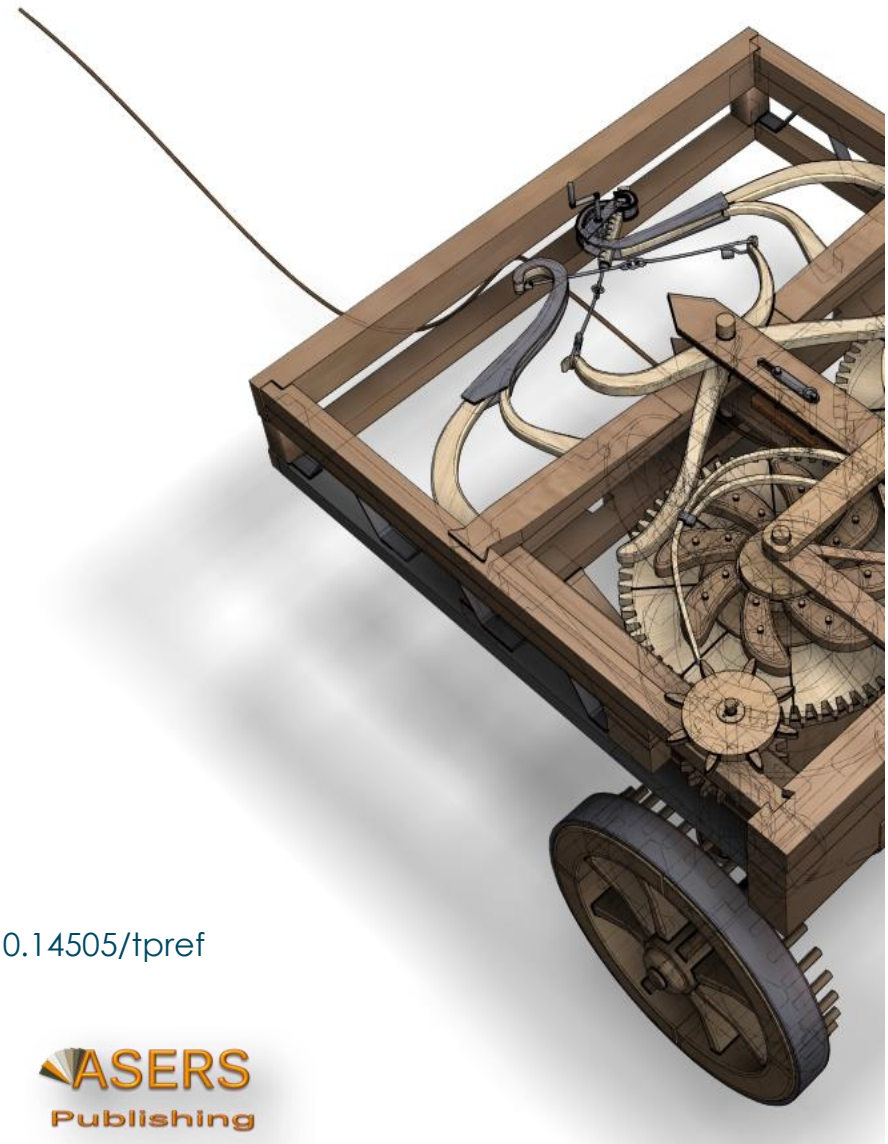
# Theoretical and Practical Research in Economic Fields



Quarterly
Volume XVI
Issue 3(35)
Fall 2025

**ISSN**: 2068 – 7710
**Journal DOI**: https://doi.org/10.14505/tpref

ASERS
Publishing

Volume XVI
Issue 3(35)
Fall 2025



**ASERS Publishing**
ISSN 2068 – 7710
Journal's Issue DOI:
https://doi.org/10.14505/tpref.v16.3(35).00

## Table of Contents

Volume XVI
Issue 3(35)
Fall 2025



**ASERS Publishing**
http://www.asers.eu/asers-publishing
ISSN 2068 – 7710
Journal's Issue DOI:
https://doi.org/10.14505/tpref.v16.3(35).00

# Call for Papers
# Winter Issue
# Theoretical and Practical Research in Economic Fields

Many economists today are concerned by the proliferation of journals and the concomitant labyrinth of research to be conquered in order to reach the specific information they require. To combat this tendency, **Theoretical and Practical Research in Economic Fields** has been conceived and designed outside the realm of the traditional economics journal. It consists of concise communications that provide a means of rapid and efficient dissemination of new results, models, and methods in all fields of economic research.

**Theoretical and Practical Research in Economic Fields** publishes original articles in all branches of economics – theoretical and practical, abstract, and applied, providing wide-ranging coverage across the subject area.

Journals promote research that aim at the unification of the theoretical-quantitative and the empirical-quantitative approach to economic problems and that are penetrated by constructive and rigorous thinking. It explores a unique range of topics from the frontier of theoretical developments in many new and important areas, to research on current and applied economic problems, to methodologically innovative, theoretical, and applied studies in economics. The interaction between practical work and economic policy is an important feature of the journal.

**Theoretical and Practical Research in Economic Fields** is indexed in Scopus, RePec, ProQuest, Cabell Directories and CEEOL databases.

The primary aim of the Journal has been and remains the provision of a forum for the dissemination of a variety of international issues, practical research, and other matters of interest to researchers and practitioners in a diversity of subject areas linked to the broad theme of economic sciences.

At the same time, the journal encourages the interdisciplinary approach within economic sciences, this being a challenge for all researchers.

The advisory board of the journal includes distinguished scholars who have fruitfully straddled disciplinary boundaries in their academic research.

All the papers will be first considered by the Editors for general relevance, originality, and significance. If accepted for review, papers will then be subject to double blind peer review.

| | |
|---|---|
| **Deadline for submission of proposals**: | 10th of November 2025 |
| **Expected publication date**: | 30th of December 2025 |
| **Website**: | http://journals.aserspublishing.eu/tpref |
| **E-mail**: | tpref@aserspublishing.eu |

To prepare your paper for submission, please see full author guidelines in the following file: https://journals.aserspublishing.eu/tpref/Template_for_Authors_TPREF.docx on our site.

Volume XVI, Issue 3(35), Fall 2025

DOI: https://doi.org/10.14505/tpref.v16.3(35).04

# Spillover Effects of CAP Greening Measures on the Economy and Biodiversity of Regional Europe: Evidence from Greece

Alexandros GKATSIKOS
Department of Business Administration
University of Thessaly, Greece
ORCID: 0000-0001-8235-0554
agkatsikos@uth.gr

**Article info:** Received 15 June 2025; Received in revised form 28 June 2025; Accepted for publication 27 July 2025; Published 30 September 2025. 

**Abstract:** This study investigates the impact of the 2013 CAP reform related to green payments on the economy and biodiversity of rural Greece. As the literature had addressed only the impact on the agricultural sector, a regional input-output model was constructed to capture the direct and indirect effects of CAP greening on output, income and employment generation for a NUTS-2 region throughout the last implementation period 2013-2020. Input-output modelling was selected for impact analysis as it is suitable for short- and mid-term evaluations in a quick and easy manner. The Shannon's diversity and evenness indices (SDI, SEI) were estimated to determine the effect of green payments on crop diversification in the studied period. Empirical results imply that while farmers' net income decreased, green payments had a minor, yet positive, spillover effect on the regional economy and record on average 0.86% output growth, 0.65% income increase, and 0.43% more jobs created. Additionally, jobs created due to CAP greening provided resilience and a standard share of total regional employment, especially in times of crisis. The main goal of biodiversity increase is slightly achieved as SDI and SEI increased by 7.6% from 2016 to 2019. Further research is needed on the dispersion of income of Common Agricultural Policy payments in rural areas, particularly for those vulnerable to climate change.

