IDENTIFICATION OF THE NECESSARY ELEMENTS FOR ESTABLISHING OF THE STATISTICAL-ECONOMETRICAL MODELS APPLICABLE TO THE RETERIORIZATION OF LAND AND AGRICULTURAL STRATEGIES

Denis-Arthur STRIJEK PhD Student *(denis.strijek@gmail.com)*
Academia de Studii Economice din București
ORCID ID 0009-0003-2997-8571

Abstract

In the context of increasing energy needs and European policies adopting sustainable development strategies and decarbonization strategies for energy production, significant areas are being displaced from the agricultural circuit, areas that are transferred, in this way, exclusively to investments generating energy from renewable sources, more specifically to photovoltaic parks generating energy produced with the help of the sun and wind parks, generating energy from the speed of the wind. Reterritorialization represents a viable solution to reduce the deficit produced by the agricultural fund by displacing land areas from the agricultural circuit and to participate and continue to support sustainable development and the concept of sustainability.

The global context has, in addition to the elements of sustainability and the environment, supported by the concept of sustainable development, also elements of energy security of the states. Romania and the other European states are involved in the development process of this branch of the energy industry with clear progress targets. Equally, the aim is to reduce dependence on energy solutions from Russia, i.e. gas imported by both Romania and Europe, as well as the dependence of this industry on the Chinese supply chain, the provision of infrastructure elements being made almost exclusively by Chinese manufacturers.

In this article, the author set out to identify the elements necessary to establish some statistical-econometric models that are optimal and applicable to the concept of land reterritorialization. The concept of reterritorialization emerged in the context of the dynamic development of the renewable energy field, namely photovoltaic parks, but not only being applicable to wind energy parks. The major developers and investors of these energy producing establishments have displaced significant areas from agricultural circuits for the development of these investments. National energy needs are a priority in the economy due to sustainable development strategies, which are even part of European strategies. Agriculture is part of the essential needs of humanity, which makes it equally a strategic economic branch.

In order to emphasize the importance that should be given to this subject and to argue this, the article presents some relevant statistical data to identify developments. Agriculture has been facing difficulties generated by climate change in recent years, such as drought, floods, abrupt temperature variations and, last but not least, extreme phenomena, which have become increasingly frequent, these being part of the unpredictable category, generating significant losses for farmers once they occur. At the same time, we can say that in Romania, the irrigated area has decreased dramatically.

Keywords: sustainability, agrophotovoltaic model, green energy, sustainable development, econometric model.

JEL Classification: C10, O13, Q56.

Introduction

The concept of reterritorialization based on the agrophotovoltaic concept has as its principle the use of unused space around photovoltaic panels for agricultural crops or other complementary purposes, which leads to a partial reuse of land. This approach symbiotically combines green energy production with agricultural activities, creating a synergy between renewable energy production and agriculture, contributing to a greener and more resilient economy, contributing to the efficient use of land. By implementing various crops between photovoltaic panels, land that has been removed from agricultural use for energy production can be partially revitalized.

The agrophotovoltaic model integrates photovoltaic panels with agricultural activities on the same land, optimizing both uses. In order to effectively implement such a system, it is essential to consider both the technical aspects of installing photovoltaic panels, as well as the space available for crops and the climate and soil conditions.

At the level of further development, it would be necessary to take into account from the design phase the elements necessary for the efficient and sustainable use of land in accordance with sustainable development strategies. In the case of wind farms, the concept of reterritorialization should also be implemented as a mandatory element from the design stage, given the large distances required between wind turbines. The remaining available spaces for reterritorialization are proportionally much larger than the technological space required for wind turbines. We must not lose sight of the enormous available space on which the development of wind farms is based, this land being also extracted from the agricultural circuit, causing a decrease in cultivated land areas, and consequently of the food-generating infrastructure for the ever-growing population.

