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Published online: 24 Aug 2020.

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Modelling EU agriculture's regional disparities under the national accounting system's approach. The impact of the new economic and environmental challenges

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ABSTRACT

The performance farming is a new bet for the EU in the context of the present's major climate and economic challenges. This paper aims at defining a model of agricultural competitiveness for the EU and its application for the evaluation of regional agricultural performance, in relation to the global competitiveness index, using the theory of catastrophes. The objectives of the analysis are: to evaluate the current growth theories in agriculture, to conceptualize a new model of agricultural performance improvement (RAP), to test the model and to obtain the relevant working tools after its application. The used methods are: the study of the general models of growth in agriculture; the dynamic analysis of the Eurostat data on agricultural performance and Member States' data published in the National Accounts System; the conceptualization of the RAP (Regional Agricultural Performance) growth model; the statistical testing of the model, its connectivity with global competitiveness indexes and climate change; the hypotheses' building in order to eliminate the climate transformations influences according to the catastrophe theorem's results; and providing a viable and sustainable tool for the national strategy for agriculture's forecasting changes to the Member States. The novelty element brought by the present proposed model is that of quantification in a broader and special way of the impact of environmental changes on the performing agricultural output in terms of National Accounting System.

1. Introduction

The current global context is dominated by the strong population growth, which reached 7.7 billion inhabitants in 2019, compared with 3 billion in the 1960s. The

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challenges to agriculture, which sustains the population's food needs, become multiple by enhancing the demand in relation to food security requirements. The function of agricultural supply dissociates from the demand function due to the influences of the catastrophes and the intensification of these influences.

Another challenge for the supply function is the decline in soil quality due to the extensive use of the agricultural fertilizers and the food production with a high environmental risk. This general picture assesses the imbalance in global demand-supply, an imbalance that is known by national and regional decision-makers and counterbalanced by the investment process, refining the human resource, importing technologies and mechanisms for the agricultural output storing and redistributing surplus.

This research aims to evaluate the current models and theories of the regional agriculture growth and to define a revelatory and easy to implement tool, namely the RAP model.

The authors' motivation regarding the present scientific approach lies in their preoccupation for the significant improvement of the agricultural performance, which in Romania is much diminished compared to the other branches of the economy. Thus, compared to an occupational employment process in agriculture of 30%, the agricultural economic efficiency rate in recent years has not exceeded 5% of GDP. Moreover, the organization of the agricultural entities and the climate disturbances are other challenges for agriculture, which hinders the process of its sustainable growth.

In relation to the significant research directions identified by the authors during the literature review (presented below), the authors found that there are multiple performance concerns in the current research, but which do not reach all the necessary aspects to identify the national performance in the European context. From our point of view, it is necessary to implement a new model for the analysis of development in the branch, a model that takes into account competitiveness for the EU and its application for the evaluation of regional agricultural performance, in relation to the global competitiveness index, using the theory of catastrophes. In this context, we consider that it is opportune to develop the RAP model as a means of agricultural performance improvement.

2. Literature review

Against the background of the growing and intensifying challenges of increasing regional disparities in agricultural systems, there is an intense concern of the researchers in the field of providing viable models of industry growth and protection against uncertainty factors. A synthesis of representative contributions in the field is presented in Table 1, which quantifies the impact on regional agricultural performance, as well as the differences from the integrated approach proposed by the RAP model.

All the above challenges are solved by RAP model proposed in this paper.

On a global scale, a variety of performance improvement models are used in agriculture, but these models are not correlated with the new socio-economic and climatic challenges. The RAP model proposes an integrated vision of socio-economic

and climatic factors and contributes to the improving predictability of the agricultural performance.

The analysis of the specialized literature shows several strategic directions on which the researchers focused mainly on the concept of agricultural performance. Thus, the use of the sustainable sources in order to achieve performance is a significant pillar which is transposed into current practice through the efforts of the international bodies to develop the sustainable economy.

Other directions aim at the interaction with the high-tech segments and the added value of research-innovation in the branch, spatial models for sustainable agriculture development, greening campaigns and investments in clean technologies, identification of Input-Output type performance models to substantiate agricultural performance, the use of the predictive capacities to compare the European framework with different development peaks in order to identify the impact of the performance enhancing factors, including the environmental factors, transposition into practice of composite environmental indices to mitigate regional disparities and create conditions for performance, etc.

3. Research methodology

The authors identified four topics of interest in conceptualizing their new model. These are aimed at: the dynamics of agricultural exploitation in the EU and on Member States; the agricultural output, labour productivity in agriculture and occupational structure; the economic performance in agriculture, taken on the basis of National Accounting System; and the agricultural production structure by types of products.

In order to adjust the model, the global competitiveness indices were used. The climate change dynamics and the adaptive factors support the agricultural producers behaviour in a climate crisis situation based on accumulated over time experience (know-how). Starting from these aspects, the authors have established the following *working hypotheses*:

H1: the regional economic performance in agriculture is directly proportional to regional managerial goodwill in terms of sustainable economic growth and maximizing the beneficial effects of investment in line with the national strategy in agriculture;

H2: the diversity of the agricultural production structure and the homogeneity of the distribution in the territory are directly related to the economic performance, creating the premises of sustainability in agriculture;

H3: the climate change evolution generates adaptive behaviour in the context of the competitiveness constraints increasing, which eliminates through causal relationships the economic failure in the branch;

H4: the economic performance in the agricultural sector is even higher as the percentage of use of agricultural land is higher and the degree of concentration of the agricultural producers is higher, too;

Table 1. Summary of economic regional models vs RAP model.

Author/s	Author's approach	Impact on regional agricultural performance	New RAP model
Lemaire et al., 2014	analysing the negative impact on agriculture on the climate change's background; the solution is to adopt an integrated agricultural system, combining technological innovation with sustainable management practices.[5]	agricultural performance is supported by cheap energy, fertilizers and the presumption of a static climate, and by managerial capabilities in the labour's efficient use and the environment exploitation; the disruptive factors of the current agricultural system consist in the necessity to ensure food security, in the context of population growth and the implementation of effective environmental protection measures and increasing the quality of agricultural production in relation to the uncertainties related to the continuous climate change.	we agree that research has impact on agricultural performance, but the research results are not supported by mathematical approach, and the correlations between growth factors and disturbing factors are not tested to demonstrate the viability of the proposed solution.
Berger & Troost 2014	the authors argue on the opportunity of developing software programs for climate change analysis as an alternative control measure in the agricultural policies management adopted by the farmers.[6]	a new integrated model (MAS / LOOK) is proposed; the model was transposed on the IT interface based on the interaction diagram of the decision makers and uses a recursive decision approach.	the model involves the use of large data series, the sample being sized for 5400 farmers and using 250 iterations. This creates the inconvenience of the research translating into practice through additional consumption of human and computer resources needed for a viable product, addressing only to organisms with high analytical capability.
Candel et al., 2014	food security analysis in the context of the CAP and the reform of food policies under the overall security framework; provide solutions for global food security decision makers and identifies the CAP's contribution to this area.[7]	conceptualizing the development, trade and regional development matrixes, and allocating these components to a general food security chart by weighting them in order to create a common vision for the agricultural development.	there are some limitations of the research related to the environmental impact through climate change and the decision makers' subjectivity.
Balbi et al., 2015	a direct correlation between soil types, agricultural crops and environmental factors in order to optimize the agricultural system[8]	the need to analyse and understand organic farming systems and to propose a spatial model based on ecosystem services as a measure of optimization of regional agricultural systems, introducing into the model several environmental variables, water supply and climatic regulators.	the model is based on the probabilistic calculation of airflow and climate change, the authors pointing to the fact that there are limitations on the ecosystem services; the model uses the scenario technique, which implies certain limitations depending on the used scenarios and the user's ability to create these scenarios.
Antonelli et al., 2015	the analysis of the global investments in agriculture and the environmental impact's assessment; the investigation of the EU's role on the agricultural	the impact of the approach is low and is limited to assessing the profile of the agricultural investor in the context of the feasible existence of the investment	the importance of developing and adopting a guide to the responsible agricultural investor, including the principle of social and environmental sustainability. the approach is

(continued)

Table 1. Continued.