**Keywords:** regional economic impact; CAP greening; spillover; biodiversity indicators; input-output model.

**JEL Classification:** C67; Q18; Q57; R15; A13.

## Introduction

The 2013 reform of the EU Common Agricultural Policy (CAP) introduced green payments to incentivize environmentally friendly farming practices across Member States. While the ecological rationale behind these payments - such as crop diversification, ecological focus areas, and grassland maintenance - is well established, empirical evidence of their broader economic and environmental impacts remains limited. Existing studies have focused predominantly on the direct agricultural effects at the national or EU level, often using simulation models like CAPRI (Gocht *et al.* 2017; Louhichi *et al.* 2018).

However, few studies evaluate the real-world, regional-level spillover effects of green payments on income, employment, and biodiversity - particularly in Southern Europe where small-scale farms dominate and compliance is uneven. This study addresses that gap by employing a regional input–output model for Thessaly (Greece), assessing how CAP greening influenced not only agriculture but also the wider economy during 2013–2020.

We further integrate field-based biodiversity metrics, namely Shannon's diversity and evenness indices, to capture environmental outcomes often missed in macroeconomic simulations. By combining economic and ecological indicators in a regional context, the paper offers novel insights for more targeted and efficient CAP policy design.

## 1. Literature Review

Ever since the 2013 CAP reform, ecological practices and related payments have been incorporated as a standard for European agricultural policy. Few studies pinpoint the importance of biodiversity in the economic cycle (Ando, 2022; Barbier, 2022) and the notion behind this shift towards environmentally friendly agriculture is justified by the need for crop resilience, food security, biodiversity conservation, climate change mitigation and

farmers' support. The introduction of the "green payments" was the main novelty of the last period and the subject has attracted the attention of academics from the beginning of its implementation (Matthews, 2013; Singh, Marchis and Capri, 2014; Erjavec and Erjavec, 2015). Beneficiaries had to meet three key obligations to receive this payment (European Commission, 2013): i) crop diversification, namely grow at least two crops for farms with more than 10 ha and at least three crops for farms with more than 30 ha, b) maintain permanent grassland with the ratio of pasture to agricultural land being flexible per Member-State and iii) maintain an Ecological Focus Area (EFA) within the agricultural holdings of 15 ha and more; the ratio was set at 5% per holding and EFAs included fallow land, landscape features (hedges, terraces, etc.), afforested areas and nitrogen-fixing crops (legumes, alfalfa, clover etc.).

It should be noted that this scheme affects a portion of the Member-States (MS) as southern countries such as Malta (1 percent), Cyprus (18 percent), Greece (22 percent) and Italy (27 percent) report little compliance with the measure as land is scattered in small farms below 10 ha and were not obliged to CAP greening (Louhichi *et al.* 2018); the fragmentation of land in such small holdings increases crop diversification de facto. Therefore, the impact of green payments on the agricultural sector is explored in a handful of studies either at national or regional levels (Sauquet, 2022; Jezierska-Thöle *et al.* 2022; Díaz-Poblete *et al.* 2021) with ambiguous results (Dupraz and Guyomard, 2019).

The majority of studies focuses on the effects of the newly implemented CAP payments on the agricultural sector that include economic benefits such as land use change, income increase (Louhichi *et al.* 2018; Lakner and Oppermann, 2018), environmental gains such as greenhouse gas emissions reduction (Solazzo *et al.* 2016) and biodiversity conservation (Birkhofer *et al.* 2018) or mixed studies that address both economic and environmental perspectives (Bertoni *et al.* 2021; Gocht *et al.* 2017). Results so far suggest that the green payments have little effect on the economic structure of the European agricultural sector and the well-being of farmers.

Although farmers' income is slightly increased in various cases at national (Díaz-Poblete *et al.* 2021), regional (Louhichi *et al.* 2018) and EU-wide level (Gocht *et al.* 2017), the heterogeneity of farms within regions of the same country did not allow for a consensus on the impact of CAP greening (Jezierska-Thöle *et al.* 2022; Hristov *et al.* 2020; Cortignani *et al.* 2018). In some cases, the measure has augmented biodiversity conservation (Sauquet, 2022; Pardo *et al.* 2020) and achieved its goal through crop diversification, fallow land, EFA adoption, etc. but failed to significantly affect farmers attitude towards sustainable farming practices (Gaymard, Goujon and Lefebvre, 2020; Mili, Judez and De Andres, 2017) and reported ecological benefits are attributed to crop diversification and their diminished input requirements (Cortignani, Severini and Dono, 2017; Cortignani and Dono, 2015).

As stated previously, the heterogeneity among territories does not allow for safe and widespread conclusions, thus targeted studies are required to determine the effectiveness, the pitfalls and potential of the CAP greening. Lakner and Oppermann (2018) argue for the regional assessment of green payments to increase the efficiency of intended policies in conjunction with early evidence from Díaz and Concepción (2016) that acknowledged this need.

Nonetheless, more recent studies highlight mixed results, particularly in Southern Member States, where post-2020 CAP evaluations have failed to provide conclusive evidence of improved biodiversity or enhanced environmental sustainability (Sotte and Arcuri, 2025). Similarly, Pe'er *et al.* (2022) argue that the Greening measures delivered limited biodiversity gains across the EU and advocate for a fundamental restructuring of the CAP in the 2023–2027 programming period. On the contrary, other scholars report that the crop diversification criterion for EU payments and pro-environmental policy measures resulted in increased biodiversity and enhanced environmental performance of the farms (Brutti *et al.* 2025; Diop and Védrine, 2025; Rudnicki *et al.* 2023).

One of the most comprehensive simulation efforts to date has been conducted through the Common Agricultural Policy Regionalised Impact model (CAPRI), developed by the European Commission's Joint Research Centre (JRC). Gocht *et al.* (2016) apply a partial equilibrium approach to evaluate the impacts of CAP reform across EU Member States and regions. It assesses a wide range of outcomes including changes in land use, production patterns, prices, greenhouse gas emissions, and biodiversity indicators - typically represented through indices such as Shannon diversity or biodiversity-friendly farming practice (BFP) scores. Although highly useful at the EU scale, the CAPRI model has been limited in its ability to capture economic spillovers at sub-national levels and to evaluate resilience effects during economic downturns. Moreover, CAPRI simulations are largely predictive or counterfactual in nature, whereas there remains a significant need for empirical, ex post evaluations of the actual effects of greening measures on local economies and ecosystems study. However, as

with most studies, this tool focuses only on the farming sector and the generated effects and neglects the indirect impact of greening measures even at the regional level (Bertoni *et al.* 2021).