Literature review

Angelsen (2010) presented a series of elements that are taken into account in what agricultural production means, and Anghel, Anghelache and Panait (2017) analyzed the results obtained in agriculture in the European Union, both as a whole and for each member state. Anghelache, Samson and Stoica (2020) analyzed the main elements of the European Union strategy regarding the agricultural sector. Anghelache and Dumitrescu (2015) analyzed agricultural production indices. Anghelache, Strijek and Dumitru (2024) analyzed the dynamics of plant production in Romania of the main crops in 2023. Bezemer and Headey (2008) addressed aspects regarding the measures that can be implemented for the development of agriculture. Quamrul and Michalopoulos (2015) researched the implications of climate fluctuations on agriculture. Swintona, Lupi, Robertson, Hamilton (2007) analyzed the role of agricultural ecosystems for various benefits. Strijek D (2024), presented the importance of energy in industrial production.

Thus, Anghelache C. and Anghel M.G. (2024) address a sensitive issue regarding the European Union's dependence on single suppliers, which is an issue of concern and constitutes a fundamental component of energy security. Best R. (2017) studies the importance of financial capital and its influence in development considering the consumption of different types of energy: biofuels and waste, hydro, coal, oil, natural gas, nuclear, wind, solar and geothermal. Cheikh N.B., Zaied Y.B. (2024) are concerned with the dynamic interdependence between renewable energy sources and its main drivers, emphasizing the role of geopolitical events. Correlj A., Hoppe T., Künneke R. (2024) have a multidisciplinary analytical perspective, which addresses governance, institutional and ethical aspects, regarding the involvement of citizens in sustainable urban energy systems, starting from the reality that cities are directly involved in the emission of approximately 75% of the total global CO2 emissions. The transport and construction sectors are the largest contributors in this regard. Deleidi M., Mazzucato M., Semieniuk G. (2020) have examined the effect of direct public investments on private investments regarding

renewable energy production technologies. Husain S., Sohag K., Wu Y. (2024) are concerned with the effectiveness of environmental policies in promoting renewable energy production, conducting a study in this regard using the CS-ARDL estimation method, which is a more advanced version of the group average estimation method. Iacob and Strijek (2024) also explore in their work the importance of sustainable development and its key elements, and Strijek (2024) makes known the importance of reterritorialization as part of sustainable development and the recovery of agricultural land in the context of the symbiosis of two strategic areas. The data envelopment (DEA) methodology was developed and presented by Charnes, Cooper and Rhodes (1978) and was later deepened by Banker, Charnes and Cooper (1984).

Methodology, data, results and discussions

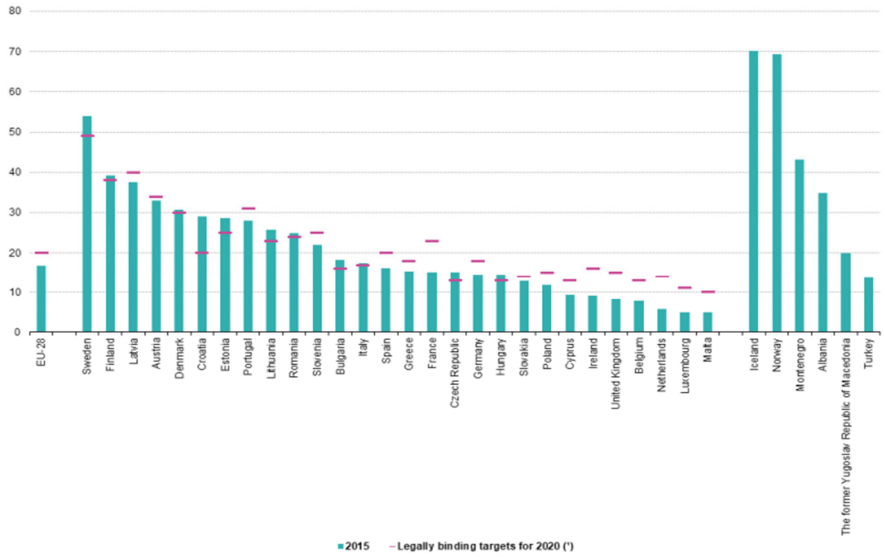
Considering all the above elements, the question arises as to how we need to approach the problem in order to find a suitable solution. Thus, the idea is developed to identify statistical-econometric models applicable to the reterritorialization of land and agricultural agri-food strategies. This is part of a larger study because it contains extremely many variables that influence the applicable results.

