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EU DEMOGRAPHIC CHARACTERISTICS: GLOBAL MEGATRENDS AND OPPORTUNITIES FOR THE RETAIL SECTOR

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ABSTRACT

The article proposes the complex of economic and mathematical models for assessment and analysis of the peculiarities of the demographic situation in the EU countries for the formation of recommendations on improving the retail trade sector development adapted to each group of countries. Key global megatrends such as population ageing, declining share of the working-age population, increasing migration flows, urbanization, digitalization and consumer behaviour changing, and increasing environmental awareness are analyzed. The study highlights the challenges and opportunities these changes present for the retail sector.

A cluster-based model is developed to categorize countries into distinct demographic profiles, facilitating targeted retail strategies. The research employs factor analysis and multidimensional assessment methods to quantify the influence of demographic indicators, incorporating both stimulating and disincentive effects on retail market dynamics. This structured approach enables the design of differentiated business strategies, ensuring optimal market positioning and consumer engagement. The research also includes the examination of meta-spatial business collaborations as a crucial mechanism for retail adaptation. Particular focus is given to the adaptation of business models to cater to the needs of an ageing population, and the development of inclusive product assortments for multicultural communities. The results allow us to identify countries, in which it is optimal to develop youth-driven digital engagement models, senior-friendly shopping environments, and culturally inclusive retail ecosystems. The study underscores the necessity of aligning demographic data with emerging retail innovations to foster economic adaptability in an evolving global landscape. Companies can use demographic insights to form business collaborations with suppliers, brands, and marketing agencies that complement their audience, ensuring more effective partnerships and increased profitability. Based on demographic characteristics, government authorities can effectively regulate the trade sector, and ensure the availability of goods for the population. The findings underline the importance of integrating demographic analysis into strategic planning to enhance the retail sector's resilience.

Keywords: business collaborations, cluster analysis, country's population, demographic indicators, factor analysis, global megatrends, interaction, marketing strategies, retail companies, retail trade sector

JEL Classification: F13, F14, L81, O24

INTRODUCTION

The demographic situation is a key factor influencing the development of retail trade. Studying demographic trends helps make informed decisions regarding product assortment, store locations, and marketing strategies, contributing to business growth and its adaptation to changing consumer needs. Demographic analysis helps businesses identify their target audience and its characteristics. For example, parameters such as age, gender, income level, education, family status, and geographic location allow you to segment consumers and determine which products or services will be most in demand.

Demographic trends such as population ageing, migration, and the number of young families or children are influencing demand patterns, with an increasing elderly population driving demand for medical products, while a growing youth population is driving demand for fashion and technology. Analyzing population size and density in different regions can help to identify optimal places for new retail locations, such as opening stores in areas with high youth concentrations that may be beneficial for electronics retailers, and in suburbs with family homes, for supermarkets.

Researching demographic traits enables the adjustment and enhancement of product and service offerings to better align with consumer preferences. In high-income areas, premium products will be in demand, while in lower-income areas, economy offers will be popular. Demographic information also helps with strategic planning, namely, an increase in the birth rate can contribute to the development of the children's goods sector, and urbanization can increase the number of stores in urban areas.

Demographic data allows businesses to create effective marketing strategies, and use targeted advertising and promotions that appeal to specific population groups, in particular, promotions on social networks will be effective for young people, while the older generation responds more to traditional advertising. Such phenomena as increased migration, changes in household structure (increased number of single people) or the popularity of an ecological lifestyle allow trade to adapt faster to global changes and offer relevant products.

Thus, a complex analysis of the demographic situation will allow the retail sector to increase competitiveness by providing personalized solutions for different consumer groups and creating attractive marketing campaigns tailored to specific population groups.

LITERATURE REVIEW

Contemporary economic studies extensively explore the impact of demographic indicators on the retail sector development. Research shows that demographic factors, such as age characteristics, population ageing, migration processes, and changes in household structure, significantly affect consumer habits.

Demographics are a key tool for strategic planning in retail. Existing research in the scientific literature confirms that retailers that take demographic changes into account gain a competitive advantage through a better understanding of their customers' needs and the ability to adapt business models to new realities. However, most of the research only covers individual countries.

Voigtländer & Seipelt (2018) explore how demographic factors influence the retail sector in Germany. Their study examines how net migration to urban areas translates into potential retail consumption. Researchers have demonstrated that rising migration levels have contributed to a growth in the availability of retail products, particularly in major cities. Similarly, Landegren & Dimitrova (2016) analyze the connection between demographic trends and retail success. Their research focuses on understanding how different age groups affect overall retail revenue. Their analysis focuses on the demand side, specifically consumer characteristics. Using data from 290 Swedish municipalities collected in 2014, which includes variables like retail sales, age demographics, income levels, population density, and gender ratios, the study identifies a notable positive impact of individuals aged 18 to 44 on retail sales.

Formánek & Sokol (2022) conducted a study of retail trade in the Czech Republic. They say that for physical retail businesses, the location of a store plays a critical role in determining its success, influencing both the volume and composition of sales. A deep understanding of how location-related factors impact sales trends and leveraging this insight can provide a competitive advantage in the marketplace. Store locations are typically defined by a combination of geospatial characteristics and socio-demographic attributes that influence customer behaviour and accessibility.

Pooler (2018) in his book "Demographic Targeting: The Essential Role of Population Groups in Retail Marketing" absolutely rightly points out that retailers who overlook customer demographics do so at significant risk. By analyzing how age and gender influence shopping behaviours and preferences, consumers can be grouped into distinct demographic categories, each with unique characteristics and tendencies. For instance, middle-aged shoppers often have more disposable income but less free time for shopping. These insights are invaluable for tailoring marketing strategies and improving sales approaches. Demographic-focused strategies are critical for achieving success in contemporary retail environments. This perspective emphasizes the importance of viewing shopping habits through the lens of demographic analysis to better understand and meet the needs of today's consumers.

Green & Hendershott (2007) analyze the impact of age on retail sales using single cross-sections of household data of age and birth year. The authors assess the effects of age on retail spending. Findings indicate that households headed by

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individuals over 40 years old tend to spend more on retail compared to those led by individuals under 40. This highlights how both age and generational factors shape consumer behaviour in retail markets.

Singh & Sao (2015) study the evolution of the Indian retail market in response to India's changing demographics. They write that India's retail sector is experiencing rapid growth, driven by demographic shifts and the expansion of the middle class. This presents significant opportunities for both organized and unorganized retail segments. They explore consumer perceptions and shopping experiences regarding these two retail formats, with a focus on the Delhi and NCR regions. Additionally, they examine whether consumer preferences for organized or unorganized retailing are influenced by demographic factors or remain independent of them. Their study aims to provide insights into the evolving dynamics of retail choices in a transforming marketplace.

A similar analysis is also carried out by Kashyap & Chopra (2018). Their paper provides insight into the impact of demographic factors such as, for example, the increasing population of women on the buying behaviour of consumers between organized and unorganized retail sectors.

Bernadus et al. (2021) examine the state of hypermarket retail in Indonesia using demographic data. The findings highlight the typical profile of hypermarket customers in the country: they are predominantly women, most of whom are married, hold bachelor's degrees, and fall within the 46–55 age range. On average, they visit hypermarkets 7–10 times annually, with some visiting as frequently as 11–14 times.

Mehra (2016) investigates how demographic aspects, particularly age and monthly household earnings, influence consumers' preference for private-label brands of instant noodles and dairy products in organized retail stores in Chandigarh. The study employs an exploratory methodology, utilizing questionnaires to collect data. The results indicate that income does not play a significant role in determining consumers' preference for private-label brands in either product category. However, age is a key factor that increases the likelihood of purchasing private-label dairy products, while it does not have the same impact on private-label instant noodles.

Dewangan et al. (2015) analyze how demographic characteristics influence consumer purchasing behaviour for household products. Their research considers factors such as socio-economic background, age, decision-making patterns, and place of residence as independent variables, with consumer behaviour serving as the dependent variable. The findings emphasize the crucial role that demographic attributes play in shaping consumers' choices for everyday goods.

Gogoi (2013) examines how socio-demographic traits contribute to shifts in consumer behaviour with the rise of organized retail outlets.

Multivariate regression analyses of Walzer et al. (2018) identify the importance of demographic, economic, locational, and business environment factors on sales performance.

Muneendra & Prakash (2018) try to prove that there is a significant association between core demographic variables and the selection of a retail format. The factors influencing retail format selection include age, gender, education, income, marital status, and occupation. The results suggest that gender, education, income, occupation, and marital status significantly affect the choice of retail format, while age does not have a notable impact. Based on these findings, the study recommends targeting and segmenting retail strategies based on demographic profiles to better cater to consumer preferences.

