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ECONOMIC SIZE AND SUSTAINABILITY OF THE AGRICULTURAL HOLDINGS

ABSTRACT
OF
PhD DISSERTATION

For graduating of educational and scientific degree "doctor" in PhD programme
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The materials for the public defense are available to interested parties at the headquarters of the Agricultural Academy, Sofia.

GENERAL CHARACTERISTICS OF THE DISSERTATION

The agricultural holdings are a structural factor in the development of agriculture, food security, the production of raw materials for the processing industry, the provision of employment and export (currency) security of the trade balance of each country.

Agricultural production, with its highly intensive nature, has the main attraction for maintaining jobs in the regions, and within its responsible management also contains the root of protecting the environment from pollution. In recent years, the sustainable development of the microstructures that make up agriculture has gained an increasingly significant influence on the economic system in Europe. The Old Continent depends more and more on adaptation to climate changes, the depopulation of rural communities, the limitation of natural resources, which is the reason why enormous expectations are placed on sustainable management for the balance between nature, society and the economy. Recently, the question of the optimal ratio between the number of agricultural holdings and their productivity and efficiency has become increasingly relevant. On the one hand, a critical amount of human capital is needed, and on the other hand, a significant scale of production is needed to realize the main economies in any agricultural (economic) micro system. These socio-economic issues are also accompanied by corresponding environmental challenges such as water and irrigation systems, soil erosion, loss of natural value in the ecosystem (biodiversity), growing deficits in natural reserves (quality of soils, "management" of forests, number of natural reservoirs and aquaculture, etc.).

All this has placed high expectations on the process of transformation in agriculture, including in the value chain and the food chain, meeting the needs of the ever-growing population and the subsequent increase in food demand. Instead of answers, however, the number of nascent questions continues to grow - are the agricultural systems becoming more and more resource-intensive (water, energy, fertilizers, plant protection products, etc.), is the depopulation of the regions increasing, is the agricultural market being distorted as a result of practices to support producers and/or production, is their efficiency compromised. Sustainable development implies that agricultural production minimizes the production factors usage and maximizes the yields at the same time, goals also enshrined in the Strategic Plan for the Development of Agriculture and Rural Areas 2023-2027 (Common Agricultural Policy) of the EU, as well as the goals of stimulating "smart, sustainable and inclusive growth" enshrined in the Europe 2020 strategy. Mainly, the policies are aimed at: transparency and fairness of direct support measures; assistance in farmer`s positioning in the supply chains of raw materials and foodstuffs; increasing efficiency in implementing CAP measures; legislative changes ensuring the safety of food products reaching the market; creation of a system of measures to alleviate the consequences of climate change; support for economic growth, support for creating employment in rural municipalities. In order to facilitate the analysis of the structural characteristics of agricultural holdings and their economic results, a homogeneous classification of agricultural holdings by economic size and type of production by technical-economic orientation has been introduced[1]. The use of this classification in the Farm Structure Survey (by Eurostat) enables an assessment of the condition of agriculture within the EU, both in terms of perspectives, trends and transformation in the structure of holdings, and for modeling the expected impacts of external to agriculture factors or new proposals for agricultural policies. The sustainability assessment of the agricultural holdings is most often perceived as a snapshot of the situation, based on data for a one-year period, or on data averaged over several years. The sustainable development of agricultural holdings, however, is related to their dynamic restructuring and adaptation to the changing market, institutional and natural environment. This process predetermines the decreasing importance and sustainability of a certain type of holdings and the transformation of small holdings into sustainable and diversified economic units integrating various productions and services. Due to the rapidly changing economic size of agricultural holdings, it is imperative to examine sustainability in dynamics in order to reveal the real trends in the development of different categories of agricultural holdings. **The purpose of the study is to assess the sustainability of agricultural holdings in the EU in terms of economic size and to propose a model for their dynamic sustainable development.**

To achieve the goal, the following **tasks** are formulated:

1. To review the understandings and basic postulates about sustainability and specifically at the level of agricultural holdings.

2. To apply a holistic approach based on an Aggregate Index to measure sustainability by economic size of holdings.

3. To investigate the correlation dependences of the sustainability

4. To propose models for sustainable development of agricultural holdings among those surveyed in the EU.

5. To make recommendations for improving policies regarding the sustainability of agricultural holdings.

In order to realize the set goal, it is necessary to define the concept of "sustainability" in the context of seeking high productivity, feeding the world population, achieving economic competitiveness, as a guarantee of economic existence. Where exactly is the trade-off between the level of intensification and sustainable agriculture on the one hand and the drive for a constant

[1] Commission Decision No. 85/377/EEC of 7 June 1985 establishing a Community typology for agricultural holdings.

increase in profitability, financial results and high yield on the other. Sustainability is considered in a holistic perspective, representing equality between the economic, ecological and social pillars and can be assessed through a comparative unified approach carried out with the average population of agricultural holdings throughout the European Union.

The main research thesis of the study is that economic size affects the level of sustainability of agricultural holdings.

Research hypotheses:

1. Larger farms in terms of economic size have higher sustainability.
2. The assessment of sustainability according to individual pillars differs in the overwhelming number of cases and the achievement of a harmonized balance between economic, social and environmental interests is still not widespread, which shows the sensitivity of the concept of sustainability.
3. Medium-large farms have relatively high sustainability as well as the Large farms.
4. The sustainability of agricultural holdings in the majority of old EU member states is above average, while in most of the new members from Central and Eastern Europe is below the EU average.

The object and subject of the study are the agricultural holdings of the European Union, represented by the synthetic data for one (statistical average) holding of each member state, which essentially represents its national structure of the agricultural sector. **The subject of the study** is the influence of economic size on the sustainability of agricultural farms.

The main methods used to conduct the research are: Relative Comparative Assessment (RCA); DEA-BoD analysis (Data Envelopment Analysis - modified Benefit of the doubt model); Ranking assessment; Correlation analysis; Statistical significance test.

The information used in the study is based on the database providing information on the business operations of the market-oriented farms, the Farm Accountancy Data Network with the scope of the study 2007-2019.

Study limitations

The main limitations in this study are three: The first is related to the selection of data in the study of the European Commission - Farm Accountancy Data Network - FADN and concerns the difference in the selection of farms participating in the survey - the minimum threshold of economic size for participation in the representative sample for each member state. The formation of the average economic size of the studied units also depends on this threshold - the averaged data for obtaining the microeconomic unit representing each member state.

The second limitation leaves open the question of structural differences in the farm specialization of specific average holdings from the point of view of the composition of specialization of individual member states by economic size.

The third one is related to the indicators and comes down to the lack of sufficient quantitative and qualitative indicators covering Bulgaria's membership in the EU in a long-term aspect. Therefore, some of the desired indicators should not be used in their quantitative values - mineral fertilizers are represented by measuring values - incurred costs (quantitative values for fertilizers are collected after 2014), data on the income of farms from non-agricultural activities and others. The indicators used are exclusively based on economic data for this compilation, apart from the indicators for the economic pillar, but also the social and environmental ones.

II. BRIEF DESCRIPTION OF THE DISSERTATION

CHAPTER ONE: THEORETICAL CONCEPTUALIZATION OF SUSTAINABLE DEVELOPMENT AND ITS DEPENDENCE ON INNOVATION AND TECHNOLOGY

The concept of sustainability and sustainable development is a result of a long historical process in which the need to protect nature is in conflict with the production intensification (Garnett, 2012) - on a global scale and especially in developing countries.

Sustainability, conceptually, represents the ability of a system to exist continuously, even permanently, over time (Bonem, 2018). On the other hand, the Brudtland Report defines sustainability as the process of sustaining change in a balanced environment where the exploitation of resources, the direction of investments, the direction of technological development and institutional changes are in harmony and enhance the current and future potential to meet human needs and aspirations (World Commission on Environment and Development, 1987).

Sustainability, in its multicriteria nature, is usually assessed and measured using a complex of quantitative and qualitative indicators. Quantitative describe the extent of change and support, while qualitative describe its stability, or its ability to self-sustain, self-reproduce, or self-develop after the act of initial change. In practice, these are the two sides of development, motivated in parallel to stabilize and improve the ecological, social and economic in all their dimensions independently of, or even in spite of, the forces at work in any particular situation. This explains why sustainability in specific activities is taken so seriously, and why it is so difficult to be achieved in practice.

In the report Our Common Future, **sustainable development is defined as that which meets the own needs of the present without compromising the ability of future generations to meet their own needs** (World Commission on Environment and Development, 1987). Sustainable development can be the organizing principle of sustainability, while other authors could see the two terms as paradoxical, i.e. development is inherently unsustainable (Madhavan et al., 2011).

1.1. Historical roots of the concept

In 1992, the United Nations Conference on Environment and Development was held in Rio de Janeiro. The "Three Pillars of Sustainability Model" was created, with which the three mutually complementary dimensions are united and the decision is made to develop them in parallel, ensuring the sustainability of communities with social, environmental and economic priorities. As the main appeal addressed to the international community, the "development and identification of indicators of sustainable development in order to improve the information base" for monitoring the "decision-making units" is singled out. (United Nations, 1992).

1.2. Three Pillars of Sustainability

1.2.1. Social Sustainability

The main long-term goal for social sustainability is the unification of society, and the short-term sub-goals are related to alternatives for personal development and ways of making management decisions in the spheres of a public nature. Again, it is only a matter of time before such a thesis is dislodged - recently Heimberger asked the question "why the most significant consequences of economic globalization are: competition and increasing income polarization"

(Heimberger, 2019) and where this fact is leading humanity - the increasingly rapid loss of value in skills, educational training and professional qualifications, which are a source of uncertainty. In an attempt to alleviate this effect, social sustainability raises the following questions, which it sets as its goals: "guaranteeing social security; taking practical action to ensure equal opportunity; stimulating social justice through a helping, supporting, but also demanding a welfare social state"“ (Behrendt & Anh Nguyen, 2018).

1.2.2. Economic Sustainability

Economic sustainability is at the core of the interplay between economic relationships in modern society. Economic growth in any country is precisely what the toolkit is based on to ensure stability in the material and financial aspect of well-being in modern society. The main importance of practices and policies to protect society's interests and needs for resources, employment, social security, economic growth, innovation, intergenerational balance, international stability (García & Gruat, 2003). Economic sustainability represents: "the broad interpretation of ecological economics, in which the changing dimensions of the environment and ecology and the issues affecting them are fundamental, but also part of a multidimensional perspective".

