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Examining disparities in common agriculture policy direct payments among farming systems: evidence from Portugal

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Abstract

One of the stated goals of the common agricultural policy reforms has been to provide a fairer distribution of payments across and within member states, but little progress has been accomplished, with about 20% of farmers receiving 80% of the total amount of direct payments. This research aims to investigate the underlying structural factors that contribute to this inequity in Portugal, with a particular focus on farming systems. A logit model was developed using agricultural census data at the commune level, with the percentage of farmers receiving direct payments as the dependent variable. The findings reveal that the local importance of arable crops (cereals) and cattle farming systems, as well as the existence of larger farms and younger farmers, all contributed to farmers' increasing access to direct payments between 2009 and 2019. In traditional Mediterranean farming systems, access to direct payments has been restricted to a smaller proportion of farmers. Nevertheless, it is evident that a certain degree of redistribution took place during the previous programming cycle of the common agricultural policy. This redistribution included a shift in support from larger to smaller farmers, older to younger farmers, and from olives, cereals, and cattle to other farming systems, particularly vineyards.

Keywords: Agricultural censuses, Common agriculture policy, Direct payments, Farming systems, Logit, Portugal, Small farmers

Introduction

The common agricultural policy (CAP) has undergone several reforms since its inception in 1962, shifting its emphasis from product support through prices to producer support through direct payments (DP), with an increasing emphasis on promoting sustainable agriculture, protecting the environment, and supporting rural development. In the 1992 CAP reform, DP were introduced for the first time to compensate farmers for the negative impact of price support reductions. At the time, the amount of DP received by each farmer was determined as a function of the amount of land cultivated or livestock. In 1999, "Agenda 2000" introduced the two-pillar structure of the CAP that is still valid today. The first pillar includes DP for farmers and market measures, and the second pillar holds the rural development programs. Pillar II schemes are voluntary for farmers and include compensation for costs incurred or income reduction (Brady et al. 2017; Cunha and Swinbank 2011; Philippidis and Hubbard 2003). In the 2003 CAP reform, most DP in Pillar I were decoupled from the volume and type of production, and a single payment scheme (SPS) based mainly on historical references was implemented (Boinon et al. 2007; European Commission 2004; OECD 2004). More recently, in the 2013 CAP reform, a new direct payment approach was introduced, replacing the SPS with a new and articulated direct payment system, the basic payment scheme (BPS) (Ciaian et al. 2018; Ciliberti and Frascarelli 2018; European Comission 2013; Henke et al. 2015). One of the stated objectives of the reform has been to introduce a more equitable distribution of payments across and within member states (MS) to overcome the recognised disparities in the distribution of DP between types of farmers and regions (Davidova et al. 2013; Davidova and Kenneth 2014; European Commission 2013; Sinabell et al. 2013; Volkov et al. 2019).

Nevertheless, according to the report on the distribution of DP for 2019, little progress has been made in the European Union (EU) regarding the fair distribution of DP. Around 80% of the entire amount of DP from Pillar I is still granted to approximately 20% of the largest beneficiaries (European Commission 2020, 2021a), while around 42% of holdings did not get Pillar I DP at all in 2020 (European Comission, n.d.). In Portugal around 17% of beneficiaries get 80% of the amount of DP in Pillar I (European Commission 2021b) and 35% of holdings were excluded in 2020 (European Comission, n.d.). According to Espinosa et al. (2020), Portugal was one of the MS most adversely impacted by the 2013 CAP reform, both in terms of reduced farm income and loss of DP. If we ignore collective entities, such as companies, cooperatives and the State, the number of farmers that received DP in Portugal, including Pillar I and Pillar II, was around 60% in 2019, ranging from 25.9% in the agrarian region *Ribatejo e Oeste* to 81.2% in *Trás-os-Montes* region (Fig. 1 and Table 1).

After the implementation of the 2013 CAP reform, the share of sole owners who receive DP remained almost steady in the country. Nevertheless, the pattern was not consistent across the nation, with four agrarian regions[1] experiencing a decrease in the percentage of sole holders (hereby identified as farmers) getting subsidies and five regions experiencing an increase (Table 1).

Recent research has examined the impact of subsidies on agricultural systems throughout Europe (Biagini et al. 2023; Delattre et al. 2020; Jambor and Szerletics 2022; Lipcsei 2022) but the opposite perspective, focusing on the impact of structural initial conditions, such as resource base or dominant farming systems, on the allocation and distribution of DP, has not been investigated. The current study's general hypothesis is that inequalities in farmers' access to DP are significantly influenced by the predominant farming systems in each region. Because farming systems differ substantially across and within Portugal's agrarian regions, the distribution of DP is likely to vary significantly. This research seeks to understand the spatial diversity in DP distribution as well as the

[1] In addition to administrative divisions, Statistics Portugal uses agrarian regions for the dissemination of agricultural statistical information. In this study, agrarian regions were chosen as an intermediary geographical entity in place of NUT2 because they better reflect macro-level agroecological differences across the country.