## 2. Materials and Methods

### 2.1 Economic Assessment

The Input-Output analysis is a widely applied methodology for impact assessment purposes that has gained prominence among scholars for its versatility that extends from environmental issues such as energy consumption (Ueda, 2022), greenhouse gas emissions (Akpan *et al.* 2015) and natural resources consumption (Gkatsikos and Mattas, 2021) to policy evaluation and particularly CAP measures implementation; especially for regional territories in Greece (Karelakis *et al.* 2019; Loizou *et al.* 2019). The method connects linearly the sectoral output and final demand (Leontief, 1936, 1941) hence allowing for impact assessment through the utilization of multipliers. These indicators are valuable for they estimate the effect of an exogenous change in final demand such as household spending, foreign investments and government payments (in our case CAP greening payments) on the whole economy.

A symmetric table or square matrix describes the structure of an economy where rows represent the output of each sector that is distributed to the rest of the economy and columns represent the inputs required by each sector to produce its output (Miller and Blair, 2009). The ratio of an input for a given sector over the total output of this sector, known as the technical coefficient, forms the basic linear equation as in Equation (1):

$$X = AX + F \tag{1}$$

As the final demand is considered exogenous for impact assessment purposes, Equation (1) is solved with regard to X and can be written as:

$$x = (I - A)^{-1} \times f, |I - A| \neq 0 \tag{2}$$

where $(I - A)^{-1}$ is the Leontief inverse matrix and describes the total requirements (direct and indirect) of an economy to produce its total output given a specific final demand.

The related input-output multipliers and elasticities are estimated based on the Leontief inverse to account for policy measure evaluation and impact analysis; further notice can be found in (Miller and Blair, 2009). Since there is no available I-O table for the study area, we constructed a regional I-O by adapting the National I-O table of Greece by applying a technique known as GRIT (Gkatsikos *et al.* 2022) based on Mattas *et al.* (2006).

### 2.1 Environmental Assessment and Biodiversity

As one of the targets for the greening measure was to increase the number of species cultivated this study will examine its success with the use of the well-known Shannon's diversity index (Shannon, 1948) that can be applied in various fields from wild animal dispersion (Evans and Potts, 2015) to agricultural land use (Wąs, Zawalińska and Britz, 2014). A lot of studies have assessed changes in crop biodiversity as a result of CAP measures with Shannon's diversity (SDI) and evenness (SEI) indices (Dabkiene, Balezentis and Streimikiene, 2021; Pardo *et al.* 2020; Lazíková *et al.* 2019; Mahy *et al.* 2015) and is even acknowledged by Eurostat. The index estimates the proportion of different species in a single dataset. In our study the species are the selected crops, and the dataset refers to total cultivated land in the Region of Thessaly. The Shannon's diversity index (SDI) is expressed mathematically as:

$$H_s = -\sum_{i=1}^{s} p_i \times ln(p_i) \tag{3}$$

where $H_s$ is the Shannon's diversity index, s is the number of crops observed in the dataset, and $p_i$ is the proportion of hectares of one particular species (n) divided by the total hectares of crop production (N). As SDI does not have specific boundaries, a more interpretable and comparable index is estimated to measure the evenness of species in the study area known as the Shannon's evenness index (SEI) that is expressed as:

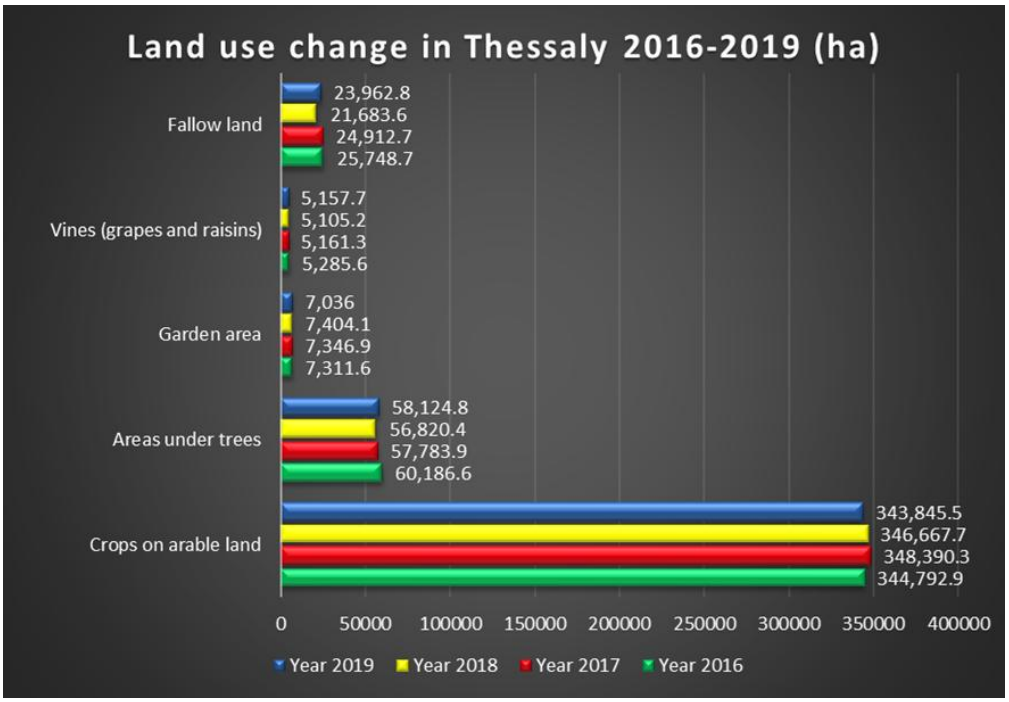
$$E_H = \frac{H_s}{H_{max}}, \qquad H_{max} = \ln s \tag{4}$$

SEI takes values between 0 and 1 with 1 indicating that all species are evenly allocated in the study area.

## 2.3 Profile of Study Area

Thessaly (NUTS-2 region), located in central Greece, is commonly referred to as Greece's "breadbasket." The area is a significant food producer, with cereal grown and cattle bred in the central plain and sheep and goats bred in surrounding mountains (Pindos, Mt Olympus, Mt Pelion). The Region of Thessaly is one of the 13 administrative Regions of Greece and produces 5% of national GDP. Agriculture is the main employer in the area with 20.8% of total employment being farmers and the significance of the primary sector is demonstrated by its 12% of total gross added value share in the regional economy (ELSTAT, 2019a, 2019b).

