QUANTITATIVE ANALYSIS OF THE DEVELOPMENT ENVIRONMENT OF AGRICULTURE IN THE EU FROM THE ASPECT OF SUSTAINABLE DEVELOPMENT[*]

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Abstract

An agricultural development environment is comprised of a number of complex factors interacting in space and time. Those are economic, social and ecological factors that define certain conditions for agriculture development from the aspect of sustainable development, and they do so through their simultaneous effect. These factors are made up of different variables, i.e. determinants, the effects of which cannot always be predicted with reliability, yet they can significantly influence the (un)sustainability of a development environment of agriculture. This paper analyses the development environment of agriculture in the EU from the aspect of sustainable development, using the quantitative statistical method called factor method. Quantitative analysis is conducted by using available statistical data from the Common Agricultural Policy of the EU and the statistical data available from the European Commission EUROSTAT. This type of analysis is particularly important in the context of finding suitable measures to improving the agri-economic activity, achieving the agri-social equality and preserving the agri-ecological ambient.

Key words: *development environment, agriculture, EU, quantitative analysis, factor method, sustainable development*

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Introduction

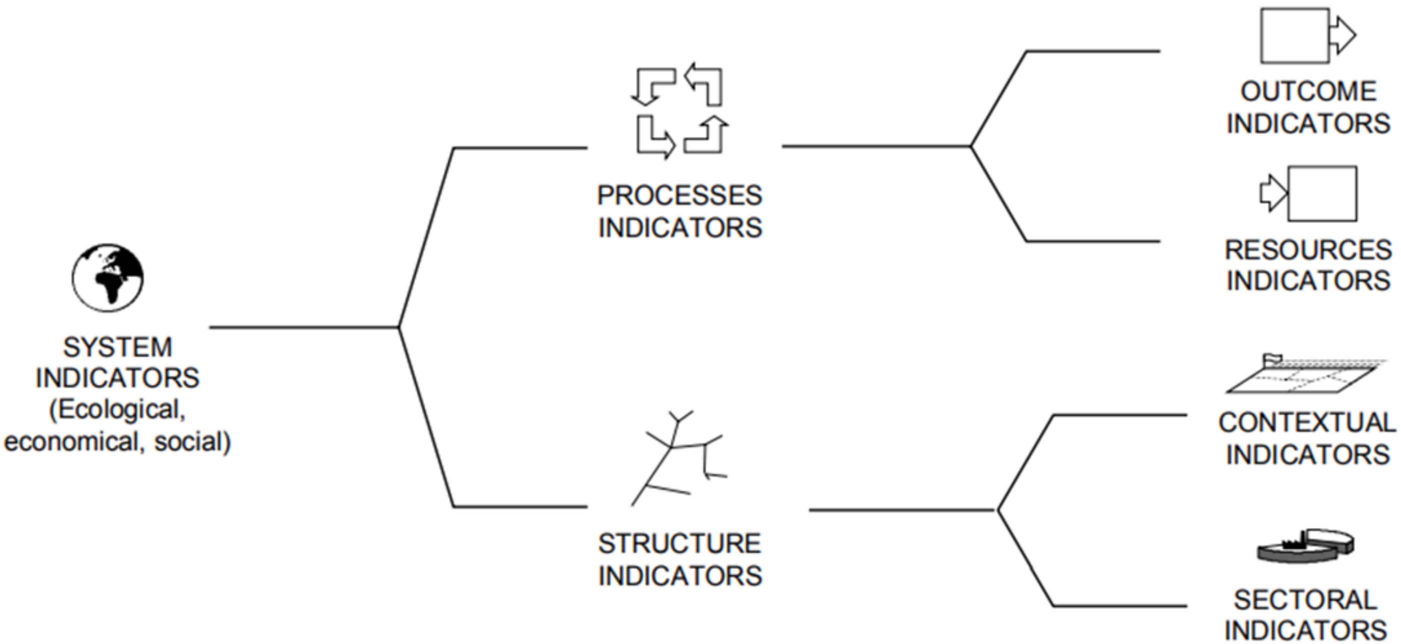
Sustainable development is development balanced between economy, society and ecology, and that makes it possible to satisfy the current and future needs of the population. The concept of sustainable development is widely used in the scientific community through its multidisciplinary approach, and it is therefore applicable in diverse research with the goal of providing a more complete overview of a certain development environment from the aspect of its sustainability.