1.2.3. Ecological Sustainability

Environmental sustainability, as an expression of a strategic humanitarian goal for future human generations, is associated with the protection of the natural environment (Liu, 2017). There are two main ways to reduce the negative impact on humans and nature by enhancing ecosystem services (Millennium Ecosystem Assessment, 2005). The first of these is environmental management. This direct approach is based largely on information obtained from earth science, environmental science and biology. However, it is management at the end of a long series of indirect causal factors that are initiated by human consumption so that the second approach is through demand management in human resource usage. Managing human consumption of resources is an indirect approach based largely on information obtained from the economic system. Herman Daly proposes three broad criteria for environmental sustainability: renewable resources must provide sustainable yield (the rate of consumption must not exceed the rate of resource regeneration); non-renewable resources should have equivalently developed substitutes from renewable sources; waste generation must not exceed the assimilative capacity of the environment (Daly, 1990).

1.3. Characteristics of farmer organizations and sustainability in agriculture

1.3.1. Theory of agricultural organizations

The organization of a farm can vary from a single-owner or family-owned operation, where the payment of labor is equivalent to the profit of the activity, to a more complex agribusiness, including administrative, production and/or managerial department(s), up to a public organization corporation with many anonymous owners and specialized wage labor.

A "pure" family farm is the simplest case where one farmer owns the production and controls all farm assets, including all labor assets (Allen & Lueck, 1998). Corporate farming in an industrial form is the most complex case when there are many owners, which creates the need for professional management and the hiring of labor to perform the work operations.

Although the organization of industrial business as a whole follows a transition from family firms to large industrial-type corporations, agriculture remains the last bastion of a family production organization. Allen & Lueck (1998) consider that agricultural production stages tend to be short, sparse, composed of few discrete tasks, thus limiting the benefits of specialization and wage labor, making them particularly costly to control. They tend to summarize that only when farmers can control the effects of nature, when they mitigate the effects of seasonality and market shocks on supply and demand, then the farm organization may take an industrial type, developing into the large-scale corporate forms that are familiar in the non-agricultural economy. In this way, in theoretical terms, two main ideas about the existence of economic organizations in agriculture appear and develop - the production-maximizing theory and the institutional concept of transaction costs.

In his capital work “The Nature of the Firm”, Coase attempts to explain why there are market transactions if organizations can reduce costs (Coase, 1937). According to Coase (1937), the reasons lie primarily in the relationship between firm size and the costs of managing intrafirm transactions. The second reason mentioned by Coase (1937) is that "as transactions increase, entrepreneurs fail to make the most optimal decision for the allocation of resources and factors of production". This is explained by technological needs and resource provisions, which by definition are insufficient, and economic subjects make an economy by choosing different alternatives. According to Ivanov (2023), "transaction costs arise and are divided into two main types: those that mediate the process of passing and movement of goods and services along the value chain. The other main source and category are transaction costs arising in the adaptation of individual subjects and organizations to the institutional environment”. Transaction costs arise because not everything is perfectly arranged, not all information is available, the control within business units is becoming increasingly complex due to the expansion and growth of scale and the implementation of complex production technologies that require many more new partnerships and business relationships, and a value chain involves more entity requirements and standards, while regulations and institutional environments become increasingly detailed and discriminating.

In agricultural business management, the management practices research methodology requires the researcher to integrate three distinct interrelated processes: "management process", "decision making process" and "problem solving process" to be used interchangeably in the literature (Scoullar, 1975). Over the next decade, other features took shape that built on and upgrade these processes. The authors base their understanding of management again on three, but not exactly processes, but rather functions of management, namely planning, implementation of the plan and its control (Boehlje & Eidman, 1984; Kay & Edwards, 1994). These fundamental processes are the result of combining the six functions proposed by Johnson et al. (1961): defining the problem, its monitoring, analyzing, solving, acting on and taking responsibility.

1.3.2. Sustainability of the institutional environment

The study and analysis of the institutional framework provides clarity on the formal (or informal) rules in force, according to which the structure-determining processes take place in a given institutional system, where specific agents, conductors of the processes, with their rights and obligations in the sanctioning system find their place. in case of violation of the specific requirements (Ivanov, 2023; North, 1991; Furubotn & Richter, 2005). There are also other agents to support the reporting activities to ensure the goals of the supported farms, as well as the relevant market "players" who close the circle of interests for agrarian entrepreneurs. The set of external, internal and informal agents form the structure of the institutional environment and can be subject to identification and analysis. Sustainability and its three dimensions are subject to management by the institutions on which the development of agriculture and its constituent decision-making units depend, which, on the other hand, require transparency and predictability in the order and mechanisms of institutional management (Bachev, 2020).

Existing issues and challenges facing agriculture and its institutional management are also subject to identification, its sources of shortcomings and failures, the potential for improving the work of institutions in the European context of sectoral development and sustainable perspectives in front of all dimensions - from economic efficiency, through social responsibility to environmental compatibility, the results of which are a consequence of the applied policy in agriculture and farms.

The present study examines the complex policy for managing sustainability in agriculture of individual member countries. Each individual farm, considered as a country average, in effect represents the overall behavior of the farming system of all farms in a member state. Investigating the behavior of agricultural units, the functioning of institutional mechanisms and management policies in the agricultural sector is also observed.

1.3.3. Agrarian sustainability (at sector level)

In the third decade of the 21st century, agrarian sustainability with its three dimensions is gaining an increasingly significant presence on the agenda of politically responsible entities, who rely more and more on sustainability criteria for their decision-making. In particular, analysts need to rank decision-making units according to sustainability criteria and offer policymakers more solutions and insights into the different perspectives behind the three dimensions of sustainability. The strong political demand for comprehensive assessments faces the challenge of establishing clear and science-based criteria for sustainability. This is not an easy task due to the fact that the concept of sustainability is a "social construction", where reference points are related to ranking criteria and are not easily derived from social preferences. (Mela et al., 2012).

Chrabrin Bachev points out the abundance of developed methodologies for assessing agrarian sustainability at the international level and for a specific industry (FAO, OECD) and warns about the lack of measurements at the lowest "farm level" and its perceptibility (Bachev et al, 2016). Also he adds that "in this way, the important links between farm management and the impact on agroecosystems and the sustainability of agrosystems of different types are not considered.".

There are several factors, including **increasing water and land scarcity, increasing demand for biofuels, declining agricultural productivity, rising income per capita, and the adverse impacts of climate change**. (Neufeld, 2007), which have compounded an already serious challenge. On the other hand, technological innovations that helped to double global cereal production between the 1960s and 1990s and therefore increase global food supply per capita could work in the opposite direction. (Tilman et al., 2002).

Meeting the growing food challenge will require intensive production methods on existing land while investing in measures to reverse the trend towards soil fertility depletion and environmental degradation (Rockström et al., 2009), as well as adopting technologies to improve efficiency in the use of production factors such as nutrients and water (Tilman et al., 2011).

Due to the close interconnection between agricultural activity and natural capital (the environment), the sustainability dimension is one of the crucial issues in the reform of the Common Agricultural Policy (CAP). There is a growing conflict between economic and social objectives, which are essential and characterize public intervention in the agricultural sector with the increasing importance of the new priority - the environmental dimension. The creation of an information system to monitor the development of agriculture from an ecological perspective is one of the first steps towards a more comprehensive analysis (Longhitano et al., 2012).

The measurement and analysis of agrarian sustainability is about to take an increasingly significant part in the allocation of funds to support agricultural holdings (European Commission, 2021). This requires the creation of a generally accepted algorithm for its assessment at the farm level which to result on the new support measures to be constructed.

CHAPTER TWO: METHODOLOGY FOR ASSESSING THE SUSTAINABILITY OF AGRICULTURAL HOLDINGS

2.1. Sustainability Assessment Aproach

The following three methods are applied for the sustainability assessment:

- **Relative Comparative Assessment (RCA)**;
- **DEA-BoD (Data Envelopment Analysis – Benefit of the Doubt);**
- **Composite Index –** arithmentical average of the above mentioned methods.

The applied assessment methods are based on such an index that is based on 15 indicators, by 5 for every sustainability pillar: economic, social and ecological. The index varies from 0 to 1, as the maximum sustainability value is expressed by 1.

2.1.1. Relative Comparative Assessment (RCA)

It is based on indicators selected or developed by the author, distinguishing the activity of agricultural holdings. The sustainability index (SI_{RCA} or Index RCA) represents statistical average of the three sustainability pillars indexes – economic, social and ecological and can be formulated as following:

$$\mathbf{SI_{RCA} = (Ii + Is + Ie) / 3.}$$

Each pillar index values is received as a statistical average of the normalized values of the 5 indicators that make it up. For the normalization purposes of the input data, the following formula is applied (Ivanov, B., 2023):

$$\textbf{Normalized value} = \frac{\textbf{FADN value * (0.5 + 0.5 * VC}^2\textbf{)}}{\textbf{Standard Deviation + Arithmetical Average}}$$

Variation Coefficient (VC) = Standard Deviation/ Arithmetical Average

The above mentioned formula makes it possible to derive a comparative index for assessing the sustainability of each country based on the values for each individual indicator. The individual assessment for each indicator, for each country, is located on a scale between 0 and 1, with the basic principle being that the average relative comparative assessment for the entire population receives a factor of 0.5, which is the median of the measured scale. The applied method concentrates the normalized data around the middle of the scale, and in some exceptional cases, a normalized value above 1 can be obtained, which are equated to 1, and when there are negative values, they are equated to 0. The formula is applied to each of the 15 used indicators, for each average holding of each member state and the whole inspected period.

Before the normalization formula is applied, the extreme values - very high positive or negative values - are removed from the data for the specific indicator, so as not to affect obtaining adequate data in the numerator and denominator.

2.1.2. DEA-BoD method (benefit of the Doubt)

DEA-BoD is a modified version of the Data Envelopment Analysis (DEA). Classic DEA measures the sustainability by technical efficiency coefficient of decision making units (DMUs). Technical efficiency is appropriate to measure the sustainability, because points out comprehensively (or separately) the results of the impact of economic, social and environmental factors.

At the core of technical efficiency measurement are the ideas of Farrell (1957), who drew on the work of Debreu (1951) and Koopmans (1951) to conceptualize a measure of firm efficiency that could account for multiple outputs. Farrell proposes that the efficiency of a firm consists of two components: technical efficiency, which reflects the firm's ability to obtain the maximum output from a given set of available resources (data); and allocative efficiency, which reflects the firm's ability to use the input resources in optimal ways. proportions, considering their prices.