We can also say that development strategies are sometimes focused on one field, or industry without taking into account its effects in relation to the others, or omitting some of the three industries. For example, we can consider the energy industry and the high need for its development to satisfy the increasing consumption necessary for today's society. Starting with the industries producing and processing goods, services provided to the population, up to the increased need for charging electric cars.

European countries have set themselves, within the framework of sustainable development strategies, objectives and targets for the production of energy from renewable sources, these being attributed mainly to wind production sources, but especially solar.

Certainly, the production from these sources will increase, the guarantee being the commitments assumed by the European states which are presented below in figure no. 1:

Green energy production and assumed objectives



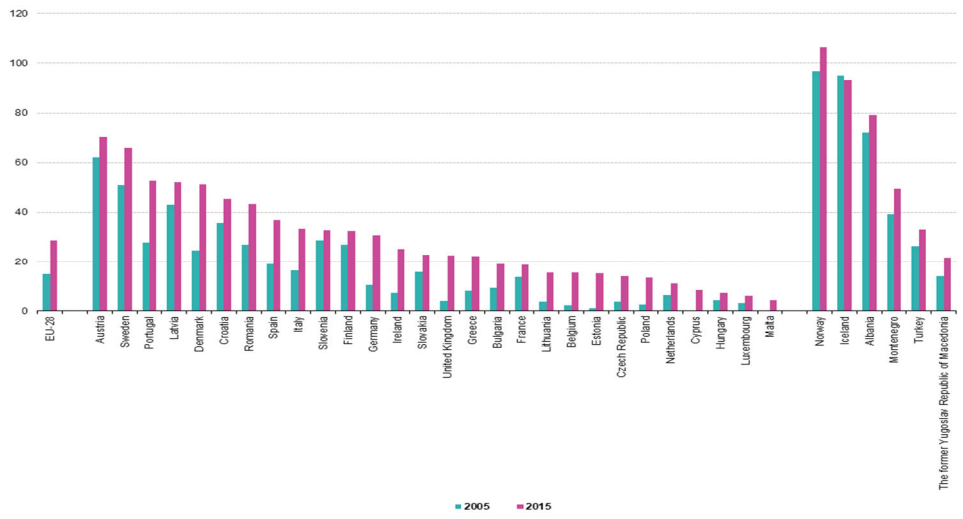
Source: Eurostat

Europe's climate commitments and the concern for renewable, sustainable energy sources are sustained over time, with Europe being an important player in the climate pact.

In this context, Romania ranks among the first places, being among the countries that have exceeded their assumed objectives in renewable energy production, above the European average. To support this argument, figure no. 2, presented below, presents the share of electricity generated from renewable sources in 2005 and 2015, with a significant increase evident.

Share of electricity generated from renewable sources, 2005 and 2015

Figure no. 2



Sursa: Eurostat

Following the Covid-19 pandemic, the European economy has been severely affected. The European Commission, in accordance with the adopted European Green Deal, has assumed an ecological approach to economic recovery, but even if the political will exists, the investments that are necessary for the recovery after the pandemic episode and, implicitly, the expenses necessary to mitigate the consequences of the ongoing war, have the effect of slowing down the implementation of ecological policies and commitments, and the recovery is being done by sacrificing some ecological considerations. The new decisions at the European level certify that the decarbonization targets were too idealistic and in fact affected industries, added production costs and caused important players in key development areas to become uncompetitive and lose their economic advantages. Moreover, some of them were forced to restrict their activity. This decision to reanalyze the targets, direction and speed of development also comes from the new directions that the United States of America is giving with the re-election of President Trump.

The US decision to rejoin the Paris Agreement, under Joe Biden's presidency and the organization of an international climate summit, brought hope, showing the world a significant shift from President Trump's first-term policy, indicating at the time that the US was on a trajectory of climate-friendly commitments. However, implementing long-term climate action in the US remained a challenge, given the depth of political divisions at the time and strong opposition from influential forces, with China and other Asian economies accounting for most of the global growth in the coal sector. Commitments to climate neutrality by several Asian countries, however, suggest a move towards greater

emission reductions, but even the largest players have set long deadlines, 2060 for China and 2070 for India. The pace of change remains uncertain given the long deadlines and the instability of policymakers. However, given the re-election of Donald Trump as US president and his immediate decision to withdraw the US from the climate pact again, immediately after taking office, the prospects for green energy are truly uncertain. The need for investment in order to produce energy predominantly from renewable sources is great, and a major player in the industry such as the US can tip the balance in the opposite direction of sustainability.