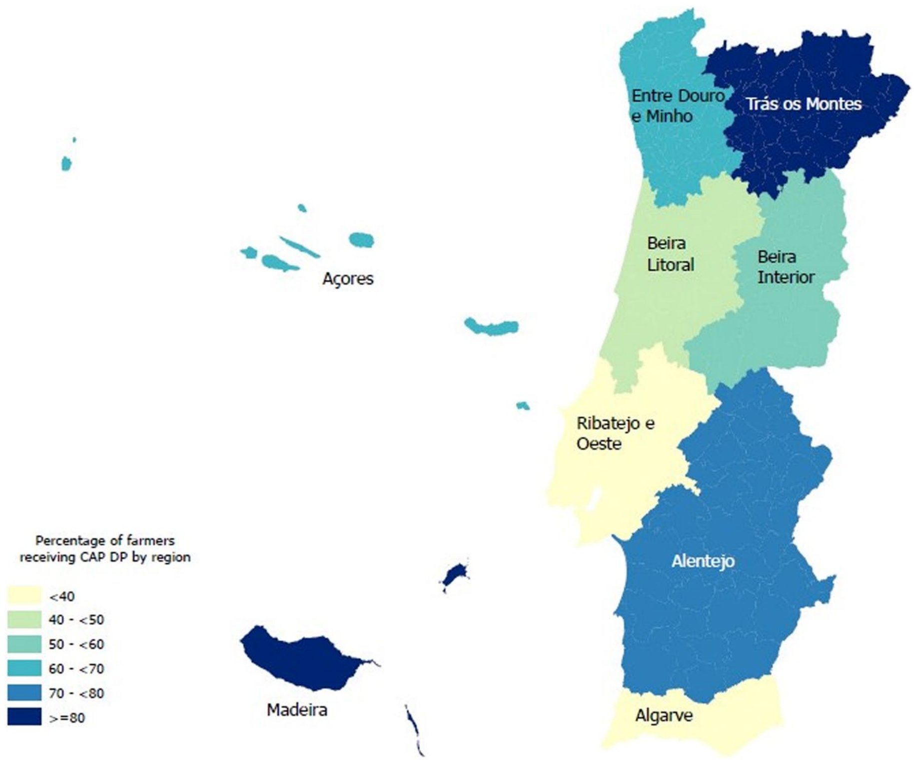

Fig. 1 Percentage of farmers receiving CAP DP in Portugal in 2019, by agrarian region

Table 1 Percentage of farmers receiving CAP DP in Portugal in 2013 and 2019, by agrarian region. *Source*: Statistics Portugal, Base agricultural statistics (www.ine.pt)

Agrarian Region	2013	2019	Change
Entre Douro e Minho	70.3	64.9	− 5.5
Trás-os-Montes	80.1	81.2	1.1
Beira Litoral	51.2	44.7	− 6.5
Beira Interior	60.8	58.9	− 1.9
Ribatejo e Oeste	28.6	25.9	− 2.8
Alentejo	64.4	71.4	7.0
Algarve	29.9	35.2	5.3
Açores	54.7	67.7	13.0
Madeira	77.8	81.0	3.1
Portugal	61.0	60.5	− 0.4

local structural conditions that influence farmers 'access to DP, with a focus on farming system diversity.

The study focuses on the smallest administrative areas of the Portuguese territory—the communes[2]—to fully understand the relationship between farming systems and equity in DP access. At a smaller geographical scale, all farms have a similar natural resource base, and a dominant pattern of farm activities and networks.

[2] Freguesias in Portuguese.

Given that some of the farming systems that are common in the Portuguese territory may also be found in other MS, especially southern ones, we anticipate that our findings will shed light on the relationship between farming systems and DP throughout Europe.

