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- *doctoral dissertation*

Environmental factors and the competitiveness of farms in the regions of the European Union.

The European Union was established on the basis of the idea of integration, which had not only economic but above all civilisational significance: stabilisation and a community of interests. The process of accession to the EU requires the fulfilment of the Copenhagen criteria: a democratic institutional order, a free-market economy, and the acceptance and implementation of EU legislation and treaty frameworks. Within this architecture, one of the oldest and most enduring pillars remains the Common Agricultural Policy, in operation since 1962. Its original objective was to ensure food security, stable supplies of high-quality food at affordable prices, and an adequate standard of living for farmers. Over time, the CAP has acquired a strongly dynamic character, as agriculture, as a specific branch of the economy, is simultaneously subject to market, institutional and environmental pressures. Today, the CAP must respond to challenges including food security, the stable development of rural areas, reactions to price fluctuations on global markets, climate change mitigation, and the establishment of principles for the sustainable use of natural resources. In this context, one of the key tasks of agricultural economics is the search for a model ensuring the highest possible economic efficiency of farms. As agriculture in the EU undergoes continuous transformation, the entities that remain on the market are primarily those that are competitive, capable of adapting to changing conditions, and able to generate a favourable income volume from their activities. At the same time, the Common Agricultural Policy offers a broad range of instruments supporting environmentally sustainable agricultural practices. These include, among others, subsidies for agri-environmental practices (such as crop rotation, cover cropping, and organic farming), support within Rural Development Programmes (investments in agricultural infrastructure, training and advisory services), as well as investments in research and innovation related to environmentally oriented agricultural technologies and methods. As a result, the issue of combining economic efficiency with environmental requirements is gaining importance, which directly justifies the topic undertaken in this dissertation.

Competition, present in economic and social life, acquires an additional dimension in agriculture: farms operate not only as economic entities but also as units strongly embedded in natural and regulatory conditions. Research on farm competitiveness in EU regions allows for the identification of advantages, developmental differences and directions of adjustment. In the dissertation, the competitiveness of farms in EU regions is understood as resource competitiveness, defined as the efficiency of transforming resources into production outcomes relative to other farms. This understanding is consistent with the resource-based view, emphasising the role of resources and capabilities as the foundation of competitive advantage.

In the realities of the growing importance of sustainable development, assessing the impact of environmental factors on farm competitiveness becomes particularly significant. In this spirit, the main objective of the dissertation is formulated as: “the assessment of the impact of environmental factors on the competitiveness of farms from individual regions of the European Union”. This objective leads to the main hypothesis, according to which: “the inclusion of environmental inputs results in changes in the competitiveness of farms in individual regions of the European Union”. Three partial hypotheses were also formulated:

H1: The productivity of land, labour and capital is characterised by greater fluctuations in dynamics in countries that acceded to the EU in 2004 than in the EU-14 countries.

H2: After taking environmental inputs into account, the competitiveness of farms from regions that acceded to the EU in 2004 increases more frequently than in farms from regions belonging to the EU-14.

H3: During the analysed period, over time, changes in the competitiveness of farms in EU regions resulting from the inclusion of environmental inputs become increasingly smaller.

The detailed objectives subordinated to the verification of the hypotheses are as follows:

C1: To determine the dynamics of land, labour and capital productivity in farms of EU regions and to compare them in EU-14 countries and the accession countries of 2004.

C2: To distinguish quartiles of EU regions according to the competitiveness of farms without environmental inputs, and subsequently after their inclusion.

C3: To assess changes in the competitiveness of farms without environmental inputs and after their inclusion in different EU regions.

The dissertation is based on primary and secondary sources. Secondary sources include domestic and foreign scientific publications concerning EU agricultural funds, changes in agriculture and competitiveness. At the same time, the importance of production-economic analyses is emphasised in the context of the evolution of the CAP and contemporary turbulence resulting, among others, from environmental and climate changes, as well as fluctuations related to the COVID-19 pandemic and the geopolitical situation. The data were obtained from existing databases, including resources of the European Parliament library, FAO bulletins, Eurostat and OECD, while the main data source is FADN (Farm Accountancy Data Network) at the regional level (UEFADN). The empirical analysis covers the years 2004–2023, allowing long-term changes to be captured, and the choice of time boundaries is justified: 2004 as the year of accession of Poland and other countries and their inclusion in a comparable data system, and 2023 as the last year with complete and verified data in the FADN database. The twenty-year period was divided into four five-year intervals: 2004–2008, 2009–2013, 2014–2018, 2019–2023, enabling continuous and comparative analysis of changes. As the main research method is DEA (Data Envelopment Analysis), a balanced panel dataset was applied, which requires complete observations for each region in each year. Consequently, units with data gaps were excluded, including countries acceding to the EU after 2004 (Bulgaria, Romania, Croatia), the United Kingdom (lack of data after leaving the EU), Malta, selected Hungarian regions, regions of Portugal and France, and the Hamburg region. Ultimately, the research sample includes 108 FADN regions with complete, uninterrupted data series for the entire period 2004–2023. The dissertation uses the following abbreviations: EU-14 (countries that joined the EU before 2004, excluding the United Kingdom), EU-9 (countries that joined the EU in 2004, excluding Malta), and EU-23 (the combined group of EU-14 and EU-9).