Author/s	Author's approach	Impact on regional agricultural performance	New RAP model
	investments, highlighting the specific drivers.[9]	object, namely the ecologically possible agricultural land.	limiting because it addresses the expansionist phenomenon of investment, a phenomenon that has undergone important compression in the present.
Ciutacu et al., 2015	the analysis of rural development models of Romanian agriculture in European context [10]	the analysis covers 20 years and takes into account the main aggregates for the agriculture's assessment under the macroeconomic context and its proximity to the European performing models.	the analysis is relevant in view of the used database extent, but suffers from the perspective of convergence objectives with the requirements of a modern European agriculture; the model does not take into account the impact of climate change on agricultural performance.
Czyżewski & Smędzik-Ambroży, 2015	the use of Input-Output analysis model with applicability in agriculture based on a high-performance model [11]	the model identifies performance based on linkages between economic sectors with implications for agricultural development in Poland	significant impact for the dedicated analysis; unfortunately, the statistical database covers 2000-2005
Fraisse et al., 2016	a climate risk management tool based on climate forecasts regarding the risk resources management and increasing efficiency and profitability in agriculture.[12]	the use of an on-line platform to provide information for the decision-makers involved in agricultural activity and to reduce and manage the risk associated with climate variability.	significant impact through consistent input of quality information in managing risk reduction in agriculture; the model doesn't quantify the vectors linked to investment and used land, with emphasis only on the quantification of climatic factors.
Popescu et al., 2016	the analysis of farm structure and land use concentration in Romania.[13]	the authors use statistical techniques for testing hypotheses by comparison and indexing approaches with impact coefficients, concluding that, in Romania, the improvement process of the used land concentration and farm structure optimization is favourable but slowed in relation to CAP's objectives.	the models used allow the validation of the research, but it remains deficient through the limits of the hypotheses included in the study, in the sense that the objectives regarding the environmental protection and the impact of climate change are ignored, the research goal being the pragmatic analysis of agribusiness development and agricultural competitiveness.
Clark & Tilman 2017	a comparative analysis of the environment impact on the agricultural production systems by estimating the inputs' efficiency in agriculture; 742 agricultural systems and over 90 basic food products were evaluated.[14]	the analysis of greenhouse gas emissions attributable directly to different types of food; an interesting system of dietary change to increase the consumption of less polluting products with a direct impact on the environment quality. This change will bring benefits, including the agricultural inputs' efficiency and represents a viable alternative to the current agricultural system.	the study has a major impact on the agricultural performance system's development, but this analysis does not take into account the climate change and its impact on the proposed model's implementation.

(continued)

Table 1. Continued.

Author/s	Author's approach	Impact on regional agricultural performance	New RAP model
Vlontzos & Pardalos 2017	the authors analyse the greenhouse gas emission forecast for the EU agricultural production using the artificial neural networks; there are significant disparities between Member States in relation to the efficiency of using environment, depending on the macroeconomic development.[15]	if the development rate is lower and the dependence on the agricultural system is higher, the environmental impact is greater; the effectiveness of greenhouse gas emissions management in the primary sector across the Member States is analysed, with a direct impact on the CAP.	the approach does not take into account the climate change, its negative impact on the agricultural production and the direct causal relationship with the environment efficiency; countries like Cyprus, Ireland, Portugal and Romania are ranked first in efficiency models, while Greece, Italy, Slovakia and Poland are at the opposite end, which no longer corresponds to the realities.
Feher et al., 2017	evolution of the agricultural system in Romania from the perspective of the growth poles as France and Germany and of a similar system (Hungary); highlighting the possibilities offered by the Romanian agriculture based on the annual growth rates of the national economy.[16]	until 2038, the authors analyse the possibilities of the Romanian agriculture to reach the European contextual level regarding the financing of the branch.	- the approach needs to be improved by applying the corrections regarding the European environmental protection requirements, sustainable growth and the influence of climate change on the performance of agriculture.
Popescu et al., 2017	analysing the aspects regarding the competitiveness of the agri-food trade in Romania in the context of the land use's limiting factors; the competitiveness of Romanian agro-food products on the global market, the objective for which the Balassa index was calculated.[17]	a structural change in land use will encourage grain production, which is assumed as having a competitive advantage on the global markets.	low impact at local level; the model cannot be extrapolated excepting by repeating the reconfiguration of the premises for a region different of Romania.
Zeverte-Rivza et al., 2017	analysing the main agricultural outputs in parallel with the EU labour market forecasting.[18]	the labour models used in agriculture are based on the productive potential of the region and on climate change; the AGMEMOD model is considered as the most representative across the EU.	the inventory of the models does not cover the agricultural performance due to the investment factor; - the comparison system analyses the models only through four parameters (modelling approach, unit of analysis, key structural elements, modelling scale).
Antle et al., 2017	creating a new generation of data systems, models and information for agricultural systems.[19]	defining the information characteristics for farmers on five levels (agricultural extension, development and evaluation of technologies for intensifying operations in agriculture, investments, managerial support and distribution chains to ensure sustainability).	the five discussed levels do not cover the complexity of the performance process in agriculture.

Table 1. Continued.

Author/s	Author's approach	Impact on regional agricultural performance	New RAP model
Lanz et al. 2018	the global economic growth is in relation to the agricultural land conversion under the improving productivity conditions; a reference article for stochastic research on sustainable agricultural growth; the use of randomized models of evolution of the total productivity factor in agriculture, optimizing the risks related to agricultural land failure, through a bipolar approach to optimal consumption and population growth at regional level.[20]	high impact, well-structured and grounded study; validate and statistically disseminated model, including the forecast made until 2030.	the model does not take into account climate change and can be improved.
Czyżewski & Grzelak, 2018	the authors update their own model at the level of Polish agriculture from 2005-2010[21]	the authors point out the obvious transformations of the structural development of the Polish economy based on the application of the sectoral model Input-Output	-the study has a major impact on the agricultural performance system's development.
Fritz et.al., 2019	a comparison of the global monitoring system in agriculture in light of the deficiencies of the main eight regional systems for monitoring agricultural systems based on input data, used models and outputs.[22]	the authors consolidate the main deficiencies found by applying a questionnaire survey and propose measures to adjust and improve these deficiencies.	the analysis does not take into account the impact of investments on agricultural performance.
Czyżewski et al., 2020.	the authors propose an analysis tool to assess deadweight loss in environmental policy. The analysis is performed on the variables that enter the structure of the composite environmental index (soil quality, air and biodiversity)[23] .	the authors elaborate a model for calculating the efficiency rate of the public expenditures on the environmental protection (Effectiveness of Environmental Policy). the Composite Index of Environmental Prospects (CIEP) has improved at the EU average during the analysed period (2005-2016), but this improvement contains disparities between Member States, there is a group of states (Poland, Czech Republic, Austria, Slovakia, Hungary and Malta) for which the index depreciated considerably.	- the authors' conclusion lies in recommendations for the use of promoting innovative policy tools. Moreover, the authors recommend a greater monitoring of the soil erosion. Third, the allocation of the environmental policy funds is often a cause for concern due to the failures of the strategies in the field.

Source: authors' contribution.

H5: the optimization of economic performance in agriculture follows the cyclic process of the Markov chains, in which the optimal area is defined on the basis of the previous critical area, adjusted with the adaptive factor and the core of the policy adapted to global trade.

We define the model of agricultural performance improvement (RAP) as follows:

- ($\exists$) the regionally defined vector F that expresses the dynamics of agricultural holdings in the region:

$$\hat{F}_i = \overline{\widehat{Aa_i} \oplus \widehat{Ah_i} \oplus \widehat{Sf}_i \oplus \widehat{Ff}_i};$$ (1)

where: i ϵ (1, 5), respectively: EU28, Germany, France, Poland and Romania; Aa – the use of agricultural areas in the region; Ah – agricultural holdings in the region at a moment; Sf – small farms from an economic point of view (turnover < 8000 euros); Ff – family farms that cover more than 50% of employees from family members.