Background

Numerous studies have examined the impact of direct payments (DP) on agricultural systems from an economic perspective. These studies have emphasised the role of DP in resource allocation (Becvarova 2011), land productivity and land market dynamics (Bartolini and Viaggi 2013; Guastella et al. 2018; O'Neill and Hanrahan 2016; Valenti et al. 2021), capital productivity (Czyzewski and Smedzik-Ambrozy 2017), and labour productivity (Garrone et al. 2019; Jambor and Szerletics 2022). The literature has also extensively investigated the implications of DP in several social dimensions, such as family farming, farm employment, income diversification, and farm exit (Bojnec and Fertő 2022; Hennessy 2014; Kazukauskas et al. 2013; Weltin et al. 2017). Furthermore, research has been conducted on the environmental consequences (Coderoni and Esposti 2018; Heyl et al. 2021), as well as the facets of sustainability and resilience (Buitenhuis et al. 2020; Morkunas and Labukas 2020; Sadłowski et al. 2021; Žičkienė et al. 2022) concerning DP.

The issue of disparities in the distribution of DP and their impact on income distribution has also been studied in several European contexts by multiple researchers (Ciaian et al. 2015; Hansen and Teuber 2011; Severini et al. 2016; Severini and Tantari 2013b; Svatoš and Chovancová 2013; Trnková and Malá 2012). These studies have revealed that the inequalities can be attributed to a combination of structural, natural, and historical factors.

At the structural level, the degree of variation in farm size is significant both between and within MS. Regions characterised by larger farms tend to derive greater benefits from the CAP compared to regions where the farm structure predominantly consists of small and medium-sized family farms (Grochowska et al. 2021). Furthermore, it is worth noting that the process of applying for CAP subsidies can be intricate and characterised by bureaucratic procedures (Beluhova-Uzunova et al. 2019; Henke et al. 2015; Hennessy 2014), potentially discouraging small-scale farmers from engaging in the application process. In contrast, large farms, possess the necessary means to effectively manoeuvre within the system, thereby enabling them to secure a greater amount of subsidies. In the context of structural level analysis, existing literature has demonstrated the influence of land property rights on the distribution of DP (Brady et al. 2017; Ciaian et al. 2015, 2018; Ciliberti and Frascarelli 2018; Dinis and Simões 2021) because non-farming landowners may capture a part of DP, sometimes leading to further income inequality among farmers. Additionally, it may hinder the growth of farm size and the entrance of new farmers by discouraging landlords from renting out their land.

The amount of DP a farm receives may be significantly influenced by natural constraints which are partially associated with location (Czyzewski and Smedzik-Ambrozy 2017; Garrone et al. 2019; Viegas et al. 2023). Producers operating in less favoured areas, which encompass remote and constrained rural areas, are eligible for specific income support payments. It is also important to note that informal and formal rural institutions, climatic conditions, and local market imperfections may vary enormously between regions (Ciaian et al. 2015).

Moreover, agroecological conditions and the viable crops in a given location are determined by natural factors. It is well known that certain types of farming and products receive more subsidies than others, with a marked distributive imbalance between Continental and Mediterranean products, such as vegetables, fruit, and other permanent crops (Brady et al. 2017; Henke et al. 2015; Matthews et al. 2013; Segrelles 2017). In Italy, it has been observed that non-beneficiary farms tend to have a greater focus on horticulture and permanent crop production while exhibiting less emphasis on beef, dairy, and sheep production (Severini et al. 2016; Severini and Tantari 2013a). Using the Gini concentration coefficient, Severini et al. (2016) show that farm income is highly concentrated in field crops and beef farms while it consistently decreases in olive farms, due in part to the negative evolution of the concentration coefficient of DP. According to Hansen and Teuber (2011), prior to the 2013 CAP reform, the EU provided significantly higher per-hectare support for animal farming systems compared to crop farming systems. This disparity was particularly pronounced for dairy cows and cattle.

At the historic level, by decoupling payments from farm production, the Luxembourg Agreement (2003) led to a major reform in the way subsidies were allocated to EU farmers. While the CAP applied to all EU countries, MS were granted a certain degree of flexibility in the implementation of the SPS. In particular, MS could choose between two models: the historic model or the regional model (Kazukauskas et al. 2013). Several countries, including Portugal and various Mediterranean countries, adopted the historic decoupling model, whereby the income support entitlements of farmers were linked to their historical production levels and land. This approach ensured that larger and more productive farmers maintained their entitlement to higher payments and consequently received a disproportionate amount of subsidies (Brady et al. 2017; Cong and Brady 2012; Hennessy 2014).

As stated by Viegas et al. (2023), despite the EU's efforts, unacceptable inequalities in the distribution of direct CAP support remain. Although under the Agenda 2000 CAP reform, MS had the option to use modulation on a voluntary basis, few did so for a variety of reasons (European Commission 2004). Modulation became mandatory only with the CAP Health Check in 2003 (European Commission 2004; Grochowska et al. 2021; Henke et al. 2015) to finance the additional rural development measures. Between 2005 and 2012, DP for farms receiving more than EUR 5 000 a year was progressively reduced. However, it became clear shortly after the reform's implementation that the CAP's structure as it was could not promote a more balanced distribution of support among MS (Hansen and Teuber 2011; Henke et al. 2015).