The dissertation is embedded in four main theoretical streams: the theory of sustainable development, the theory of competitiveness, the institutional approach, and environmental economics. The theory of sustainable development constitutes the starting point, emphasising the necessity of conducting economic activity without compromising the ability of future generations to meet their needs, through rational management of natural resources and the inclusion of environmental considerations in decision-making processes. Within competitiveness theory, the perspective of farm efficiency was adopted: the inclusion of land, labour and capital in the analysis, followed by environmental inputs, makes it possible to

assess whether and how the environmental component affects the ability to compete at the regional level. The institutional approach highlights that legal and organisational frameworks, including the CAP, shape farm behaviour. Environmental economics, in turn, provides tools for incorporating the ecological dimension into the assessment of competitiveness, including through the modification of the traditional production function by adding an environmental input. The dissertation is based on the assumption that efficiency is fundamental to competitiveness: it translates into lower costs and prices, while increases in productivity strengthen the efficiency of production processes, sales and profits. Consequently, the use of efficiency indicators determined by the DEA method is justified as the application of synthetic indicators of competitiveness in a resource-based perspective.

The dissertation consists of four chapters, leading the reader from a conceptual approach to empirical analysis.

Chapter 1. Propaedeutics of competitiveness

The first chapter serves an organising function: it presents the multidimensionality of the concept of competitiveness and competitive advantage, as well as the evolution of its understanding in economics from classical approaches, through neoclassical and institutional perspectives, to contemporary concepts emphasising adaptive capacity, innovation and the quality of resource management. The chapter presents price and non-price competitiveness, discusses methods of measuring competitiveness (micro- and macroeconomic, synthetic indices), and concludes with the identification of determinants of competitiveness: resource-based, structural, institutional and environmental.

Chapter 2. Competitiveness of farms

The second chapter focuses on the competitiveness of farms, emphasising the specificity of this sector compared with other branches of the economy. It presents the essence of farm competitiveness as the ability to use resources efficiently and to maintain an advantage over entities with a similar production profile. Both the functioning of farms within the EU market and the importance of efficiency as the foundation of competitiveness, resulting from the relationship between inputs and production outputs, are highlighted. The chapter also presents measures of competitiveness used in agricultural research and justifies the significance of the regional approach, in which competitiveness results not only from farm characteristics but also from spatial, environmental and institutional conditions. An important

part is devoted to the evolution of the EU Common Agricultural Policy and its role in shaping the directions of agricultural development and adapting it to environmental requirements.

Chapter 3. Input productivity as a determinant of competitiveness

The third chapter constitutes a transition from theoretical considerations to a methodological-analytical perspective by embedding competitiveness in the framework of input productivity. The first part presents the methodology for calculating productivity and the importance of three key production resources in agriculture (land, labour and capital), indicating their specificity and regional differentiation within the European Union. Particular attention is then devoted to environmental factors, which in agriculture constitute both a resource and a constraint on productivity growth. The chapter concludes with an analysis of changes in input productivity in 2004–2023, forming the basis for assessing long-term dynamics of competitiveness in a spatial perspective.

Chapter 4. The impact of environmental factors on changes in competitiveness

The fourth chapter is empirical in nature and includes an analysis of the impact of environmental factors on the competitiveness of farms in EU regions. Competitiveness is understood here as a resource-based phenomenon resulting from the efficient use of land, labour and capital, enriched by an environmental component. The chapter presents the construction of a competitiveness indicator based on the DEA method, as well as procedures for data preparation, including normalisation. Comparative analysis made it possible to assess changes in the competitive position of regions after taking environmental inputs into account and to formulate conclusions regarding directions of EU agricultural development and recommendations for the Common Agricultural Policy in the context of the growing importance of environmental requirements.

The aim of the dissertation was to identify the extent to which the inclusion of environmental inputs changes the competitiveness of farms in the regions of the European Union. The analytical focus was therefore placed on the contemporary realities of European agriculture, in which competitiveness is increasingly verified not only by costs and productivity but also by environmental footprint and the ability of farms to comply with environmental requirements resulting, among others, from the regulations of the EU Common Agricultural Policy.