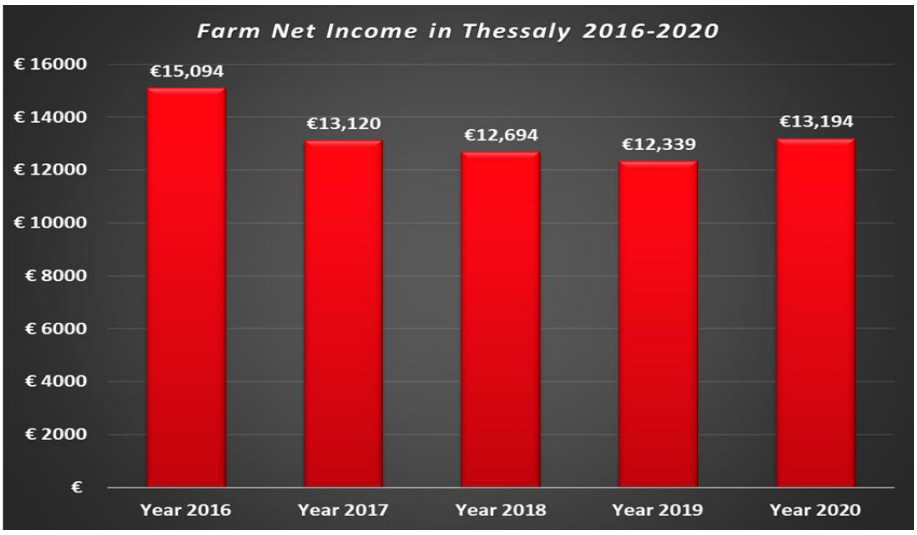
Figure 1. Land use change in Thessaly 2016-2019




*Source*: (ELSTAT, 2019c)

Land use is dominated by arable crops with a modest cultivation of trees. During the implementation of the CAP greening policy no significant changes have occurred in the structure of cultivated land (see Figure 1). The 2013 reform and its initial evidence denote a net income reduction for farmers in Thessaly by 12.6%. From an annual average of €15,094, the net farmer's income reduces to €13,194 marking a contradictory change to studies reviewed in the first chapter, where the green payments increased slightly the income of farmers (see Figure 2).

Figure 2. Farmer's net income in Thessaly




*Source*: (FADN, 2022)

### 2.4 Data

The latest available National Input-Output Table for Greece (2015), set at 64x64 sectoral size, was used to apply the GRIT technique to construct the regional model; employment data that were used to calibrate the national table and construct the regional one was obtained from the National Statistics Service. Data for the CAP greening payments for Thessaly for the years 2018, 2019 and 2020 were available and were obtained from the Greek Payment Authority of Common Agricultural Policy Aid Schemes (OPEKEPE) to be used for the impact analysis. For the estimation of the diversity indices (SDI, SEI) the Annual Farm Surveys for 2016 and 2019 were utilized to explore the crop diversification in Thessaly after the implementation of CAP greening.

## 3. Research Results

The first part of this chapter demonstrates the key multipliers and elasticities for the Region of Thessaly; the second part illustrates the results of the impact analysis associated to the green payments for 2016-2020 and the last part reveals the crop diversification changes from 2016 to 2019.

### 3.1 Analysis of the Economy of Thessaly

#### *Multiplier-Based Analysis for Thessaly*

The results of the calculation of output, income, and employment multipliers, depicted in Table 1, reveal the apparent dependence of the region of Thessaly on manufacturing sectors rather than services and agri-food sectors, with few exceptions for growth in terms of welfare indicators such as income and employment.

Textiles, wearing apparel, and leather products appear to be the most significant industry within Thessaly's economy in terms of output multipliers, with a positive stimulation of the final demand by one million euros generating almost triple the output (2.836). The sector is followed by Rubber and other non-metallic products (2.020), Wood, paper, and printing (1.920), Furniture and other manufactured goods (1.905), and the Petroleum and pharmaceuticals industry (1.881). To recap, the most impactful sectors in terms of output multipliers appear to be all related to manufacturing in the region of Thessaly.

Table 1. Key I-O multipliers for the Region of Thessaly

| Sector | Output | R | Income | R | Employment | R |
|---|---|---|---|---|---|---|
| Agriculture, hunting & related services | 1.492 | 19 | 1.839 | 15 | 1.223 | 24 |
| Forestry, logging, and related services | 1.258 | 26 | 1.171 | 25 | 1.144 | 28 |
| Fish and other fishing products | 1.596 | 14 | 3.490 | 5 | 3.456 | 19 |
| Food products, beverages and tobacco | 1.827 | 8 | 1.880 | 14 | 3.397 | 4 |
| Textiles, wearing apparel and leather | 2.836 | 1 | 4.078 | 1 | 2.964 | 5 |
| Wood, paper, printing | 1.920 | 3 | 2.363 | 10 | 1.982 | 9 |
| Real estate | 1.053 | 29 | 1.232 | 22 | 3.780 | 1 |
| Petroleum, pharmaceuticals | 1.881 | 5 | 3.490 | 3 | 3.546 | 2 |
| Rubber and other non-metallic | 2.020 | 2 | 2.323 | 11 | 2.076 | 8 |
| Electric, electronics and other equipment | 1.828 | 7 | 3.651 | 2 | 2.841 | 7 |
| Motors and transport equipment | 1.609 | 13 | 3.247 | 4 | 2.901 | 6 |
| Furniture; other manufactured goods | 1.905 | 4 | 3.122 | 6 | 1.724 | 11 |

*Source*: Author's elaboration

It is worth mentioning that of the three primary sectors Forestry, logging, and related services (1.258) is the least impactful and the Fish and other fishing products sector ranks among the top five in terms of income multipliers in Thessaly's economy with a multiplier of 3.160. Finally, Food products, beverages and tobacco products ranked 8th in terms of output multiplier (1.827). More interestingly, products of Agriculture, hunting, and related services ranked 19th with an output multiplier of 1.492. In other words, a one-million-dollar stimulation of final demand for agricultural products boosts the output by 1.492 times in the region of Thessaly.

Regarding income generation, the Food products, beverages, and tobacco sectors and products of Agriculture, hunting, and related services ranked 14th and 15th in terms of their multiplier, with a one-million-euro stimulation of final demand generating 1.880 1.839 times more income, respectively. In terms of the employment multiplier effect, the Real estate activities and imputed rents sector ranked first with a multiplier amounting to 3.780. In other words, the sector generates 3.780 times more jobs for a one-million-dollar stimulus of final

demand for its products. The rest of the top five, in order, are Petroleum and Pharmaceutical (3.546), Mining and Quarrying (3.467), interestingly, Food products, Beverages, and Tobacco products (3.397), and Textile, Wearing apparel, and Leather products (2.964). Nevertheless, it is interesting to see the food products sector ranking fourth in the economy of Thessaly with such a powerful multiplier effect on employment. Products of Agriculture, hunting, and related services ranked 24th out of the 30 sectors with an employment multiplier of 1.223.

The sector of products of Agriculture, hunting, and related services in Thessaly ranked 19th in terms of the output multiplier (1.492), 15th in terms of the income multiplier (1.839), and 24th in terms of the employment multiplier (1.223). Based on that, the sector may rank around 18th in terms of its overall multiplier effect. On the other hand, Food products, beverages, and tobacco products ranked 8th in terms of the output multiplier (1.827), 14th in terms of the income multiplier (1.880), and 4th in the employment multiplier. Based on that, the sector is estimated to be ranked 6th in terms of its overall multiplier effect on output, income, and employment.

### *Elasticity Based Analysis for Thessaly*

Contrary to the results of the multiplier-based analysis in which manufacturing industries dominated the regional economy of Thessaly in terms of impact, the output, income, and employment elasticities (Table 2) show the high impact of some tertiary sectors such as trade, real estate, and public administration services on the region's economy which was not clear in the previous analysis.

The Real estate and Food, beverages, and tobacco sectors ranked first and second in all three types of elasticities in the Thessalian economy. A 1% increase in the final demand for the Real estate will generate 0.208%, 0.206%, 0.294% (output, income, employment) and Food, beverages and tobacco products 0.106%, 0.098%, and 0.160% (output, income, employment) increases in Thessaly, respectively.

