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Multifactor models for studying the EU countries' international trade

Abstract. Successful decision-making in the field of international trade is a background for further development of international trade in a balance between the economic interests of its participants. It is based on use of the latest tools for making such decisions, in particular, multifactor methods for economic processes analysis. The purpose of this study is to develop multifactor models of the international trade study by using factor, cluster and discriminant analyses to determine the quality of the model results depending on the method used. In the process of study, the following general scientific and special methods were used: system analysis to determine the directions of the international trade study; cluster analysis, factor and discriminant analysys for the development of multifactor models of the international trade study.
Based on the results of factor analysis, 13 indicators were grouped according to their influence. With the help of cluster modelling, the EU countries were grouped according to quantitative indicators such as GDP, final consumption expenditure and gross capital formation. According to discriminant analysis, significance of the selected factors was interpreted. Consequently, such factors as exports and imports of goods and services, the population size and emigration of population have direct significant impact on the countries' economic development, namely on GDP, final consumption expenditure and gross capital formation. Theoretical and methodological provisions are brought to the level of specific and practical proposals to form the basis of studying indicators of international trade and develop specific models for studying international trade by using multifactor modelling alternative methods.
Keywords: Multifactor Modelling; Discriminant Analysis; Clustering; International Trade; Factor Analysis
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Багатофакторні моделі дослідження міжнародної торгівлі країн Європейського Союзу
Анотація. У статті використано факторний, кластерний і дискримінантний аналізи для розробки багатофакторних моделей дослідження міжнародної торгівлі. Для проведення дослідження використано статистичні дані 28 країн Європейського Союзу. На основі результатів факторного аналізу було згруповано показники за напрямом їх впливу. За допомогою кластерного моделювання країни ЄС було згруповано за такими кількісними показниками, як ВВП, витрати кінцевого споживання та валове формування капіталу. За результатами дискримінантного аналізу було інтерпретовано значимість обраних факторів.
Ключові слова: багатофакторне моделювання; дискримінантний аналіз; кластеризація; міжнародна торгівля; факторний аналіз.

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Многофакторные модели исследования международной торговли стран Европейского Союза
Аннотация. В данной статье использованы факторный, кластерный и дискриминантный анализы для разработки многофакторных моделей исследования международной торговли. Для проведения исследования использованы статистические данные 28 стран Европейского Союза. На основе результатов факторного анализа были сгруппированы показатели по направлению их воздействия. С помощью кластерного моделирования страны ЕС были сгруппированы по следующим количественным показателям: ВВП, расходы конечного потребления и валовое формирование капитала. По результатам дискриминантного анализа была интерпретирована значимость избранных факторов.
Ключевые слова: многофакторное моделирование; дискриминантный анализ; кластеризация; международная торговля; факторный анализ.

1. Introduction

International trade is an integral part of the national economy of any country. Classics of economic theory have proved that effective international trade provides the country with economic growth and national prosperity. Thus, successful decision-making in the field of international trade, both at the level of governments of the countries, and at the level of international organisations, integration unions, etc., is a background for further development of international trade in a balance of economic interests of its participants. Current practice of decision-making in all spheres and types of economic activity is based on the use of the latest tools for making such decisions, in particular multifactor methods for analysing economic processes.

International trade as a complex economic process on one hand and a complex phenomenon of global scale on the other hand is characterised by a complex correlation between economies of the countries [1]. Accordingly, when studying, evaluating and analysing international trade at the level of specific countries or integration formations, there arises a problem of the optimal choice of a set of identifiers that can be used in modelling of such processes. The problem in the context of multifactor modelling requires development of specific models of international trade study based on the use of multifactor modelling alternative methods.

2. Brief Literature Review

Many works by prominent scientists such as A. B. Bernard, S. J. Redding and P. K. Schott (2011) [2], P. Antràs and A. Costinot (2011) [3], L. Caliendo and E. Rossi-Hansberg (2012) [4], R. D. Ludema and A. M. Mayda (2013) [5], J. Caron, T. Fally and J. R. Markusen (2014) [6], H. Fan, Y. A. Li and S. R. Yeaple (2015) [7], E. Jonathan, S. Kortum, B. Neiman and J. Romalis (2016) [8], G. Idrisov, V. Mau and A. Bozhechkova (2017) [9], R. C. Johnson and G. Noguera (2017) [10], F. Tintelnot (2017) [11], A. Rodrigo, A. Costinot and D. Donaldson (2017) [12], G. I. O. Licandro (2018) [13], P. Mutrejaa, B. Ravikumarb and M. Sposi (2018) [14], A. Cristiano (2019) [15] and others are devoted to the research, evaluation, analysis and modelling of trade.