Gupta and Singh (2015) aim to validate three specific hypotheses: that customers' age significantly influences their choice of retail stores, that their profession plays a role in in-store selection, and that their income level affects their retail preferences. Their findings suggest that age and income are key factors shaping consumers' perception of a store's image, which in turn influences their store selection behaviour.

A number of studies are aimed at investigating the influence of demographic factors on retail trade in various market segments and different industries. Kevrekidis et al. (2021) offer fresh perspectives on consumer behaviour by identifying crucial demographic aspects that determine pharmacy and over-the-counter (OTC) medicine choices. Their research reveals that individuals with lower education levels and retirees tend to consistently shop at the same pharmacy ($p < 0.001$). Older consumers place higher importance on pharmacy staff and additional services ($p < 0.01$), whereas students show a preference for maintaining a formal relationship with pharmacists ($p < 0.001$). Those with lower education levels are more likely to have predetermined purchase intentions ($p < 0.05$), while women exhibit a greater tendency for impulse buying of OTC products ($p < 0.05$). Additionally, wealthier consumers place more emphasis on a product's country of origin ($p < 0.05$) and manufacturer ($p < 0.01$) while valuing a pharmacist's advice less than lower-income customers ($p < 0.05$). Overall, education, occupation, and age significantly influence pharmacy selection, while gender and income level play a crucial role in OTC medicine purchases.

FitzGerald and Arnott (1996) investigate how demographic factors shape consumer responses to marketing strategies in service industries such as airlines. They highlight those variations in gender, age, cultural background, and usage frequency impact perceptions of advertising, promotional offers, and public relations efforts, ultimately influencing purchasing behaviour. Similarly, Gandee et al. (2003) and Bhandari and Mishra (2018) analyze the role of demographic characteristics on retail in the agriculture sector.

While there is extensive literature on retailing, much of it lacks quantitative analysis of how customer demographics affect sales performance. Existing studies do not group countries by demographic characteristics to suggest differentiated retail solutions based on country group characteristics. Therefore, this study will focus on this research question.

AIMS AND OBJECTIVES

The article's purpose is a set of economic and mathematical models building for assessment and analysis of the peculiarities of the demographic situation in the EU countries for the formation of recommendations on improving the retail trade sector development adapted to each group of countries.

METHODS

The study of the demographic situation in the European Union countries and its impact on the retail sector is conducted according to the scheme shown in Figure 1.

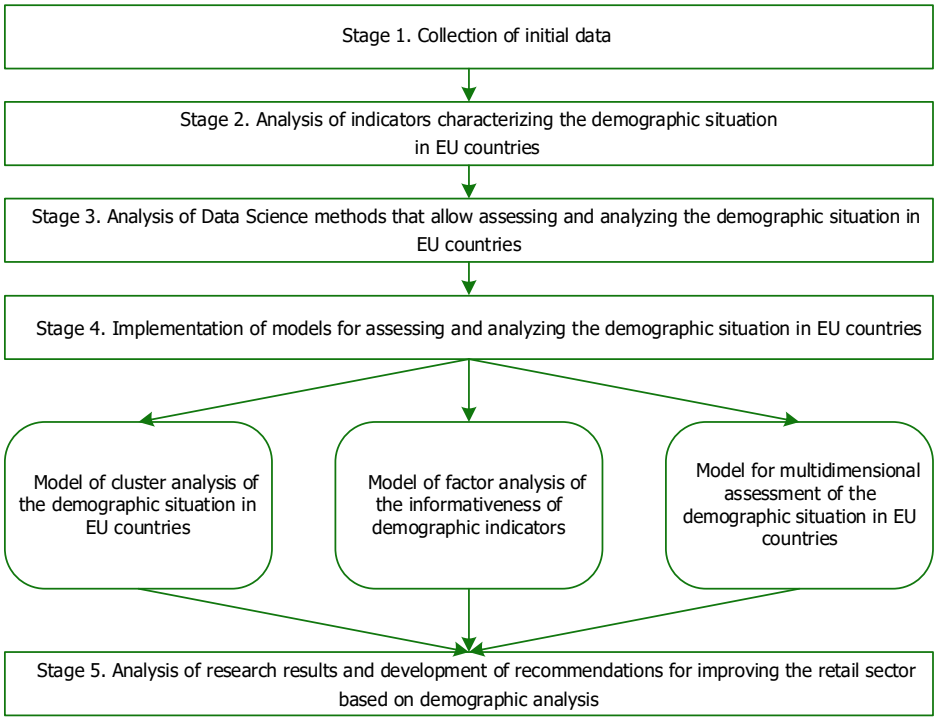

Figure 1. Conceptual diagram of the study.

The study uses Data Science methods that make it possible to analyze large amounts of data, identify trends, build forecasts, and make informed decisions, and is aimed at using mathematical models, statistics, machine learning algorithms, and visualization to study demographic megatrends. Among the proposed Data Science methods, the following methods are used:

1. The cluster analysis method is based on hierarchical clustering and the K-means method, which will allow us to obtain groups of countries that are homogeneous in terms of the demographic situation in order to develop strategies for the resulting groups of countries.
2. The factor analysis method will allow us to identify the main indicators that best describe the demographic situation in EU countries and will allow us to determine the information value of these indicators.

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3. A multidimensional assessment method for assessing the demographic situation in EU countries is built taking into account the results of implementing a factor analysis model, which allows determining weighting coefficients for each indicator that describes the demographic situation in the country.

Thus, the proposed Data Science methods will allow us to analyze and assess the demographic situation in each EU country and develop recommendations to improve the situation.

The research is based on the confirmation of the following empirical hypotheses:

- *Hypothesis 1.* Trends in the development of demographic processes in EU countries are heterogeneous.
- *Hypothesis 2.* The main megatrends for most European countries are facing the problem of mortality and population ageing, a decline in the share of the working-age population, migration and the growth of a multicultural population, changing family structures, digitalization and changing consumer behaviour, increasing urbanization, and growing environmental awareness.
- *Hypothesis 3.* Researching demographics makes it possible to increase the retail sector competitiveness by providing personalized solutions for different consumer groups.

The research implements the cluster, factor analysis, and model of multidimensional assessment of the demographic situation in 27 EU countries for the period 2021-2022.

For countries clustering the following indicators were taken:

1. PPEU – population as a percentage of the EU-27 population (from 2020).
2. PP-0-14 – share of the population aged 0-14 years.
3. PP-15-24 – share of the population aged 15-24.
4. PP-25-49 – share of the population aged 25-49.
5. PP-50-64 – share of the population aged 50-64.
6. PP-65-79 – share of the population aged 65-79.
7. PP-80 – share of the population aged 80 and over.
8. CRTPC – the total population growth rate – is the ratio of the change in population during the year (the difference between the population on January 1 of two consecutive years) to the average population in that year. The value is expressed per 1,000 people.
9. CRNCP – the rate of natural population change – is the ratio of the natural increase during a year (live births minus deaths) to the average population size in that year. The value is expressed per 1,000 people.
10. CRNMSA – net migration rate plus statistical adjustment – is defined as the ratio of net migration (including statistical adjustment) during a year to the average population size in that year. The value is expressed per 1,000 people. Net migration plus adjustment is calculated as the difference between the total change and the natural change in the population.
11. CMR – marriage rate – is the ratio of the number of marriages during a year to the average population size in that year. The value is expressed per 1000 people.
12. CDR – divorce rate – is the ratio of the number of divorces during a year to the average population size in that year. The value is expressed per 1,000 people.
13. IMR – infant mortality rate – is the ratio of the number of deaths during a year of children under one year of age to the number of live births in that year. The value is expressed per 1000 live births.
14. OADR – the ratio of the demographic burden of older people (population 65 years and older to population 15-64 years old). This indicator is the ratio between the number of people aged 65 years and older (the age at which they are usually economically inactive) and the number of people aged 15 to 64 years old. The value is expressed per 100 people of working age (15-64).
15. CDeathR – total mortality rate – is the ratio of the number of deaths during a year to the average population size in that year. The value is expressed per 1000 people.

16. CBR – total birth rate – is the ratio of the number of live births (the birth of children who showed any signs of life) during a year to the average population size in that year. The value is expressed per 1,000 people.
17. MAWFB – average age of women at first birth.
18. TNI – the share of long-term immigrants who arrived in the reporting country during the reporting year in the total population at the beginning of the year.
19. TNE – the share of long-term emigrants who left the reporting country during the reporting year in the total population at the beginning of the year.
20. TFR – total fertility rate – the average number of children a woman would give birth to alive during her lifetime if she had survived and lived through her childbearing years according to age-specific fertility rates in a given year.

The second stage of the study involves the analysis of indicators characterizing the demographic situation in EU countries. The third stage is the analysis of Data Science methods that make it possible to assess and analyze the demographic situation in EU countries.