Table 2. Key I-O elasticities for the Region of Thessaly

| Sector | Output | R | Income | R | Employment | R |
|---|---|---|---|---|---|---|
| Agriculture, hunting & related services | 0.052 | 7 | 0.065 | 11 | 0.043 | 10 |
| Food products, beverages and tobacco | 0.106 | 2 | 0.098 | 2 | 0.160 | 2 |
| Petroleum, pharmaceuticals | 0.047 | 8 | 0.081 | 6 | 0.084 | 3 |
| Motors and transport equipment | 0.027 | 12 | 0.093 | 3 | 0.079 | 4 |
| Trade | 0.084 | 3 | 0.063 | 12 | 0.060 | 8 |
| Transport,warehouse, postal services | 0.062 | 6 | 0.073 | 8 | 0.062 | 7 |
| Accommodation and food services | 0.074 | 4 | 0.090 | 4 | 0.070 | 5 |
| Real estate activities and imputed rents | 0.208 | 1 | 0.206 | 1 | 0.294 | 1 |
| Public administration and defense services | 0.069 | 5 | 0.060 | 13 | 0.067 | 6 |
| Health and Social work | 0.042 | 9 | 0.039 | 16 | 0.039 | 11 |

*Source*: Author's elaboration

Interestingly, products of the "Agriculture, hunting, and related services" sector ranked 7th in terms of output elasticity (0.052). In other words, a 1% increase in the final demand for the agriculture sectors induces a 0.052% increase in total output. On the other hand, the Fish and other fishing products and related services and Repair and installation services of machinery and equipment sectors ranked last in terms of output elasticity with 0.001% elasticity for both.

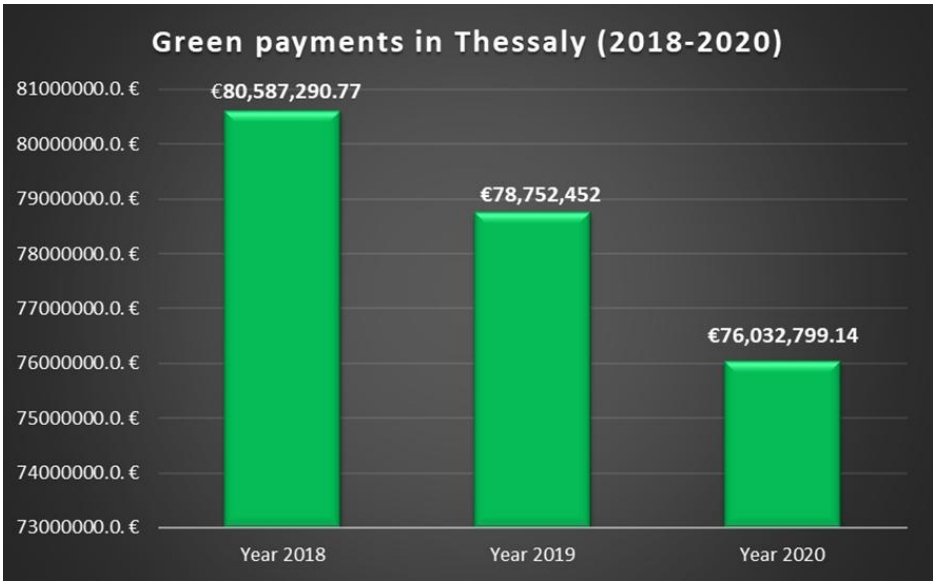
Products of Agriculture, hunting, and related services sector ranked 11th in terms of income elasticity (0.065). In other words, a 1% increase in the final demand for the agriculture sector induces a 0.065% increase in total income, while they ranked 10th in terms of employment elasticity (0.043). In other words, a 1% increase in the final demand for the agriculture sector induces a 0.043% increase in total employment. On the other hand, the Wood, paper, printing, and products of Forestry, logging, and related services sectors ranked last in terms of employment elasticity, with elasticities of 0.009% and 0.006%.

## 3.2 Impact Analysis of the Green Payments on the Thessalian Economy

The impact analysis is based mainly on the utilization of the multipliers and elasticities calculated for the region of Thessaly based on its regional input-output table. In this analysis, we refer to the payments made to farmers who benefited from green payments as being the exogenous shock within the studied economy. The final demand for agricultural products in the region of Thessaly has been estimated at €786,102,220.8 and the economy of

Thessaly generated a total output of €22,556.63 million, a total income of €3,155.718 million, and total employment of 256,574 people.

Figure 3. Green payments in Thessaly (2018-2020)




*Source*: Author's elaboration derived from OPEKEPE.

The amounts of green payments made in Thessaly between 2018 and 2020 totaled €235,715,715.52 and are depicted in Figure 3. The payments were provided to 63,154, 62,927, and 62,821 beneficiaries in 2018, 2019, and 2020, respectively. Data reveals a diminishing trend both for beneficiaries and green payments throughout the studied timeline.

### *Multiplier-based impact analysis*

The multiplier-based impact analysis reveals that in 2018, the total output increased by €120,236,332.1 plus the initial amount of the green payments, while the total income increased by €148,200,027.71, and 99 jobs were created in Thessaly as a result of the exogenous shock of the green payments. In 2019, the total output increased by €117,498,751.52 plus the initial amount of the green payments, while total income increased by €144,825,759.23, and 96 jobs were created in Thessaly as a result of the exogenous shock of the green payments. The total amount of green payments for 2019 amounted to 10.02% of the final demand of the model. Finally, in 2020, the total output increased by €113,953,041.72 plus the initial amount of the green payments, while total income increased by €140,455,413.91, and 93 jobs were created in Thessaly as a result of the exogenous shock of the green payments (Table 3). The total amount of green payments for 2020 amounted to 9.72% of the final demand of the model.

Overall, over the three years, green payments led to an accumulative direct and indirect increase in total output by €587,060,667.24, total income by €433,481,200.85, and the creation of 288 jobs during the three years studied.

Table 3. Multiplier effects of Green Payments in Thessaly

| I-O Multiplier effect in Region of Thessaly | | | |
|---|---|---|---|
| **Year** | **Output** | **Income** | **Employment** |
| **2018** | € 120,236,332.1 | € 148,200,027.7 | 99 |
| **2019** | € 117,498,751.5 | € 144,825,759.2 | 96 |
| **2020** | € 113,953,041.7 | € 140,455,413.9 | 93 |

*Source*: Author's elaboration

### *Elasticity-based impact analysis*

Based on the available data, the number of green payments made in 2018, 2019, and 2020 correspond to 10.25%, 10.02%, and 9.72% of the final demand for agricultural products in the region of Thessaly, respectively. Based on the latter and the elasticities demonstrated previously in the results, in 2018, the green payments led to

a 0.533% increase in total output, a 0.668% increase in total income, and a 0.441% increase in employment. Translating those proportions into euros, the results indicate an indirect increase of total output by €120,226,837.90, an increase in total income by €21,080,196.24, and 1,131 new jobs. By the same approach, the green payments in 2019 increased total output indirectly by 0.521% (€117,520,042.30), generating 0.653% more total income (€23,235,672.42), and 1,106 new jobs. Finally, the green payments in 2020 indirectly increased total output by 0.505% (€113,910,981.50), generating 0.633% more total income (€19,975,694.94) and 1,072 new jobs (see Table 4). Overall, according to the elasticity-based analysis, the green payments over the three years generated €587,030,403.60 more total output, €61,662,729.72 more total income, and 3309 new jobs in the Region of Thessaly.