Also the use of multifactor modelling methods is widely used by researchers who trade. In particular, I. S. Marchenko [16] explores the preconditions for the development of the foreign trade potential of Ukraine as one of the factors of competitiveness through multifactor cluster and factor analysis. O. R. Marets [17] uses the method of multifactor regression to model the export and import of goods in Ukraine with major trading partners from the EU countries on the example of foreign trade indicators (export and import) of Ukraine and Germany. M. Yu. Barna [18] uses a correlation-regression analysis to construct multifactor econometric models in order to determine the impact of the environment factors of institutional and transformational (image of the country in the international market, political situation in the country, development of trade infrastructure, development of transport infrastructure, development of sectoral information and communication networks, presence of unions and associations in the industry, number of economic entities in branch (wholesale and retail)), economic (macroeconomic situation in the country, stage of economic development of the country, state of competitiveness of the domestic and foreign commodity markets, quality of suppliers) and social (income level, population expenditure structure (consumer expenses), labour and free time of population) character on the domestic trade of Lviv region and Ukraine. B. Vahalík and M. Staníčková (2016) devoted their work [19] to identifying key factors of competitiveness of foreign trade through the use of factor analysis, as well as using cluster analysis to identify countries with similar characteristics of competitiveness factors.

3. Identification of unexplored parts of the general problem

Despite the depth of modern scientific study on the development of international trade of the countries, imperfection of practice to construct specific models of international trade study on the basis of use of multifactor modelling alternative methods indicates the need for further study, evaluation and analysis of international trade at the level of specific countries in order to optimally select the set of identifiers that can be applied in modelling of the relevant processes.

4. The purpose of this study is to develop multifactor models for studying international trade by using factor, cluster and discriminant analyses to determine the quality of model results depending on the method used.

5. Results

Some indicators are used to determine the degree of economic development in the country, the most important of which are GDP, exports, imports, foreign trade turnover, inflation, the level of unemployment, etc. Since one of the methods of calculation (final consumption method) of GDP is the sum of final consumption of goods and services, gross capital formation and the balance of exports and imports of goods and services [20], we consider it expedient to take into account indicators characterising final consumption expenditure and gross formation of capital. It is known that economic growth depends partly on the demographic situation in the country. Therefore, we consider demographic indicators such as the population size of the country and migration. Also, apart from exports and imports, we take into account the indicators of the economy openness, which characterise the country's activity in the field of international trade [21].

To conduct the factor analysis, we selected the following variables:

$X1$ - GDP on market prices, EUR million;
$X2$ - final consumption expenditure, EUR million;
$X3$ - gross capital formation, EUR million;
$X4$ - export of goods and services, EUR million;
$X5$ - import of goods and services, EUR million;
$X6$ - population size;
$X7$ - balance, EUR million;
$X8$ - foreign trade turnover, EUR million;
$X9$ - export quota,%;
$X10$ - import quota,%;
$X11$ - foreign trade quota,%;
$X12$ - emigration of population;
$X13$ - immigration of population.

Our task is to combine a large number of indicators that characterise the country's economic development by means of factor analysis into a smaller number of factors artificially constructed on their basis, so that the system of indicators (describing sample data as well as output one) was more convenient in terms of meaningful interpretation.

To conduct the factor analysis, we used Eurostat statistics from the 28 countries of EU as of 2016 [22] and the software STATISTICA 10 (module Factor analysis).

When performing the factor analysis, we obtained the following correlation matrix (Figure 1).

As we can see from the correlation matrix, the variables $X1$ (GDP on market prices, EUR million), $X2$ (final consumption expenditure, EUR million), $X3$ (gross capital formation, EUR million), $X4$ (exports of goods and services, EUR million), $X5$ (imports of goods and services, EUR million), $X6$ (population size), $X7$ (balance, EUR million), $X8$ (foreign trade turnover, EUR million), $X9$ (export quota,%), $X10$ (import quota,%), $X11$ (foreign trade quota,%), $X12$ (emigration of population), $X13$ (immigration of population) are also correlated.