To measure technical efficiency, a marginal production function of the maximally efficient producer corresponding to a given real producer (firm, farm, etc.) is constructed. The maximally efficient producer can be real, but also virtual, without being known in practice and formed by the most efficient producers from the observed sample. The performance of the remaining producers is taken as the "comparative distance", measured as the percentage of *backwardness (inefficiency)* compared to the distance from the most efficient and most sustainable farms (Cooper et al., 2007). The efficiency of the virtual producer is 1 (100%), and of the relatively inefficient producers it takes values between 0 and 1.

The DEA-calculated results (or weights) of the various types of inputs and outputs parameters are such that the efficiency of the considered unit is maximal (Gerdessen & Pascucci, 2013). DEA is used to both minimize costs (or inputs) and maximize output ("input/output oriented" model) using selected variables, such as costs or final product. The **DEA-BoD** method applied in the present study was originally designed to determine a composite Human Development Index (HDI), based on three dimentions – income, health and education (Melyn & Moesen, 1991). Later, DEA-BoD found wide application in the construction of composite indices, including for sustainability assessment (Castro-Pardo et al.).

DEA-BoD uses all indicators as "outputs" and ignores the input of the production system (Cherchye et al., 2006). Despotis (2005) notes that representing the indicators as outputs and assigning them to a “virtual input indicator” equal to one (input = 1) leads to the original constant returns to scale DEA model presented by Charnes, Cooper & Rhodes (1978).

The objective function in this case maximizes the weighted sum of the indicators based on a homogeneously determined set of optimal weighting coefficients. These DEA-BoD derived weights reflect the relative importance of each indicator (Adler et al., 2010), in such a way that more weight is given to components considered more important to the sustainability of the average farm (Munda & Nardo, 2003).

Non-negativity constraints are also applied so that each indicator is used in the calculation of the composite sustainability index, thus eliminating the possibility of a unit using zero weights on a particular metric that performs relatively poorly and placing all its weights on the metrics for which it performs best (Gerdessen & Pascucci, 2013). DEA-BoD combines multiple variables by endogenously selecting weights that maximize the sustainability score for each unit (Zhou et al., 2007), i.e. each Member. Each unit receives its own best possible combination of metric weights

(Shen et al., 2013) with the highest relative weights assigned to those indicators in which the unit under consideration achieves the best results (Cherchye et al., 2006).

DEAP 2.1 software is used to construct the sustainability index (Coelli, 1996), which constructs endogenous relative sustainability weights for each DMU (EU member state), combining indicators from the three pillars, as well as separately for each pillar.

2.3.3. Composite Sustainability Index

The compound indice contributes to broadening the scope of the general assessment of sustainability, being indicative both of the efficiency of the production activity of farms and of the effective use of applied policies regarding sustainability. Изчислява се за всеки от трите стълба на устойчивостта и за общата устойчивост, като се формулира по следния начин:

Composite Sustainability Index = (RCA Index + DEA-BoD Index) / 2

2.4. Indicators for sustainability assessment

2.4.1. Indicators used in the Relative Comparative Assessment method

Methods that construct indices by data accumulating, synthetic complex indicators (relating one quantity to another) are required to assess sustainability. When complex (or synthetic, "performance") indicators are available, we measure pillars sustainability by directly summing the obtained results.

Economic indicators

Indicators for assessing the economic pillar of sustainability, taking into account the characteristics of the farm, include both the main factors of production (labor, land and capital) and measures of their efficiency, effectiveness and profitability. The selected indicators are:

1. Labor productivity – the ratio of total gross output to the total labor input:

Labor productivity =

Gross production (SE131) / Total labor input (SE010)

Level of production diversification - the reciprocal value (coefficient not greater than one) of the ratio between the most large-scale production (of all production specializations) of the farm to the total production (gross production), weighted through the prism of the average value:

$$\textbf{Production diversification} = 1 - \frac{\textbf{(Max - Avg) + (Avg - Min)}}{\textbf{Gross production (SE131)}}$$

Max – the production specialization with the largest share in total output

Avg – arithmetic average of all specialized production lines

Min – the production specialization with the smallest share in total output

Gross production – the sum of the value of the all production directions

3. Profitability – the ratio of total net income to total costs (requires removal of negative values (equated to 0) before normalization):

Profitability = Farm net income (SE420) /

(Total costs (SE270) – Farm use (SE265))

4. Capital productivity – the ratio of the total gross product to the average capital of the holding:

$$\textbf{Capital productivity} = \frac{\textbf{Gross production (SE131)}}{\textbf{Farms average capital (SE510)}}$$

5. Economic resilience – is derived from the ratio of the difference between gross output and subsidies to the fixed costs (Bachev et al., 2017):

Economic resilience = (Gross production (SE131) – Production subsidies (SE605) – Investments subsidies (SE406)) / (Other direct inputs (SE356) + Depreciations (SE360) + Total external factors (SE365))

Social indicators

The socioeconomic status of rural households includes different units of measurement and the variables used in this study are based on a literature review and synthesis of variables used in similar studies:

1.Farm income per family member – ratio of net family income to unpaid labor in the holding:

= **Farm income per family member (SE430)**

2. Farmhouse consumption per family member (requires the highest value to be equalized to the next largest value before normalization). It is calculated by dividing the total amount of internal household consumption by the unpaid labor units and is presented in euros.

= Farmhouse consumption (SE260) / Unpaid labor units (SE015)

3. Level of payment of hired labor - it is presented as a relationship of the costs of wages, social security (and insurance) per unit of hired personnel (salaries of workers considered unpaid or paid less than normal for the unit are not included - they are considered household members) to paid annual work units:

= Wages costs (SE370) / Paid labor units (SE020)

4. Land ownership – the share of own land as a percentage of the total agricultural area used. It is calculated as the reciprocal of the share of rented land ot the total agricultural area:

= **1 - (Rented UAA (SE030) / Total utilized agricultural area (SE025))**

5. Own produced factors per unit UAA and LU:

= 1/2 [Own produced factors (SE265) / Total UAA (SE025)] +
1/2 [Own produced factors / Total livestock units (SE080)]

Ecological indicators

Agri-environmental indicators track the integration of environmental measures from Common Agricultural Policy (CAP) framework at central (EU), national and regional levels.

1. **Stocking density (SE120)** – it is presented by the average value of mammals per unit area (LU/ha), that is used for fodder production, including permanent grassland, fallows and area out of production for the current production season.

2. Fertilizers used per unit input intensive agricultural area

= Fertlizers costs (SE295) / Intensive area*

3. Pestisides used per unit input intensive agricultural area

= Pestisides costs (SE300) / Intensive area *

Represents the ratio of the budget for the purchase of herbicides, insecticides, fungicides and other plant protection products (except those used for forestry) to the intensively used agricultural area in hectares.

* Intensive agricultural area is presented as a sum of areas used for annual and perennial crops

4. Energy used per unit area – represents tha ratio of amaunt paid for motor fuels and lubricants, electricity nad heating fuels to the total utilized agricultural area (UAA).

= Energy costs (SE345) / Total UAA (SE025)

5. Crop rotation participation of the protein (nitro-fixing) crops:

= **Protein crops** (SE145) /

Cereals (SE140) + Energy (SE146) + Potatoes (SE150) + Sugar beet (SE155) + Oil seeds (SE160) + Industrial (SE165) + Flowers and vegetables(SE170)

The indicator is presented as a ratio of the gross production from leguminous crops to the sum of the gross production from the crops participating in the crop rotation in euros).

2.4.4. Sustainability measurement indicators in DEA-BoD

In order to create a balanced index, it is necessary to select an equal number of indicators from the three pillars. Considering the source of the data, a system for monitoring business operations on EU farms, the information is abundant on economic indicators, while environmental and social indicators are severely limited. After the reforms in the system (2014), which began to specify the physical volumes of mineral fertilizers input, income from non-agricultural activities and other specific measures, the choice is significantly more diversified, but this would only limit the studied time period.

Economic indicators:

1. Labor resources input (AWU) SE010;
2. Total UAA (ha) SE025;
3. Gross livestock production from a livestock unit (euro/LU) SE207;
4. Total assets (euro) SE436;
5. Holding`s gorss production (euro) SE131.

Social indicators:

1. Net farm income per unpaid (family) labor unit (euro) SE430;
2. Costs for wages ot the paid labor (euro) SE370/ SE020;
3. Farmhouse consumption (euro) SE260;
4. Own produced factors (euro) SE265;
5. Gross farm income (euro) SE410.

Ecological indicators

1. Fertilizers costs (euro) SE295;
2. Plant protection costs (euro) SE300;
3. Energy costs (euro) SE345;
4. Stocking density (LU/ha) SE120;
5. Legumes participation in the crop rotation – coefficient to measure the ratio of the protein crop`s gross output to the total gorss output SE145/ SE135.

2.5. Formation of classes by economic size of the agricultural holdings

For the purposes of the analysis and classification of agricultural holdings according to the sustainability results calculation and their presentation in dynamics and according to the economic size of the holdings, five classes are constructed (Table 1), based on the methodology of the FADN and the available agricultural units, with minimal corrections in the first class.

Table 1: Economic size classes according to FADN nomenclature

FADN Sample (EC)		Availabe number of holdings in the sample	**New formed classes**	
Class (EC)	Economic size (Euro SO)		Economic class (category)	Economic size (Euro SO)
IV	from 8 000 to less than 15 000	1 / 4	**First class (small)**	to less than 25 000
V	from 15 000 to less than 25 000	3 / 4		
VI	from 25 000 to less than 50 000	8	**Second class (medium-small)**	from 25 000 to less than 50 000
VII	from 50 000 to less than 100 000	6	**Third class (medium-large)**	from 50 000 to less than 100 000
VIII	from 100 000 to less than 250 000	5	**Fourth class (large)**	from 100 000 to less than 250 000
IX	from 250 000 to less than 500 000	5	**Fifth class (very large)**	more than 250 000

Source: FADN, EC

2.6. Models for sustainable development of agricultural holdings

They represent benchmarks for the sustainable development of agricultural holdings, based on those identified in the available set of holdings.

2.6.1. Statical approach for selecting sustainable agricultural holdings

For this purpose, a comparison is made between the farms in the EU-28 countries on the basis of the *averaged static (non-dynamic) results for sustainability* and an answer is sought to the question "which are the available examples of farms that fulfill at a satisfactory or high level the established reference values for sustainability as in its three pillars", as well as in the final evaluation, or is a compromise necessary given the contradiction in the concept of sustainability - that economic activity could be environmentally friendly while being economically efficient and socially responsible.