The development environment of agriculture is fairly complex, and reaching its sustainability requires solving many problems in development, which are closely connected to its most significant characteristics such as durability, dynamics and adaptation. Generally seen, the development environment of agriculture is made of economic, social and ecological factors that work simultaneously to define the appropriate development conditions of agriculture from the aspect of sustainable development. These factors contain different variables, i.e. determinants, the effects of which cannot always be predicted with reliability, and that can significantly influence the (un)sustainability of the development environment of agriculture.

With this in mind, monitoring the development environment of agriculture also demands monitoring multiple different indicators. This is a consequence of the modern approach to agriculture monitoring, based on multifunctionality and sustainability. Multifunctionality is oriented towards developmental activities, while sustainability is oriented towards developmental resources (EC, 2011). Multifunctionality and sustainability are two mutually connected complex processes, because they originate from one another, and therefore they demand defining an appropriate framework, i.e. system of indicators for monitoring the developmental changes in an agricultural environment (image 1).

Developmental functions of agriculture in the domain of economy, society and ecology are interconnected and they mostly depend on the developmental policy conducted on the global, regional, national and local levels. The developmental changes in an agricultural environment must constantly be monitored for the purpose of timely detection of either positive or negative influences on the economy, society or ecology.

Image 1. *System of indicators for monitoring developmental changes in an agricultural environment*



Source: *EC (2001, p.11)*

That is why monitoring and evaluating the development environment of agriculture through certain indicators from the aspect of sustainable development has crucial significance and demands regular and constant monitoring of inputs, outputs, and the influence of the developmental activities on the set goals (Królczyk & Latawiec, 2015).

Research into the development environment of agriculture in the EU from the aspect of sustainable development, using an appropriate statistical method of quantitative analysis, such as factor method, is of great significance in the context of defining an adequate framework for strategic planning of sustainable development of agriculture in the future, because it can answer two basic questions:

(1) *What does the development environment of agriculture in the EU look like from the aspect of sustainable development?*

(2) *What determinants within the economic, social and ecological factorial dimensions define the development environment of agriculture in the EU from the aspect of sustainable development, and to what extent does a certain factor determine such a state?*

The basic presumptions of quantitative analysis using factor method

In the past years, we have witnessed an expanding use of different statistical methods of quantitative analysis in almost all areas of scientific research. There are two main reasons for that. One is the development of computer technology and software, which made possible a relatively simple use of statistical methods of quantitative analysis for data processing. The second is realising the need of a lot of scientific research to analyse simultaneous mutual dependencies of several variables.

Quantitative analysis means finding the adequate structure of data through observing appropriate determinants, in order to determine which factors, i.e. variables best determine the observed structure. In other words, it is necessary to identify those factors/variables that will in the best way possible explain the observed structure and correlations in the data structure, i.e. determine the latent connection between them.

For that purpose, we use factor method, which is a statistical method of quantitative analysis. Factor method presumes that a part of the variability of the observed factors, i.e. variables cannot be explained through data structure, so it becomes necessary to determine what units those are. Generally seen, factor method is made of two basic phases:

(1) *determining the number of variables to be excluded or left out in the analysis, i.e. checking the possibility of applying the analysis to available data after checking the adequacy of the sample from the aspect of using each variable in the analysis separately, which means testing the whether the observed determinants are linearly connected or not;*

(2) *observing the influence of the variables, i.e. interpreting the factors using a load matrix, which we can get by rotating the appropriate variable transformation matrix.*

Using factor method as a statistical method of quantitative analysis enables us to simply detect and explain the background structure of the development environment of agriculture in the EU from the aspect of sustainable development through the aggregation of influence from the most important development variables from the environment.

Databases as a starting point for quantitative analysis using factor method

Defining a database is a starting point for quantitative analysis using factor method. So, in order to perform a quantitative analysis of a development environment of agriculture in the EU from the aspect of sustainable development, it is needed to form an adequate database.

Forming an adequate database is preceded by a detailed and structured research of the available statistical data from the Common Agricultural Policy of the EU and the statistics from the European Commission EUROSTAT from 28 member states (year 2016). This enables us to make a correct choice of indices as development variables within the economic, social and ecological factors that have the most influence on the modern development environment of agriculture. Those are the so-called contextual indicators that reflect the relevant aspects of common developmental trends in the economy, society and ecology, but also have an influence on the implementation, achievements and efficacy of the Common Agricultural Policy of the EU (EC, 2017a).

The research is structured in a way that simplifies the assessment of indicators as relevant factor variables that create the development environment of agriculture in the EU from the aspect of sustainable development. Namely, the influence of certain elements of the development environment of agriculture in the EU from the aspect of sustainable development has been assessed.