Among the methods of Data Science, we propose to use cluster analysis methods, factor analysis methods, and multivariate evaluation methods.

We propose to build cluster analysis models based on hierarchical clustering methods and the k-means method, which will allow us to obtain groups of countries with homogeneous demographic situations and to develop strategies for the retail sector for them. The factor analysis model will allow us to identify the main indicators that best describe the demographic situation in the EU countries and to determine the information value of these indicators. Next, we build the model for assessing the demographic situation in the EU countries based on the methods of baht-dimensional assessment taking into account the results of the implementation of the factor analysis model, which allows us to determine the weight coefficients for each indicator describing the demographic situation in the country.

Thus, the proposed Data Science methods will allow us to analyze and assess the demographic situation in each EU country and develop recommendations to improve the situation in the retail sector, taking into account the dynamics of demographic indicators.

RESULTS

The result of building a cluster analysis model based on the complete linkage method and Euclidean distance is shown in Figure 2.

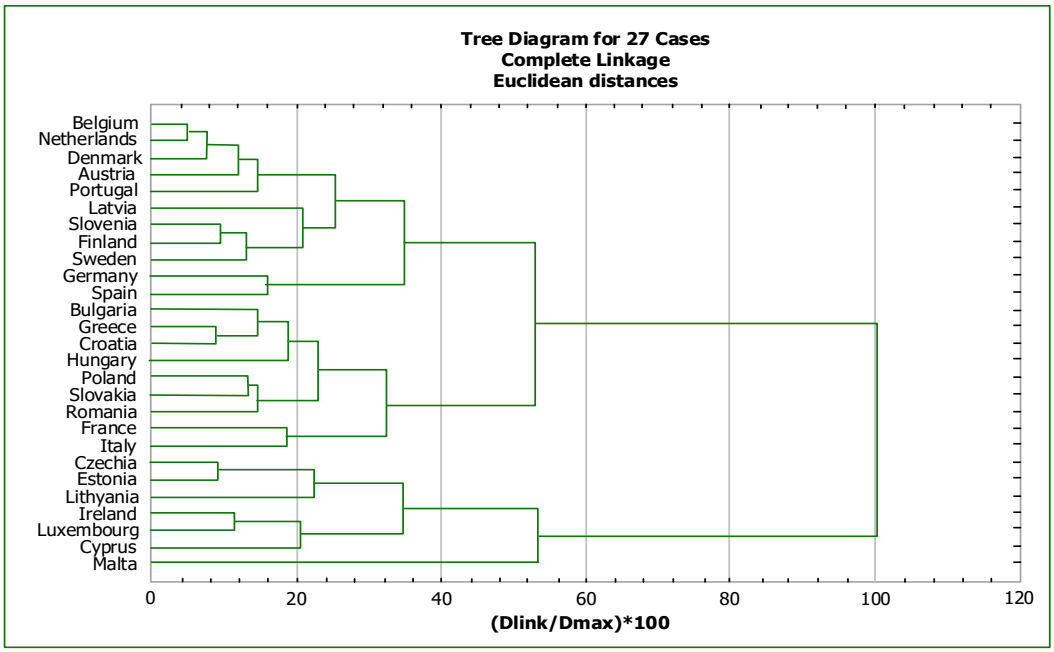

Figure 2. The result of building a cluster analysis model based on the complete linkage method and Euclidean distance.

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The first cluster includes the Czech Republic, Estonia, Lithuania, Malta, Ireland, Luxembourg and Cyprus. The second cluster includes Belgium, the Netherlands, Denmark, Austria, Latvia, Portugal, Slovenia, Finland, Sweden, Germany and Spain. All other EU countries are included in the third cluster.

The result of building a cluster analysis model using the full linkage method based on the distance of "city blocks" (Figure 3) gave the following results. The composition of the first cluster: Czech Republic, Estonia, Malta, Ireland, Luxembourg and Cyprus. Lithuania, which moved from the first cluster, is in the second cluster.

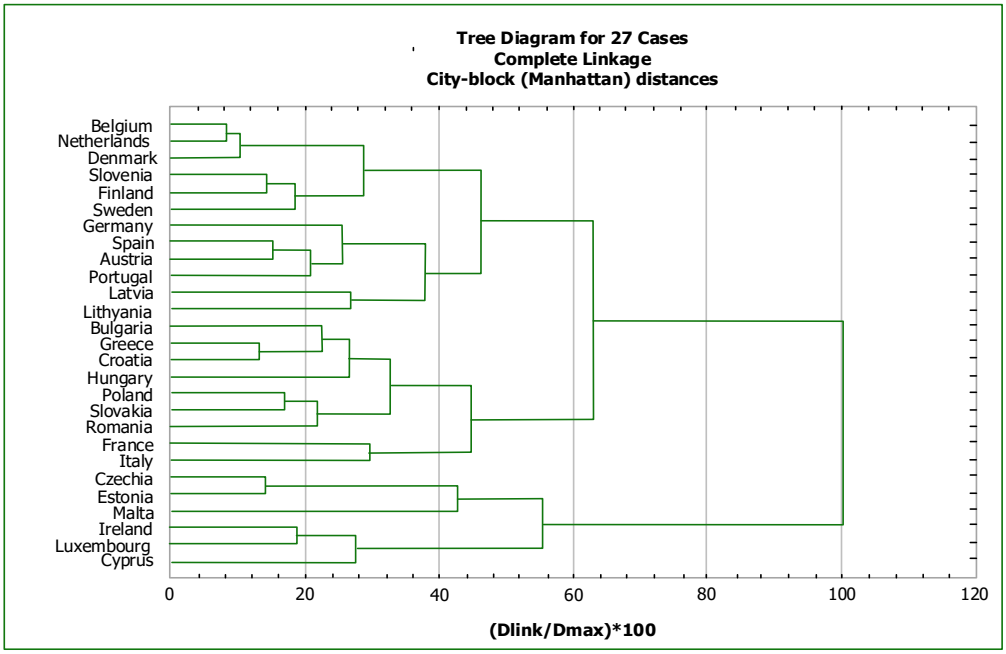

Figure 3. The result of building a cluster analysis model using the full linkage method based on the distance of "city blocks".

Next, we build a cluster analysis model based on the K-means method. The EU countries were divided into three groups, and the division into three groups is clearly visible in Figure 2 and Figure 3.

The average values for the indicators for each of the clusters are shown in Figure 4.

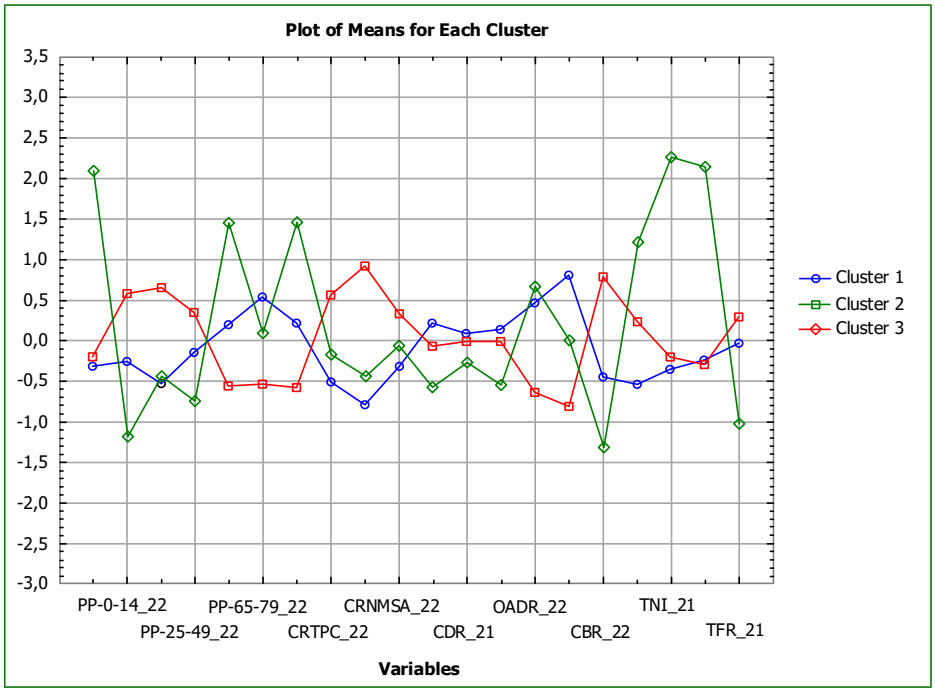

Figure 4. Average values of indicators by clusters (standardized data).