Several mechanisms were put in place in the 2014–2022 CAP period to generate a more equitable distribution of DP, namely degressivity, redistributive payment, the Small Farmers Scheme, and the Young Farmers Scheme (European Commission 2013; Henke et al. 2015). Degressivity, which was a mandatory scheme for all MS, imposed a 5% reduction on the part of basic payments above 150,000 euros. Complementary, an optional redistributive payment could be attributed to the first hectares of the farms to provide more targeted support to small and medium-sized farms. Both instruments aimed at redistributing resources: in the case of degressivity, from those farms receiving a large amount of support to rural development policy measures; in the case of redistributive payment, from larger to smaller farms (Henke et al. 2015). Additionally, the Small Farmers Scheme simplified the procedures for small farmers, significantly easing their access to DP and reducing their administrative burden. Finally, the Young Farmers Scheme was created to complement the start-up aid provided to young farmers as part of Pillar II to encourage them to pursue farming. The Scheme was mandatory for all MS, which were required to set aside up to 2% of their total allocation of income support for its financing. One of the main goals of the 2014–2022 CAP period was to address the problems facing young farmers and encourage them to maintain their parents' businesses (Volkov et al. 2019). The younger farmers scheme targeted farmers of no more than 40 years of age who were setting up for the first time an agricultural holding as head of the holding or who had already set up such a holding during the five years preceding the first application for the scheme. Young farmers also benefited from priority in accessing the national or regional reserve (European Commission 2016).

Recent research (Alfaro-Navarro and Andrés-Martínez 2021) shows a marked trend towards greater equity in the distribution of subsidies since the 2013 reform, although with differences between the countries of the East and the West and a more equitable distribution in Western European countries, probably due to a more rapid adaptation to change.

Overall, in the CAP new cycle, implemented on January 1, 2023, for a period running until 2027, MS has increased subsidiarity in the planning and implementation of the CAP (Barral and Detang-Dessendre 2023; Boinon et al. 2007; Kremmydas and Tsiboukas 2022). Nevertheless, the main schemes aimed at fostering a more equitable allocation of payments were maintained, particularly those that contribute to supporting the income of young farmers and small-scale farms. Furthermore, the redistributive payment, which was previously optional during the 2014–2022 CAP, will now be mandatory across all MS. It is reasonable to predict that these measures will promote some payment redistribution and expand farmers' access to DP. In their recent research, Lososová and Zdeněk (2023) predict that, according to the Czech Republic Strategic Plan, the new payment system will lead to a reduction in direct payments for farms larger than 313 ha. On the contrary, taking into account the Portuguese Strategic Plan, Viegas et al. (2023) do not estimate a significant change to the system that, in the last decades, has induced a strong polarisation of support. Still, hectare-based payments remain the primary CAP instrument, and, as Heyl et al. (2021) point out, ambitions to develop effective redistributive instruments appear improbable given that most member states either did not implement the redistributive payment when it was facultative or were hesitant to do so, as is the case in Portugal, which only began in 2017. The optional reintroduction of coupled income support, although limited, will boost farmers' access to DP in areas where the supported farming systems are prevalent (cereals and livestock in Portugal), but it will not necessarily result in a more equitable allocation of DP.

Material and methods

Data

The vast majority of studies assessing the impact of DP on farms and farming systems use the farm accountancy data network (FADN) database (Ciaian et al. 2015; Ciliberti and Frascarelli 2018; De Castris and Di Gennaro 2018; Espinosa et al. 2020; Grochowska et al. 2021). However, the FADN survey does not cover all farms in the EU but only commercial ones, leaving out smaller farms (Cagliero et al. 2021; Cisilino et al. 2021). Besides, FADN is constructed to be representative of the number of commercial farms in each cluster, defined by region, economic size, and production specialisation (Cagliero et al. 2021; Espinosa et al. 2020; Staniszewski and Borychowski 2020) and therefore it might not be representative of farming systems diversity for lower territorial levels such as municipalities or communes.

The data set used in this study was derived from the agricultural censuses (AC), broken down by communes, the smallest unit in Portugal's administrative division. The commune was chosen as the unit of analysis primarily for the benefit of using territorial data at the lowest possible aggregation level. Portugal has a total of 3091 communes, with 2882 on the mainland, 155 in the autonomous Region of the Azores, and 54 in the autonomous region of Madeira. Only 2913 commons were included in the study because 178 are communes with less than 10 farms, mostly urban.