Thus, on the basis of the correlation matrix, we can distinguish two relatively independent factors: one includes quantitative characteristics of the EU countries such as the population size, taking into account emigration and immigration of population, GDP, final consumption expenditure, gross capital formation, the volume of export and import flows of goods and services, and, accordingly, foreign trade turnover; the second one includes relative indicators of the EU countries, namely the export quota, the import quota and the foreign trade quota.

Analysing the main components, we obtain a table with factor loadings, that is, the matrix of correlations between the variables and two factors (Figure 2). As we see in Figure 2, the first factor is more correlated with the variables than the second one.

In addition, factor loadings should be considered in the scatter plot (Figure 3). In this diagram, each variable is represented by a point.

Correlations (Spreadsheet1)
Casewise deletion of MD
N=28

Variable	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1	1.00	1.00	0.99	0.93	0.96	0.96	0.46	0.94	-0.39	-0.43	-0.41	0.89	0.95
X2	1.00	1.00	0.98	0.90	0.94	0.96	0.40	0.92	-0.41	-0.44	-0.42	0.88	0.93
X3	0.99	0.98	1.00	0.93	0.96	0.94	0.45	0.95	-0.38	-0.41	-0.39	0.89	0.93
X4	0.93	0.90	0.93	1.00	0.99	0.85	0.70	1.00	-0.23	-0.28	-0.25	0.86	0.94
X5	0.96	0.94	0.96	0.99	1.00	0.88	0.60	1.00	-0.27	-0.31	-0.29	0.87	0.94
X6	0.96	0.96	0.94	0.85	0.88	1.00	0.39	0.87	-0.46	-0.50	-0.48	0.93	0.91
X7	0.46	0.40	0.45	0.70	0.60	0.39	1.00	0.65	0.03	-0.03	0.00	0.48	0.62
X8	0.94	0.92	0.95	1.00	1.00	0.87	0.65	1.00	-0.25	-0.29	-0.27	0.86	0.94
X9	-0.39	-0.41	-0.38	-0.23	-0.27	-0.46	0.03	-0.25	1.00	0.99	1.00	-0.43	-0.36
X10	-0.43	-0.44	-0.41	-0.28	-0.31	-0.50	-0.03	-0.29	0.99	1.00	1.00	-0.46	-0.40
X11	-0.41	-0.42	-0.39	-0.25	-0.29	-0.48	0.00	-0.27	1.00	1.00	1.00	-0.44	-0.38
X12	0.89	0.88	0.89	0.86	0.87	0.93	0.48	0.86	-0.43	-0.46	-0.44	1.00	0.95
X13	0.95	0.93	0.93	0.94	0.94	0.91	0.62	0.94	-0.36	-0.40	-0.38	0.95	1.00

Fig. 1: **Correlation matrix**
Source: Compiled by the author with the use of STATISTICA 10

For the correct interpretation of the obtained results, it is necessary to address to the axes turnabout in order to obtain a simple structure in which the most of the observations are close to the coordinate axe.

Thus, after turnabout we get a matrix of loadings for each factor in such a way that they differ as much as possible (Figure 4).

Now the obtained result can be clearly interpreted. As can be seen from Figure 4, the first factor is most often related to the variables $X4$, $X5$ and $X8$, and to a lesser extent to the variables $X1$, $X2$, $X3$ and $X13$, and the least to the variables $X6$ and $X12$. The second factor is closely related to the variables $X9$, $X10$ and $X11$. Thus, we have divided the variables into two groups.

After the axes turnabout let us look at the scatter diagram again (Figure 5).

In order to verify whether we have received the correct number of factors, we shall consider the graph of characteristic values (Figure 6). On the graph, we need to find a place where the decrease of characteristic values from the left to the right slows down the most. As we see in Figure 6, four or five factors can be left after conducting the analysis.