The perimeters with a notably positive influence were assessed with a 5, and the perimeters with a notably negative influence were assessed with a 1. It was also noted that a significant number of individual elements within the development environment of agriculture in the EU could influence the achievement of sustainability.

Based on the conducted analysis, we made a reduction of the observed variables for the purpose of finding aggregate factors, in order to identify the latent structure of the development environment of agriculture in the EU from the aspect of sustainable development.

The database as the foundation of the quantitative analysis of the development environment of agriculture in the EU from the aspect of sustainable development is defined through the following crucial changes within the economic, social and ecological factors (EC, 2017b; Eurostat, 2017):

(1) economic growth (mark 1);

(2) unemployment (mark 2);

(3) investments (mark 3);

(4) productivity (mark 4);

(5) income (mark 5);

(6) education (mark 6);

(7) poverty (mark 7);

(8) labour force age (mark 8);

(9) organic production (mark 9);

(10) irrigation (mark 10);

(11) soil quality (mark 11);

(12) renewable energy sources (mark 12);

(13) agricultural areas of high natural value (mark 13);

(14) greenhouse gas emission (mark 14).

The application of quantitative analysis based on factor method

For quantitative analysis based on factor method, we used the Statistical Package for Social Sciences 22.0 software. In order to conduct the analysis, it is required to have a positively determined correlation matrix of 14 variables that make the database and determine the development environment of the EU.

Based on descriptive statistics, we can conclude that out of the total number of analysed observations, none of the variables has a significant amount of missing data in the form of an extreme value, which makes the matrix positively determined (table 1). This means that no variables should be excluded from further quantitative analysis. This thesis needs to be backed by determining how well the variability of the variables is explained by the given data structure, i.e. the initial and the extraction communalities of each variable.

This type of approach is very significant, because quantitative analysis takes into account certain variables whose variability cannot be explained by the observed data structure. Variability explained below 20% indicates that the variable must be excluded from further quantitative analysis, because it only faintly explains the observed data structure.

Based on the conducted analysis we can conclude that all of the included variables have a variability explained above 20%, i.e. they are well represented in the analysis, so there is no reason to remove any of the variables from further analysis (table 2).

Table 1. *Descriptive statistics of the variables*

Variable mark	Average	Standard deviation	Missing data
1	2.29	2.765	1
2	2.02	0.877	3
3	2.24	0.814	1
4	2.98	0.920	1
5	2.10	1.035	2
6	2.47	1.132	4
7	2.95	0.986	2
8	3.15	0.899	4
9	3.24	0.943	3
10	2.63	1.564	3
11	3.12	0.937	2
12	2.05	1.063	5
13	2.00	0.894	1
14	2.95	1.005	1

Source: *Author's calculation using the Statistical Package for Social Sciences 22.0 software*

Table 2. *Initial and extraction communalities of the variables*

Variable mark	Initial communality	Extraction communality
1	0.478	0.673
2	0.355	0.487
3	0.448	0.680
4	0.408	0.665
5	0.390	0.475
6	0.268	0.352
7	0.289	0.314
8	0.406	0.578
9	0.471	0.582
10	0.509	0.668
11	0.375	0.444
12	0.312	0.458
13	0.245	0.319
14	0.366	0.412

Source: *Author's calculation using the Statistical Package for Social Sciences 22.0 software*

Considering that there are no reasons to exclude any of the variables from further quantitative analysis based on factor method, we should determine whether the variables correlate with each other.

In other words, we must determine the adequacy of the observed sample from the aspect of using each of the variables individually in the analysis, which means testing whether the observed determinants are linearly connected or not, i.e. if the correlation matrix of the variables is an identity matrix.

If the correlation matrix of the variables is an identity matrix, then it means that the observed variables are not mutually correlated, i.e. that they are not suitable for revealing the background (latent) data structure.

For that purpose, we use the anti-image correlation matrix that measures the adequacy of a sample for each individual variable, by pointing out the variability proportion caused by background or latent data structure.

Besides the positive partial quotients of co-variation, i.e. correlation, the anti-image matrix also contains negative quotients, found everywhere within the matrix, except on the main diagonal, which proves the methodological accuracy of the conducted calculations.

The quotient values found on the main diagonal of the anti-image correlation matrix represent how adequate the sample is for the observed variable. The variables where the adequacy measure is between 0.5 and 1.0 are suitable for quantitative analysis based on factor method.

If we observe the main diagonal of the anti-image correlation matrix, we can conclude that all variables can be used in further analysis in order to determine the final influence of the variables, i.e. adequate interpretation of the economic, social and ecological factors (table 3).

The values of the other quotients that are small or close to zero, and that can be found outside the main diagonal of the anti-image correlation matrix, indicate that the variables from the quantitative analysis based on factor method have been cleared of influence from unexplained correlations.