The verification of the first partial hypothesis (H1) allowed the transformational context of European agriculture to be captured, leading to the conclusion that the productivity of land,

labour and capital does not develop uniformly across the EU. In farms from EU-14 countries, productivity dynamics, especially in the area of capital, are relatively more stable than in regions from countries that acceded to the EU in 2004, which probably results from the greater maturity of production systems in EU-14 farms compared with EU-9 farms, due to their significantly longer exposure to the influence of the EU Common Agricultural Policy. In countries that acceded to the EU in 2004, the amplitude of changes in farm productivity is clearly higher, which should be interpreted as the effect of accelerated structural transformation, modernisation and the catching-up process in relation to farms from the EU-14. In this group, cyclical fluctuations in capital are particularly evident: investments supported by public funds and community mechanisms may in a short period generate sharp increases in productivity, but also quickly reveal susceptibility to economic fluctuations, energy costs, price pressure on fertiliser and feed markets, variability of trade conditions or geopolitical uncertainty. In practice, this means that EU agriculture currently operates along two trajectories. The first is a more stable trajectory, characteristic of mature systems, while the second is typical of economies in which the process of modernisation remains intensive and not always even. Farms within this trajectory are characterised by dynamic changes and high sensitivity to external conditions. This finding is significant for the interpretation of subsequent results, as it suggests that differences in the response of farms to the environmental component are rooted not only in their approach to the natural environment but also in the pace of change, production structure and capacity to absorb capital.

The second partial hypothesis (H2) focused on answering the question of whether, after including environmental inputs, the competitiveness of farms in regions of countries that acceded to the EU in 2004 increases more frequently than in regions of the EU-14. At the beginning of the analysed period, regions from countries that joined the EU in 2004 showed a greater tendency to improve their position after incorporating the environmental component. However, this was only observed at the beginning of the analysed period, namely in 2004–2008. In subsequent years, the advantage of farms from these countries over farms from the EU-14 was practically unnoticeable. In 2014–2018, farms from the EU-14 even recorded a significantly higher increase in competitiveness resulting from the inclusion of environmental variables than farms from regions located in countries that acceded to the EU in 2004. From a long-term perspective, it is therefore difficult to indicate whether the length of EU membership leads to a different impact of environmental inputs on farm competitiveness. The

analyses even contradict such a tendency, showing that the inclusion of environmental inputs increases the competitiveness of farms from both groups of regions, EU-14 and EU-9. Additionally, it is worth noting that responses to the implementation of environmental variables through increases in competitiveness were even stronger in EU-14 regions (an increase of three quartiles). This is a particularly important conclusion, as it indicates that the environmental component strengthens the competitiveness of farms regardless of region. In practice, this mechanism may be described as follows: as technological modernisation progresses, resource management improves, the capacity to absorb environmental instruments increases, and farm strategies increasingly combine production goals with environmental requirements, the relationship between economic outcomes and production and environmental inputs becomes more favourable. It is precisely this relationship, rather than production intensity itself, that determines shifts in competitiveness after the inclusion of environmental inputs. This is consistent with the direction of changes in the EU market, where farm competitiveness increasingly depends on compliance with environmental requirements and the ability to implement innovations that save resources. It may even be said that the ecologicalisation of efficiency assessment has become a requirement of contemporary EU agriculture.

In the third partial hypothesis (H3), it was assumed that changes in the competitiveness of farms from EU regions resulting from the inclusion of environmental inputs would become increasingly smaller. However, the analyses indicate that changes in competitiveness are not decreasing but remain stable over time. The influence of the environmental component on the competitiveness of farms in EU regions is persistent throughout the research period, and certain symptoms of its limitation can be observed only in the most recent years of analysis, namely 2019–2023. This stability of influence allows it to be stated that the environmental component differentiates the competitiveness ranking and performs an ordering function in EU farm competitiveness. This is quite clear, emphasising that EU agriculture is in a phase in which environmental standards are becoming part of the everyday functioning of farms. This means that standards, technologies, support instruments and production practices in agriculture in EU-14 and EU-9 countries are beginning to converge in the sense that environmental requirements are increasingly internalised and predictable for farms in both groups. In the realities of the current EU market situation, rising energy costs, price volatility, pressure to reduce emissions, discussions on the future of the Green Deal and growing

consumer expectations, this conclusion is particularly important. It shows that the agricultural sector as a whole is “learning” the environment, and that those farms which better adapt to environmental requirements are the ones that “win” by increasing their competitiveness.