Cluster 1 is characterized by the highest values of the share of the population aged 0 to 14 and 25 to 49, the highest rates of total, natural and migration growth, the highest fertility rate, as well as the lowest values of the population as a percentage of the EU population, the shares of the population aged 50 to 64, 65 to 79 and over 80. As a result of this distribution of the population by age groups, countries from this cluster have the lowest value of the demographic burden indicator, which shows what share of the population aged 65 and over falls on the working-age population (from 15 to 64 years) and the lowest value of the mortality rate. The first cluster includes the following countries: Czech Republic, Estonia, Ireland, Lithuania, Luxembourg and Malta. The comparison of the European Union countries based on selected socio-economic and demographic indicators is also done by Hurbánková & Krasňanská (2019) but for the year 2016.

The countries of the second cluster are characterized by the highest percentage of the population aged 50 to 64, over 80 years old and the average percentage of the population aged 65 to 79. These countries also have the highest divorce rate and the highest average age of women at the birth of their first child, as well as the lowest percentage of the population in the active working age group – from 25 to 49 years old and the lowest infant mortality rate. The second cluster includes such countries as Belgium, Denmark, Germany, Spain, Cyprus, Latvia, the Netherlands, Austria, Portugal, Slovenia, and Sweden.

Countries from the third cluster are characterized by the highest indicators of the share of the population aged 65 to 79, infant mortality, total mortality, demographic burden, and marriage rate, as well as the lowest indicators of the share of the population aged 0 to 14, 15 to 24, natural and migration growth, divorce rate, total fertility rate. The third cluster includes such countries as Bulgaria, Greece, France, Croatia, Italy, Hungary, Poland, Romania, Slovakia and Finland.

Table 1 shows the matrix of Euclidean distances between clusters.

Table 1. Matrix of Euclidean distances between clusters. Notes: distances are below the diagonal; squared distances are above the diagonal.

Cluster Number	Euclidean Distances between Clusters (Demogafy Dataset)		
	No 1	No 2	No 3
No 1	0.000000	28.46561	83.35760
No 2	5.335318	0.000000	15.265749
No 3	9.130038	3.90736	0.000000

Table 1 shows that the greatest distance exists between the first and third clusters, while the countries from the second and third clusters are closer to each other.

Thus, on the basis of cluster analysis, groups of countries were formed that are homogeneous in terms of demographic indicators. For these groups of countries, the adapted strategies and opportunities for the retail sector can be developed. For example, for countries in the third group (cluster), it is necessary to improve the health care system in order to reduce mortality, in particular child mortality. Despite the fact that these countries have the highest marriage rate and the lowest divorce rate, that is, the institution of the family is respected here, the birth rate is low. It is necessary to stimulate birth rates in order to change the distribution of age groups and add to the future number of the working-age population.

Subsequently, we implement factor analysis models of demographic indicators. The results are shown in Table 2.

Table 2. The result of the factor analysis model based on the principal components method after rotation.

Variable	Factor Loadings (Varimax normalized) (Demogafy Dataset) Extraction: Principal components (Market loadings are >.700000)		
	Factor 1	Factor 2	Factor 3
PPEU_22	0.297658	-0.133735	-0.487797
PP-0-14_22	0.105528	0.886168	0.132955
PP-15-24_22	-0.013544	0.790988	-0.369352
PP-25-49_22	-0.719910	0.134502	0.552422
PP-50-64_22	0.264290	-0.617472	-0.348808
PP-65-79_22	0.583736	-0.548775	0.027169

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Table 2. Continued.

Variable	Factor Loadings (Varimax normalized) (Demogafy Dataset) Extraction: Principal components (Market loadings are >.700000)		
	Factor 1	Factor 2	Factor 3
PP-80_22	0.321410	-0.598604	-0.641753
CRTPC_22	-0.771678	0.227044	-0.139667
CRNCP_22-	-0.446435	0.807381	-0.292690
CRNMSA_22	-0.730240	-0.000561	-0.064703
CMR_21	-0.117337	0.003643	0.626542
CDR_21	0.113821	0.018666	-0.001029
IMR_21	0.149022	0.010734	0.653853
OADR_22	0.620978	-0.583365	-0.313122
CDeathR_22	0.553083	-0.616791	0.451640
CBR_22	0.004897	0.916125	0.221948
MAWFB_21	-0.372283	0.095667	-0.825908
TNI%P_21	-0.911821	0.172610	0.043758
TNE%P_21	-0.854175	0.099602	0.169722
TFR_21	0.572502	0.609886	0.175206
Expl. Var	5.227988	5.174195	3.255732
Prp. Totl	0.261399	0.258710	0.162787

The selected number of factors well describes the entire set of initial indicators (Table 3).

Table 3. Eigenvalues and percentage of explained variance.

Value	Elgenvalues (Demogafy Dataset) Extraction: Principal components			
	Eigenvalues	% Total variance	Cumulative Eigenvalue	Cumulative %
1	7.147950	35.73975	7.14795	35.73975
2	3.431396	17.15698	10.57935	52.89673
3	3.078569	15.39285	13.65792	68.28958

As can be seen from Figure 3, the first three factors explain more than 68% of the variance.

At the same time, the first factor has the largest factor loadings for the following indicators: the share of the population aged 25 to 64, the total population growth rate, the population migration growth rate, and the share of long-term immigrants and emigrants in the total population of the country. This is the factor of the working-age population.

The second factor has the largest factor loadings for the following indicators: the share of the population aged 0 to 14, the share of the population aged 15 to 24, the natural growth rate, and the total birth rate. This is a factor in the formation of the country's demographic potential by increasing the birth rate and, as a result, the number of young people.

The third factor has the largest factor loading for such an indicator as the average age of women at the birth of their first child. This is a factor of the standard of living in the country. The higher the standard of living (higher income, higher level of healthcare), the higher the average age of a woman at which she gives birth to her first child.

Figure 5 shows the distribution of indicators in the space of the first two factors, where three groups of indicators can be observed:

1. The first is the percentage of children and adolescents, the birth rate, and the natural population growth rate.
2. The second is the share of the working-age population, the share of long-term migrants, the total and migration population growth.

3. The third is the proportion of elderly people, the ratio of the demographic burden of people of retirement age on the working-age population, and the mortality rate.

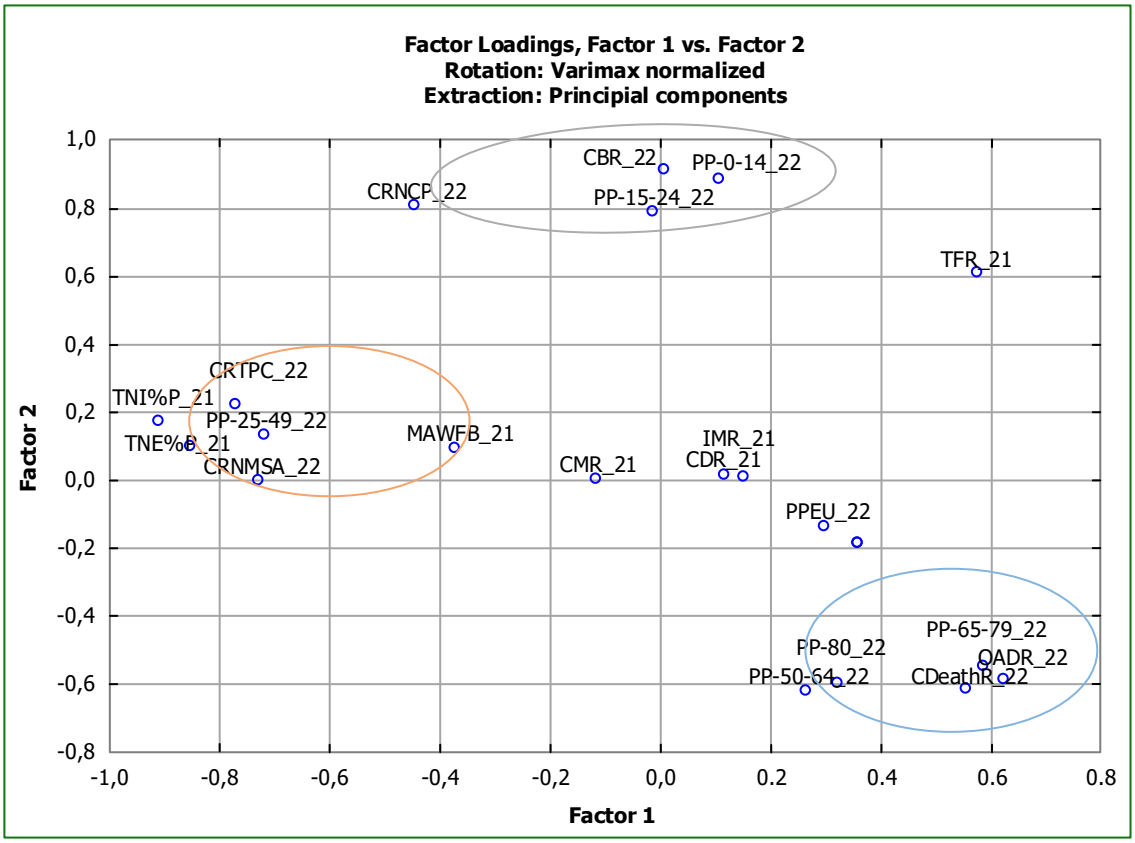

Figure 5. Distribution of indicators in the space of the first two factors.