The AC covers the entire national territory, and it's an exhaustive statistical survey, binding on EU and Council Regulation 2018/1091, which gathers data on all national farms, generating results at detailed geographical levels. The data are collected by a face-to-face interview through a duly accredited interviewer and seeks to meet national and international statistical needs (Statistics Portugal 2019), in particular farm structure; agricultural production systems; agricultural production methods; family farming population and agricultural labour force; farmers' source of income; gainful activities not directly related to the agricultural holding; and farm succession. The Portuguese AC was conducted every ten years from 1979 to 2019. However, information on DP is only available for the two most recent AC.

Estimation procedures

In order to fulfil the objectives of the research, two distinct statistical models were estimated: a multiple linear regression model and a logit model. The multiple linear regression analysis was performed in order to understand the structural variables that impacted the percentage of farmers getting direct payments (DP) in Portugal in the baseline year of 2009, while the binary logit model was used to analyse the impact of these same structural factors on the rise in the number of farmers who received DP between 2009 and 2019.

Multiple regression is a popular statistical method for modelling the relationship between numerous independent variables and a dependent variable. The relationship can be mathematically represented by the equation:

$$Y = \propto + \beta X + \varepsilon. \quad (1)$$

In this equation, Y represents the dependent variable, α represents the intercept (which indicates the value of Y when all independent variables are set to zero), β represents the vector of coefficients for the explanatory variables (X), and ε represents the error term.

Logit estimation is a statistical methodology often applied to represent binary outcomes. The dependent variable is limited to two discrete values, commonly denoted as 1 and 0. The logit model utilises the logit function to estimate the likelihood of the binary outcome, which can be denoted as

$$\Pr(Y=1|x)=\frac{\exp\left(\alpha+\beta x\right)}{1+\exp\left(\alpha+\beta x\right)}, \tag{2}$$

where exp is the base of natural logarithms, α is the constant of the equation, and β are the coefficients of the explanatory variables. The coefficients predict the impact of the explanatory factors on the likelihood of the outcome being 1, specifically referring to the probability of an increase, between 2009 and 2019, in the percentage of farmers obtaining DP in the context of the current research. In their comprehensive work, Long and Freese (2006) thoroughly examine the many aspects related to the estimation, fitting, and interpretation of regression models for binary dependent variables. All the econometric procedures were performed using the STATA/IC 16.1 software.

Models and variables

As previously mentioned, a multiple linear regression model was estimated with the percentage of farmers receiving DP in the study's baseline year (2009) as the dependent variable (*Receive09*). Beside DP from Pillar I, the two most important annual payments granted through rural development programs (Pillar II)—Agri-environmental Payments and Less Favoured Area Payments—are also comprised.[3] Location as well as several farming system characteristics, such as farm size, landownership, crops, livestock, and farmers' age, were included as explanatory variables. All the independent variables in the models are briefly described in Table 2.

In order to estimate the impact of different farming systems and other structural factors on changes in farmers' access to DP between 2009 and 2019, the following logit model was estimated:

$$\begin{aligned}\Pr\left(\Delta DP=1\right)=&f\Bigg(\alpha_0+\sum_{i=1}^{9}\beta_i\text{Location}_i+\sum_{j=1}^{2}\gamma_j\text{Size}_j+\delta\text{Owner}\\&+\sum_{k=1}^{5}\varepsilon_k\text{Crop}_k+\sum_{l=1}^{3}\theta_l\text{Livestock}_l+\sum_{m=1}^{2}\mu_m\text{Age}_m+\rho\text{Farms}\Bigg)\end{aligned} \tag{3}$$

in which the probability of an increase in the proportion of farmers receiving subsidies ($\Pr(\Delta\text{DP}=1)$) is expressed as a logit function of the same explanatory variables included in the multiple linear regression combined with a new variable controlling for the variation in the number of farms. The dependent variable (ΔDP) is dichotomous, taking the value 1 if the proportion of farmers receiving DP has increased between 2009 and 2019 and 0 otherwise. The rise in the proportion of farmers benefiting from DP is a significant measure of shifts in DP access disparities because, as shown by Viegas et al. (2023), a substantial portion of the unequal allocation of CAP support in Portugal stems from a significant number of farmers who are marginalised from the system and do not receive any form of subsidy.