Tabel 4. I-O Elasticity effect in Region of Thessaly

| I-O Elasticity effect in Region of Thessaly | | | |
|---|---|---|---|
| Year | Output | Income | Employment |
| 2018 | € 120,226,837.9 | € 21,080,196.2 | 1131 |
| 2019 | € 117,520,042.3 | € 20,606,838.5 | 1106 |
| 2020 | € 113,910,981.5 | € 19,975,694.9 | 1072 |

Especially for employment as total jobs decreased in the same period for the Region of Thessaly at a rate of 1.79%, the jobs created due to CAP greening were 1,103 on average and consisted 0.38% of total employment, thus abating unemployment phenomena, and offering resilience in the economy in times of crisis.

### *Land use change and biodiversity*

Crop biodiversity increased during the first CAP greening period. The Shannon's diversity index was estimated at 2.622 in 2016 and at 2.821 in 2019 which indicates that there were more species cultivated in total agricultural land. Additionally, the normalized Shannon's evenness index was estimated at 0.581 in 2016 and at 0.625 in 2019 indicating that not only did the number of species cultivated increased, but their land allocation was more evenly distributed after the implementation of the green payments scheme in the Region of Thessaly.

## 4. Discussion

The findings of this paper contribute to the ongoing discourse surrounding the efficacy of the CAP's greening instruments by offering a regionally disaggregated and empirically grounded evaluation. While studies such as Gocht *et al.* (2017) and Louhichi *et al.* (2018) conducted through the JRC CAPRI framework provided important ex ante projections, this study delivers an ex-post assessment for the Region of Thessaly - a prominent agricultural region in Greece. By utilizing a regional input-output model, we go beyond the CAPRI model's partial equilibrium scope to estimate how green payments ripple through the entire local economy, including the manufacturing, services, and trade sectors. This approach captures both the direct economic benefits to agriculture and the indirect multiplier effects in related industries, which are often underestimated in macro-scale models.

Our estimates reveal modest but positive spillover effects: on average, green payments led to a 0.86% increase in output, a 0.65% rise in income, and 0.43% more employment in Thessaly. These numbers highlight the resilience-enhancing properties of CAP greening in rural regions, particularly under stress conditions such as the COVID-19 pandemic, which is a dimension not considered in CAPRI simulations. Furthermore, while CAPRI includes biodiversity indicators based on modeled land use changes or ecological scores, this paper uses observed field-level data to compute Shannon's biodiversity and evenness indices. Results show a 7.6% increase in crop diversity and a more equitable land allocation among crops over the study period (2016–2019), validating the environmental intent of CAP greening. This lends empirical support to broader findings in the CAPRI literature while also reinforcing the need for field-based biodiversity metrics in policy evaluation frameworks.

Empirical data collected from the FADN database for Thessaly imply that farmer's net income has diminished during the 2016-2020 by 12.6% (see Figure 3), contrary to the literature that argues for a slight increase in farmer's income around 1% (Louhichi *et al.* 2018; Louhichi *et al.* 2017; Gocht *et al.* 2017), and CAP greening could not reverse this negative shift. A possible explanation for this contradiction is that CAP greening is not widely implemented in Greece due to small agricultural holdings that are mostly funded under the Small Farmers scheme, hence all economic benefits are not captured through CAP greening.

Yet, the main goal of the Scheme for crop diversity was achieved through the studied period as the Shannon's diversity index increased by 7.6% between 2016 and 2019 and land allocation of the various species was more equally distributed as illustrated by the evenness index increase. Evidence from other published

studies suggests that this is a controversial issue as land use change is multifactorial and cannot be attributed solely to subsidized farming (Wąs, Zawalińska and Britz, 2014). Rotchés-Ribalta *et al.* (2021) report that agricultural policy measures that seek to increase biodiversity are effective for extensive farming while Dabkiene, Balezentis and Streimikiene (2021) argue that they have a lower impact on more intensive farms such as horticulture. As the study area is dedicated mostly to extensive farming with cotton and cereals dominating cultivated land, it can be concluded that CAP green payments contributed to the increase of crop biodiversity in the region. Moreover, crop diversity increases in regions with high soil fertility as is the study area but may cause an overall decrease at the national level (Lazíková *et al.* 2019). As smallholder farms adopt crop diversification as vital tool for their resilience (Mahy *et al.* 2015) this could be an alternative factor that contributed to local biodiversity increase.

Importantly, the study confirms earlier observations (Bertoni *et al.* 2021; Hristov *et al.* 2020) that while environmental gains may be apparent, economic benefits - especially farmer income - remain limited or even negative in some contexts. In Thessaly, farmers' net income declined by 12.6% during the implementation period, highlighting the disconnect between policy intent and local outcomes. This discrepancy aligns with CAPRI projections that green payments yield only marginal income improvements EU-wide but also underscores the need for region-specific targeting, as suggested by Díaz and Concepción (2016).

## Conclusions and Further Research

This study aimed to assess the ex-post economic impact of the post-2013 CAP green direct payments on the entire economy of the Thessaly area (NUTS-2 region) in Greece. Additionally, crop biodiversity changes were assessed with the estimation of Shannon's biodiversity and evenness indices to unveil the increase or reduction of number of species cultivated in the study area.

The green payments provided in 2018, 2019, and 2020 were used as an exogenous shock in the model to estimate their generated impact on the regional economy. Results suggest that on average, CAP greening generated on average an increase of 0.86%, 0.65%, and 0.43% in the region's total output, income, and employment, respectively. Although it cannot be denied that the CAP green payments have contributed to the economic growth and employment in the Region of Thessaly, it is hard to judge the contribution as being exceptionally significant, considering proportionality. However, results of the study for 2020, during the COVID-19 pandemic, underpin the importance of agriculture as a main employer in rural areas and as a resilient industry for every economy.

Future research should explore the distributional impacts of green payments across farm sizes and production systems, ideally through disaggregated micro-data. Further integration of spatial ecological metrics could also help assess the long-term sustainability of biodiversity gains. Finally, extending the input-output approach to other NUTS-2 regions across Europe could enhance the generalizability of results and inform the design of more equitable and effective CAP instruments under the 2023–2027 programming period.

## Credit Authorship Contribution Statement

**Alexandros Gkatsikos**: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization

## Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Declaration of Use of Generative AI and AI-assisted Technologies

The author declares that he has used generative AI and AI-assisted technologies during the preparation of this work for improving academic language.

## References

[1] Akpan, Uduak S., Ovunda A. Green, Subhes Bhattacharyya, and Salisu Isihak. (2015). Effect of Technology Change on CO 2 Emissions in Japan's Industrial Sectors in the Period 1995 – 2005: An Input – Output Structural Decomposition Analysis. *Environmental and Resource Economics,* 61: 165–89. DOI:https://doi.org/10.1007/s10640-014-9787-7

[2] Ando, Amy W. (2022). Equity and Cost Effectiveness in Valuation and Action Planning to Preserve Biodiversity. *Environmental and Resource Economics*, 83 (4): 999–1015. DOI: 10.1007/s10640-022-00674-1

[3] Barbier, Edward B. (2022). The Policy Implications of the Dasgupta Review: Land Use Change and Biodiversity. *Environmental and Resource Economics,* 83:911–35. DOI: 10.1007/s10640-022-00658-1.