Thus, the factor analysis model makes it possible not only to reduce the dimensionality of the original indicator space, to identify the main groups of indicators, but also to analyze the distribution of indicators by groups.

Further, an assessment of the state of the demographic systems of the EU countries was carried out based on multidimensional assessment methods. The initial indicators values standardization was carried out according to the formula:

$$\bar{x}_{ij} = \begin{cases} \dfrac{x_{ij}}{\max\limits_{i} x_{ij}}, & if\ x_{ij} - stimulator \\ \dfrac{\min\limits_{i} x_{ij}}{x_{ij}}, & if\ x_{ij} - destimulator \end{cases},$$

where x_{ij} *– the value of the* j*-th indicator, which assesses the demographic situation, for the* i*-th country.*

Before standardization, it is necessary to determine which indicators are stimulators and which are destimulators. The results of the division of indicators are given in Table 4.

Table 4. Division of indicators into stimulator and destimulators.

No.	Name	Indicator	Stimulator / destimulator	+/–
1	PPEU_22	population as a percentage of the EU-27 population	stimulator	+
2	PP-0-14_22	share of the population aged 0-14 years	stimulator	+
3	PP-15-24_22	share of the population aged 15-24	stimulator	
4	PP-25-49_22	share of the population aged 25-49	stimulator	+

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Table 4. Continued.

No.	Name	Indicator	Stimulator / destimulator	+/–
5	PP-50-64_22	share of the population aged 50-64	stimulator	+
6	PP-65-79_22	share of the population aged 65-79	destimulant	–
7	PP-80_22	share of the population aged 80 and over	destimulator	–
8	CRTPC_22	total population growth rate	stimulator	+
9	CRNCP_22	natural population change rate	stimulator	+
10	CRNMSA_22	net migration coefficient plus statistical adjustment	stimulator	+
11	CMR_21	marriage rate	stimulator	+
12	CDR_21	divorce rate	destimulator	–
13	IMR_21	infant mortality	destimulator	–
14	OADR_22	coefficient of the demographic burden of elderly people	destimulator	–
15	CDeathR_22	overall mortality rate	destimulator	–
16	CBR_22	total fertility rate	stimulator	+
17	MAWFB_21	average age of women at the birth of their first child	destimulant	–
18	TNI%P_21	share of long-term immigrants	stimulator	+
19	TNE%P_21	share of long-term emigrants	destimulator	–
20	TFR_21	the estimated number of live births a woman would have throughout her lifetime if she were to survive through her reproductive years, based on age-specific fertility rates for a particular year.	stimulator	+

From Table 4 it is clear that the increase in such indicators as the coefficient of total and infant mortality, divorce rate and demographic burden of the elderly, as well as the increase in the number of people aged 65 and older and the increase in the number of long-term emigrants within the framework of this study, it is considered a disincentive effect on the country's demographic system. The question may arise why the increase in the average age of women at the birth of the first child is also considered negative. On the one hand, the increase in this indicator indicates a woman's interest in education and career. However, in our opinion, the later a woman gives birth to her first child, the less likely it is to have subsequent children. From a demographic perspective, this trend will ultimately result in a long-term decline in the nation's population (Svatošová, 2010).

In the next step, the weights were determined based on the factor loadings obtained in the factor analysis model. The formula for calculating the weights is:

$$w_j = \frac{f_j}{\sum_{j=1}^{n} f_j},$$

where f_j – the value of the factor loading j-th indicator, corresponding to one of the three main components.

The result of the weight coefficients calculation is given in Table 5.

Table 5. Result of weight coefficients calculating.

No.	Indicator	Factor Loadings	wj	No.	Indicator	Factor Loadings	wj
1	PPEU_22	0.2977	0.0252	11	CMR_21	0.1173	0.0099
2	PP-0-14_22	0.8872	0.0751	12	CDR_21	0.1138	0.0096
3	PP-15-24_22	0.7910	0.0670	13	IMR_21	0.1490	0.0126
4	PP-25-49_22	0.7199	0.0610	14	OADR_22	0.6210	0.0526
5	PP-50-64_22	0.2643	0.0224	15	CDeathR_22	0.5531	0.0468
6	PP-65-79_22	0.5837	0.0494	16	CBR_22	0.9161	0.0776
7	PP-80_22	0.3214	0.0272	17	MAWFB_21	0.8259	0.0699
8	CRTPC_22	0.7717	0.0653	18	TNI%P_21	0.9118	0.0772
9	CRNCP_22	0.8074	0.0684	19	TNE%P_21	0.8542	0.0723
10	CRNMSA_22	0.7302	0.0618	20	TFR_21	0.5725	0.0485

In the next step, the demographic situation in each country was assessed using the weighted summation method:

$$WSM_i = \sum_{j=1}^{n} \bar{x}_{ij} w_j \, , i = \overline{1,m}$$

where WSM_i – the value of the integral assessment of the demographic situation in the i-th country, obtained using the weighted summation method; $\bar{x}_{ij}$ – standardized value of the j-th indicator assessing the demographic situation for the i-th country; w_j – the value of the weight coefficient for the j-th indicator.

The results of the integral indicator calculation using the weighted summation method are shown in Figure 6.

The highest value is in Ireland (the integral indicator is 0.7613). The lowest value is in Bulgaria, whose integral indicator is 0.3340. The average value among all countries is 0,5189.

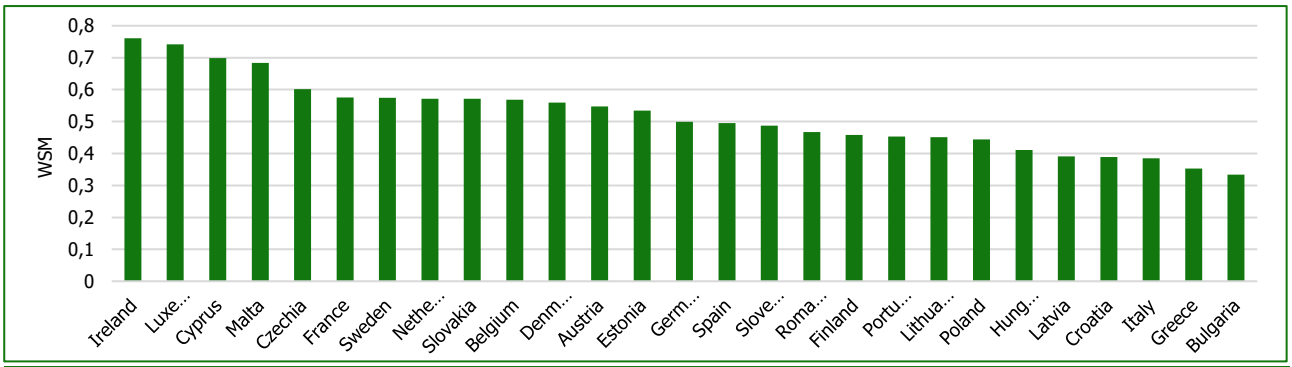

Figure 6. Results of calculating the integral indicator using the weighted summation method.

In the next step, the demographic situation in each country was assessed using the weighted multiplicative method using the formula:

$$WPM_i = \prod_{j=1}^{n} \left|\bar{x}_{ij}\right|^{w_j}, \qquad i = \overline{1,m}$$

where WPM_i – the value of the integral assessment of the demographic situation in the i-th country, obtained using the weighted multiplicative method; $|\bar{x}_{ij}|$ – the absolute standardized value of the ji-th indicator assessing the demographic situation for the -th country; w_j – the value of the weight coefficient for the j-th indicator.

The results of calculating the integral indicator using the weighted multiplicative method are shown in Figure 7. With this method, the maximum value is also in Ireland, whose integral indicator is 0.6255. The minimum value is in the Slovak Republic, which has an integral indicator of 0.3225. The average value among all countries is 0.4615. The values above the average are in such countries as Hungary (0.4719), Austria (0.4911), Portugal (0.4955), Spain (0.5041), Cyprus (0.5284), Germany (0.5402), Estonia (0.5426), Latvia (0.5452), Luxembourg (0.5477), Czech Republic (0.5894), Ireland (0.6255). All other analyzed countries have values below the average.