Although the most recent programming period of the CAP does not align with the 2009–2019 decade, it is feasible to establish a connection between access to DP and the 2014–2022 CAP programming period. This can be done by assuming that by the

[3] In the Portuguese AC, the variable "Importance of subsidies and grants on income" incorporates Payments for Agri-Environmental Schemes and Least Favoured Areas from Pillar II in addition to Pillar I subsidies.

Table 2 Dependent variables description

Variable	Description
Location	Categorical
LocEDM	= 1 if the commune is in *Entre Douro e Minho* and = 0 otherwise
LocTM	= 1 if the commune is in *Trás-os-Montes* and = 0 otherwise
LocBL	= 1 if the commune is in *Beira Litoral* and = 0 otherwise
LocBI	= 1 if the commune is in *Beira Interior* and = 0 otherwise
LocRO	= 1 if the commune is in *Ribatejo e Oeste* and = 0 otherwise
LocALT [Baseline]	= 1 if the commune is in *Alentejo* and = 0 otherwise
LocALG	= 1 if the commune is in *Algarve* and = 0 otherwise
LocMD	= 1 if the commune is in *Madeira* and = 0 otherwise
LocAZ	= 1 if the commune is in *Azores* and = 0 otherwise
Size	Continuous
Acreage	Average UAA measured in hectare
Small	% of small holdings (UAA < 5 ha)
Landownership	Continuous; % of UAA explored by owner farming
Crops	Continuous
Fruit	Fruit area in UAA (%)
Olive	Olive groves area in UAA (%)
Vineyard	Vineyard area in UAA (%)
Cereals	Cereals area in UAA (%)
Vegetables	Vegetables area in UAA (%)
Livestock	Continuous
Cattle	Number of cows per ha of UAA
Sheep	Number of sheep per ha of UAA
Goat	Number of goats per ha of UAA
Young	Continuous; farmers under the age of 35 (%)
Farms	Continuous; number of farms growth rate between 2009 and 2019 (%)

year 2009 farmers had already made the necessary adaptations to comply with the SPS applied in Portugal between 2005 and 2014 and that they had already adjusted to the BPS, implemented in the 2014–2022 CAP programming period, by 2019. Based on the underlying assumption, it is reasonable to consider the years 2009 and 2019 as the baseline and follow-up years, respectively, in order to assess the potential influence of agricultural structural conditions on farmers' access to subsidies post-2013.

The agroecological conditions and, as a result, the agricultural systems exhibit significant variations across different agrarian areas. The explanatory variable *Location* is a categorical variable that considers territorial heterogeneity and varying choices in CAP implementation in the autonomous regions of Açores and Madeira. The variable *Location* has nine distinct categories, each corresponding to an agrarian region. However, the *Alentejo* region was used as the baseline category and hence excluded from the model. The variable in each category has a value of 1 if the commune is in that region and 0 otherwise. Two size variables were added to the model as explanatory variables to determine whether size is a significant structural component in addressing access to DP. The first one (*Acreage*), representing the average Utilised Agricultural Area (UAA), was complemented with the variable *Small* to also capture the effect of the presence of small farms (with less than 5 hectares of UAA) in DP access.

A continuous variable indicating the percent of UAA held by the farmers was added to the model to capture the effect of *Landownership* on DP access.

Two sets of variables, namely crops and livestock, were used in the model to account for the effect of crops and animal production on farmer´s access to DP. Five crops were chosen to represent the diversity of farming systems across the country, including three permanent crops (f*ruit*, *olive groves*, and *vineyards*) and two temporary crops (*cereals* and *vegetables*). Three species were considered in livestock (*cattle*, *sheep,* and *goats*). The crop variables were measured by their share of UAA, and the livestock variables were measured by the number of animals per hectare of UAA.

Taking into account the implementation of the Young Farmers Scheme, a higher response to DP payments may be expected in farming systems where the presence of young farmers is higher. The variable *Young*, measured by the proportion of farmers in the commune who are under 35, was included in the model to account for this effect.

Finally, the *Farm* variable was added to the logit model to control for changes in the number of farms in the communes between 2009 and 2019, because the change in the share of farms receiving DP may be affected by the total number of farms existing in each year.

The livestock variable and the *Young variable* were added to the linear model in logarithmic form to deal with heteroskedasticity that was found during the estimation process.