[4] Bertoni, Danilo, *et al.* (2021). Estimating the CAP Greening Effect by Machine Learning Techniques: A Big Data Ex Post Analysis. *Environmental Science and Policy*, 119: 44–53. DOI: 10.1016/j.envsci.2021.01.008

[5] Birkhofer, Klaus, *et al.* (2018). The Contribution of CAP Greening Measures to Conservation Biological Control at Two Spatial Scales. *Agriculture, Ecosystems and Environment,* 255. DOI:10.1016/j.agee.2017.12.026

[6] Brutti, Zelda, Marzia Freo, and Laura Serlenga. (2025). The Causal Effect of Crop Diversification Obligations on Crop Diversity: An EU-Level Analysis. *Ecological Economics*, 237. DOI:10.1016/j.ecolecon.2025.108715

[7] Cortignani, Raffaele, and Gabriele Dono. (2015). Simulation of the Impact of Greening Measures in an Agricultural Area of the Southern Italy. *Land Use Policy,* 48. DOI: 10.1016/j.landusepol.2015.06.028

[8] Cortignani, Raffaele, *et al.* (2018). Green Payment and Perceived Rural Landscape Quality: A Cost-Benefit Analysis in Central Italy. *Sustainability* (Switzerland), 10 (2910). DOI: https://doi.org/10.3390/su10082910

[9] Cortignani, Raffaele, Simone Severini, and Gabriele Dono. (2017). Complying with Greening Practices in the New CAP Direct Payments: An Application on Italian Specialized Arable Farms. *Land Use Policy*, 61: 265–75. DOI*:* https://doi.org/10.1016/j.landusepol.2016.11.026

[10] Dabkiene, Vida, Tomas Balezentis, and Dalia Streimikiene. (2021). Development of Agri-Environmental Footprint Indicator Using the FADN Data: Tracking Development of Sustainable Agricultural Development in Eastern Europe. *Sustainable Production and Consumption*, 27: 2121–33. DOI: 10.1016/j.spc.2021.05.017

[11] Díaz, Mario, and Elena D. Concepción. (2016). Enhancing the Effectiveness of CAP Greening as a Conservation Tool: A Plea for Regional Targeting Considering Landscape Constraints. *Current Landscape Ecology Reports*, 1 (4): 168–77. DOI: https://doi.org/10.1007/s40823-016-0017-6

[12] Díaz-Poblete, Carmelo, María Carmen García-Cortijo, and Juan Sebastián Castillo-Valero. (2021). Is the Greening Instrument a Valid Precedent for the New Green Architecture of the Cap? The Case of Spain. *Sustainability* (Switzerland), 13 (10): 1–11. DOI: https://doi.org/10.3390/su13105705

[13] Diop, Thierno Bocar, and Lionel Védrine. (2025). Did Crop Diversity Criterion from CAP Green Payments Affect Both Economic and Environmental Farm Performances? Quasi-Experimental Evidence from France. *Ecological Economics,* 227:108405. DOI: https://doi.org/https://doi.org/10.1016/j.ecolecon.2024.108405

[14] Dupraz, Pierre, and Hervé Guyomard. (2019). Environment and Climate in the Common Agricultural Policy. *EuroChoices,* 18 (1). DOI: https://doi.org/10.1111/1746-692X.12219

[15] Erjavec, Karmen, and Emil Erjavec. (2015). 'Greening the CAP' - Just a Fashionable Justification? A Discourse Analysis of the 2014-2020 CAP Reform Documents. *Food Policy*, 51. DOI:10.1016/j.foodpol.2014.12.006

[16] Evans, Samuel G, and Matthew D Potts. (2015). Effect of Agricultural Commodity Prices on Species Abundance of US Grassland Birds. *Environmental and Resource Economics,* 62. DOI: 10.1007/s10640-014-9829-1

[17] Gaymard, Sandrine, Boris Goujon, and Marianne Lefebvre. (2020). Adherence to Environmental Regulation in the European Union Common Agricultural Policy: Social Representations and Conditionality among French Farmers. *Journal of Agricultural & Food Information*, 21. DOI: 10.1080/10496505.2020.1772078

[18] Gocht, Alexander, *et al.* (2017). EU-Wide Economic and Environmental Impacts of CAP Greening with High Spatial and Farm-Type Detail. *Journal of Agricultural Economics,* 68 (3). DOI: 10.1111/1477-9552.12217

[19] Hristov, Jordan, *et al.* (2020). Impacts of the EU's Common Agricultural Policy 'Greening' Reform on Agricultural Development, Biodiversity, and Ecosystem Services. *Applied Economic Perspectives and Policy*, 42 (4): 716–38. DOI: https://doi.org/10.1002/aepp.13037

[20] Jezierska-Thöle, Aleksandra, Marta Gwiazdzinska-Goraj, and Małgorzata Dudzínska. (2022). Environmental, Social, and Economic Aspects of the Green Economy in Polish Rural Areas-A Spatial Analysis. *Energies,* 15 (3332). DOI: https://doi.org/10.3390/en15093332

[21] Lakner, Sebastian, and Rainer Oppermann. (2018). A CAP-Reform Model to Strengthen Nature Conservation-Impacts for Farms and for the Public Budget in Germany. *Austrian Journal of Agricultural Economics and Rural Studies*, 27 (17): 129–37. DOI: https://doi.org/10.15203/OEGA_27.17

[22] Lazíková, Jarmila, Anna Bandlerová, Ubica Rumanovská, Ivan Takáč, and Zuzana Lazíková. (2019). Crop Diversity and Common Agricultural Policy-The Case of Slovakia. *Sustainability* (Switzerland), 11: 1416. DOI:https://doi.org/10.3390/su11051416

[23] Louhichi, Kamel, Pavel Ciaian, Maria Espinosa, Angel Perni, and Sergio Gomezy Paloma. (2018). Economic Impacts of CAP Greening: Application of an EU-Wide Individual Farm Model for CAP Analysis (IFM-CAP). *European Review of Agricultural Economics*, 45 (2): 205–38. DOI: https://doi.org/10.1093/erae/jbx029

[24] Mahy, Louis, Bérénice Elisabeth Therese Ismée Dupeux, Guido Van Huylenbroeck, and Jeroen Buysse. 2015. Simulating Farm Level Response to Crop Diversification Policy. *Land Use Policy*, 45: 36–42. DOI:10.1016/j.landusepol.2015.01.003

[25] Matthews, Alan. (2013). Greening Agricultural Payments in the EU's Common Agricultural Policy. *Bio-Based and Applied Economics*, 2 (1): 1–27. DOI*:* https://doi.org/10.13128/BAE-12179

[26] Mili, Samir, Lucinio Judez, and Rosario De Andres. (2017). Investigating the Impacts of EU CAP Reform 2014-20 and Developments in Sustainable Olive Farming Systems. *New Medit*, 16 (3): 2–10.