The comparative analysis is done through a developed author rating point system, in which each farm (country) receives a rating point when it demonstrates a sustainability index higher than the reference index (EU-28 average), for the three assessments (by the three approaches) and for the two reporting program periods (2007-2013 and 2014-2019). With the ranking formulated in this way, the maximum rating for each of the presented dimensions (economic, social, environmental and sustainable) for a given country is 6 points (3 assessment method - RCA, DEA-BoD, Composite index – by 2 reference periods).

The classification is based on the sum of the points for the three pillars and the final overall sustainability score, without weighting the individual pillars. The names of the sustainability categories are based on the nomenclature developed by the certification company Control Union and are the following (the last category is not subject to certification and is given by the author): Platinum, Gold, Silver, Bronze, Vulnerable and/or endangered farms**.**

The boundaries of these categories are determined based on a statistical criterion - an arithmetic mean of the results obtained.

The classification of holdings is carried out in three variants: the first, in which the reference value is equal to the EU-28 average for the two reporting program periods, and the second, in which a compromise is allowed and taking 90% of the average for the two periods as the reference value. This option aims to clearly highlight which member states have reached the so-called (relative) cohesion or convergence and which are in a state of "derogation" from the set plans for (sustainable) development of the European Community in the agricultural sector.

In the third option, a priority is given to the economic pillar with a tolerance of 10%, with which sustainable farms include those that are around the average level in each dimension of sustainability.

2.6.2. Construction of a dynamic coefficient for selecting sustainable agricultural holdings

In order to measure the change in sustainability, the achieved level of sustainability in each of its dimensions (by Composite indices) from the three different estimates, the value of the second program period is compared to the arithmetic mean between the level of sustainability from the first program period and the its EU-28 average. In this way, the progress of agricultural holdings in sustainability in relation to the EU-28 average is taken into account.

Formula for compiling a dynamic coefficient for the assessment of stability:

$$\mathbf{S_{dyn}} = \frac{\mathbf{S_2}}{\mathbf{(S_1+AVG_1) / 2}} = \frac{\mathbf{2\ S_2}}{\mathbf{S_1+AVG_1}}$$

where:

$\mathbf{S_{dyn}}$ – dynamic coefficient for sustainability change

S_1 – individual sustainability level from a reference period 1 (2007-2013);

S_2 – individual sustainability level from a reference period 2 (2014-2019);

AVG_1 – average EU-28 sustainability level from the reference period 1.

The coefficient formed in this way is indicative of the impact of the CAP on the development of sustainability in individual EU-28 member states.

2.7. Selection of sustainable models based on the Composite Sustainability Index

Composite index as an arithmetic mean between the RCA and the DEA-BoD is applied in the analysis of the general level of sustainability. When selecting sustainable models, which are a benchmark for the rest of the agricultural holdings, the statistical significance (compatibility) between the two assessments is checked in advance. The aim is to achieve greater precision and reliability of the results.

The compatibility check between the two estimates is based on a statistical toolkit, which defines as significant the relationship between the two estimates of farms in each EU member state and when the significance coefficient is above 1, and when it is below – as insignificant, respectively. In this way, 28 significance coefficients are compiled for each of the measured quantities (for each pillar and for the Composite Sustainability Index). In case that statistically significant coefficients predominate among the obtained coefficients for farms in the 28 member states (over 70%), it can be assumed that the two separate measurements are compatible for the construction of integral indices.

The statistical toolkit at this point is borrowed from the work of Bashev et al. and the "Competitiveness of Bulgarian Farms" (2023) for comparing an unlimited number of indices and reconciling them into a final assessment of a given dimension. For the purposes of this study, and considering the comparison of only two indices, the formula is greatly simplified:

$$\text{Statistical significance} = 2\,\frac{\text{AVG} - \text{St Dev}}{\text{AVG} + \text{St Dev}}$$

where:

AVG is the arithmetic mean between the two different assessments (RCA and the DEA-BoD) for each specific pillar, which are presented as an arithmetic average of the results of the entire period under this study (2007-2019) of the particular holding

St Dev is the standard deviation of the described population

The Composite Index used for selection of sustainable holdings represents the arithmetic mean of the total sustainability scores (indices) received by the Relative Comparative Assessment and DEA-BoD.

2.8. Correlation analysis of the obtained sustainability estimates and the studied variables related to sustainability

Correlation analysis is applied to trace how the agricultural holdings sustainability depends on:

- economic size;
- the level of CAP support.

Correlations of sustainability with economic size and level of support are determined for the three sustainability assessments given by RCA, DEA-BoD and the Composite Index. The obtained results are compared to establish the difference in the influence of economic size and CAP support on the level of sustainability.

The research is done at the EU-28 level and separately for each EU member state.

CHAPTER THREE: SUSTAINABILITY ASSESSMEN OF THE AGRICULTURAL HOLDINGS

3.1. Sustainability evaluation by the Relative Comparative Assessment (RCA) method

3.1.1. Economic pillar

The maximum level reached in the dimension is a consequence of 1.4% increase and belongs to Belgium for the last time period – 0.59 while the EU level rise is 1.6% and reaches 0.44. The second rising economy is Italy - 4.9% and reached level of 0.58. Belgium's leading position is supported by high results in labor and capital productivity, economic resilience, while the strength of Italian farms is based on high production profitability and product diversification. In third place is Spain with a growth of 3.4% and received sustainability level of 0.556, which fundamental basis is economic resilience, production profitability and product diversification.

Portugal's fourth place is accompanied by 4.1% growth, and its base is similar to Spain's, adding the capital productivity. The top 5 production leaders are completed by the farms of the Netherlands, which are experiencing difficulties only with the diversification and profitability.

Malta and Romania have also developed a good economic resilience for the development of their farms, as a result of which their production profitability is at a high level. Romania's small farms also realize a very good level of capital productivity and production diversification.

Farms with above-average economic sustainability are complemented by Greece's small micro-units, which saw a decline in all economic indicators except labor productivity. Irish and Hungarian farms find their place above the dividing line in economic pillar thanks to conditions in economic suitability and profitability, and in Hungary above average capital productivity and diversification. The farms of Sweden and Denmark find a place among the best, and this is due to high labor productivity (the top 3 is completed by the Netherlands).

The rest of the micro structures complementing the more successful and sustainable half of the EU have above average economic size. They are characterized by very high productivity, both of labor and capital, and Germany, France and the UK are also adding significant diversification to their agricultural portfolios.

The "new" members of the European Union are concentrated below the dividing line and their position does not depend on the farm economic size. The low capital productivity does not allow the large farms of Luxembourg, and the medium-large Austria and Finland to approach the average levels of economic sustainability, which also fail to develop the business microclimate conditions to the average European level. Cyprus's small units have an advantage on exactly these indicators, but lag severely in terms of labor productivity and degree of diversification.

A common problem for the countries of Central and Eastern Europe is low labor productivity. In the last two places in this ranking are the farms of Slovenia and Bulgaria, which for the Alpine country should not be such a huge failure, as in practice it represents for our country, which is the heir to a territory with absolute and relative advantages and centuries-old traditions in agriculture, but it is inferior both in terms of profitability and diversification of production. In the group of the most vulnerable farms also fall those of Lithuania, Latvia, Poland, Croatia and even the medium-large ones of Estonia, the large of Czech Republic and the very large ones of Slovakia, as the commonality between all "at the tail" of the European Union is lower labor productivity.

3.1.2. Social pillar

The European average rise by nearly 4%, a positive trend across almost the entire union. Exemptions are also limited within this range for small holdings – Romania (-0.6%) and Greece (-3.5%), and for medium-sized farms, the drop is between 3.4% and 4.6% – Poland, Latvia and Cyprus. This group experiences the most significant problems in the field of self-made factors of production, the low wages of employed in the sector and, last but not least, the income of a person in a rural household. What these countries have in common is the lagging of their farms from the average European level of social sustainability, which is also present in Bulgaria, Lithuania, Hungary, the Czech Republic, due again to the low wages of the employed. Farms in Portugal, Spain (sharing the same problem) and Belgium have a relatively low social sustainability, united by low usage of own production factors and internal consumption. Minimally, however, German and French holdings also remained below average in the second period. This is due to the low levels of land ownership, accompanied by the low assurance of own production factors.

In the UK, there is a negligible decrease (-0.7%), but the degree of social sustainability remains high, and the only indicator on which agricultural holdings lag behind is internal consumption. The social level is highest in Denmark, with high levels in all indicators, excluding internal consumption. First place in this direction is also occupied by Slovakia, which reaches leadership positions and ranks to Denmark in terms of the level of general social sustainability reached. Net income per household member and own production factors contribute to the 18% growth of the social index. After them, among the leaders are Austria and the Netherlands, because of high wages and share of the own agricultural land.

Above the average and with growth above 5%, Sweden (due to its high level of self-sufficiency in productive resources) and Italy (with high rates of entrepreneurial income) are added to the list of countries with social excellence thanks to the highly valued employed labor and gravitating around the average of the land ownership. Ireland, Finland, the UK and Luxembourg complete the well-performing social agricultural holdings, and their merits are in the good level of labor remuneration and the high share of own agricultural area.

Half of the small farms are also among the socially successful. Slovenia and Croatia deserve their respectful place due to the significant ownership of land for agricultural activities, and self-sufficiency in the provision of production factors and production self-sufficiency which also includes Estonia in the group of socially developed European farms. The remaining "new" members are located below the median line - Romania, Poland, Lithuania, Latvia (after the first period), Hungary and the Czech Republic.

The last place belongs to Bulgaria, which is justified by the refusal of a significant part of farmers to exercise this activity in the last 2 decades, as well as the increasingly felt shortage of (skilled or not) labor, the lagging development of the regions, depopulation and depopulation. By adding the low results of the economic pillar, we can conclude the highly vulnerable position of the Bulgarian producers of raw materials for the processing industry.

3.1.3. Ecological pillar

For the purposes of constructing an ecological pillar and considering that the most of indicator values are of the "less is better" type (except the one for the crop rotation) and the methodological approach for valuing the results is between zero and one, these indicators are presented with their reciprocal values.

One in three countries failed to record growth in the latest medium-term indicative period. The leading countries that determine the increase of the ecological level by 2.6% are Lithuania, Latvia and Estonia with values crossing the border of 0.80. This trend is mainly due to the largest open spaces for pasture cultivation (along with Slovakia), low pesticide inputs, minimal energy consumption and the inclusion of nitro-fixing crops in the crop rotation.

Farms from Spain, Sweden and Finland show the prioritization of proper crop rotation, and additionally achieve optimal levels in the use of chemical preparations for crop protection, mineral fertilizers and soil improvers, as well as in the consumption of energy resources.