We can define the vectors' components in relation to the climatic transformations and the adaptive factor as follows:

$$\widehat{Aa_i} = \frac{\frac{Aa_i}{Aa_{EU}} \cdot FA_i}{\Delta C_i};$$ (2)

where: Aa_{EU} –EU farming area; FA_i– the adaptive factor; ΔC_i – the climate change.

$$\widehat{Ah_i} = \frac{\frac{Ah_i}{Ah_{EU}} \cdot FA_i}{\Delta C_i} \cdot \frac{I_i}{I_{EU}},$$ (3)

where: Ah_{EU} – agricultural holdings across the EU; I_i - the beneficial effects of investment in line with the national strategy in agriculture; I_{EU} - the beneficial effects of investment in line with the European agriculture strategy.

$$\widehat{Sf}_i = \frac{\frac{Sf_i}{Sf_{EU}} \cdot FA_i}{\Delta C_i} \cdot \frac{I_{EU}}{I_i},$$ (4)

where: Sf_{EU} – small farms across the EU.

$$\widehat{Ff}_i = \frac{\frac{Ff_i}{Ff_{EU}} \cdot FA_i}{\Delta C_i} \cdot \frac{I_{EU}}{I_i},$$ (5)

where: Ff_{EU} – family farms across the EU.

- ($\exists$) the regional Lf vector defined as expressing the dynamics of regional labour productivity in the agricultural holdings:

$$\widehat{Lf}_i = \overline{\frac{\widehat{Ea_i}}{\hat{E}_i} \oplus \frac{\widehat{Eaq_i}}{\widehat{Ea_i}} \oplus \frac{\widehat{Eay_i}}{\widehat{Ea_i}} \oplus \frac{\widehat{Eam_i}}{\widehat{Ea_i}}};$$ (6)

where: Ea – the absorption rate of the regional agricultural labour; Ei - the absorption rate of the national agricultural labour; Eaq - the rate of absorption of the regional qualified labour in agriculture; Eay - the absorption rate of the regional youth employment factor (below 40) in agriculture; Eam - the absorption rate of the regional male labour factor in agriculture.

• (∃) Ec regional vector defined as expressing the regional economic performance in the agricultural holdings:

$$\widehat{Ec}_i = \overline{\frac{\widehat{GDPa}_i}{\widehat{GDP}_i} \oplus \frac{\widehat{GVA}_i}{\widehat{GDPa}_i} \oplus \frac{\widehat{NGDPa}_i}{\widehat{GDPa}_i} \oplus \hat{A}_i};\tag{7}$$

where: GDPa – agriculture's contribution to the regional GDP; GVA – gross added value in basic agricultural prices; NGDPa - the contribution of agriculture to the net regional GDP; A –A factor (the agricultural income factor/annual labour unit); GDP – regional GDP.

• (∃) the AS regional vector defined as expressing the regional structure of agricultural production on the seven basic components: cereals, root crops, permanent crops, fresh vegetables, raw milk, bovine meat, pig meat and poultry meat:

$$\widehat{AS}_i = \frac{\frac{\sum_{j=1}^{7} AS_{ij}}{\sum_{j=1}^{7} AS_{EUj}} \cdot FA_i}{\Delta C_i} \cdot \frac{I_i}{I_{EU}},\tag{8}$$

where: AS_{EU} – the structure of European agricultural production.

We define the model of agricultural performance improvement (RAP) according to the vector relation equation as follows:

$$RAP_i = \left(\overline{\hat{F}_i \oplus \widehat{Lf}_i \oplus \widehat{Ec}_i \oplus \widehat{AS}_i}\right) \cdot \frac{FA_i}{\Delta C_i} \cdot \frac{IC_i}{IC_{EU}}; \quad FA_i \ll \Delta C_i; \; IC_i = \frac{\sum_{k=1}^{m} IC_{ik}}{\sum_{k=1}^{m} k},\tag{9}$$

where: IC – Global Competitiveness Index, ie components: Pillar 4 - Macroeconomic stability, Pillar 5 - Health, Pillar 6 - Skills, Pillar 7 - Product market and Pillar 8 - Labour market [1].

According to the Global Competitiveness Index, at the level of the analysed sample, there is a performance rating in favour of Germany and France, which manage to reach and even exceed the European average on pillars 5, 6 and 8 (Table 2).

RAP model operates according to the catastrophe theorem, quantifying the negative amplitude of climate adjustments optimized by the adaptive factor according to the substitution position and offsetting the negative impact of these climate transformations by increasing the restrictions on global competitiveness indices. The model ensures a net growth of the vectors between two successive climatic events, thus optimizing agriculture's outputs by applying sustainable policies in line with the national strategy.

Table 2. Global Competitiveness Index's structure on specific pillars (%).

Economy	Pillar 4 - Macroeconomic stability	Pillar 5 - Health	Pillar 6 - Skills	Pillar 7 - Product market	Pillar 8 - Labour market
EU28	100.0	88.5	75.3	80.0	63.8
France	99.9	99.1	72.6	62.5	61.5
Germany	100.0	94.5	85.4	72.0	74.1
Poland	100.0	86.2	72.9	61.2	59.8
Romania	89.2	79.8	61.8	57.3	60.7

Source: authors' contribution using Klaus Schwab (2018).

4. Results and discussion

For the RAP model's testing/implementation, the authors analysed the statistical data provided by Eurostat during 2010-2018[2]. The authors collected the official final data at the time of writing. For 2019, the data were provisional.

The collected data were analysed for EU28 and four Member States: France, Germany, Poland and Romania, in order to create a generally confirmed/infirmed profile at Member States' level. Thus, there are over 10.5 million agricultural holdings across the EU28, of which the most (2/3) have less than 5 ha land.

The total EU28 agricultural area used for productive purposes is 173 million ha[3].

From the farm dynamics point of view, France (16.1% of all EU28 agricultural land) has the highest land use rate, being far removed from the other analysed countries, which do not exceed 10%. The lowest share of agricultural used land is held by Romania, which, although having the most agricultural holdings, does not resolve the good the natural soil advantage of the good quality due to the deficiencies of the regional administrative system and the lack of technology in agriculture.

A special case is represented by Germany, the country where agricultural holdings are minimally represented by the EU average, but they are grouped on small and very small farms with the aim of using the agricultural area within the upper 10% range. Thus, a regional profile for the dynamics of agricultural exploitation is outlined in the sense that European agriculture is concentrated in agricultural holdings whose economic performance depends to a large extent on the capacity and autonomy of the regional authorities to support the agricultural branch in regions. The agricultural productivity is dependent on managerial and financial tools available to farmers (Figure 1).

The aggregate indicator of labour productivity in agriculture and occupational structure by age and gender, captures the complexity of agricultural supply through the input of human resources segregated according to several structural criteria (vocational training, age and sex of agricultural workers). There is an occupational asymmetry within the agricultural branch.

Across the EU and each Member State, meaning that at most 4.2% of the EU population is working in agriculture, but the disparities between Member States in relation to this indicator are very high. The differences related to the labour employed in agriculture are "in favour" of Romania, which held the largest number of farmers from the four analysed Member States (1.96 million farmers) in 2016. Poland ranks second, followed by France and Germany (Figure 2).
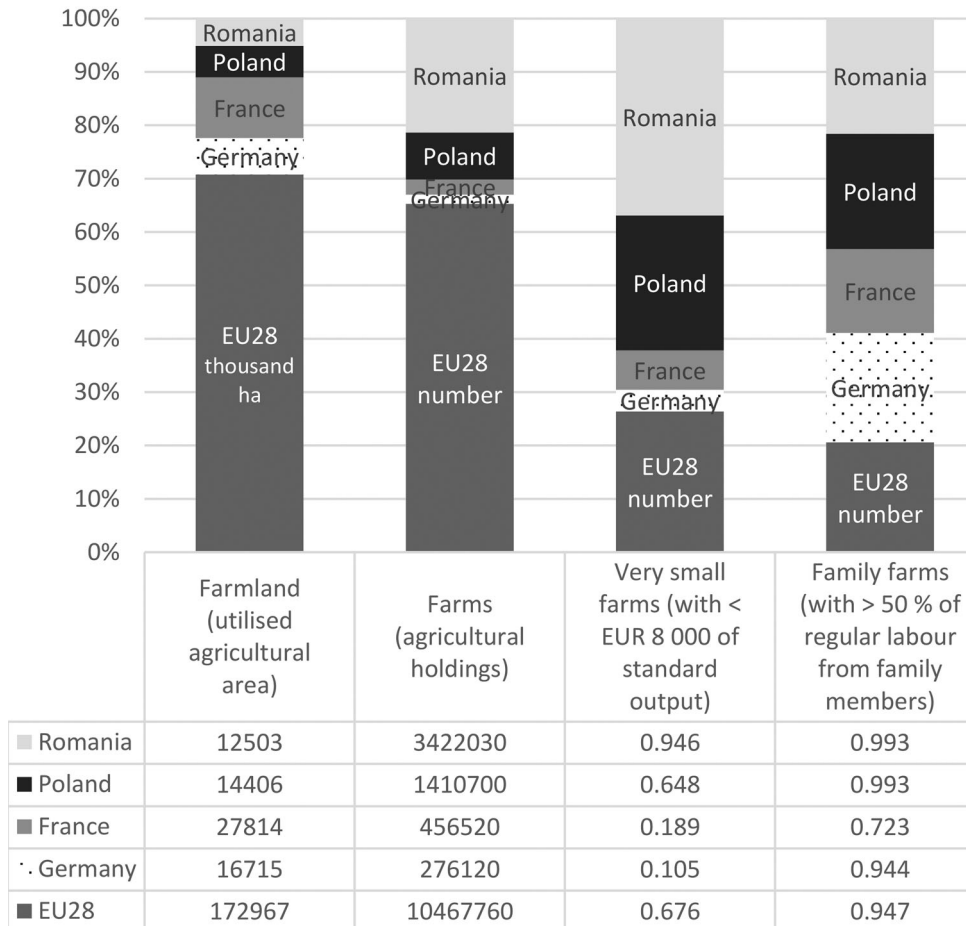
	Farmland (utilised agricultural area)	Farms (agricultural holdings)	Very small farms (with < EUR 8 000 of standard output)	Family farms (with > 50 % of regular labour from family members)
Romania	12503	3422030	0.946	0.993
Poland	14406	1410700	0.648	0.993
France	27814	456520	0.189	0.723
Germany	16715	276120	0.105	0.944
EU28	172967	10467760	0.676	0.947