The results of the verification of the three partial hypotheses lead to the unequivocal confirmation of the main hypothesis: the inclusion of environmental inputs causes changes in the competitiveness of farms in individual regions of the European Union. The impact of the environmental component on competitiveness acts as a mechanism rearranging the competitiveness ranking of EU farms. The inclusion of the environmental component in the competitiveness model makes it possible to capture the direction of EU agricultural development: from a model based primarily on intensification and scale to a model in which competitive advantages are built through resource efficiency and the reduction of environmental pressure.

On this basis, a synthetic conclusion may be formulated: European agriculture increasingly relies not solely on unit cost or physical productivity, but more and more on the ability to maintain economic performance under growing environmental and regulatory constraints. This is consistent with EU market realities, where the importance of emission reduction pressure, climate resilience and supply chain stability is increasing. Within this framework, the Common Agricultural Policy cannot be designed as a set of uniform incentives, as farms in the EU differ significantly. For this reason, the CAP should be precise, as the effectiveness of environmental instruments depends on whether they address real sources of environmental pressure. Moreover, regions with mature production structures require different types of incentives than regions still undergoing intensive transformation and catching up technologically.

The results of the analyses conducted in the dissertation also allow several recommendations regarding the EU Common Agricultural Policy to be specified. The first recommendation is to shift the emphasis from mere compliance with requirements towards building environmental productivity, understood as the ability to achieve specific economic outcomes with lower resource inputs and reduced environmental pressure. This means that CAP instruments should increasingly reward not the activity itself but the result: reduction of nutrient losses, improvement of fertilisation efficiency, water savings, emission reduction, soil quality improvement or increased resilience to climate stress. Otherwise, part of the

environmental instruments will generate administrative and adaptation costs without delivering proportional improvements in synthetic competitiveness.

The second recommendation is the introduction of clearer segmentation of interventions. Regions with high production intensity and mature structures, typical of many EU-14 areas, are increasingly approaching the limits of easy improvements. There, further improvement in the relationship between outcomes and environmental pressure requires precision technologies, digitalisation, new management models and investments in reducing point-source pressures. In these regions, policy should reward innovation and qualitative modernisation: technologies that reduce resource use per unit of output, solutions increasing drought resilience, as well as restructuring production where environmental pressure is persistent and high. In turn, in regions of countries that acceded to the EU in 2004 and later, it is crucial that environmental instruments be designed as support rather than as an additional cost. This results from the fact that these are typically Central and Eastern European countries characterised by lower income levels per capita than EU-14 countries.

The third recommendation is to strengthen the stabilising function of the CAP in the area of investment. Since capital productivity in farms from EU-9 countries exhibits greater fluctuations over time than in the EU-14, policy should limit situations in which investments are undertaken abruptly in response to temporary economic conditions or the availability of subsidies and subsequently lose efficiency when market conditions deteriorate. Instruments encouraging long-term investments are needed: in soil, water retention, rationalisation of production structure, as well as solutions that sustainably reduce environmental costs. Within this approach, support should be linked to the durability of outcomes and real improvements in the relationship between results and environmental pressure, rather than solely to the purchase of technology or the implementation of a project.

The fourth recommendation is to treat the environmental component not as an additional cost but as a parameter of resilience for the EU agricultural market. In current conditions, environmental pressure, climate change, instability of raw material supplies and growing regulatory requirements are factors directly affecting costs, stability and the capacity to maintain production. The CAP should therefore combine environmental objectives with the building of economic resilience of farms, as only such a structure allows the tension between competitiveness and ecology to be reduced. In practice, this means a greater role for adaptive

instruments: water management, improvement of soil fertility, increased resilience to extreme weather events and reduction of risks associated with fluctuations in input costs.

In summary of all the analyses conducted, it may be concluded that the obtained results form a picture of transformations in the competitiveness of EU agriculture under conditions of increasing environmental pressure and the progressive institutionalisation of sustainable development objectives. The dynamics of these processes vary spatially and temporally. Against this background, the role of the environment as a factor shaping competitiveness becomes particularly significant. The inclusion of environmental inputs in the assessment of competitiveness reveals that their impact is not one-off. Throughout the research period, the environmental component acted as a differentiating stimulus, leading to shifts in competitiveness among farms from individual EU regions. The research results indicate the lasting importance of the environment within the system of efficiency and competitiveness assessment. The environment ceases to be a factor triggering strong, one-time reactions and becomes a permanent parameter of competitiveness, organising the relative positions of farms within the EU.

From this perspective, the fundamental challenge for the Common Agricultural Policy is not to mitigate the tension between environmental objectives and competitiveness, but to design support instruments in such a way that both dimensions reinforce one another. Only in this way can the CAP effectively support agricultural competitiveness understood as the capacity for sustainable, resilient and balanced development within the conditions of the European Union's common market.