The medium-small of Portugal and small farms of Greece also find a place among the ecologically oriented. Their advantages are in the use of less mineral fertilizers and the good conditions for raising animals.

In the presentation of Romania, Bulgaria, the Czech Republic, Slovakia and Hungary, a common pattern of behavior can be observed - for all indicators there are values above the average (without crop rotation). The UK and Austria are also among the ecological ones, and their strength lies down in the conditions for animals husbandry , the use of mineral fertilizers and reasonable limits on the consumption of energy resources.

Greece and Italy have common environmental problems, but their farms find their place among the successful ones. The energy intensity of their productions and the costs of chemical preparations are around and even slightly above the average, together with fertilizers and the density of breeded animals. Only the areas occupied by protein crops are of significant scale during the two program periods, which contributes to an above-average level of the ecological pillar.

The negative effect of economic activity on ecology is strongest in Belgium, the Netherlands and Malta despite their minimal progress. The farms of Cyprus are characterized by low pesticide use, and Luxembourg farms by low energy intensity. The difficulties in these countries can be explained by the shortage of arable land and the correspondingly high production intensification.

Despite the good conditions for animal husbandry in Slovenia and Ireland, the countries fail to overcome the dependence of their production on high levels of chemical treatments, and for the island country this also applies to fertilization, while in the Alpine country it refers to energy costs.

Croatia is the closest to the average level, and the lag there is concentrated only on the costs of fertilization and the insignificant area for nitrogen-fixing crops. The intensive productions of Denmark, Germany and France have a similar problem. The EU founding countries have pesticides costs above average.

3.1.4. Sustainability assessment (Compound Sustainability Index)

In a significant part of the member states (almost 90%), an increase in sustainability is observed, which is a proof that the EU policy realizes the planned effect, and the average level increases by 2.6% and reaches a level of 0.486.

There are three exceptions. The UK is one of the countries with the highest measured sustainability for the period to 2013, but its large farms are in decline across all pillars. However, they remain at significantly above average levels. Polish medium-small farms are improving only in environmental terms, at the expense of the other two pillars, and the sustainability score remains below the average line. Lithuania's holdings in the same class, however, remain above the dividing line, despite unsatisfactory results in the dimensions other than ecological ones.

Estonia takes the place after the leaders, despite the shortcomings in economic terms, but environmental indicators compensate for this. The disadvantage of Denmark's huge farms is precisely in this pillar, but on the other hand they have the highest social standards. Their economic score have a very high performance but not as this of the smallest farms of Romania supporeted also by the evnorenmental pillar.

Despite the considerable production scale, the farms of Austria and Slovakia do not develop their economic conditions in the best way, but their place among the most sustainable is guaranteed by top social indicators, including comparative ecological advantages.

The ecological practices of medium-small Portuguese farms also determine their place above average levels of sustainability, which is also supported by the economic results. The latter are also reflecting in the final assessment of small Croatian farms, which is justified by their high social pillar.

On the other side of the dividing line are the medium-small farms of Malta and the huge ones in the Netherlands, despite of high growth in their sustainability scores (~5%). Their low ranking is based on the negligible environmental sustainability score.

Five out of six EU founding countries do not find the path to make their farms cope with environmental challenges and their sustainability is below the average line (excluding Italy). French farms worsened their eco-indicators in the second study period, besides they were above average values (which increased after 2013), while the huge farms of Luxembourg, Germany and especially Belgium did not optimize the costs associated with the negative impact on environment. In these three countries, the social pillar also lags behind, although minimally from the average values for the Union, which once again proves what heights European standards have reached.

Small Greek farms are very close to the reference values, but their growth is lower than the average by 1.5%, which is why they fall below the European average. The main reason that affected this rating comes from a decline in most of the social indicators. Their economic pillar remains stable, but this does not apply to the average small farms of Cyprus, which are failing along with the social, and the growth in the environmental fails to lead to a good final score.

Opposite processes are observed on Irish farms, where good socio-economic performance is undermined by environmental shortcomings.

A large proportion of the “new” member states holdings fall below the average farm sustainability measured by the Relative Comparative method. The huge farms of the Czech Republic and the medium-small ones of Poland lag behind in social and economic sustainability. Hungarian medium-large farms are progressing economically and have good environmental values, but remain socially vulnerable, which is the most significant achievement of Slovenia's small farms.

Bulgaria's agricultural holdings are in last place in the European Union, and the reason lies in the socio-economic context (with the exception of the Netherlands and Malta due to the objective deficit of arable land, which determines ecological practices there). This is the final result of the CAP implementation in Bulgaria, and the research shows to what extent the rest of the Eastern European countries have benefited from the funds for the development of agriculture and how there might be a policy of putting farmers in complete vulnerability, aiming to remove them from land tenure and land use.

Conclusions

The large and very large (corporate) agricultural holdings of the founding countries of the Community demonstrate results around and below the average. On the other hand, the medium-small (Portugal and Ireland) and medium-large farms that predominate in Italy, Spain, Estonia, Finland and Austria form a large part of the group demonstrating high sustainability. There, of course, is also a place for the low-intensive agricultural structures of the very large sized in Slovakia, Denmark, Sweden and Great Britain.

Countries with very limited utilized agricultural area, despite their good results in the economic and social dimensions, cannot reduce the intensity of land use due to the need to maximize production, as a result of which environmental indicators remain at an unsatisfactory level.

Economic size affects sustainability, but to some extent, and is not the factor determining its level. That sustainability evaluation shows that the approach to managing agricultural holdings within the framework of the Common Agricultural Policy has a leading role in achieving high agrarian sustainability on a farm level. Institutional sustainability models the indicators of the three pillars depending on the set national priorities applied by the administration responsible for the implementation of the commitments made to the EC.

3.2. Sustainability evaluation by DEA-BoD (Data Envelopment Analysis - Benefit of the Doubt)

3.2.1. Economic pillar

The methodology using the principle of institutional sustainability results in significantly higher values of the economic pillar – the EU average level (which rises by 5.7% after 2013) exceeds by about 0.2 the scores calculated by the RCA method (reported growth of 1.6%).

While the Relative Comparative Assessment method put four of the holdings under EUR 50,000 SO above the EU average, the DEA-BoD tool place there only two.

The first to demonstrate such a score (by economic size) are the farms of Malta, where economic sustainability increases to around 10% above the EU-28 average. Second are the farms of Cyprus, where the reported growth is just over 2%, placing them among the top five in the Union with an average sustainability score of over 0.85.

The number of farms with results above the average for units between 50 and 100 thousand euros SO remains unchanged - three by both methods. Third are the farms of Austria (ES = EUR 62 000 SO), which are characterized by an increase in economic sustainability by more than 13% to the level of more than 0.80. The fourth and fifth positions in the order of economic size belong to farms of Finland and Estonia where the growth of economic sustainability is 6.1% and 9.4%, respectively, and the level reached is 0.87 and 0.70.

In class IV and V, the difference is not significant and is limited to one holding. 13 farms in total are above the EU average value, and the remaining 15 are below it (for the second period). The sixth result belongs to Sweden, the increase is nearly 14%, and the level reaches 0.75. Luxembourg is seventh with an increase of 8% and almost reaches 0.78.

This is followed by the farms of Great Britain, Germany and the Czech Republic, which in terms of economic size occupy eighth to tenth place, and their increase is 15.4, 8.6% and 5.7%, respectively, and their results are in the range 0.85-0.88. The farms with the highest economic sizes in Denmark, Slovakia and the Netherlands have the highest values of the economic pillar - the corresponding increases are: 5.9%, 0.9% and 13.7%, and their values are above 0.90.

The holdings with a lower ES than Malta's are Romania, Greece, Croatia, Poland and Lithuania. Their results reach almost 0.58%, with a decline (-1.8%) noted only in Greece, where the most significant rise is Poland (+7.7%).

Next is the group with an ES between that of Malta and Cyprus - Portugal, Bulgaria and Latvia, where a classical dependence on the economic size is observed, and the reached levels, respectively 0.42, 0.50 and 0.56, are accompanied by a slight increases (1% - 7%).

Next are those with an ES located between that of Cyprus and Austria - Ireland and Hungary. The island farms grew by 8.8% and reached a score of 0.50 and ceased to be the worst DEA-BoD performing economic pillar. On the other hand, Hungary's farms have a decline, albeit by a minimal 0.7% to an estimate of 0.57.

Medium-large Spain`s and Italy`s farms and large ones in France join the huge Belgium farms for the bottom of the list of units performing below average levels. They all have a common 5% economic boost, excluding Italy with a marginal change of less than 1%.

3.2.2. Social pillar

Unlike the economic pillar, which has higher results in DEA-BoD compared to RCA, in the social pillar the difference is negligibly small, but in favor of RCA but the EU average of the social pillar has a higher growth – 6.9%, compared to 3.6% of RCA.

The holdings with ES up to €50,000 SO, only Ireland shows a score above the average score. Again, the Relative Comparative Assessment method estimates more holdings with indices above the EU average in the small and medium-small class – three while the DEA-BoD assesses only one. This is also somewhat relevant for economic units between 50 and 100 thousand euros, where the difference is the index of Estonia, which does not exceed the average in this measurement. The remaining two groups do not contain holdings below the average DEA-BoD levels, while RCA shows two holdings from the both largest economic classes with values below the average. The distribution of the farm units is equal, 14 are above and respectively below the average values, and the majority of medium-large farms (up to 100 thousand) - reach the reference of the first period. All farms with an ES above the average (€125,000 SO) demonstrate results above the EU average.

3.2.3. Ecological pillar

Like the social pillar, the environmental one has a lower sustainability rating compared to the calculations by the RCA method. The rate of increase, however, was higher in the DEA-BoD, with the increase in the second reporting period being 5.1% (compared to 2.6% in the RCA). This growth is mainly due to the CAP measures to increase protein crops in the crop rotation of Bulgaria, Poland and the Baltic countries and varies from 10% to over 40%. Although the most of farms from the IV and V economi class (above the average ES) are ecologically efficient, the evaluation of the eco pillar does not have a classical dependence of the scores on the ES.

The small farms of Greece shows negative dynamics - with an initial value of about +0.10 above the reference, which falls below the raised EU average during the following period and corresponds to the decrease in its economic resilience by 10%. The medium-small micro units of Lithuania and Malta finish the studied period with values significantly above the benchmark for the EU, despite the island farms drop down by 6%.