Figure 1. Dynamics of agricultural exploitation in the EU and on Member States. Source: author's contribution.

The agricultural output is quantified in terms of the branch's contribution to GDP. EU-level representativeness is 1.2% of GDP, which means a minimal contribution of the branch to the total EU economy, including the orientation towards high value-added commerce, perceived as a generator of economic welfare in the EU. The dissemination of national results on quartile representation intervals indicates that France transposed the CAP most faithfully. The countries where economic development is clearly inferior to France and Germany (Poland and Romania), have an agricultural sector's contribution to the GDP of 2 and 4 times greater than the EU average. Germany has the lowest contribution of agriculture to GDP (0.6%), reflecting the top position from the economic point of view, on the principle of supplying goods and services with high added value. The agricultural output brings to EU an annual plus of 188460 million euros at basic prices. The highest agricultural output (29526 million euros) is held by France, namely 15.7% of gross value added at basic prices. France is followed in the ranking of the analysed countries by Germany (20882 million euros gross value added of the agricultural sector), the last place being
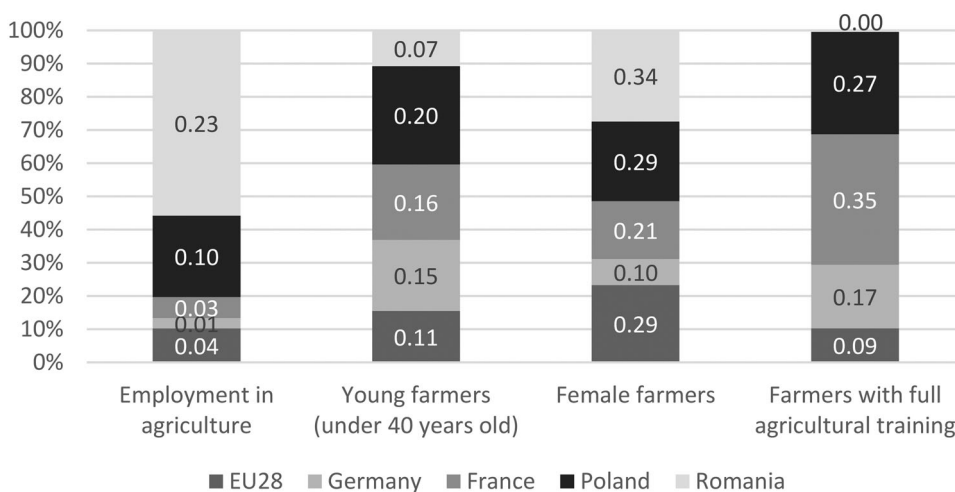
Figure 2. Labour productivity in agriculture and occupational structure by age and gender. Source: author's contribution.

ranked by Romania with a contribution of three times lower than that of France (7845 million euros), (Figure 3).

We define the economic performance in agriculture, taken on the basis of the National Accounting System (NAS), as the cumulative positive effects of the branch in relation to the national economy, quantifiable at the NAS level by the gross amounts contributed to the national/European GDP and by the direct influence of the branch to the sustained growth of the economy, namely to obtain an annual budget surplus and to keep the GDP growth synergy constant after harmonization with the inflationist phenomenon. For the reporting unit, the authors analysed the performance dynamics values using the basic price system to keep the proportions and increase the degree of similarity between the data of the various national economies.

The Performance Scoreboard is achieved by quantifying six indicators and calculating national representativeness in relation to the EU agricultural performance. The six indicators included in the calculation are: Contribution of agriculture to GDP (CA_GDP); Value of agricultural output (OUTPUT); Value of animal output (ANIMAL_OUTPUT); Value of crop output CROP_OUTPUT); Gross value added (GVA); Agricultural factor income per annual work unit (A). The values obtained from the analysis of the indicators are compared on the basis of the impact weights in relation to the European performance and allow to build a performance ranking (Figure 4).

Figure 4 represents a diagram made by IBM-SPSS 25 software, which reflects horizontally and vertically the ranking of the analysed items according to the segregation criterion (zoning). In Figure 4, CA_GDP is represented vertically for the five analysed economic entities (EU, France, Germany, Poland and Romania). It is found that France occupies a significant share and holds the first position in the ranking, its performance influencing the overall EU score. On second place is Germany, followed by Poland and Romania.
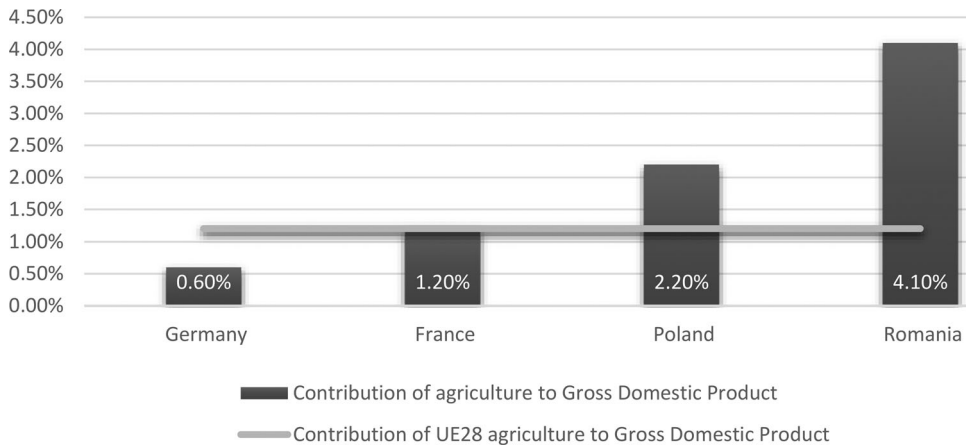
Figure 3. Contribution of agriculture to GDP (%). Source: author's contribution.

In terms of agricultural output, Germany is the country closest to the EU average, followed by France, Romania and Poland. The animal output has a similar structure in terms of ranking as the agricultural output, excepting the change of positions between Germany and France.

The CROP_OUTPUT value places Germany in first place in the European ranking, followed by France, Poland and Romania (the analysis was performed for the sample established in this research).

GVA confirms the GDP trend for France and Germany, but ranks Romania on 3rd, followed by Poland. Finally, A identifies vulnerabilities for Germany and an improved position for Romania due to the fact that in Romania, a large part of the rural labour factor works in agriculture.

The agricultural production structure by types of products covers: Cereals, Permanent crops, Root crops, Raw milk, Pig meat, Bovine meat, Poultry meat and Fresh vegetables. Across the EU, the main category of agricultural inputs to GDP is Cereals, followed by Root crops and Raw milk (Figure 5).

France and Germany have the highest shares in European production of agricultural products, compared to Romania, where the representativeness does not exceed an average of 22% of the potential of these two. This aspect is primarily due to the poor economic performance of the branch, amid the scarcity of investment programs and cataclysms produced lately in Romania, cataclysms that, in addition to climate change, are generated by systematic forest eradication (Figure 6).