Results and discussion

Descriptive statistics

The main descriptive statistics on the study's variables are displayed in Table 3. The percentage of farmers receiving DP in each commune in 2009 was 59.9% on average, and between 2009 and 2019, that percentage increased in 48.8% of the communes. Additionally, it reveals that 45% of the farms are concentrated in the northern part of the country, in the agrarian regions of *Entre Douro e Minho* and *Trás-os-Montes*. The mean of the average acreage is 11.9 ha, varying from 0.1 to 395.5 ha with the smaller farms (UAA < 5 ha) representing on average 21.8% of the total number of farms. In terms of land ownership, farmers hold, on average, more than 75% of the UAA. Permanent crops are quite important. On average, more than 25% of UAA is dedicated to fruits, olive groves, and vineyards. On average, farmers under the age of 35 represent 2.3% of the overall farmer population.

Multiple linear regression

The estimation results of the multiple linear regression model are displayed in Table 4. The ordinary least squares (OLS) model has several strengths, such as the presence of statistically significant coefficients, a relatively high R-squared value of 0.6355, and a low p-value for the F-statistic, suggesting its general robustness. According to Ozili (2023), an R-squared higher than 0.50 is considered acceptable in social science research. This is particularly true when the majority of explanatory variables are statistically significant, as is the case in the present study. In addition, other diagnostic procedures were conducted to establish the validity and robustness of the model. The model proved to be quite stable since removing specific variables or observations did not seriously affect the significance or the value of the coefficients. In order to assess the presence of multicollinearity, a correlation matrix was built, and the Variance Inflation Factor (VIF) was calculated, as

Table 3 Descriptive statistics

Variables	Mean	S.D	Min	Máx
Receive09 (%)	59.9	23.7	0	99.2
Receive19 (%)	*58.8*	24.4	0	99.2
*ΔDP**	0.488	–	0	1
*LocEDM**	0.291	–	0	1
*LocTM**	0.159	–	0	1
*LocBL**	0.168	–	0	1
*LocBI**	0.106	–	0	1
*LocRO**	0.112	–	0	1
*LocALT**	0.074	–	0	1
*LocALG**	0.022	–	0	1
*LocMD**	0.017	–	0	1
*LocAZ**	0.050	–	0	1
Acreage (ha)	11.9	28.3	0.1	395.5
Small (%)	21.8	18.1	0	100
Landownership (% UAA)	77.2	20.9	0	100
Fruit (% UUA)	4.0	10.2	0	93.3
Olive (% UUA)	10.2	17.0	0	100
Vineyard (% UUA)	12.4	17.5	0	97.4
Cereals (% UUA)	11.0	12.1	0	100
Vegetables (% UUA)	3.5	8.1	0	83.4
Cattle (animals/ha UAA)	0.7	1.2	0	10.4
Sheep (animals/ha UAA)	0.9	1.3	0	35
Goat (animals/ha UAA)	0.4	0.8	0	18.7
Young (%)	2.3	3.6	0	50
Number of Farms 2009	99.2	90.3	1	918
Number of Farms 2019	93.5	87.9	1	831

*For binary variables the mean corresponds to relative frequency; standard deviations are omitted

shown in Appendix 1 (Tables 7, 8). The findings did not provide evidence for the existence of collinearity. To evaluate the presence of heteroskedasticity, the Breusch–Pagan/Cook–Weisberg test was conducted. The results suggest no violation of the assumption of constant variance in the error terms of the regression model (P-value = 0.1384). In contrast, the residual analysis revealed a significant departure from a normal distribution, as shown by the p-values of 0.000 obtained for both skewness and kurtosis. In order to account for the deviation from normality in the residuals and minimise its possible influence, a robust model was estimated (Table 4). Although the Hausman test suggests that the coefficients in the two models cannot be considered equal ($\chi^2 = 265.10$; P-value = 0.000), the interpretation of the findings is similar in both cases. Except for location in Açores (*LocAZ*) and *Landownership*, all the other explanatory variables present statistical significance, with most of them exhibiting p-values under 1%.

The results show that, all other things remaining equal, the percentage of farmers receiving DP in 2009 was smaller in the agrarian regions of *Ribatejo e Oeste* and *Algarve* than in *Alentejo* (the baseline region that was left out of the estimation). The opposite occurred in the other agrarian regions. The high coefficient for the *Madeira* region is most likely due to the fact that the Portuguese autonomous regions have their own distinctive array of agricultural policy tools. The geographic diversity of agroecological conditions, as well as the varying dynamism of the regional services