Table 3. *Adequacy matrix for the sample of variables*

Variable mark	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**0.793**	0.125	-0.035	0.256	0.329	-0.509	0.024	-0.130	-0.065	-0.033	0.050	-0.020	-0.004	0.053
2	0.125	**0.695**	-0.422	-0.112	0.233	-0.089	0.015	-0.071	0.086	0.003	-0.099	-0.017	-0.062	0.129
3	-0.035	-0.422	**0.882**	0.009	-0.018	0.077	-0.045	0.289	-0.115	-0.038	-0.081	0.152	-0.235	-0.177
4	0.256	-0.112	0.009	**0.770**	-0.085	-0.002	0.121	-0.040	-0.032	-0.245	-0.196	-0.043	0.105	-0.006
5	0.329	0.233	-0.018	-0.085	**0.681**	0.136	-0.014	0.043	-0.111	0.049	0.119	0.019	0.091	-0.088
6	-0.509	-0.089	0.077	-0.002	0.136	**0.712**	0.078	-0.030	-0.052	0.085	-0.070	-0.012	0.044	-0.036
7	0.024	0.015	-0.045	0.121	-0.014	0.078	**0.810**	-0.005	0.028	-0.024	-0.039	0.059	-0.065	0.207
8	-0.130	-0.071	0.289	-0.040	0.043	-0.030	-0.005	**0.662**	0.038	0.001	0.241	-0.029	0.189	-0.005
9	-0.065	0.086	-0.115	-0.032	-0.111	-0.052	0.028	0.038	**0.732**	0.022	0.113	-0.045	0.333	0.191
10	-0.033	0.003	-0.038	-0.245	0.049	0.085	-0.024	0.001	0.022	**0.803**	-0.015	0.247	-0.031	-0.030
11	0.050	-0.099	-0.081	-0.196	0.119	-0.070	-0.039	0.241	0.113	-0.015	**0.768**	0.088	-0.085	0.026
12	-0.020	-0.017	0.152	-0.043	0.019	-0.012	0.059	-0.029	-0.045	0.247	0.088	**0.760**	0.123	-0.290
13	-0.004	-0.062	-0.235	0.105	0.091	0.044	-0.065	0.189	0.333	-0.031	-0.085	0.123	**0.834**	0.007
14	0.053	0.129	-0.177	-0.006	-0.088	-0.036	0.207	-0.005	0.191	-0.030	0.026	-0.290	0.007	**0.578**

Source: *Author's calculation using the Statistical Package for Social Sciences 22.0 software*

For observing the final influence of the variables, i.e. for an adequate interpretation of the economic, social and ecological factors, we use the load matrix, which is made by rotating a certain variable transformation matrix, i.e. simplifying it through orthogonal transformation.

Orthogonal transformation simplifies a load matrix of the variables in accordance with the economic, social and ecological factors, which does not influence the level of their explanation or influence from the aspect of determining the development environment of agriculture in the EU in the context of sustainable development.

Factorial loads for each of the variables can be represented in the form of a matrix, where any given value represents the weight quotient of the observed variable for the given factor. These weight quotients are used for interpreting the economic, social and ecological factors of the development environment of agriculture from the aspect of sustainable development.

So, then we speak about interpreting development factors in the environment of agriculture in the EU from the aspect of sustainable development, we use certain weight quotients from the load matrix of variables, that simplify the interpretation of the observed development phaenomenon. The factorial load values are between -1 and +1, where negative values show a negative influence of the observed variable on the development environment, while positive values indicate a positive influence of the observed variable on the development environment. The higher the value of the factorial load, either positive or negative, i.e. the closer it gets to +/-1, the better the observed factor/variable is at explaining the development environment (table 4).