There is a balance of agricultural production as a national representatively towards the EU between Germany and France on Root crops and Raw milk. In terms of grain production, France is the leader (21.8% representative), while in pork production, Germany holds the first position (23.3%). Fresh vegetables are harvested by France (11.4%) while Germany keeps a low interest (2.5% of EU production). Raw milk products are exploited and marketed more heavily in Germany (19.2%), while these products reach a representation of 15.3% in France. Poland holds the leading position in poultry meat, while Romania is constantly on the last place at all chapters. The
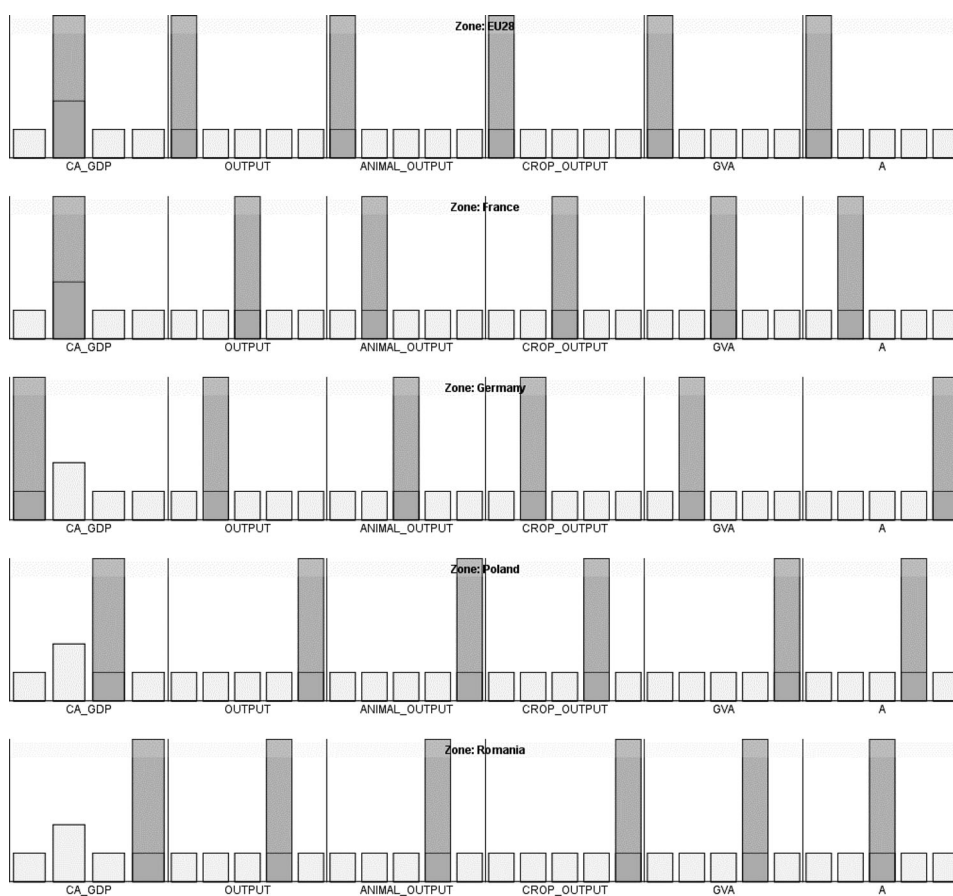
Figure 4. Agricultural performance ranking. Source: author's contribution.

most serious situation is recorded in the production of bovine meat for which Romania owns only 0.8% of the EU production.

The average ranking of all categories of agricultural products is dominated by France (15.51%), Germany (14.21%), followed by Poland (9.46%) and Romania (3.19%).

According to Figure 6, it is observed that on the main agricultural products, the representation of the country's advantage ranks France on the 2nd place for fresh vegetables, raw milk and permanent crops, on the 3rd place for poultry meat and on the 4th place for cereals, pig meat and bovine meat. Germany ranks 1st place in poultry meat, 3rd in cereals, raw milk and permanent crops, pork and bovine meat and fresh vegetables. Poland ranks 1st place in cereals, 2nd in root crops and the last place in the other analysed productions. Romania ranks 2nd place in permanent crops, 1st in pork and bovine meat, 3rd in root crops and the last place for other productions.

From the climatic point of view, several databases have been investigated [www. metnet.eu, www.aemet.ro, regional climate center (www.ecad.eu), global framework for climate services (www.wmo.int)], which allowed the structuring of a current climate profile for the analysed countries and the EU28 (Table 3).
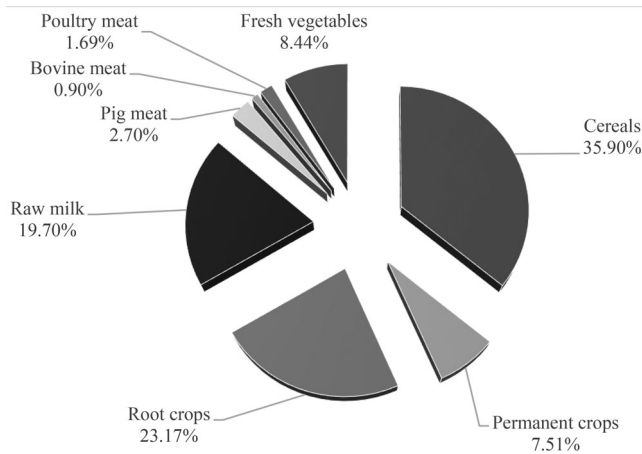
Figure 5. EU agricultural production structure (%). Source: author's contribution.

The influence factors were defined on a scale of 1 to 5, in which 1 - low influence and 5 - maximum influence. For the risk indicators whose impact was highlighted in the above table, the frequency coefficients of influencing the model variables were evaluated (under probabilities' approach), resulting in a matrix distribution of environmental risk over the model (Table 4).

The probable matrix allocation on each variable of the risk factor model allowed the calculation of the risk representativeness averages for each variable, weighted averages for each analysed state in part according to the existing climate (IPCC classification at European level), and the effective risk-protection measures adopted by each country. This resulted in a classification of vulnerability to climate change applicable on the 1-4 scale, in which value 1 was allocated to Germany (the best defence system against climate change), value 2 was allocated to France (opening to the Atlantic Ocean and being more vulnerable to climate change than Germany), the value 3 was allocated to Poland (the country that managed to create certain functional mechanisms against natural calamities), and the value 4 was allocated to Romania, the country that is currently very affected by the calamities that occur with an increasing frequency (extreme temperature, floods).

The obtained data were introduced in a forecast procedure, with an average increase in the branch in line with the achievements reported by Eurostat for each of the four countries and EU28 during 2009-2018, as follows:

- EU28's branch (industry) growth: 33.82%;
- Germany's branch (industry) growth: 9.87%;
- France's branch (industry) growth: 20.11%;
- Poland's branch (industry) growth: 18.72%;
- Romania's branch (industry) growth: 143.8% (Eurostat, 2019).