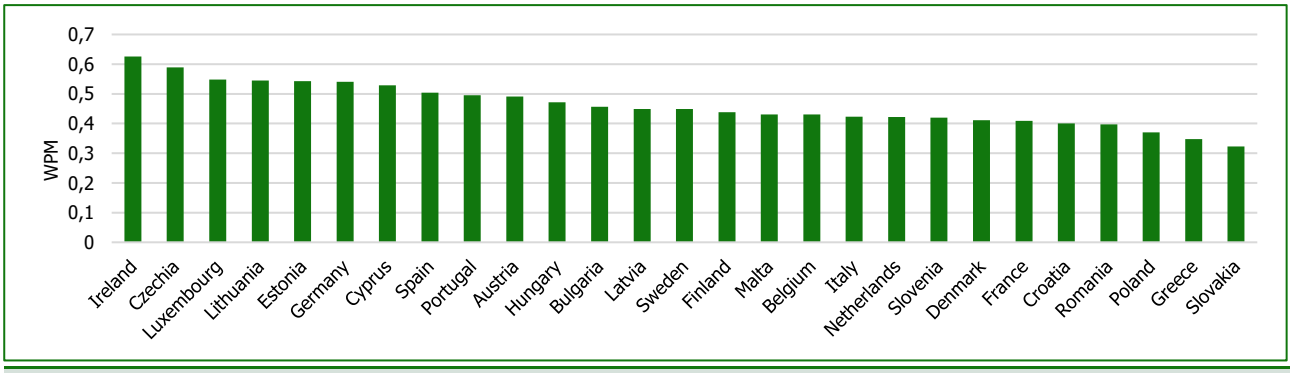

Figure 7. Results of calculating the integral indicator using the weighted multiplicative method.

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As we can see from Figure 6 and Figure 7, there are some differences between the results of these two methods. Therefore, it is advisable to apply the weighted aggregation method in the next step, which processes the results of these two methods and outputs an integral indicator as an average value according to the formula:

$$WAM_i = 0{,}5 \cdot WSM_i + 0{,}5 \cdot WPM_i = 0{,}5 \cdot \sum_{j=1}^{n} \bar{x}_{ij} w_j + 0{,}5 \cdot \prod_{j=1}^{n} \bar{x}_{ij}^{w_j}, i = \overline{1,m}$$

where WAM_i – the value of the integral indicator of the demographic situation in the i-th country, obtained using the weighted aggregation method.

Table 6 shows the results of calculating the integral score using this method and two others, indicating the rating position of the score using each method and the cluster number to which the country belongs.

Table 6. Results of calculating the integral indicator using three methods.

No.	Country	WSM	Rank WSM	WPM	Rank WPM	WAM	Rank WAM	Cluster
1	Belgium	0.5687	10	0.4306	17	0.4996	11	second
2	Bulgaria	0.3340	27	0.4569	12	0.3954	25	third
3	Czechia	0.6011	5	0.5894	2	0.5952	4	first
4	Denmark	0.5596	11	0.4113	21	0.4854	15	second
5	Germany	0.4997	14	0.5402	6	0.5200	7	second
6	Estonia	0.5345	13	0.5426	5	0.5385	6	first
7	Ireland	0.7613	1	0.6255	1	0.6934	1	first
8	Greece	0.3531	26	0.3480	26	0.3505	27	third
9	Spain	0.4953	15	0.5041	8	0.4997	10	second
10	France	0.5756	6	0.4088	22	0.4922	14	third
11	Croatia	0.3894	24	0.4007	23	0.3951	26	third
12	Italy	0.3853	25	0.4235	18	0.4044	24	third
13	Cyprus	0.6988	3	0.5284	7	0.6136	3	second
14	Latvia	0.3906	23	0.4494	13	0.4200	22	second
15	Lithuania	0.4509	20	0.5452	4	0.4980	12	first
16	Luxembourg	0.7418	2	0.5477	3	0.6448	2	first
17	Hungary	0.4107	22	0.4719	11	0.4413	20	third
18	Malta	0.6837	4	0.4308	16	0.5572	5	first
19	Netherlands	0.5717	8	0.4220	19	0.4969	13	second
20	Austria	0.5472	12	0.4911	10	0.5191	8	second
21	Poland	0.4442	21	0.3705	25	0.4073	23	third
22	Portugal	0.4533	19	0.4955	9	0.4744	16	second
23	Romania	0.4673	17	0.3970	24	0.4321	21	third
24	Slovenia	0.4871	16	0.4194	20	0.4533	17	second
25	Slovakia	0.5716	9	0.3225	27	0.4471	19	third
26	Finland	0.4583	18	0.4382	15	0.4482	18	third
27	Sweden	0.5744	7	0.4488	14	0.5116	9	second

Special focus should be given to countries that belong to the first cluster and hold leading positions in the rankings. (Table 7).

Table 7. Results of calculating the integral score for the countries of the first cluster.

Country	WSM	Rank WSM	WPM	Rank WPM	WAM	Rank WAM	Cluster
Czechia	0.6011	5	0.5894	2	0.5952	4	first
Estonia	0.5345	13	0.5426	5	0.5385	6	first
Ireland	0.7613	1	0.6255	1	0.6934	1	first
Lithuania	0.4509	20	0.5452	4	0.4980	12	first
Luxembourg	0.7418	2	0.5477	3	0.6448	2	first
Malta	0.6837	4	0.4308	16	0.5572	5	first

A visual analysis of the rating distribution for the countries of the first cluster is shown in Figure 8.

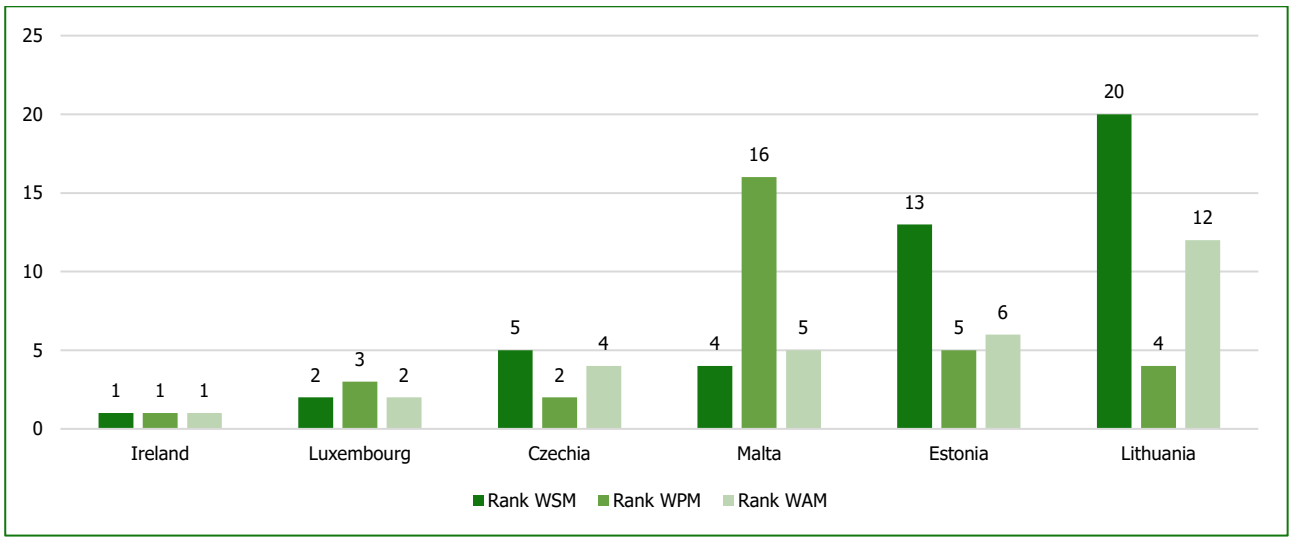

Figure 8. Ranks obtained as a result of the integral score calculated for the first cluster countries.

Lithuania ranked 12th in the ranking, but in the cluster analysis model, it fell into the first cluster. Lithuania received a low score according to the weighted summation method, while according to the weighted multiplicative method, it received the fourth-ranking position. The weighted multiplicative method is more sensitive to changes in the values of the initial indicators and the degree indicator – the weighting coefficient.

The values of the integral indicators of the demographic situation in the countries that belong to the second cluster are given in Table 8.

Table 8. Findings from the computation of the integral indicator for the countries of the second cluster.

