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 analyses 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

JEL Classification: C10; F14

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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 economic processes [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. Mutreja, B. Ravikumar and M. Sposi (2018) [14], A. Cristiano (2019) [15] and

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Among these 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. Bar- na [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, state 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 in 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 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:

| Variable | Description |
|----------|-------------|
| X1 | GDP on market prices, EUR million |
| X2 | final consumption expenditure, EUR million |
| X3 | gross capital formation, EUR million |
| X4 | export and import of goods, EUR million |
| X5 | export and import of 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 |

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 GDP, 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.

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**Table 1: Correlations (Spreadsheet)**

| Variable | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 |
|----------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|
| N=28     |    |    |    |    |    |    |    |    |    |     |     |     |     |
| 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    | |
| 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    | |
| 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    | |
| X4       | 0.93 0.93 0.93 1.00 | 0.99 0.85 0.70 1.00 -0.23 -0.28 -0.25 0.86    | |
| 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    | |
| 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    | |
| 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 0.6 | |
| 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

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### Table: Factor Loadings (Varimax normalized) (Spreadsheet)

| Variable | Factor 1 | Factor 2 |
|----------|----------|----------|
| X1       | 0.940736 | 0.277916 |
| X2       | 0.917999 | 0.305702 |
| X3       | 0.937219 | 0.266150 |
| X4       | 0.828459 | 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 | -0.962823 |
| 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 |

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### Table: Factor Loadings (Marked loadings are > 0.700000)

| Variable | 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      | -0.965897 | -0.128525 |
| Expl.Var | 9.338645  | 2.956796  |
| Prp.Totl | 0.718357  | 0.199754  |
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 discriminatory 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 discriminatory 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
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).

The significance of the functions resulting from the analysis is verified by using the y-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).

### Table: Classification Matrix (Spreadsheet1)

| Group     | Correct | low | high | medium |
|-----------|---------|-----|------|--------|
| low       | 100.000 | 19  | 0    | 0      |
| high      | 100.000 | 0   | 4    | 0      |
| medium    | 80.000  | 1   | 0    | 4      |
| Total     | 96.4286 | 20  | 4    | 4      |

Source: Compiled by the author with the use of STATISTICA 10

### Table: Classification of Cases (Spreadsheet1)

| Case     | Observed | 1 | 2 | 3 |
|----------|----------|---|---|---|
| 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 |
| Netherland| medium | medium | low | high |
| Austria  | low      | low | medium | high |
| Poland   | medium   | medium | low | high |
| Portugal | low      | low | medium | 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   | medium | low | high |
| United Kingdom | high | high | low | medium |

Source: Compiled by the author with the use of STATISTICA 10

### Table: Standardized Canonical Discriminant Function Coefficients (Spreadsheet1)

| Effect | Function 1 | Function 2 |
|--------|------------|------------|
| Intercept | 0.000000 | 0.000000 |
| X₄      | 3.103953  | 1.281452  |
| X₅      | -3.575804 | -0.165166 |
| X₁₂     | -2.214320 | -0.580319 |
| X₁₃     | 2.756740  | 2.309996  |
| X₁₅     | -0.842937 | -2.082673 |
| Eigenvalue | 31.514673 | 0.142534  |
| Cum Prop | 0.995498  | 1.000000  |

Source: Compiled by the author with the use of STATISTICA 10
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

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