The forecasted values for the 5 economic entities were rounded up for the first 4, and in the case of Romania, the actual growth opportunities of the agricultural branch were taken into account.
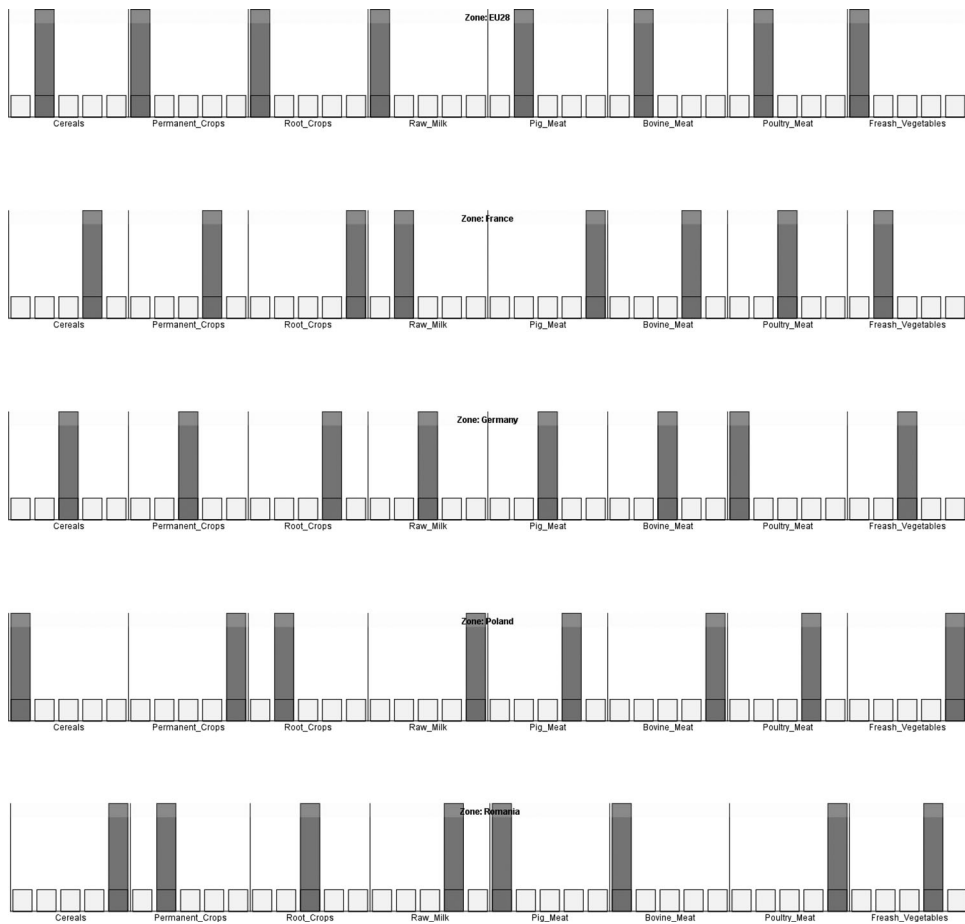
Figure 6. Ranking of agricultural performance by representative products. Source: author's contribution.

The investment impact on agricultural performance was quantified using the Eurostat database for the value of national accounts in agriculture during 2009–2018 (Economic Accounts for Agriculture - Values at Constant Prices" and European Commission 2018).[4]

According to these data, positive growth trends of investments in agriculture have resulted for 4 of the 5 economic entities: EU 0.5% annual net investment growth (30.4% of GVA in 2017), Germany 2.5% (a net investment of 92.7 billion euros), Romania 2.5% (17.5% of national GVA) and Poland 2% (15.5% of national GVA). The case of France is atypical because it shows a 0.1% reduction in investment in agriculture calculated over the period 2009–2018 (36% of the national GVA).

In order to determine the projected values for the next 10 years, a forecasting function based on the current data adjustment with the direct investment values in agriculture for each variable of the model was used, thus obtaining the crude prognostic growth by investment unitary series for each of the 23 variables of the model, which have entered in an adjustment mechanism according to the climate impact assessment of the model indicators (Table 4). Data in absolute figures were compared by the average method with the current values, resulting in trending model indicators for each entity in gross and adjusted predicted values. The statistical calculation

Table 3. Current climate profile.

Decreasing the ecosystem service as a result of climate change (F1)	5
Variation of the demand of land (F2)	2
Warming trend (F3)	5
Extreme (+/-) temperature (F4)	5
Extreme (+/-) precipitation (F5)	4
The risk of flooding (F6)	4
The peak water discharges (F7)	3
Decrease in water for irrigation (F8)	5
Increasing costs for flood protection (1.7 billion euros) (F9)	4
Increasing sea levels (F10)	3
Grain harvest (losses of 20%) (F11)	4
Increased economic losses by extreme heat - crop production (F12)	5
Implementation of warning systems (F13)	4
Improving air quality (F14)	4
Improving wildfire management (F15)	5
More insurance products against weather-related yield variations (F16)	5

Source: Authors' contribution.

method of the representative statistical media for each analysed economy was applied and the impact plot of the forecasting model based on the use of the investments and the impact of the climatic factors on the indicators from the national accounts and on the structural indicators of the model defined in the methodology (Figure 7).

The current data, crude/brut forecasting and net forecasting, allow the construction of neural networks capable of highlighting the validation of the six hypotheses (H1-H6) in the comparative analysis between the EU28 and each of the four Member States under review. Using the multilayer perceptron model for Germany, the hyperbolic tangent for 22 layers of the dependent variables in connection to EU28 are forecasted and predict brut values based on investment allocation coefficients and values adjusted based on climatic impact in relation to the current and predicted covariates in the two options (brut and net) with an error for the scale of the 0.054 add-on variable at 0.106 in relation to the statistical error test on the covariance variables between 1.174 and 1.176, depending on the type of data series (current, adjusted) (Table 5).

The configuration of the neural network for the case study was generated by SPSS 25 (Figure 8).

France faces to a 0 error for the scale of the dependent variable in relation to the statistical error test on the covariance variables between 0.764 and 2.073, depending on the data series (current, adjusted) (Table 6).

The configuration of the neural network for the studied case is presented in Figure 9, the degree of network dependence from the general model being smaller (the number of neural nodes being reduced by 4.5% compared to Germany).

Poland benefits of 0 error for scale of the dependent variable in relation to the statistic error test on the covariance variables between 0.195 and 0.207, depending on the data series type (current, adjusted) (Table 7).

The neuronal network configuration is shown in Figure 10, the degree of network dependence from the general model being smaller (the number of neural nodes being reduced by 9.1% compared to France).

For Romania, the analysis leads to 0.001 error for the scale of the dependent variable in relation to the statistic error test on the covariance variables between 0.523 and 0.527, depending on the data series (current, adjusted) (Table 8).

Table 4. The impact of the climatic factors on agriculture in EU and analysed countries.

FACTOR	IMPACT	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
		5	2	5	5	4	4	3	5	4	3	4	5	4	4	5	5
Farms and farmland	Farmland	0.2	0.5	0.8	0.9	0.9	0.9	0.8	0.9	1	0.5	0.1	0.1	0.2	0.2	0.2	1
	Farms	0.4	0.5	0.8	0.9	0.9	0.9	0.8	0.9	1	0.5	0.1	0.1	0.2	0.2	0.2	1
	Very small farms	0.8	0.5	0.8	0.9	0.9	0.9	0.8	0.9	1	0.5	0.1	0.1	0.2	0.2	0.2	1
	Family farms	0.8	0.5	0.8	0.9	0.9	0.9	0.8	0.9	1	0.5	0.1	0.1	0.2	0.2	0.2	1
Farmers	Employment in agriculture	0.5	0.2	0.9	1	1	1	0.9	1	1	0.2	0.1	0.1	0.2	0.2	0.2	1
	Young farmers	0.2	0.2	0.6	0.7	0.7	0.7	0.6	0.7	1	0.2	0.1	0.1	0.2	0.2	0.2	1
	Female farmers	0.2	0.2	0.6	0.7	0.7	0.7	0.6	0.7	1	0.2	0.1	0.1	0.2	0.2	0.2	1
	Farmers with full agricultural training	0.2	0.2	0.6	0.7	0.7	0.7	0.6	0.7	1	0.2	0.1	0.1	0.2	0.2	0.2	1
Economic performance of agriculture	Contribution of agriculture to GDP	1	0.1	0.8	0.9	0.9	0.9	0.8	0.9	1	0.1	0.9	0.9	0.5	0.5	0.5	1
	Gross value added (at basic prices)	1	0.1	0.8	0.9	0.9	0.9	0.8	0.9	1	0.1	0.9	0.9	0.5	0.5	0.5	1
	Value of agricultural output (production at basic prices)	1	0.1	0.8	0.9	0.9	0.9	0.8	0.9	1	0.1	0.9	0.9	0.5	0.5	0.5	1
	Value of crop output	1	0.1	0.8	0.9	0.9	0.9	0.8	0.9	1	0.1	0.9	0.9	0.5	0.5	0.5	1
	Value of animal output	1	0.1	0.8	0.9	0.9	0.9	0.8	0.9	1	0.1	0.9	0.9	0.5	0.5	0.5	1
	Agricultural factor income per annual work unit (Indicator A)	1	0.1	0.8	0.9	0.9	0.9	0.8	0.9	1	0.1	0.9	0.9	0.5	0.5	0.5	1
Agricultural production	Cereals	1	0.4	1	1	1	1	1	1	1	0.4	1	1	0.2	0.5	0.2	1
	Permanent crops	1	0.4	1	1	1	1	1	1	1	0.4	1	1	0.2	0.5	0.2	1
	Root crops	1	0.4	1	1	1	1	1	1	1	0.4	1	1	0.2	0.5	0.2	1
	Raw milk	1	0.4	0.6	0.7	0.7	0.7	0.6	0.7	1	0.4	0.5	0.5	0.2	1	0.2	0.6
	Pig meat	1	0.4	0.6	0.7	0.7	0.7	0.6	0.7	1	0.4	0.5	0.5	0.2	1	0.2	0.6
	Bovine meat	1	0.4	0.6	0.7	0.7	0.7	0.6	0.7	1	0.4	0.5	0.5	0.2	1	0.2	0.6
	Poultry meat	1	0.4	0.6	0.7	0.7	0.7	0.6	0.7	1	0.4	0.5	0.5	0.2	1	0.2	0.6
	Fresh vegetables	1	0.4	1	1	1	1	1	1	1	0.4	0	0	0.2	0.5	0.2	1