Country	WSM	Rank WSM	WPM	Rank WPM	WAM	Rank WAM	Cluster
Belgium	0.5687	10	0.4306	17	0.4996	11	second
Denmark	0.5596	11	0.4113	21	0.4854	15	second
Germany	0.4997	14	0.5402	6	0.5200	7	second
Spain	0.4953	15	0.5041	8	0.4997	10	second
Cyprus	0.6988	3	0.5284	7	0.6136	3	second
Latvia	0.3906	23	0.4494	13	0.4200	22	second
Netherlands	0.5717	8	0.4220	19	0.4969	13	second
Austria	0.5472	12	0.4911	10	0.5191	8	second
Portugal	0.4533	19	0.4955	9	0.4744	16	second
Slovenia	0.4871	16	0.4194	20	0.4533	17	second
Sweden	0.5744	7	0.4488	14	0.5116	9	second

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A visual analysis of the rating distribution for the countries of the second cluster is shown in Figure 9.

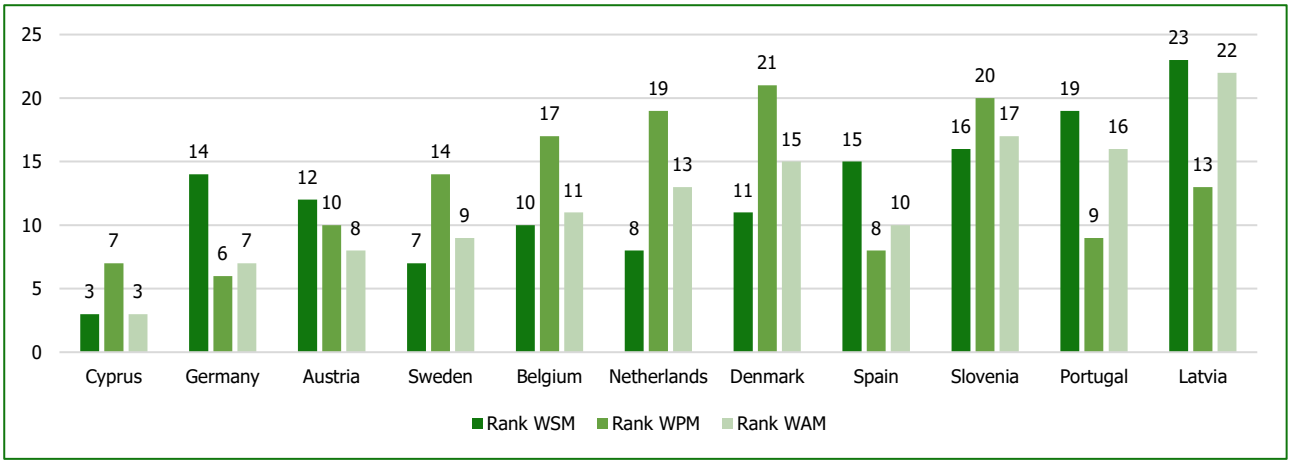

Figure 9. Ranks obtained as a result of the integral score calculated for the second cluster countries.

Cyprus is in the third-ranking position, but it belongs to the second cluster. Latvia has the 22nd position.

The values of the integral indicators of the demographic situation in the countries included in the third cluster are given in Table 9.

Table 9. Results of calculating the integral indicator for the countries of the third cluster.

Country	WSM	Rank WSM	WPM	Rank WPM	WAM	Rank WAM	Cluster
Bulgaria	0.3340	27	0.4569	12	0.3954	25	third
Greece	0.3531	26	0.3480	26	0.3505	27	third
France	0.5756	6	0.4088	22	0.4922	14	third
Croatia	0.3894	24	0.4007	23	0.3951	26	third
Italy	0.3853	25	0.4235	18	0.4044	24	third
Hungary	0.4107	22	0.4719	11	0.4413	20	third
Poland	0.4442	21	0.3705	25	0.4073	23	third
Romania	0.4673	17	0.3970	24	0.4321	21	third
Slovakia	0.5716	9	0.3225	27	0.4471	19	third
Finland	0.4583	18	0.4382	15	0.4482	18	third

A visual analysis of the rating distribution for the third cluster countries is shown in Figure 10.

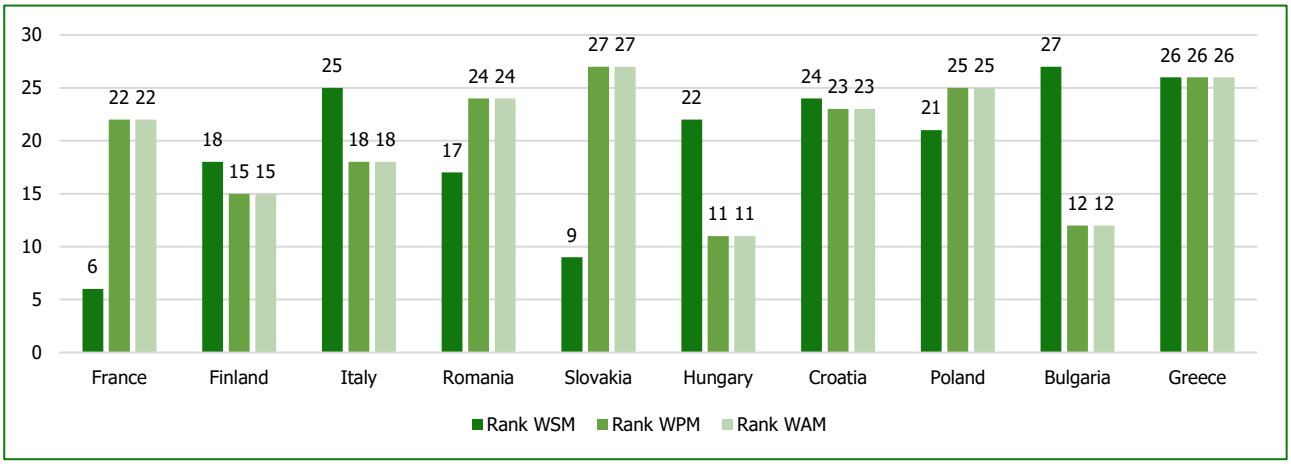

Figure 10. Ranks obtained as a result of the integral score calculated for the third cluster countries.

The third cluster includes countries with lower-ranking positions, with the exception of France, which ranks 14th. It received the best result using the weighted aggregation method.

Thus, the constructed model allows us to assess the demographic situation in each EU country, to compare it with the situation in countries falling into the same class. This assessment is carried out taking into account the stimulating and discouraging influence of individual demographic indicators and also takes into account the different information values of indicators by determining their weight coefficients.

Based on the proposed and implemented models, effective management solutions and marketing strategies for retail can be developed and adapted to the demographic characteristics of different countries (Table 10).

Table 10. Differentiated marketing strategies for the retail sector depending on the demographic characteristics of the countries.

Cluster number	Characteristic	Marketing strategies for the retail sector
Cluster 1	High population growth (total, natural, migration), highest birth rate, low level of demographic burden.	28. Segmentation of young audiences and families: ▪ development of promotions and loyalty programs for families with children (discounts on children's goods, sets for newborns); ▪ implementation of marketing activities in schools, kindergartens (partnership with educational and medical institutions). 29. Focus on growing demand: ▪ expanding the range of essential goods, children's goods, and products for young families; ▪ organizing fast delivery for the convenience of customers. 30. Digitalization of retail services: ▪ active use of social networks and Internet platforms for advertising products, promotions, and new products; ▪ implementation of mobile applications with personalized recommendations.
Cluster 2	An ageing demographic profile, a high average age of women at the birth of their first child, a high divorce rate, and a low share of the active working population.	1. Working with an older audience: ▪ offering special discounts for seniors; ▪ expanding the range of products for health and an active lifestyle (vitamins, dietary products, rehabilitation products, etc.); ▪ organization of educational events (lectures, master classes on health). 2. Targeting the audience 50-64 years old: ▪ creation of bonus programs for high-income buyers; ▪ advertising of goods for active recreation and leisure. 3. Support for working women: ▪ implementation of loyalty programs for customers with children (even at an older age); ▪ development of products and services focused on balancing work and personal life (ready-made meals, quick recipes).
Cluster 3	High mortality (infant and total), low birth rate, high level of demographic burden, predominance of the population aged 65-79.	4. Focus on medical and social needs: ▪ expanding the range of medicines and products for elderly care; ▪ discount programs for health products, equipment for home rehabilitation. 5. Support for local communities: ▪ organization of mobile pharmacies or deliveries to remote areas; ▪ cooperation with local authorities to implement social programs. 6. Socially responsible marketing: ▪ campaigns aimed at disease prevention and improving the health of the population; ▪ charitable initiatives, such as donating essential goods to vulnerable groups of the population. 7. Informing and engaging: ▪ development of information booklets about health and longevity support; ▪ support for communication channels suitable for an adult audience (television, radio).

A differentiated approach allows us to take into account the specific features of each cluster and ensure the growth of retail competitiveness, while simultaneously meeting the unique needs of the population.