The difference in the values from the two methods is impressive - Malta's RCA evaluation is very poor - below 0.10, while the DEA-BoD result is one of the leading (top three), which characterizes the efficiency in the use of fertilizers and preparations. Estonia is the next holding with above-average eco-sustainability (39% increase). Luxembourg has the only farms which does not exceed the reference value despite an above-average ES (after growth of 2% it exceeded the average of the first program period, which subsequently increased by 5%). Taking into account the limited availability of usable agricultural area, it is very difficult to apply a crop rotation with low intensity and productivity, and the priority remains to preserve the high levels of income.

The levels of ecological sustainability achieved by farmers in France, Germany and Belgium, Great Britain, the Czech Republic, Sweden and Denmark remain high. The absolute dominance in efficiency of spendings of environmentally polluting means of production belongs to cooperatives of Slovakia (3.3% progress). As a result of the huge investments in fertilizers and pesticides, the intensive farms of the Netherlands are one of the leading countries in their effective utilization, and the top 5 is completed by Estonia and Lithuania, where green payments have left their traces.

Under the ecologically efficient line, the most of farms are so called "new" member states - Bulgaria and Romania, Poland and Latvia, Hungary, Slovenia and Croatia, accompanied by a large part of the Mediterranean countries Portugal, Spain, Italy and Cyprus including Ireland.

Austria completes the picture of environmentally challenged countries in the DEA-BoD algorithm, which is due to some extent to the high share of organic farming in the country, the low-intensive nature of production with the highest number of certified organic producers, which is complemented by the high shares of own land in the sample.

3.3. A 15-indicator sustainability assessment DEA-BoD model

The combination of indicators from the three pillars of sustainability in this model characterize its complexity. The difference between the two measurements is between 2 and 3.5 tenths in favor of DEA-BoD, covered by its larger amplitude which is based on the values of the economic pillar. The reported growth for DEA-BoD is close to 7%, while that of RCA is close to 3%.

Impressive is the sustainability levelof farms in Greece, which during the initial reporting period is above the European average, but as a result of the deterioration in the business environment, they realized a decline of nearly 6% and the final score is about 13% below the sustainability reference. The remaining of the **small farms** remain in a vulnerable position below the average of both periods.

In the case of **medium-small** farms, the breakthrough of Lithuania with a growth of 26.6%, which is exclusively due to environmental aspects, makes an impression. Polish farms reach the reference value of the first period during the second one. Those of Malta and Cyprus, with progress of 6.6% and 1.5% respectively, complete the winners list in this class, generated by their economic pillars and, while Malta can add also the environmental efficiency.

Between the **medium-large** farms, above the rest in both periods are Austria and Finland, which owe this to the socio-economic development in their farms. After a progress of 27.6%, Estonia also climbs up there (increase in all sustainability dimensions).

Among **large**, the "smallest" Sweden's farms increase their index by nearly 10%, which correlates with significantly above-average values and growth in all three dimensions. This is also relevant for the UK and Germany. Their growth is 9.5% and 7.9%, respectively.

Of the **very large** farms, most have sustainability scores above the EU average. An exception is Belgium, where they do not reach the EU average levels. This is successfully achieved by the farmers of the Czech Republic, Slovakia, Denmark and the Netherlands - the highest achieved.

Latvia and Poland, of the holdings below the reference for the second reporting period, are those reached the first separator, resulting in growth of more than 10%.

The most vulnerable appear to be the small farms of Romania, Slovenia and Croatia, medium-small of Bulgaria, Portugal and Spain. They experience difficulties in all pillars, but the situation seems to be the most difficult in the social aspects. Hungary, Ireland and Italy also fall into the group of not sufficiently sustainable agricultural holdings.

3.4. Construction of Composite Sustainability Index

The results of the Composite Sustainability Index are dominated by RCA in the social and environmental dimensions, and by DEA-BoD in the economic and the final sustainability assessment and the reason is the greater average values. Composite Indexes are presented in Chapter IV, where are placed also their **correlation connections**, including the pillars, **sustainability level and economic size according to the support level (SL) for a comporison** (which one is more significant for the sustainability assessment – ES or SL).

Consclusions:

Within the below average ES farms, economically sustainable are either those from the island countries with limited agricultural area and the need for the ultimate production intensification , or the farms from the central and northern regions, which operate on a massive production scale. In the southern Mediterranean regions the observed level of economic sustainability is weaker. If we take these examples as exceptions (along with Belgium), a certain relationship between the level of economic sustainability and the economic size could be observed.

Social sustainability is in relative proportionality with economic size, evident from the rise in the results of each subsequent class of holdings, and depends on ES.

One of the shortcomings in the DEA-BoD model may be due to the absence of the homogeneous competitive environment for one of the farms in the environmental pillar (Austria), but its great achievement is the implementation of the DEA-BoD model with many more than the stable up to 6 indicators (15) using Tim Coelli's special 1996 technique.

The achieved sustainability of very large farms in Slovakia, Denmark and the Netherlands is high. This means that the institutional environment is sustainable and they effectively use the governance mechanisms. Such results were also achieved in Malta (ES €35,000 SO), which means that either these are exceptions or the high sustainability described by this model is largely independent of economic size. The small Greek farms (ES €19,000 SO) in the first reporting period and the lower-medium farms of Lithuania (ES 28,000) in the second also demonstrate significant sustainability . This is **in contrast to the hypothesis that high sustainability corresponds to huge economic size**.

Economic size does not guarantee either economic or environmental sustainability in a definitive way. All factors of sustainable development are in the hands of the managers and/or owners of a business, but the state plays a crucial role in the implementation of the CAP. Institutional sustainability can be a much more important tool for achieving high farm sustainability than the weight of economic size, as confirmed by the DEA-BoD results.

The member states` farm sustainability depends on the degree of diversification and intensification, as well as on state management, institutional sustainability or governance.

The question of increasing the size of economic units probably correlates with the concept of the EU founding states while they impose their management views and interests on how the sustainability of huge farm structures would prevail in territories with solid agricultural traditions, struggling to preserve its low-intensive economy structure with a view to preserving rural societies, including employment and biodiversity, so alien to the corporate direction of agricultural industrialization.

The challenge of finding a place in agribusiness is not for everyone - an individual or a small to medium organization. The barriers to enter the business are positioned higher and higher. Maintaining the specific business environment is a difficulty for the institutions of every state administration precisely because of the increasingly demanding EU where the goals become increasingly green and cruel towards small and medium-sized agricultural formations, which also affects their behavior (economic, social, ecological).

CHAPTER FOUR: SUSTAINABILITY DEVELOPMENT MODELS

4.1. A static approach to determining sustainable farm models

A literal reading of the obtained results should show that a large part of the EU founders and the Nordic countries occupy positions above the overall average scores, which characterize the significantly high EU average.

4.1.1. Platinum sustainability

Great Britain with its large farms demonstrate the highest score and full asset of points as evidence of the opportunities in front of agriculture to be economically efficient, socially responsible and environmentally friendly at the same time which is also evidence of the demand in this research. To a significant extent, this also concerns the farms of Denmark, Sweden and Finland, which are representatives of three different groups by economic size – very large, large and medium-sized respectively. The largest farms also fall into the platinum category – those of the Netherlands, which are clearly distinguished from the most environmentally oriented productions, and Slovakia, where there is a compromise in economic results at the expense of the protection of natural resources.

4.1.2. Golden sustainability

The golden sustainability group the leading by Austria. The results of German farms should come as no surprise - maximum score on economic indicators, relatively high - on social and relatively poor on environmental. In the Czech Republic and Estonia, the economic and social aspects are neglected in order to give priority to the environmental dimensions, while in Malta the emphasis falls exclusively on the economic results. France and Italy complete the list of gaps in economic and environmental terms, respectively.

4.1.3. Silver sustainability

Belgium is positioned first and Luxembourg last in silver sustainability and what they have in common is creating strong social responsibility and unsatisfactory environmental aspects. What the holdings of the countries occupying the positions in between have in common is the negligible level of social commitment. In particular, Spain and Greece give a slightly higher priority to the preservation of natural resources at the expense of their economic goals, which in Cyprus are the main motivation for farmers. Lithuanian farms find a place in this group mainly due to the environmental characteristics of their economic activity.

4.1.4. Bronze sustainability collects agricultural holdings with lower results than those mentioned so far, in Ireland social priorities are taken into account at the expense of environmental ones, while in Poland and Latvia the priorities are switched towards the island state. The same applies to Portugal and Romania, but they can also boast of economic achievements above the European level.

4.1.5. Endangered or vulnerable farms

Some of the farms qualified as endangered and vulnerable still have minimal achievements. Hungary hints at economic and environmental potential while neglecting its social priorities, while

Croatia and Slovenia are developing in exactly this direction. The only reported upswing of Bulgarian farms is developing at the ecological level, but this makes the agricultural units extremely vulnerable in a socio-economic aspect.

4.2. A dynamic approach to determining sustainable farm models

Economic aspects in the change of sustainability

Within the small farm class, the only ones with a positive trend are those of Romania, while Slovenia, Greece and Croatia have change coefficients below unity, behind which there is a significant lag. This also applies to Bulgaria, Poland, Lithuania, Latvia and Portugal. For all the rest, there is a positive trend, behind which are coefficients above 1.

Social aspects in the change of sustainability

In social terms, only in the first two classes appear coefficients below 1. They are Romania and Greece - in the small class and Bulgaria, Lithuania, Latvia, Cyprus and Portugal in the second one.

Environmental aspects in the change of sustainability

Slovenia and Croatia represent the small class; Malta, Portugal and Ireland – the medium-small, and Hungary – the medium-large class of holdings whose coefficients of change have a negative interpretation

Coefficient of change in Composite sustainability scores

Among the positive indications are all the founders of the European Union - the Benelux countries, Germany, France and Italy; the Scandinavian countries, most of the old members – Great Britain, Austria, Spain, Ireland and the islands of Malta and Cyprus. Among the new members, Slovakia and the Czech Republic, the Baltic countries and Poland are among the successful ones.