Consequently, while conducting the factor analysis, we selected some indicators that characterise economic development, demographic situation and the main indicators of the international trade intensity. According to the results of the analysis, all the

Variable	Factor Loadings (Unrotated) (Spreadsheet1) Extraction: Principal components (Marked loadings are >.700000)	
	Factor 1	Factor 2
X1	-0.977637	-0.080303
X2	-0.966459	-0.046184
X3	-0.970110	-0.090006
X4	-0.945237	-0.279648
X5	-0.958098	-0.233810
X6	-0.953332	0.029175
X7	-0.546574	-0.426118
X8	-0.953451	-0.258632
X9	0.485336	-0.866035
X10	0.525286	-0.837432
X11	0.504345	-0.854288
X12	-0.934395	-0.017038
X13	-0.969897	-0.128525
Expl.Var	9.338645	2.596796
Prp.Totl	0.718357	0.199754

Fig. 2: **Factor loadings**
Source: Compiled by the author with the use of STATISTICA 10

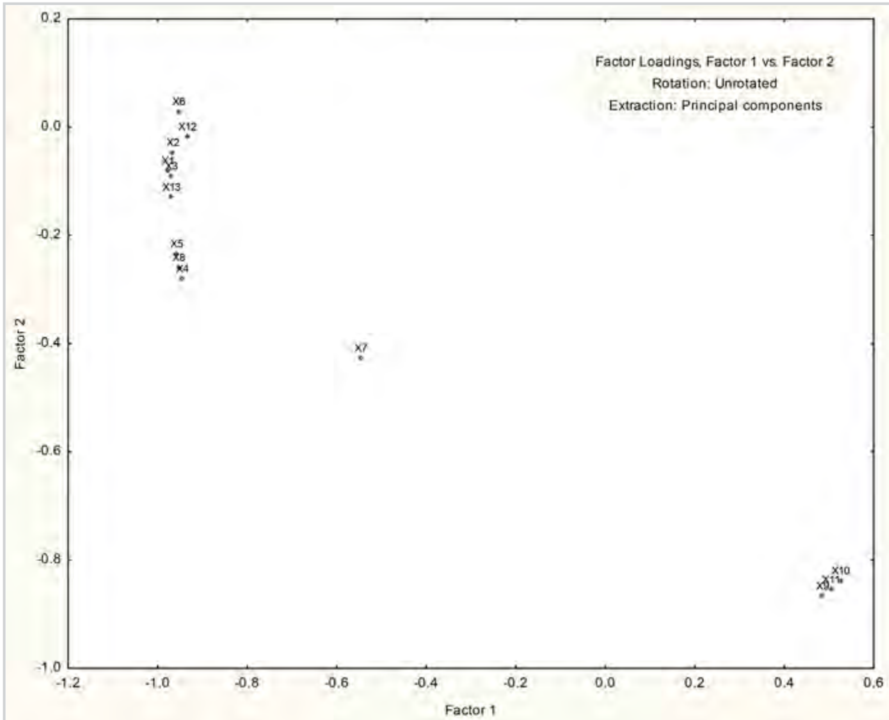

Fig. 3: **Scatter diagram**
Source: Author's own calculations by using STATISTICA 10

Variable	Factor Loadings (Varimax normalized) (Spreadsheet1) Extraction: Principal components (Marked loadings are >.700000)	
	Factor 1	Factor 2
X1	0.940736	0.277916
X2	0.917999	0.305702
X3	0.937219	0.266150
X4	0.982459	0.080313
X5	0.977912	0.127703
X6	0.878561	0.371246
X7	0.663518	-0.200156
X8	0.982536	0.102876
X9	-0.140098	-0.982823
X10	-0.187678	-0.970564
X11	-0.162065	-0.978727
X12	0.877577	0.321313
X13	0.950920	0.230151
Expl.Var	8.460634	3.474807
Prp.Totl	0.650818	0.267293

Fig. 4: **Factor loadings after axes turnabout**
Source: Compiled by the author with the use of STATISTICA 10