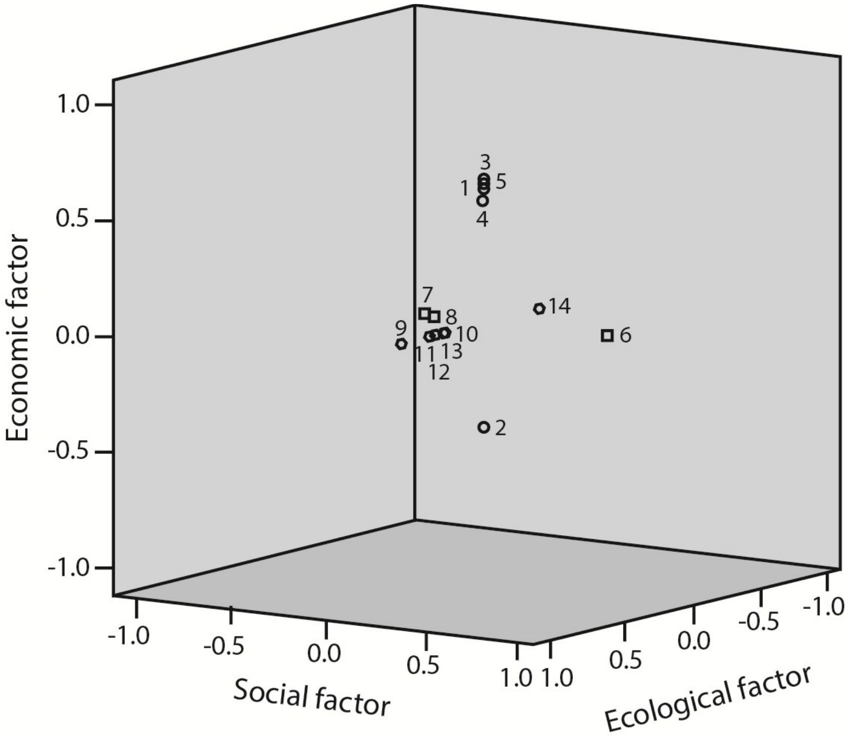
For a simpler overview of the influence of variables, i.e. interpretation of the economic, social and ecological factors as determinants for the development environment of agriculture in the EU, a load matrix can also be visually represented as a three-dimensional graph (graph 1). This type of view is significant because it simplifies the interpretation of developmental factors in the environment, especially if the connection between certain variables that characterize the development conditions is very complex.

Table 4. *Load matrix of variables according to the appropriate economic, social and ecological factors*

Variable mark	Economic factor	Social factor	Ecological factor
1	0.572	-	-
2	- 0.485	-	-
3	0.635	-	-
4	0.533	-	-
5	0.601	-	-
6	-	0.574	-
7	-	- 0.329	-
8	-	- 0.288	-
9	-	-	0.587
10	-	-	0.329
11	-	-	0.425
12	-	-	0.402
13	-	-	0.345
14	-	-	- 0.412

Source: *Author's calculation using the Statistical Package for Social Sciences 22.0 software*

Graph 1. *A three-dimensional representation of variables in the economic, social and ecological factorial space – development environment of agriculture in the EU from the aspect of sustainable development*



Source: *Author's calculation using the Statistical Package for Social Sciences 22.0 software*

Conclusion

In general, the level of variable load is not too high, which means that the appropriate structure between them is becoming harder to obtain. This implies that the variables are becoming harder to group and that they are slowly taking the role of independent influential determinants that independently influence the development environment of agriculture in the EU, which is not in accordance with the sustainable development concept. Based on this, we can conclude that the development environment of agriculture in the EU is becoming more and more complex with time, as well as difficult to understand and interpret, due to an increasing number of non-coordinated influences, which can cause its unsustainability on the long run.

Considering how the variables are distributed, the economic factor is the most significant one and it greatly influences the creation of the development environment of the EU. It is within this factor that there are the most variables with relatively high factorial load values as weight quotients, which means that they explain, i.e. determine the development environment in the best way. Investments as a variable within the economic factor have the biggest positive influence, i.e. they most clearly influence the development environment of agriculture in the EU through its positive formation, which improves competitiveness and leads to a profit increase.

The economic factor as a quantitative development determinant can represent a sort of barrier for the sustainability of the development environment of agriculture in the EU on the long run, unless a synergetic effect is made with the social and ecological factors as qualitative development determinants. This point of view is not good from the aspect of the basic postulates of the sustainable development concept, so it becomes necessary to undertake certain measures within the Common Agricultural Policy of the EU. This would lead to harmonization of the quantitative component of the development environment of agriculture with its qualitative component that is defined through the social and ecological aspects of development.

Based on the conducted quantitative analysis of the development environment of agriculture in the EU from the aspect of sustainable development and the assessed economic, social and ecological factors we can conclude that it is necessary to create an adequate ambience for the development of agriculture through creating necessary and measurable development conditions. They would serve achieving sustainable development, i.e. realising triple goal developmental functions: improving the agri-economic activity, achieving the agri-social equality and preserving the agri-ecological ambient.

The biggest influence on the development environment of agriculture in the EU from the aspect of sustainable development in the future should come from creative capital, knowledge, cooperatives and „greening“ of agri-entrepreneurship, in accordance with the new development strategy of the EU „Europe 2020“, which is based on a smart, sustainable and inclusive growth.

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