DISCUSSION

Our work builds upon and refines the contributions of several prominent researchers (Formánek & Sokol (2022), Singh & Sao (2015), Bernadus et al. (2021), etc.) in the fields of economic modelling and demographic analysis. However, we are not studying individual countries, but all EU countries and finding common and distinctive features in groups of countries by demographic development. Also, while some scholars have explored elements of demographic clustering, our study is

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unique in its direct linkage to retail sector development and its use of multivariate assessment methods for cross-country comparisons. While previous studies have focused on either general demographic trends in the EU or sector-specific economic implications, our research integrates economic and mathematical modelling to provide a more precise, structured, and actionable approach.

Existing research often relies on traditional statistical methods that do not adequately capture the heterogeneity among EU countries. By implementing cluster analysis, we categorize EU countries into homogeneous groups based on demographic indicators, offering a more granular and tailored approach to policy recommendations. This is a step forward compared to prior studies, which tend to generalize demographic trends across the EU without acknowledging inter-country variations.

Moreover, previous works typically apply principal component analysis or other simplification techniques without considering the differential information value of various indicators. Our approach not only identifies core demographic factors but also assigns weight coefficients to indicators, ensuring a more accurate representation of their impact on the economic landscape.

Another key distinction is our focus on the retail trade sector. While many studies examine the macroeconomic effects of demographic change, only a few provide industry-specific recommendations on the basis of demographic analysis. Our research bridges this gap by establishing a direct link between demographic trends and retail sector development, thereby creating practical insights for policymakers and business stakeholders.

Unlike previous research that evaluates demographic data in isolation, our model incorporates the stimulating and discouraging effects of various indicators. This nuanced approach allows for more targeted interventions and strategic planning, a feature largely absent from existing demographic studies.

We have also advanced scientific understanding by refining the classification of demographic indicators and their interdependencies. By establishing weight coefficients, we highlight the differential influence of each indicator, providing a more accurate and policy-relevant assessment.

CONCLUSIONS

In the article, we built the economic and mathematical models for assessment and analysis of the peculiarities of the demographic situation in the EU countries for the formation of recommendations on improving the retail trade sector development adapted to each group of countries. The article implements cluster analysis models that make it possible to obtain groups of countries that are homogeneous in terms of demographic indicators. We also build the factor analysis model, which allows us not only to reduce the dimensionality of the initial space of indicators, to identify the main groups of demographic indicators, but also to analyze the distribution of indicators by groups. The model, built on the basis of multivariate assessment methods, allows us to assess the demographic situation in each EU country and compare it with the situation in countries that fall into the same class. This assessment is carried out by taking into account the stimulating and discouraging effects of individual demographic indicators and also takes into account the different information values of indicators by determining their weight coefficients.

The demographic characteristics significantly influence consumer behaviour, necessitating tailored marketing strategies in the retail sector. So we propose differentiated marketing strategies for the development of the retail sector separately for three clusters: for the first cluster of EU countries, which is characterized by the highest rates of total, natural and migration growth, the highest birth rate, the lowest value of the demographic burden indicator; for the second cluster, which is characterized by the highest indicators of the share of the population aged 50 to 64, over 80 years old and the average value of the share of the population aged 65 to 79 years old, has the highest value of the divorce rate and the highest average age of women at the birth of their first child, as well as the lowest indicators of the share of the population in active working age; and for the third cluster, which is characterized by the highest indicators of the share of the population aged 65 to 79 years old, infant mortality, total mortality, demographic burden, the lowest indicators of the birth rate, natural and migration growth.

The first cluster requires youth-oriented and expansionary strategies. The second cluster demands convenience-based and experience-driven marketing. The third cluster benefits from healthcare-centric and necessity-driven retail strategies.

In addition to the demographic features inherent in each cluster of EU countries, key megatrends common to all EU countries have been identified, including population ageing, a decline in the working-age population, a growing multicultural population, changing family structures, digitalization and changing consumer behaviour, increasing urbanization, and growing environmental awareness.

These megatrends affect the retail sector in different ways. For example, demographic changes in the EU are characterized by a significant increase in the share of the elderly population, which creates new challenges and opportunities for the retail sector, in particular, the demand for goods and services for the elderly, including medical devices, health products, comfortable shopping interfaces, is becoming the main direction of market development. The decrease in the number of working-age population affects the structure of demand, therefore, retail must adapt to the needs of busy people through automation, expanding online shopping opportunities, and developing the delivery system.

Migration to the EU leads to an increase in the diversity of buyers, which creates a need for differentiated products, in particular ethnic goods, as well as the adaptation of marketing strategies to different cultural characteristics and preferences. The decrease in the number of large families and the growth of single-person households require a reorientation of the assortment towards convenient packaging formats, individual solutions and flexible services. The younger generation, which actively uses digital platforms, creates a demand for innovative technologies in the retail sector. Therefore, the implementation of omnichannel strategies, online stores and mobile applications is a necessity to attract this segment of consumers. In addition, demographic trends in the EU are accompanied by an increase in environmental awareness of the population. Consumers increasingly value products with eco-labels, which creates additional opportunities for retailers through the implementation of sustainable business practices and the expansion of environmentally friendly product lines.

Thus, demographic changes in the EU have a complex impact on the retail sector. It is important for businesses not only to respond to these demographic challenges but also to actively use them as opportunities for development. Innovation, adaptation to the needs of different population groups, as well as a focus on sustainable development can become key factors for the successful transformation of retail in the context of modern demographic realities.

But some issues remain undisclosed and controversial, namely, how the ageing of the population affects the structure of demand in retail trade, how the growth of migration flows changes the approach to marketing and the formation of the assortment, how effectively modern retail trade formats take into account the growth of urbanization and the reduction of the rural population, whether the retail trade sector adapts to changes quickly enough in the consumer behaviour of older generations, how demographic diversity (migrants, multicultural communities) affects the structure of demand, how demographic changes affect to the demand for environmentally friendly products. Therefore, our further research on this topic will be devoted to the study of these issues.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ДЕМОГРАФІЧНІ ХАРАКТЕРИСТИКИ ЄС: ГЛОБАЛЬНІ МЕГАТРЕНДИ ТА МОЖЛИВОСТІ ДЛЯ СЕКТОРА РОЗДРІБНОЇ ТОРГІВЛІ

У статті запропоновано комплекс економіко-математичних моделей оцінки та аналізу особливостей демографічної ситуації в країнах ЄС для формування рекомендацій щодо вдосконалення розвитку сектора роздрібної торгівлі, адаптованих до кожної групи країн. Проаналізовано ключові глобальні мегатренди, такі як старіння населення, зменшення частки населення працездатного віку, зростання міграційних потоків, урбанізація, цифровізація та зміна споживчої поведінки, підвищення екологічної свідомості. Дослідження висвітлює виклики та можливості, які ці зміни створюють для сектора роздрібної торгівлі.

Кластерна модель реалізована для класифікації країн за різними демографічними профілями, сприяючи розробці цільових стратегій роздрібної торгівлі. Дослідження використовує факторний аналіз і багатовимірні методи оцінки для кількісного визначення впливу демографічних показників, включаючи й стимулюючий, і стримуючий вплив на динаміку роздрібного ринку. Цей структурований підхід дозволяє розробляти диференційовані бізнес-стратегії, забезпечуючи оптимальне позиціонування на ринку та залучення споживачів. Дослідження також включає вивчення метапросторової бізнес-взаємодії як вирішального механізму адаптації роздрібної торгівлі. Особлива увага приділена адаптації бізнес-моделей для задоволення потреб старіючого населення, розробці інклюзивного асортименту продуктів для мультикультурних спільнот. Результати дозволяють визначити країни, у яких оптимально розвивати моделі цифрового залучення молоді, сприятливе для літніх людей середовище покупок і культурно інклюзивні роздрібні екосистеми. Дослідження підкреслює необхідність узгодження демографічних даних з інноваціями в роздрібній торгівлі, щоб сприяти економічній адаптації в глобальному ландшафті. Компанії можуть використовувати демографічні дані для налагодження ділової співпраці з постачальниками, брендами та маркетинговими агентствами, які доповнюють їхню аудиторію, забезпечуючи більш ефективне партнерство та підвищення прибутковості. Спираючись на демографічні особливості, державні органи можуть ефективно регулювати царину торгівлі, забезпечувати доступність товарів для населення. Результати підкреслюють важливість інтеграції демографічного аналізу в стратегічне планування для підвищення стійкості роздрібного сектора.

Ключові слова: бізнес-співпраця, кластерний аналіз, населення країни, демографічні показники, факторний аналіз, глобальні мегатренди, взаємодія, маркетингові стратегії, роздрібні компанії, сектор роздрібної торгівлі

JEL Класифікація: F13, F14, L81, O24

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