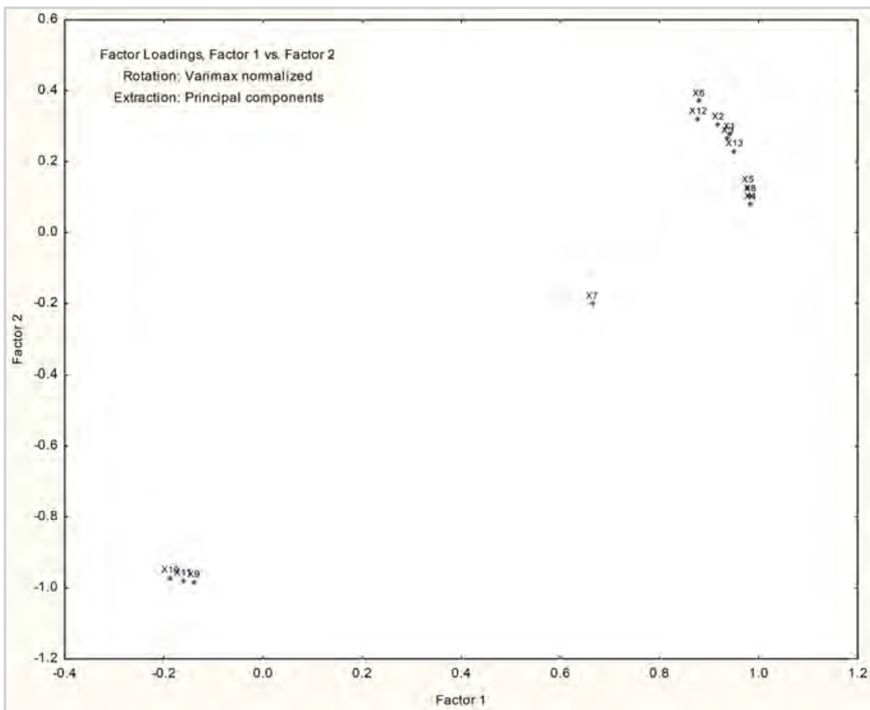

Fig. 5: **Scatter diagram after axes turnabout**
Source: Compiled by the author with the use of STATISTICA 10

selected indicators were divided into two groups: the first group includes absolute indicators such as the population size, taking into account emigration and immigration of population, GDP, final consumption expenditure, gross capital formation, the volume of exports and imports of goods and services flows, and, accordingly, the foreign trade turnover, while the other group includes the relative indicators of the economy openness, characterising the country's activity in the field of international trade.

As we can see from the results of the factor analysis, many different indicators were included in Factor 1. Let us consider identifiers of this group in details. We apply another method of classification - discriminant analysis - in order to determine the specificity of impact of the indicators analysed above (isolated from the analysis), included in Factor 1.

Since GDP is considered to be one of the most important indicators of economic development, and final consumption and gross capital formation are its components (according to the end consumption method), then, before conducting discriminatory analysis, the EU countries should be divided into clusters according to quantitative indicators such as GDP, final consumption expenditure and gross capital formation. To cluster the EU countries, we use the software product STATISTICA 10 and Eurostat statistics from the 28 EU countries as of 2016 [22].

On the basis of cluster modelling, we received 3 groups of EU countries that differ by GDP indicators, final consumption expenditure, and gross capital formation (the value of grouping mean variables is presented in Figure 7).

The countries forming each of the clusters, along with the distance to the corresponding cluster, are shown in Figures 8 - 10.

To further conduct the discriminant analysis, we select variables that are also included in Factor 1, except those that became variables of grouping of the countries into clusters, i.e.:

*X*4 - export of goods and services, EUR million;
*X*5 - import of goods and services, EUR million;
*X*6 - population size;
*X*7 - balance, EUR million ;
*X*12 - emigration of population;
*X*13 - immigration of population.

We do not include the *X*8 variable in discriminant analysis, because it describes the total volume of exports and imports of goods and services, i.e. (*X*4 + *X*5). However we take into account the division of the EU countries into three clusters (high, medium, low).

Our task is to classify countries on the basis of similar indicators.

Based on the results of the discriminant analysis, we obtain a classification matrix (Figure 11), on the basis of which it can be concluded that the constructed model correctly determines an expert assessment with an accuracy of 96.43%. At the same time, it is better to determine the assessment for groups of countries with high and low rates (100%), and worse - for the average indicators (80%).

The countries that were incorrectly assigned to the relevant groups can be seen through classification of cases (Figure 12). In the table of cases classification, the incorrectly assigned objects are indicated by a mark (*). Thus, the task of obtaining the correct samples is to exclude those objects that, by their indicators, do not correspond to most of the objects forming a homogeneous group.