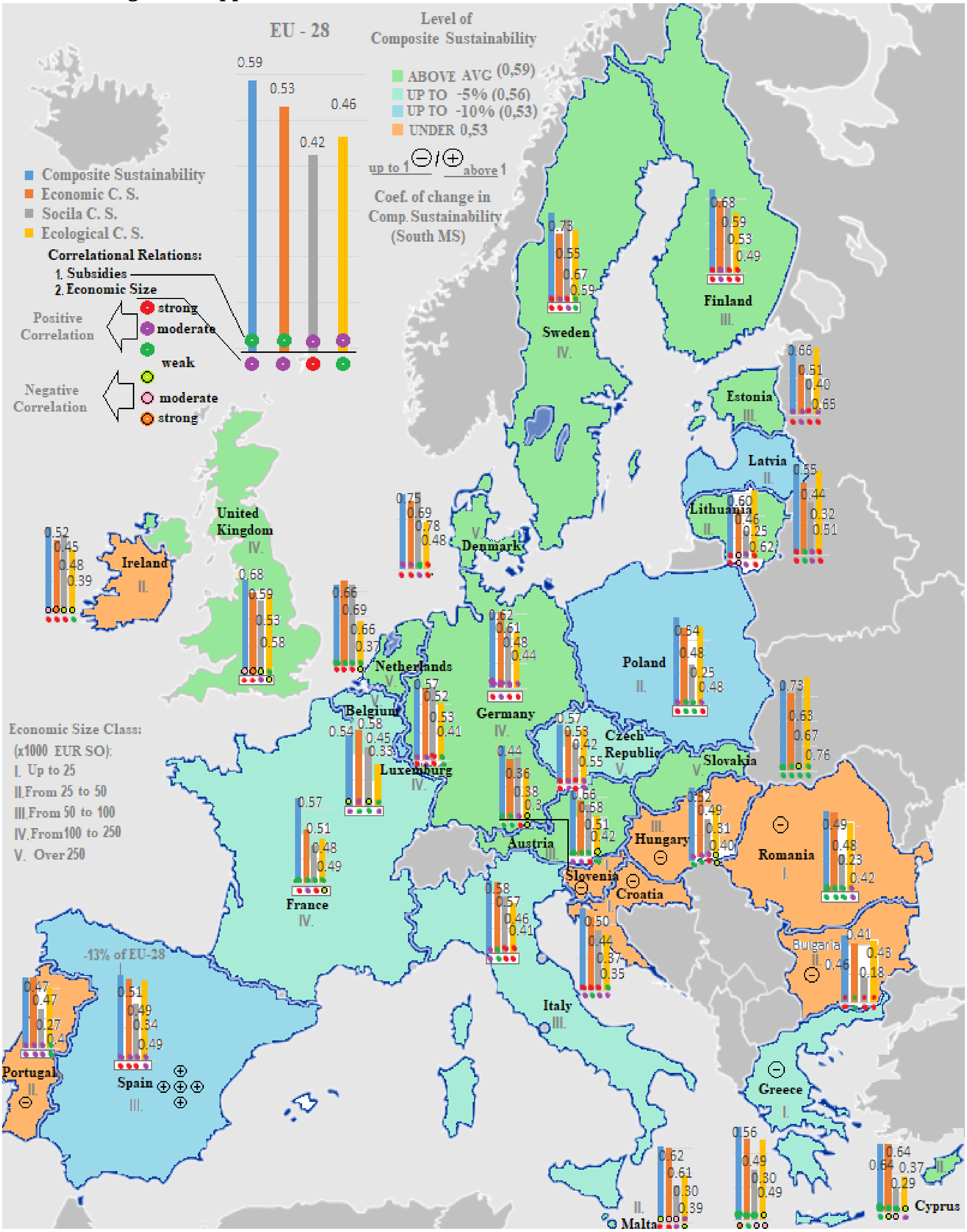
Obstacles to sustainable development are also present in some old member states. The trend is present in Greece and Portugal. The vulnerable group also includes all countries with predominant small farms. From another point of view, the vulnerable group includes all member countries from **the Balkan Peninsula** – Romania, Greece, Slovenia, Croatia, Bulgaria and Hungary.

4.3. Correlation relationships between economic size and the studied quantities related to sustainability

Figure 1 presents the correlation results between ES and support level with the Composite Sustainability Indexes (the completely studied period average) and the special cases of the coefficients of its change are taken into account. Countries with positive trends are not marked, with the exception of Ireland and Spain, where results are below average, but the coefficient greater than one, which corresponds to a trend for inclusion, convergence and success in cohesion policy.

The exceptions are the Balkan region and Portugal, where apparently the cohesion policy "failed" (or was successful) in relation to the priorities set by the European Commission. Another special case is Greece, where despite the high results, there is a negative trend in the sustainability.

Figure 1: Economic class, levels of sustainability in EU farms and their correlations with the degree of support and economic size



Source: FADN, EC, Own calculations

Correlation coefficients show a significant association between ES and the degree of support in the northern EU regions – The Czech Republic, Poland, Germany, Luxembourg, Blatic countries, the Scandinavian countries, as well as Bulgaria, Croatia, Portugal, Spain and, to a lesser extent, Italy. For Ireland, UK, Malta, Netherlands and France it applies to ES only.

This dependence is insignificant for Slovakia, Slovenia, Romania, Greece, Cyprus.

Table 2 presents a farm classification according to their economic size (below and above the EU average) and their relative level of sustainability, where the countries with high levels are distributed equally (six each) into the two ES groups, while for those with low levels, half of the founding countries are in an unenviable position, including the Czech Republic. A large part of the new EU members are located there, and also the Mediterranean Spain, Italy, Portugal and Greece.

Table 2: Classification of farms according to the average values of Composite Sustainability Index and economic size

1 - 1 Low ES Low level of sustainability	1 - 2 Low ES High level of sustainability	2 - 1 High ES Low level of sustainability	2 – 2 High ES High level of sustainability
Bulgaria Romania Slovenia Croatia Hungary Latvia Poland Ireland Italy Portugal Greece Spain	Estonia Lithuania Cyprus Malta Austria Finland	Belgium Czech Republic France Luxemburg	Denmark Germany Netherlands Sweden Slovakia United Kingdom

Source: Own calculations based on FADN data

4.5. Recommendations for sustainability policy improvements

1. Preservation of the profitability of relatively small businesses units, CAP should be oriented towards their higher proportional or priority support.

With Bulgaria's accession to the EU, a new branch of agriculture appeared, along with plant and animal husbandry, subject exclusively to the support of an area unit - the so-called "subsidy farming".

Discontinuation of area unit payments and their reorientation to the production unit through tracking (auditing) along the value chain (distribution) is of extreme importance to overcome the increasingly popular practice in agriculture - the abandonment of production on the fields by entrepreneurs whose main activity is not traditional for the industry.

2. Encouraging the development of intensive productions

The Bulgaria`s farm ES is growing permanently due to an increase in production scale, but this does not lead to significant improvements in socio-economic indicators. To strengthen social sustainability, it is necessary to retain the population in the regions and rural municipalities. For this purpose, it is necessary to specify tools to promote productions that require significant labor resources, such as vegetable production, the production of fruits and other high value added directions with a significant volume per area unit. This could be achieved by restructuring support and orienting it towards these industries at the expense of highly mechanized farms.

3. Increase control and added value per unit area

Audit trails should be oriented from farm inputs (labour, pesticide and fertilizer use), through production technologies to marketing, taking measures against fictitious turnovers and sales by following the chain to the end consumer at all intermediate units that add value to production, e.g. through processing and/or distribution in order to avoid the misuse of support funds.

For example: meadows - hay, hay - milk or meat - processing and/or direct sale to a mediator and/or end consumer. In a similar way, production chains can be traced back to consumers in other high-value-added production lines, and the support for those with a low value added should be limited to an extent that is adequate to the scale of production and possibly an export subsidy should be provided in order not to lose the comparative advantages of the Bulgarian stock market production on the international markets.

4. Increasing productivity and, accordingly, the payment of labor

An important element for increasing social sustainability is a special and individual approach to supporting small and medium-sized farms (up to EUR 50 000 SO) in a way so that they are not discriminated against, as has happened during the years of the country's membership in the EU so far through the area unit support and through the mechanisms of pressure from wholesalers, as a result of which farmers look for ways to realize their own production at a fairer price by themselves.

In addition, the income per member of the rural household began to increase compared to the wages of hired workers during the second program period under this study (after 2013), which had occurred after the withdrawal of 239,000 agricultural holdings (the majority of which were small, meeting their own food needs, but maintaining the integrity of population in the regions, growing food and preserving traditions), i.e. after a significant increase in the average utilized agricultural area per holding.

5. The CAP should focus directly on farm sustainability management

Realized (Ordinance 3 of March 2023), but again the orientation is towards supporting an area unit and to the detriment of small farms, but the support is reduced in practice (at purchase power parity) without any change in its rate (fixed on an annual basis) and keeping in mind the given inflation. The level of support "for small farmers" is extremely insignificant – BGN (levs) equivalent of 1250 euros per year (point 6), which "replaces support for interventions under article 1, paragraph 2, point 1 - 5 and 7 and is applied instead of it." (Ministry of Agriculture, Ordinance 3, 2023), which (paragraph) is completed by:

"The following interventions are applied in the form of direct payments:

1. basic income support for sustainability (BISS);

2. additional redistributive income support for sustainability;

3. climate, environment and animal welfare schemes (eco schemes);

4. additional income support for young farmers;

5. production-related income support;

7. special crop payment - cotton."

This decision in practice puts the small farms to be doomed to disappear.

As a result, the control over the utilized agricultural area falls to more and more limited number of producers (tenants - field crops) and given the share of the areas occupied by these production lines tending to 100%, which severely limit the use of labor resources and concentrate production in highly mechanized areas without special value added.

Summary of research results

The economic size and level of support can have a strong positive impact, as it does in most cases, but it can also have a negative impact - in Lithuanian farms on economic sustainability (Figure 1). In specific cases, subsidies have a negative impact on the level of sustainability: in Ireland and the UK on Composite and economic sustainability, and in Malta in economic and social aspects.

Economic size can also negatively affect sustainability. Such is the example is Greece (due to the small farm scale of production), where the impact is affecting both the Composite, the social and the environmental indices. Cyprus farms also develop their sustainability, without direct dependence on the level of support, while economic size arguably influences sustainability, supporting the environmental one and hindering the social one.

A lack of significant influence of both studied characteristics of farms on their sustainability is observed in Slovakia and is expressed in a definite way, and strong interrelationships are absent and sustainability is one of the best in each dimension.

The farms that have above the average ES, such as Belgium, only the economic size (production scale) has a significant impact on the level of sustainability, even it is not over the EU level. The Czech Republic`s farms have such an influence but represented by the degree of support, as well as in Germany and Denmark.

The correlation analysis also takes into account the negative impact of economic size on environmental sustainability - in the farms of the Netherlands and France, as well as in Sweden and Luxembourg, where the environmental effect of subsidies is analogous to that of the ES.