We note that most of the time immediate economic interests or political decision-makers mistakenly change the optimal development path, which also happened in this case, where the increased need for energy has tainted the path of the sustainable development strategy for decarbonization and has removed significant areas from the agricultural circuit for the development of renewable energy production facilities.

As we have shown in the figures above, Romania has recorded a significant development in the renewable energy sector, making it necessary to take out of the agricultural circuit, in addition to the necessary investments, significant areas of land where these investments could be made, which would otherwise have been used for agricultural production. Even if in some agricultural sectors, modern techniques and advanced machinery have led to an increase in profitability, this cannot compensate for the lack of land in use. This direction of development was the trigger for the concept of reterritorialization.

In recent times, the concept of reterritorialization has developed quite a lot, and it can even be said that it is almost proportional to the development of photovoltaic and wind farms, a concept that refers to the use of the space around photovoltaic panels or wind turbines for agricultural crops or other complementary purposes, which leads to a reterritorialization of land. The agrophotovoltaic model involves the integration of photovoltaic panels with agricultural activities on the same land, optimizing both uses. By implementing crops between photovoltaic panels, land that is no longer used for agriculture can be revitalized, through partial reterritorialization. This approach combines green energy production with agricultural activities, contributing to efficient land use and improving sustainability.

There are three main arguments in support of supporting the implementation of this concept. The first is of an economic nature and refers to an additional earning potential for the owner of the transport facility or the owner of the land depending on the form of investment or association. This additional activity cannot bring as much profitability as energy production (at least at this time and economic context), but being an additional benefit, it cannot be ignored by the business environment, as it creates the symbiosis necessary for the economy.

The second argument is that of social responsibility, given that through the investments made, lands that were otherwise cultivated by locals, worked by them, were removed from the agricultural circuit, leaving them without gainful activity and in most cases there can be no talk of their reformation for reintegration into the labor market, whether it is about age, training or access to qualification methods.

The third element, even if it is generally not so publicly exposed, is very important because it represents the image that the respective investor has in the area, the better it is, the greater its influence will be. It is generated by the second argument and also potentiates the second argument.

Identifying **statistical-econometric models** applicable to the reterritorialization of land, agri-food strategies and markets involves, as in any study, several stages, starting from the collection and preparation of data to the selection and calibration of the most appropriate econometric models. The purpose of these models is to analyze and predict the impact of changes on markets and land use, providing decision-makers with information to optimize agri-food strategies.

For this, we can define five main stages.

The first stage is the clear definition of the objectives and key variables. Before choosing or developing a model, it is necessary to establish as clearly as possible at least the following identified aspects. Two questions to establish this first stage would be:

1. What does the model want to measure?

For example:

- Agricultural productivity as a function of reterritorialization?
- Impact on agri-food markets?
- Land use efficiency for crops and renewable energy?

2. What are the independent and dependent variables?

- For example, the crop yield (dependent variable) can and certainly is influenced (but it will be important to identify to what extent) by independent variables such as soil type, climatic conditions, distance between photovoltaic panels, degree of shading, food market prices, and changes in subsidy policies..

The second stage is identified for the collection of relevant data. Here, the quality and availability of data is a critical factor in the development of reliable econometric models. The data must be detailed, complete and cover all relevant variables. We have generically identified several essential data sets for the study as necessary for this study.