As can be seen from Figure 12, in the table of cases classification there is the only one mark - on Sweden, which, by

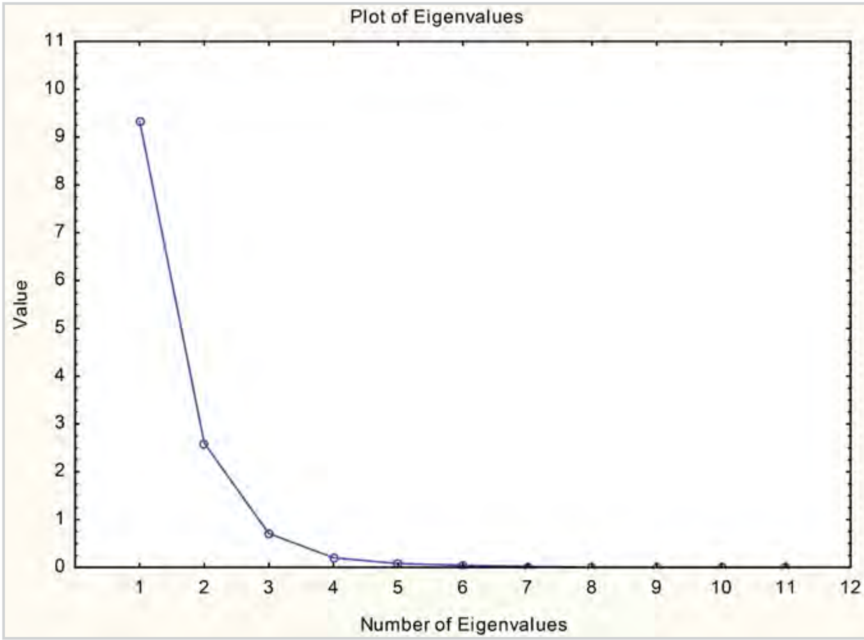

Fig. 6: **Graph of characteristic values**
Source: Compiled by the author with the use of STATISTICA 10

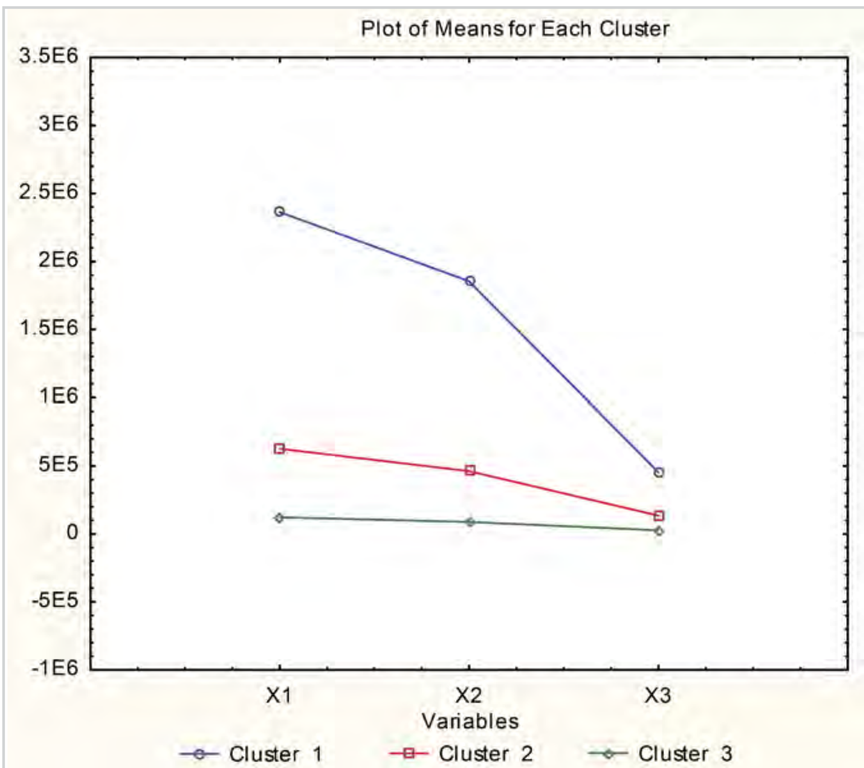

Fig. 7: **The value of grouping mean variables in clusters**
Source: Compiled by the author with the use of STATISTICA 10

means of cluster analysis (conducted on the basis of GDP, final consumption expenditure and gross capital formation), was assigned to the medium group. Taking into account other factors such as the population size, emigration and immigration of population, as well as the volume of exports and imports of goods and services, it should be assigned into the third low group.