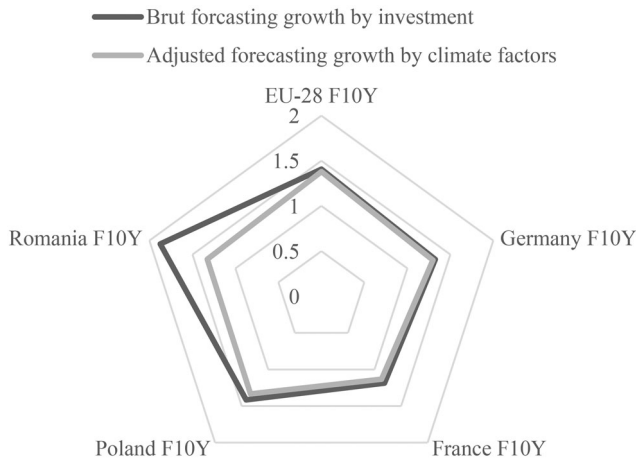Source: Authors' calculation.

Figure 7. Cumulative effect of climatic factors and investments on agricultural performance. Source: author's contribution.

The degree of network dependence on the general model is lower (the number of neural nodes being reduced by 4.6% compared to Poland).

The working hypothesis regarding the relationship between the regional economic performance and the additional good management to sustainable economic growth (**H1**), demonstrated by the authors for the four individual cases in relation to the EU average, reflects the fact that, both in terms of the current situation and 10-year representative statistical series obtained by the authors through the statistical forecasting procedure IBM-SPSS 25, the development poles France and Germany have and will maintain a superior position compared to those of Poland and Romania. There is an unfavourable difference on the forecast series in all situations involving Romania (sustainable performance management maximized by strategic investments in agriculture) while Germany mainly benefits from the forecast line by improving the situation by using the same investment lever. In the case of France, the authors assessed vulnerabilities only in terms of the interaction between strategic investment, sustainable growth and climate change for the 10-year forecast horizon compared to the EU average.

Hypothesis 2 (**H2**), which was demonstrated by the authors, aims at the fact that economic performance is directly influenced by diversified agricultural production and higher distribution capacities in the territory. They are maximized in the cases of Germany and France, containing a significant share (synaptic weigh> 0) on the predicted trend series both in relation to the EU average and in relation to the analysed sample treated homogeneously. On the other hand, for Romania, the deficiencies regarding the logistics chain and the rhythmic distribution capacity requested by the big traders reside in a major structural difficulty that slows down the economic performance and significantly diminishes the sustainability of the agricultural branch.

From the **H3** point of view of, the authors analysed the possibility of improving economic performance by creating the adaptive behaviour of agricultural entities in relation to climate change. This aspect is highlighted in Figures 8–11, as a vulnerability for all 4 analysed states, finding at most a link with a low synaptic weight (in the cases of Germany and France) or lack of connection (in the cases of Romania and

Table 5. Test statistic model multilayer perceptron for Germany.

Model Summary			
Training	Sum of Squares Error		1,839
	Average Overall Relative Error		,072
	Relative Error for Scale Dependents	EU-28 act	,054
		EU-28 F10Y	,056
		EU-28 F10Y*	,106
	Stopping Rule Used		1 consecutive step(s) with no decrease in error[a]
	Training Time		0:00:00,00

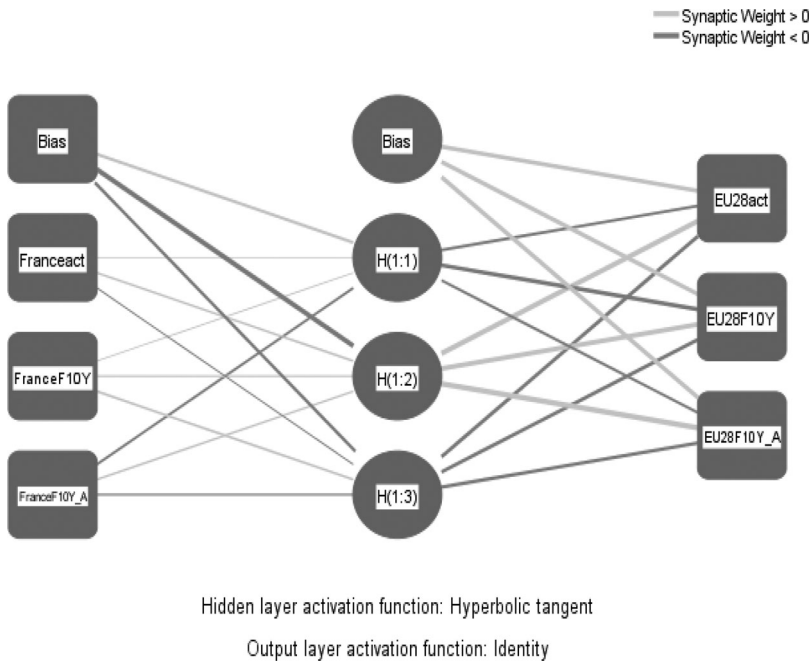Source: Authors' calculation using IBM-SPSS 25.
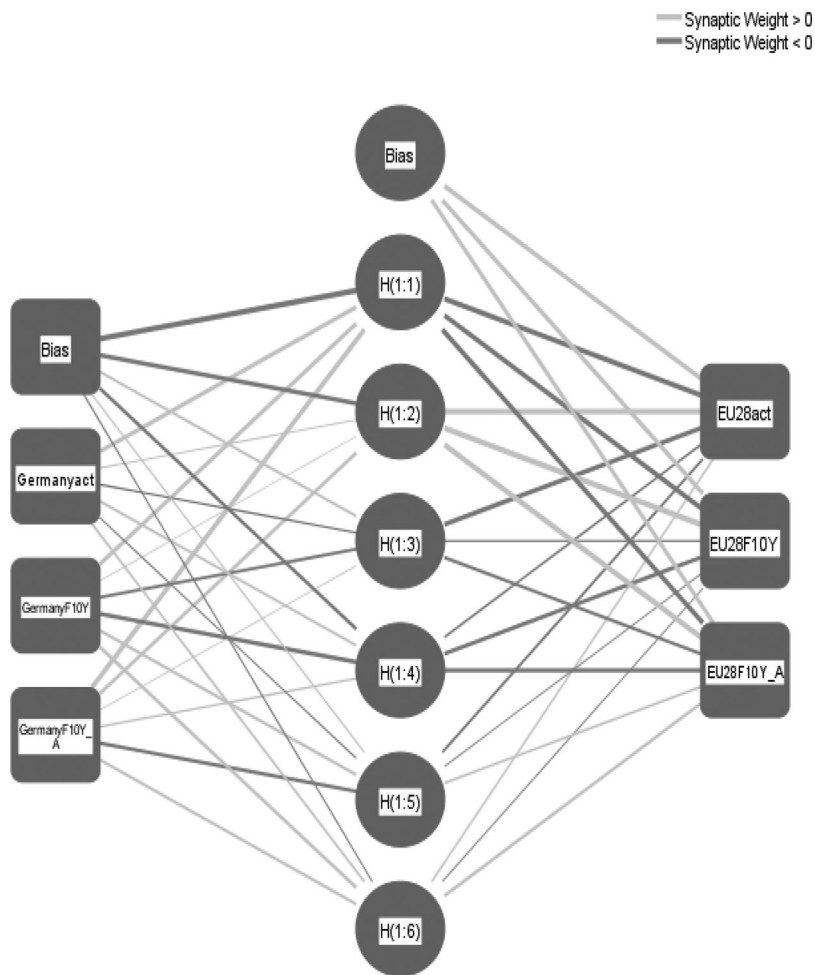
Figure 8. Neural Network: The case of German agriculture. Source: author's contribution.