[27] Pardo, Adara, *et al. (*2020). To What Extent Does the European Common Agricultural Policy Affect Key Landscape Determinants of Biodiversity? *Environmental Science and Policy*, 114 (September): 595–605. DOI: 10.1016/j.envsci.2020.09.023

[28] Pe'er, Guy, *et al. (*2022). How Can the European Common Agricultural Policy Help Halt Biodiversity Loss? Recommendations by over 300 Experts. *Conservation Letters*, 15 (6). DOI: 10.1111/conl.12901

[29] Rotchés-Ribalta, Roser, *et al. (*2021). Assessment of Semi-Natural Habitats and Landscape Features on Irish Farmland: New Insights to Inform EU Common Agricultural Policy Implementation. *Ambio,* 50 (2): 346–359. DOI: 10.1007/s13280-020-01344-6

[30] Rudnicki, Roman, *et al.* (2023). Towards Green Agriculture and Sustainable Development: Pro-Environmental Activity of Farms under the Common Agricultural Policy. *Energies,* 16 (4). DOI:10.3390/en16041770

[31] Sauquet, Alexandre. (2022). Ex Post Analysis of the Crop Diversification Measure of CAP Greening in France. *European Review of Agricultural Economics*, 1–26. DOI: 10.1093/erae/jbac022

[32] Shannon, Claude E. (1948). Mathematical Theory of Communication. *Bell System Technical Journal*, 623–56. DOI: 10.1002/j.1538-7305.1948.tb00917.x

[33] Singh, Manpriet, Alexandru Marchis, and Ettore Capri. (2014). Greening, New Frontiers for Research and Employment in the Agro-Food Sector. *Science of the Total Environment,* 472. DOI:10.1016/j.scitotenv.2013.11.078

[34] Solazzo, Roberto, Michele Donati, Licia Tomasi, and Filippo Arfini. (2016). How Effective Is Greening Policy in Reducing GHG Emissions from Agriculture? Evidence from Italy. *Science of the Total Environment,* 573: 1115–24. DOI: 10.1016/j.scitotenv.2016.08.066

[35] Sotte Franco and Arcuri, Sabrina. (2025). The CAP 2014–2020. In European Agricultural Policy: History and Analysis, edited by Gianluca Sotte Franco and Brunori, 169–94. Cham: Springer Nature Switzerland. DOI:10.1007/978-3-031-83313-7_9

[36] Ueda, Tatsuki. (2022). Structural Decomposition Analysis of Japan's Energy Transitions and Related ¬ CO 2 Emissions in 2005 – 2015 Using a Hybrid Input Output Table. *Environmental and Resource Economics*, 81 (4): 763–86. DOI: 10.1007/s10640-022-00650-9

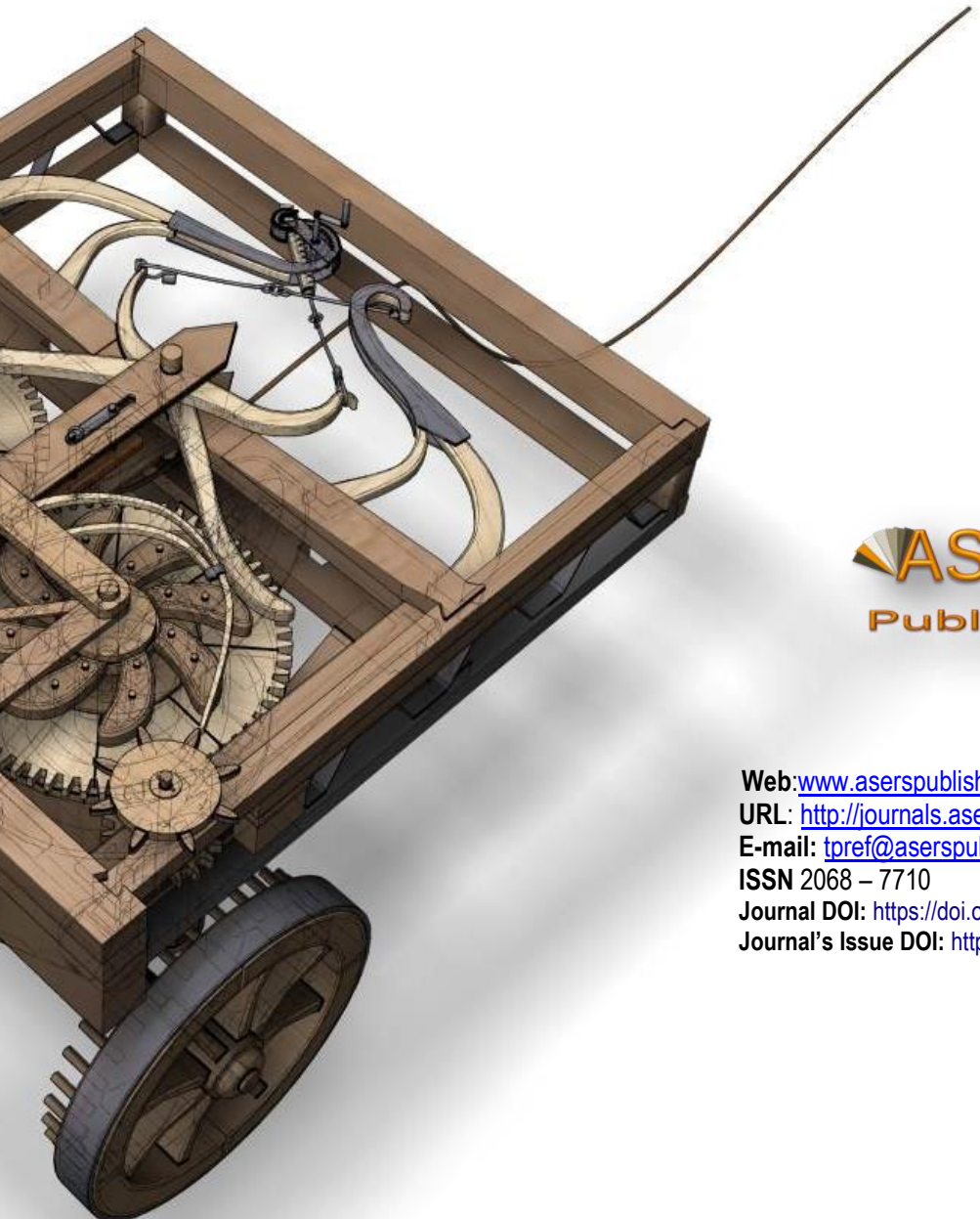
[37] Wąs, Adam, Katarzyna Zawalińska, and Wolfgang Britz. (2014). Agricultural Policy on Sustainability of European Agriculture: From Perspective. *Journal of Agribusiness and Rural Development*, 4 (34): 191–212.

[38] European Commission. (2013). Sustainable Land Use (Greening). https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/greening_en.

[39] European Commission. (2020). "The Business Case for Biodiversity. The European Green Deal." Biodiversity: Finance and the Economic and Business Case for Action. Brussels, Belgium: European Commission. https://ec.europa.eu/commission/presscorner/detail/en/fs_20_907.

[40] FADN. (2022). "Farm Accountancy Data Network." https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html#

ASERS



**Web**:www.aserspublishing.eu
**URL**: http://journals.aserspublishing.eu/tpref
**E-mail:** tpref@aserspublishing.eu
**ISSN** 2068 – 7710
**Journal DOI:** https://doi.org/10.14505/tpref
**Journal's Issue DOI:** https://doi.org/10.14505/tpref.v16.3(35).00