According to the selected factors, the rest of the countries are classified correctly.

To see how the variables divide the two sets, discriminant functions are calculated (Figure 13).

	Members of Cluster Number 1 (Spreadsheet1) and Distances from Respective Cluster Center Cluster contains 4 cases
	Distance
Germany	523962.3
France	100638.0
Italy	502368.7
United Kingdom	105696.4

Fig. 8: **EU countries - members of the first cluster**
Source: Compiled by the author with the use of STATISTICA 10

	Members of Cluster Number 2 (Spreadsheet1) and Distances from Respective Cluster Center Cluster contains 5 cases
	Distance
Belgium	145926.2
Spain	367721.8
Netherlands	45706.9
Poland	143336.1
Sweden	121917.2

Fig. 9: **EU countries - members of the second cluster**
Source: Compiled by the author with the use of STATISTICA 10

	Members of Cluster Number 3 (Spreadsheet1) and Distances from Respective Cluster Center Cluster contains 19 cases
	Distance
Bulgaria	52975.3
Czech Republic	37263.5
Denmark	112710.4
Estonia	72923.6
Ireland	98049.1
Greece	50157.2
Croatia	54133.0
Cyprus	74594.0
Latvia	69755.6
Lithuania	59391.8
Luxembourg	54987.8
Hungary	7279.1
Malta	81354.6
Austria	168638.8
Portugal	53126.4
Romania	37726.4
Slovenia	59234.9
Slovakia	29119.5
Finland	73086.7

Fig. 10: **EU countries - members of the third cluster**
Source: Compiled by the author with the use of STATISTICA 10

The significance of the functions resulting from the analysis is verified by using the χ-square criterion (Figure 14)

We can see that the first discriminant function is statistically significant (the actual value is 31.51467) and most loaded with the figures $X4$ (3.10), $X12$ (2.76), and also with the figures $X5$ (-3.58) and $X6$ (-2.21), but with the opposite signs. The second discriminant function, although insignificant, is well marked with $X12$ (2.31) and $X13$ (-2.09).

	Classification Matrix (Spreadsheet1) Rows: Observed classifications Columns: Predicted classifications			
Group	Percent Correct	low p=.67857	high p=.14286	medium p=.17857
low	100.0000	19	0	0
high	100.0000	0	4	0
medium	80.0000	1	0	4
Total	96.4286	20	4	4

Fig. 11: **Classification matrix**
Source: Compiled by the author with the use of STATISTICA 10

	Classification of Cases (Spreadsheet1) Incorrect classifications are marked with *			
Case	Observed Classif.	1 p=.67857	2 p=.14286	3 p=.17857
Belgium	medium	medium	low	high
Bulgaria	low	low	medium	high
Czech Republic	low	low	medium	high
Denmark	low	low	medium	high
Germany	high	high	medium	low
Estonia	low	low	medium	high
Ireland	low	low	medium	high
Greece	low	low	medium	high
Spain	medium	medium	low	high
France	high	high	medium	low
Croatia	low	low	medium	high
Italy	high	high	medium	low
Cyprus	low	low	medium	high
Latvia	low	low	medium	high
Lithuania	low	low	medium	high
Luxembourg	low	low	medium	high
Hungary	low	low	medium	high
Malta	low	low	medium	high
Netherlands	medium	medium	low	high
Austria	low	low	medium	high
Poland	medium	medium	low	high
Portugal	low	low	medium	high
Romania	low	low	medium	high
Slovenia	low	low	medium	high
Slovakia	low	low	medium	high
Finland	low	low	medium	high
*Sweden	medium	low	medium	high
United Kingdom	high	high	low	medium

Fig. 12: **Cases classification**
Source: Compiled by the author with the use of STATISTICA 10