Table 6. Test statistic model multilayer perceptron for France.

Model Summary			
Training	Sum of Squares Error		,005
	Average Overall Relative Error		,000
	Relative Error for Scale Dependents	EU-28 act	,000
		EU-28 F10Y	,000
		EU-28 F10Y*	,000
	Stopping Rule Used		Training error ratio criterion (,001) achieved
	Training Time		0:00:00,02
Testing	Sum of Squares Error		,017
	Average Overall Relative Error		1,210
	Relative Error for Scale Dependents	EU-28 act	,764
		EU-28 F10Y	2,073
		EU-28 F10Y*	,788

Source: Authors' calculation using IBM-SPSS 25.

Hidden layer activation function: Hyperbolic tangent

Output layer activation function: Identity

Figure 9. Neural Network: The case of French agriculture. Source: author's contribution.

Table 7. Test statistic model multilayer perceptron for Poland.

Model Summary			
Training	Sum of Squares Error		,006
	Average Overall Relative Error		,000
	Relative Error for Scale Dependents	EU-28 act	,000
		EU-28 F10Y	,000
		EU-28 F10Y*	,000
	Stopping Rule Used		Training error ratio criterion (,001) achieved
	Training Time		0:00:00,00
Testing	Sum of Squares Error		,007
	Average Overall Relative Error		,203
	Relative Error for Scale Dependents	EU-28 act	,195
		EU-28 F10Y	,207
		EU-28 F10Y*	,207

Source: Authors' calculation using IBM-SPSS 25.

Synaptic Weight > 0
Synaptic Weight < 0

Hidden layer activation function: Hyperbolic tangent
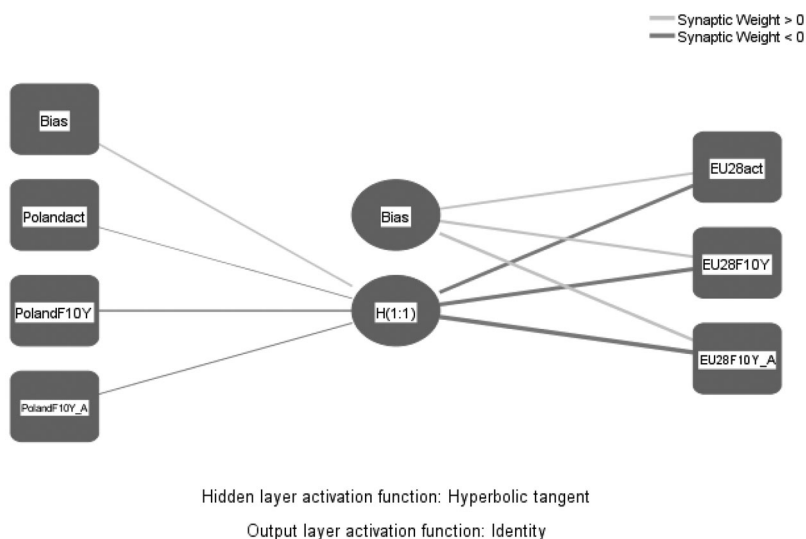
Output layer activation function: Identity

Figure 10. Neural Network: The case of Polish agriculture. Source: author's contribution.

Table 8. Test statistic model multilayer perceptron for Romania.

Model Summary			
Training	Sum of Squares Error		,012
	Average Overall Relative Error		,001
	Relative Error for Scale Dependents	EU-28 act	,001
		EU-28 F10Y	,001
		EU-28 F10Y*	,001
	Stopping Rule Used		Training error ratio criterion (,001) achieved
	Training Time		0:00:00,00
Testing	Sum of Squares Error		,007
	Average Overall Relative Error		,525
	Relative Error for Scale Dependents	EU-28 act	,523
		EU-28 F10Y	,527
		EU-28 F10Y*	,526

Source: Authors' calculation using IBM-SPSS 25.

Poland). We consider that the approach of some European models of productive behaviour adapted to climate change can be a safety element to avoid the significant economic losses that Romania faces in 2020.

The percentage of the land use and the concentration of the producer associations/holdings (**H4**) can be an engine for improving the economic performance of the agriculture. This is seen in Figures 8–11 as a significant advantage for Germany and France and as a potential advantage for Poland. At this moment, Romania does not benefit from agricultural performance by increasing the degree of concentration of agricultural entities. In addition, their economic performance is well below the European average.

The last hypothesis demonstrated by the authors aims at optimizing the economic performance based on Markov chains of economic growth (**H5**) and brings to the fore the importance of the management through advanced management of critical vulnerabilities affecting agriculture and the use of levers to eliminate these
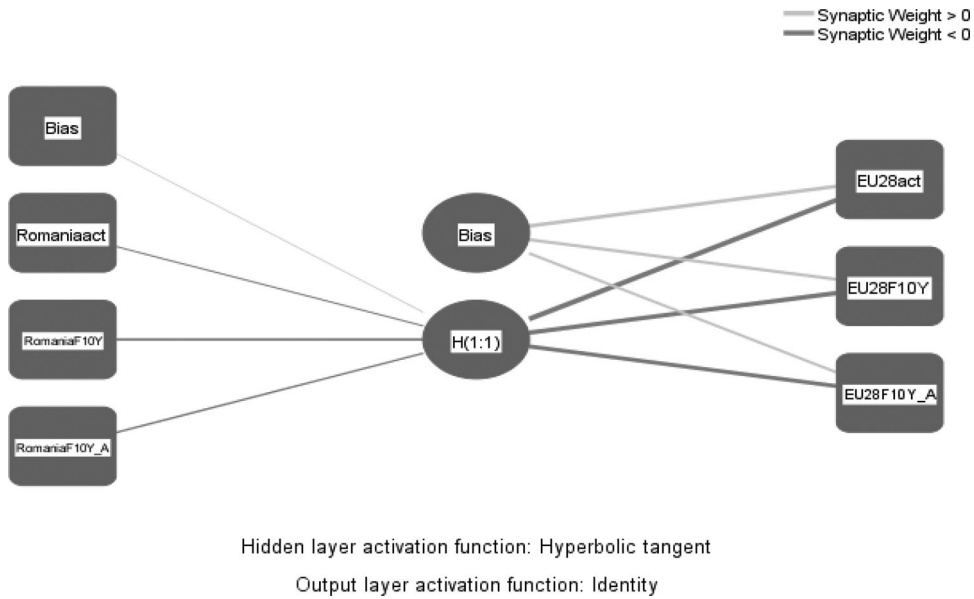
Figure 11. Neural Network: The case of Romanian agriculture. Source: author's contribution.

vulnerabilities cyclical recurrence in the future. Once again, the analysis shows that Germany has higher synapse values on the forecast series than the European average, with France also having an advantage in terms of cyclical process management. Romania, due to structural deficiencies, is at a minimum level of performance and needs to change the managerial mentality and the strategies adopted for medium and long term agricultural development for the repositioning of agriculture as a basic branch of the national economy.

5. Conclusions

The model proposed by the authors is a novel one with immediate and wide applicability through the dimensioning of agricultural flows to investment realities and climate change with impact on agricultural development policies.

In the analysis, the working hypotheses were tested and validated, the direct and indirect connections of the agricultural development under the unfavourable climatic evolution were assessed objectively, the potential being determined over a 10-year forecast of the branch development.

The proposed model in this paper combines the financial, economic, social, structural elements of investing in the configuration of the branch in the EU economy. The model can be adopted by decision-making bodies to develop a sustainable agriculture strategy because it is based on concrete data, analysed over a representative period and uses financial projections of data over the next decade interval.

We believe that for the next 10 years, a new regional approach to sustainable agricultural development is required, which provides for the improvement of agricultural infrastructure for countries with highly productive land, professional training of top agricultural managers through exchanges of experience and practical guides available

to local communities. All these will be able to dilute regional disparity and increase the average agricultural performance in Europe. On the other hand, the creation of climate change forecasting models and adaptive behaviour models can be a medium-term solution for improving the performance of all EU states in agriculture and implicitly for increasing the medium-term sustainable agricultural performance in the EU.

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Disclosure statement

Funding

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