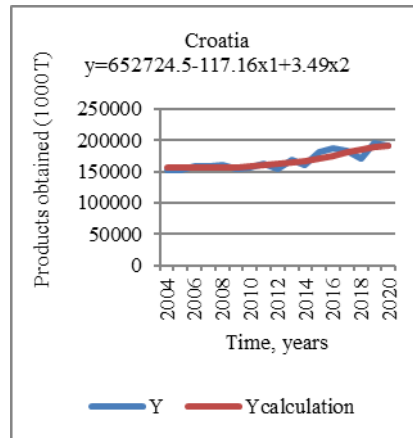
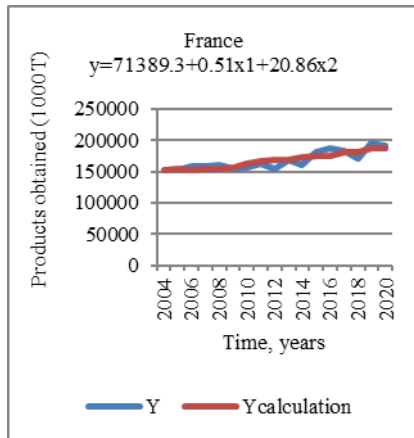
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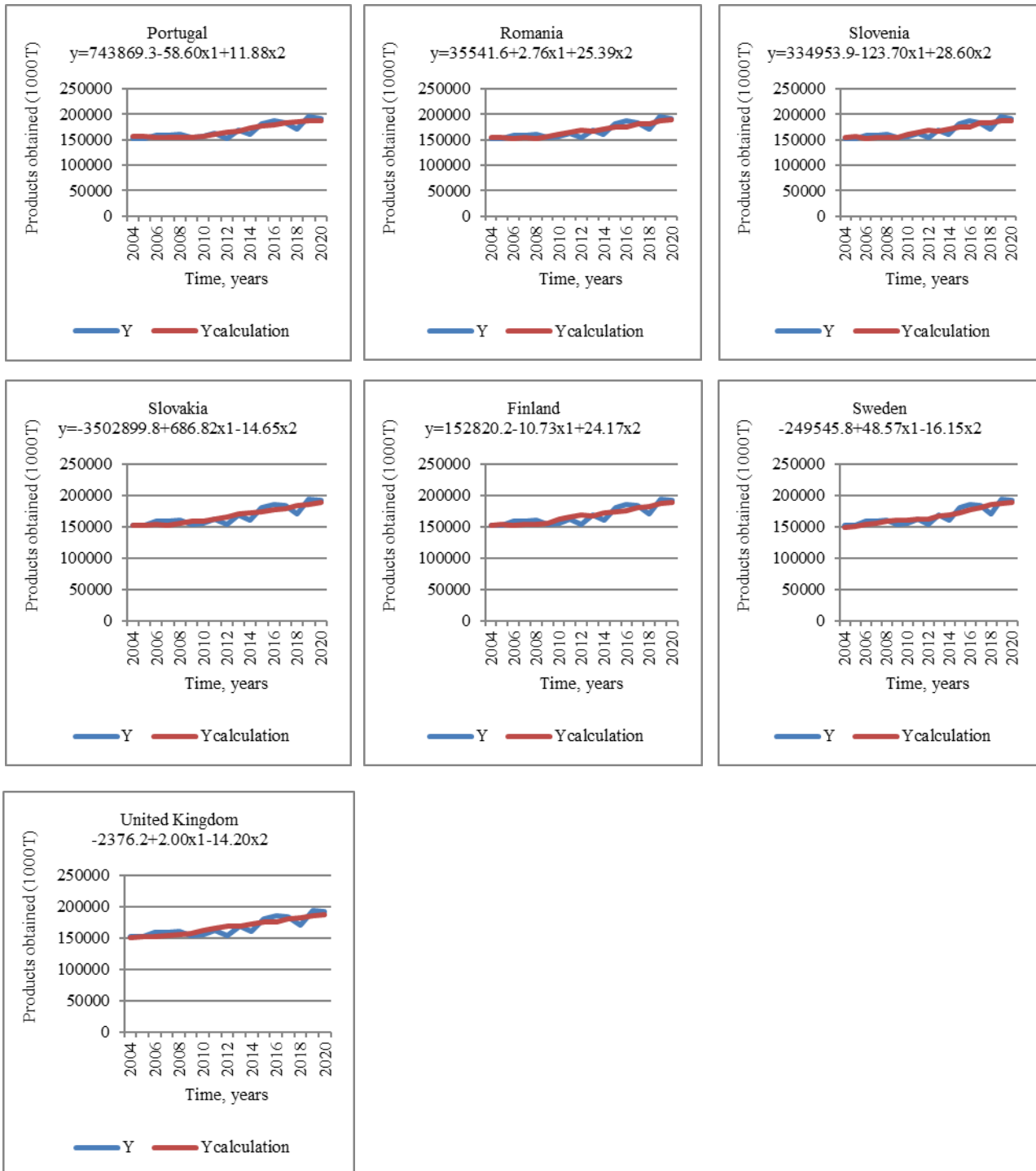


## ANNEX

### Quantitative impact of factors “Products obtained”, “Exports of Dairy Products”, and “Population” in the dairy industry of the EU-27 and Great Britain







Soures: authors' calculations based on Eurostat.

## Konwergencja czynników wpływających na rynek produktów mleczarskich: analiza porównawcza krajów Unii Europejskiej

Unia Europejska jest dużym producentem mleka i przetworów mlecznych, a jednocześnie znaczącym rynkiem konsumpcyjnym, który charakteryzuje się efektywnym popytem i znacząco wpływa na rynki innych produktów spożywczych. Głównymi producentami mleka w UE są Niemcy, Francja, Polska, Holandia, Włochy i Hiszpania. Intensywne procesy migracyjne przyczyniają się do dodatkowego popytu na produkty spożywcze, w szczególności produkty mleczne. Dało to podstawę do budowy i kalkulacji modelu dynamicznego produkcji mleczarskiej, eksportu produktów mleczarskich oraz współistnienia z populacją jako głównym konsumentem w krajach UE-27 i Wielkiej Brytanii w latach 2004–2020.

Uzyskane zależności umożliwiły analizę wpływu czynnika wzrostu populacji na wzrost wielkości produkcji. Jednocześnie zbadano zależność i wpływ eksportu produktów mleczarskich na wzrost wielkości produkcji produktów mleczarskich w krajach UE-27 i Wielkiej Brytanii.

Wyniki przeprowadzonego modelowania matematycznego wskazują na unikalne możliwości rozwoju sektora mleczarskiego poszczególnych krajów UE-27: Czech, Holandii, Polski. Kraje te mają racjonalny stosunek wpływu czynnika wzrostu liczby ludności na wzrost wolumenu produkcji mleczarskiej oraz optymalny wpływ eksportu produktów mleczarskich na wzrost wolumenu produkcji mleczarskiej.

**Słowa kluczowe:** mleko, produkty mleczarskie, Unia Europejska, producenci mleka, ludność, popyt, podaż