- *Economic data* where we include data on the prices of agri-food products on local, regional and even international markets, if applicable. At the same time, the evolution of demand and supply for various agricultural products. Data on current and future subsidies and existing public policies in the agri-food field at regional, national or international level, in our case mainly European strategies.
- *Agricultural data* regarding the yields of agricultural crops under various reterritorialization scenarios (soil type, crop type, shading due to photovoltaic panels, etc.). Investment / work volume/ labor costs / profitability ratio. Climate models that can influence productivity are absolutely necessary in conjunction with the production of potential extreme phenomena.
- *Data on renewable energy* containing the capacity and efficiency of photovoltaic panels integrated with agricultural activities. If the introduction of agricultural production reduces the return on investment. Costs and revenues from green energy production. Possibly efficiency ratios after the integration of agricultural activities
- *Demographic and socio-economic data* on demographic changes in rural areas affected by reterritorialization. Income generated by different types of agricultural and energy exploitation. Employment level in agriculture and green energy.

The third step is identified as the choice of an appropriate econometric model. Econometric models vary depending on the complexity of the phenomenon being studied and the type of data available. The most commonly used models for the analysis of agri-food strategies that can also be used in the case of reterritorialization include:

- Multiple regressions where we potentially include linear or nonlinear regression models that can analyze the relationship between dependent variables such as agricultural productivity and independent variables such as environmental conditions, the distance between photovoltaic panels and their mounting height or the price on agri-food markets. Logistic regressions are also a variant to consider for analyzing the resulting data. It can also be evaluated how changes in a certain variable such as agricultural subsidies will influence economic and agricultural results.
- Efficiency analysis models (DEA or SFA), Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) are useful for measuring the economic efficiency of reterritorialization in relation to conventional land use. These models allow the comparison of different production units such as farms or territorial units, i.e. regions, to determine which of them uses resources most efficiently.

- Time series models such as Autoregressive Integrated Moving Average (ARIMA) or Vector Autoregressive (VAR) can be used to forecast the evolution of agricultural or energy prices over time, depending on specific trends and factors affecting demand and supply.
- Computational economic models (CGE), Computable General Equilibrium simulate the interactions between different economic sectors, including agriculture and energy. These models are useful for assessing the macroeconomic impact or response of land reterritorialization on the entire economy and supply chains. These are also known as AGE (applied general equilibrium) models.

Testing economic hypotheses and calibrating results would be **the fourth stage** when once one or more models have been identified and selected, depending on the resulting data, they must be tested and calibrated based on the data collected. The steps in this stage include:

- Testing econometric hypotheses because econometric models need prior testing to verify that they meet certain statistical assumptions, such as homoscedasticity, lack of multicollinearity and normality of errors.
- Calibrating models because models must be adjusted to reflect the reality of local and regional agri-food markets, as well as the specific characteristics of the region studied; here, we can mention as an example, soil conditions and climatic conditions.
- Validating the model which is essential and is done by using different data sets to validate the model and verifying whether it can correctly predict economic outcomes in the short and long term..

The fifth stage aims at interpreting the results and formulating public policies. After applying the selected models, one can proceed to interpreting the results and formulating public policy strategies. The econometric results can highlight which are the most efficient agricultural practices in the context of reterritorialization or how the combination of agricultural production and renewable energy production can be optimized, or another solution such as how subsidies and policies should be adjusted to stimulate optimal land use. However, an important result is to find out the impact of reterritorialization on agri-food markets, especially on prices and demand on the local and regional market.

There is practically a sixth stage, not being mentioned as an initial stage in identifying statistical-econometric models applicable for the reterritorialization of agri-food strategies and markets, it is practically a subsequent stage aimed at calibrating and adjusting the models in the long term, because the models must be recalibrated periodically to reflect changes in real data, climatic, economic and political changes. With the accumulation of additional data and changing conditions on agri-food markets, the models can and must be adjusted to provide more precise predictions and recommendations.

Conclusions

To identify applicable statistical-econometric models for land reterritorialization, agri-food strategies and markets, a systematic approach is required that includes the collection of relevant economic, agricultural and socio-demographic data, followed by the selection of appropriate econometric models, such as multiple regressions, efficiency models (DEA or SFA), time series and computational models, after which the testing, calibration and validation of the models will be needed to obtain accurate predictions, and finally the interpretation of the results to support decisions on public policies and sustainable development strategies.

This process will contribute to the optimization of reterritorialization and the efficient use of land for agriculture and renewable energy production. However, the current political and economic context makes it quite difficult to sustain the pace of development in this industry.

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