	Standardized Canonical Discriminant Function Coefficients (Spreadsheet1) Sigma-restricted parameterization	
Effect	Function 1	Function 2
Intercept	0.000000	0.000000
X4	3.103953	1.281452
X5	-3.575804	-0.165166
X6	-2.214320	-0.580319
X12	2.756740	2.309996
X13	-0.842937	-2.088267
Eigenvalue	31.514673	0.142534
Cum. Prop.	0.995498	1.000000

Fig. 13: **Output coefficients of discriminant functions**
Source: Compiled by the author with the use of STATISTICA 10

Removed	Chi-Square Tests with Successive Roots Removed (Spreadsheet1) Sigma-restricted parameterization					
	Eigen-value	Canonicl R	Wilk's Lambda	Chi-Sqr.	df	p-value
0	31.51467	0.984502	0.026919	83.14362	10.00000	0.000000
1	0.14253	0.353203	0.875248	3.06472	4.00000	0.547054

Fig. 14: **Checking the statistical significance of discriminatory functions**
Source: Compiled by the author with the use of STATISTICA 10

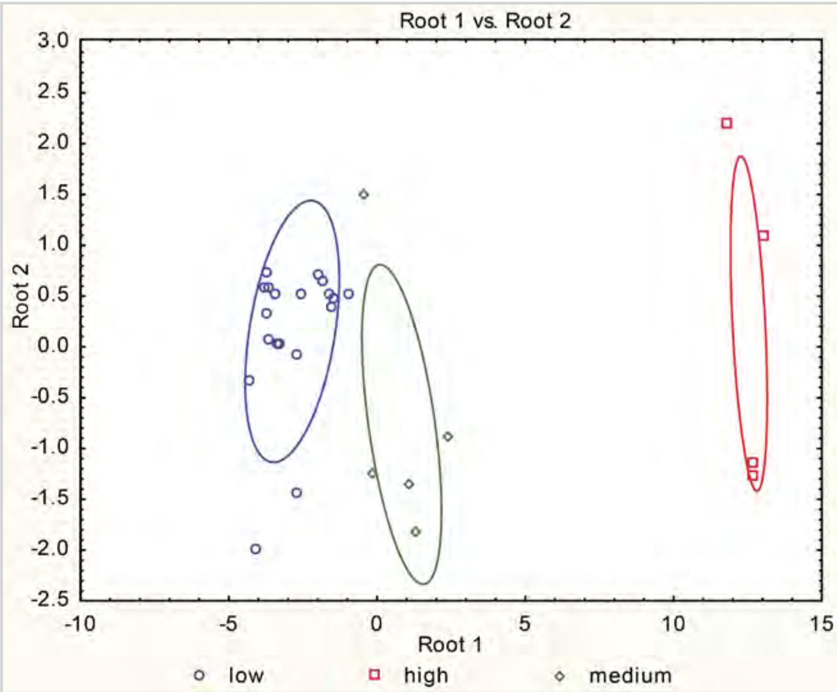

Fig. 15: **Scatter diagram of canonical figures pairs of values discriminant function 1 and 2**
Source: Calculated by the author with the use of STATISTICA 10

Consequently, such factors as exports and imports of goods and services, the population size and emigration of population have direct significant impact on the country's economic development, namely on GDP, final consumption expenditure and gross capital formation. The results of the discriminant analysis are graphically represented (Figure 15). This scatter diagram shows the correlation between the variables inside the sets.

6. Conclusions

We have developed a scientific approach to the study of international trade based on a combination of cluster, factor and discriminant analyses and a set of indicators characterising economic development, demographic situation and foreign trade of the countries and their interconnection, which makes it possible to determine the specifics of influence of the selected factors on the volume of export-import transactions and suggest a set of identifiers that can be used in modelling of these processes.

Based on the results of the factor analysis, the indicators are grouped with regard to their influence. With the help of cluster modelling, the EU countries were grouped according to quantitative indicators such as GDP, final consumption expenditure and gross capital formation. It has been proven that exports and imports of goods and services, the population size and emigration have direct impact on the economic development. The discriminant analysis enabled us to interpret the results on importance of the selected factors and proved that in order to analyse the international trade, it is necessary to use a large number of statistical indicators.

Further identification of the set of indicators should be more detailed, depending on the purpose of the international trade study.

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