A significant dependence of measured high sustainability on ES and SL is observed in Finland and Estonia within farms that had below-average ES. Sustainability levels of Spain are lower than average, but the relationship is strong, as is Portugal, Italy and Latvia, which does not affect economic sustainability, where the relationship is weak.

ES significantly affects only social sustainability of Slovenian farms, where the influence of support is also concentrated, but not to such a significant extent.

Sustainability rate of Hungarian farms is lower than EU average but ES impact is high but only in social aspect, while SL influence is wider but still not enough to reach a positive environmental attitude.

Although not a high level of combined sustainability of Polish farms, it is strongly influenced by economic size and moderately by the level of support, as is the case of ecological sustainability, which is only above average, as in Romania, but without the necessary effect.

The influence of ES and SL is strong and complex in Bulgaria, and only the economic pillar remains unaffected, despite the very low comparative levels of sustainability.

The impact of subsidies is more noticeable in Croatia, without significantly affecting the environmental pillar and that of ES is moderate, while the measured sustainability remains below the EU average.

The development of Austrian farms is an example for the subsidy impact is insignificant at the expense of economic size, which strongly supports the sustainability level. The exception is their ecological pillar, where the connection is weak, and it embodies the high cost of production, behind which stays the highest share of organic farmers. That is accompanied with higher prices of fertilizers and plant protection products according to the effect of their use including increasing mechanical treatments pushing forward the energy intensity of the production, which could not be monitored in a good way by the used methodology.

Conclusion

As a result of the applied methods for assessing sustainability in the agricultural holdings of the European Union (EU-28) and the final assessment obtained, it can be summarized that in a large percentage of cases - 71.4% (Figure 1) the comparative agricultural sustainability is about (10%) tolerance) and above average. The highest degree of sustainability is characteristic of farms from the northern regions of Europe - the Scandinavian Peninsula, Central Europe, the Baltic countries. This is due both to the CAP instruments to support it and to the economic size or scale of production. However, this is not relevant for all considered cases, and the research also shows some cases of threatened economic objects, as well as some threatening the environment.

Economic size also affects the level of intensification in small and medium-small farms (Slovenia and Croatia, Malta, Cyprus and others). Their scale of production necessitates resource-intensive production technologies due to the need to increase productivity.

Similarly, in the case of larger farms, the practice is applied to maximize the scale efficiency (Benelux countries, Germany and others). The scale efficiency gives the opportunity to some countries to afford an optimization of inputs so they could successfully apply the ecological strategy in their production (Great Britain, Sweden).

The thesis of the study (Economic size affects the level of sustainability of agricultural holdings) is consistent in all dimensions of sustainability, except the environmental one. Therefore, if increasing production scale drives the economic pillar, it follows that the ecological footprint takes a back seat for the majority of farms.

In the general population, the correlations between the economic size and the studied quantities **are** as follows**: moderately strong relationship with the Composite Sustainability Index (0.547) and the Composite Economic Sustainability Index (0.638). The relationship with the Composite Social Sustainability Index is the strongest (0.776), while that with the Composite Environmental Sustainability Index is the weakest 0.259.**

On the other hand, the Relative Comparative method shows that the majority of farms with ES below the sample mean have above the EU average sustainability score and exactly the half of holdings that have above average ES are also above the reference level of sustainability, while for the other two indices (DEA and Composite) it is the opposite.

The first working hypothesis states that larger farms in terms of economic size have higher sustainability and is proven as follows:

1. According to the Relative Comparative Assessment, 5 out of 10 farms with an economic size above the average have levels of sustainability higher than EU average in the most recent reporting period, while the proportion of smaller farms that are relatively sustainable is 61% (11 out of 18).
2. 15-indicator DEA-BoD method – 70%/ 33%
3. Composite Sustainability Index – 70%/ 39%
4. Coefficient of change in the Composite Sustainability Index – 100%/ 61%
5. Integral Assessment – 90%/ 28%

The hypothesis is confirmed by the highly predominant share of larger farms with above-average sustainability in the majority of methods, the only exception being the RCA method.

The second hypothesis is also confirmed by the last evidence. It states that sustainability assessments across individual pillars differ in the vast majority of cases and achieving a harmonized balance between economic, social and environmental interests is still not widespread, which shows the sensitivity of the concept of sustainability and is proven in over 96% of cases, with only UK farms having balanced levels in all of the pillars of sustainability.

The third working hypothesis concerns farms of the III economic class (from 50,000 to 100,000 euros SO) states that the medium-large farms have relatively high sustainability, comparable to the results of large farms. All indices clearly show how the degree of sustainability in this farm economic class is equally divided between the both sides of the scale. The same applies to the economic pillar. Regarding the Composite Indexes again these circumstances are present, in all dimensions. The Relative Comparative Assessment reveals analogous situation in the economic pillar, while in the social pillar there is a minimal predominance in favor of the hypothesis, while in the environmental pillar the scores are completely above the reference line. The DEA-BoD model shows the exact opposite for the environmental pillar, all farms perform below average (except Estonia), and in social aspect the distribution is equal according to the reference.

The hypothesis is not confirmed.

The last, fourth, hypothesis "The sustainability of agricultural holdings in the majority of the old EU member states is above the average, while in the majority of the new members from Central and Eastern Europe it is below the EU average" divides countries into old (17) and new members (11). The thesis is largely confirmed if we ignore the ecological aspects of sustainability, where only the DEA-BoD model shows confirmation. The other exception is in the economic pillar of the RCA method.

The hypothesis is confirmed.

Economic size affects the sustainability, but to some extent. It is not a determining factor. The management of the Common Agricultural Policy has a leading role in achieving high agrarian sustainability at farm level or the so-called Institutional sustainability. Institutional governance accounts for both the successes described in this study and the failures in the implementation of the measures.

In socio-economic terms, Bulgarian farms are at the lowest level in the entire EU, and of them, only the indicators of capital productivity and internal consumption are above average. The reason may be rooted in the difficulties of adding value to the production as a result of the high barriers to the processing of the production in the country as a result of the suffocating regulatory framework (e.g. the impossibility of processing in the country and the correspondingly high transport costs of hemp production, which is becoming more and more attractive for farmers, and processing in Bulgaria is not legally supported, unlike Romania).

On the one hand, the presence of a strong correlation between economic size and pesticide costs proves the adverse impact of large farms on nature. In addition, the large size and small number of farms helps to reduce employment in rural municipalities, which increases their depopulation.

Despite the officially adopted new CAP 2023-2027, which singles out agricultural sustainability as the main subject and object of support, the practices of subsidizing per unit of area are preserved in the Plan for sustainability and development of the agricultural sector, which will lead to proportional support and concentration of aid in certain farms. On the other hand, the number of structures will formally increase due to the set restrictions on support up to a certain threshold of the utilized agricultural area, but at the expense of this, natural persons (agricultural entrepreneurs) will remain in a more limited number, without this easily being officially reflected.

III. Scientific contributions of the dissertation work

From the dissertation research, two directions of contributions can be distinguished, which are characterized as theoretical-methodological and scientifically applied:

Theoretical-methodological contributions:

1. An in-depth and broad review of scientific research, analysis, studies and developments related to the concept and idea of sustainability was made, which is not fundamentally new, but creates added scientific value by systematizing a large literature material, including the interpretation in the adaptation of the concept to agriculture and the role of economic size as a structural characteristic of the production unit.
2. . An established and recognized holistic and interdisciplinary approach to research and assessment of sustainability is applied, considered in an ecological, economic and social aspect, drawing on data from the EU-wide Farm Accouncy Data Network, considering sustainability not in static terms but as a dynamic process of change, by dividing the time period studied into two sub-periods.
3. A methodological framework was adapted for the application of two fundamentally different quantitative methods for carrying out the assessment, which gives a wider and expanded picture of the dimensions of sustainability, which served to integrate the assessments to obtain the Composite Index of Agrarian Sustainability.
4. An authentic approach to the application of a universal method for compiling a Relative Comparative Assessment is proposed, which is applied to the needs of the study.
5. A new approach was applied through DEA - Benefit-of-the-Doubt for assessment through selected indicators of sustainability in agricultural holdings, reflecting the influence of the institutional environment on its level..
6. An author's approach was used to group the studied units according to the measured sustainability in relation to their economic size.
7. A check was made for the statistical significance of the obtained results between the two integrated indices obtained through RCA and DEA-BoD, which makes it possible to assess the relevance of the calculations and the reliability of the conclusions.

Scientifically applied contributions

1. On the basis of a unified methodology, it is possible to judge the state of sustainability in the agricultural holdings of the entire EU, which reveals many aspects that represent a characteristic and, in particular, reveal specific trends and features of the agricultural holdings of the EU.

2. The approach proposed for calculating the sustainability of agricultural holdings can be applied for scientific purposes in the study of agrarian reform, for the construction of sustainable policies, including the evaluation of projects in agricultural holdings based on basic accounting indicators.

3. On the basis of the comparative approach used to measure sustainability, conclusions and proposals can be made to be embedded in strategic planning and for improvement and changes in the CAP 2023-2027, mainly in relation to the environmental and social dimensions of the policy.

4. There is a practical value of the economic analysis made on the effects of the CAP measures implemented during the last two completed program periods. The analysis provides a significant basis for a "public response" to react to policy outcomes for community institutional support for economic, social and environmental protection.

5. The study of the classification and grouping of the sustainability development of agricultural holdings in the EU, trying to answer an important question revealing which agricultural holdings are more sustainable according to the criterion of economic size.

IV. List of publications linked to the Dissertation Project "Economic size and sustainability of agricultural holdings" by Veselin Ivanov Krustev, PhD student at the Institute of Agricultural Economics

1. Krustev, V., 2023, Assessment of the EU Market Farms Sustainability Based on a Composite Sustainability Index, Bulgarian Journal of Agricultural Sciences, 29 (No 4) 2023, 597–604, ISSN 1310-0351 - print; ISSN 2534-983X – online.
   https://www.agrojournal.org/29/04-04a.html

2. Krustev, V., 2016, Measuring Sustainability through Technical Efficiency of Bulgarian Cereal Farms, CAP impact on Economic Growth and Sustainability of Agriculture and Rural Areas: proceedings, 147th EAAE Seminar, Sofia, Inst. of Agr.
   Econ., p. 141 - 148 ISBN 978-954-8612-09-8.

3. Krustev, V., Ivanov, B., 2022, Relative Comparative Assessment of EU-28 Farm Sustainability, Innovative Development of Agricultural Business, Sofia, University of National and World Economy, p. 73 - 81, ISBN 978-619-232-685-2.