Table 4 Estimation results—multiple linear regression model

Variables	OLS estimation			Robust estimation		
	Coef	t	P>|t|	Coef	t	P>|t|
LocEDM	16.5591***	9.25	0.000	16.5357***	9.50	0.000
LocTM	16.3714***	9.04	0.000	15.0888***	8.56	0.000
LocBL	3.6477**	1.99	0.047	3.9831**	2.23	0.026
LocBI	5.3799***	2.95	0.003	5.2195***	2.95	0.003
LocRO	− 24.1299***	− 13.00	0.000	− 25.4542***	− 14.10	0.000
LocALG	− 19.5764***	− 6.94	0.000	− 20.9193***	− 7.62	0.000
LocMD	73.0703***	19.37	0.000	76.7185***	20.90	0.000
LocAZ	− 3.1079	− 1.18	0.238	− 39.313	− 1.53	0.125
Acreage	0.11955***	10.08	0.000	0.2062***	10.93	0.000
Small	− 0.4116***	− 13.51	0.000	− 0.4631***	− 15.26	0.000
Landownership	0.0203	0.92	0.358	0.0169	0.79	0.430
Fruit	− 0.2246***	− 5.88	0.000	− 0.2277***	− 6.13	0.000
Olives	0.2532***	8.91	0.000	0.2902***	10.50	0.000
Vineyard	− 0.2554***	− 9.16	0.000	− 0.2417***	− 8.91	0.000
Cereals	0.2023***	6.20	0.000	0.1735***	5.47	0.000
Vegetables	− 0.4563***	− 8.83	0.000	− 0.4912***	− 9.87	0.000
lnCattle	0.6267**	2.30	0.021	0.8668***	3.27	0.001
lnSheep	− 1.1426***	− 3.61	0.000	− 1.1799***	− 3.83	0.000
lnGoat	− 0.8749***	− 3.46	0.001	− 0.5827***	− 2.37	0.000
lnYoung	1.9327***	3.67	0.000	2.0010***	3.91	0.000
Constant	57.5027***	22.83	0.000	60.4050***	24.65	0.000
	F = 151.53; Prob > F = 0.000@R^2 = 0.6355; Adjusted R^2 = 0.6355; @			BP/CW χ^2 = 2.20;Prob > χ^2 = 0.1384		

****p*-value < 0.01; ***p*-value < 0.05 **p*-value < 0.1

provided by the Agriculture Ministry and non-governmental organisations engaged in rural development, may help to explain the inequalities across the other locations.

As expected, regarding farm size, the proportion of farmers getting DP is higher in communes with a higher average UAA, and the existence of farmers with less than 5 ha of UAA has an evident detrimental effect. As stated by Hejnowicz et al. (2016), scheme payments are a real issue for farmers because they can have a considerable impact on overall farm income. However, the complexity and bureaucracy involved are viewed as intimidating and can lower the number of potential applicants (Cross and Franks 2007). Smaller farmers, in particular, who lack the funds to hire advisors who would assist them in applying for and implementing these schemes, are particularly discouraged (Ocean and Howley 2021). According to the results of the regression model, farmers getting subsidies decline by 0.4 percentage points for every 1 percentage point rise in the number of small farms.

Apart from olive trees, all permanent crops have a detrimental impact on DP access. The same happens with vegetables. This is an anticipated outcome that is consistent with what has been reported in the literature. Unlike most permanent crops, olive farms are among the most supported by CAP, with DP accounting for a very large share of farm income (Severini and Tantari 2013a). Corroborating findings from Severini et al. (2016) in Italy, the weight of non-beneficiary farms was more visible in the Portuguese communes oriented towards permanent crops (fruits and vineyards) and vegetables and less oriented to cattle. In general, in the UE, DP constitutes a small share of total revenues in farms oriented towards the production of vegetables, fruits, and other permanent crops (Brady et al. 2017).

Cereals, one of the main arable crops, have a positive effect on access to subsidies as expected, reflecting, as mentioned by Guastella et al. (2018), the distribution of payments prior to the 2003 CAP reform, typically favouring arable crop and livestock farmers as compared to other sectors. Contrary to Severini et al. (2016) findings, in Portugal, other things remaining equal, goat and sheep production have a negative impact on the percentage of farmers receiving DP. In general, our findings support the argument that Continental products have benefited more from CAP support than Mediterranean products (Brady et al. 2017; Henke et al. 2015; Segrelles 2017).

Finally, the prevalence of young farmers in a commune has a positive impact on access to DP. This outcome was anticipated because age and entrepreneurial activity are typically inversely correlated (Bohlmann et al. 2017; Lévesque and Minniti 2006). A combination of factors, including less formal education in agricultural sciences,[4] limited access to internet connectivity, insufficient proficiency in using digital platforms, and physical and health constraints that limit their access to agricultural public services, may make it difficult for older farmers to apply for subsidies. Furthermore, older farms may have obsolete infrastructure that does not meet modern regulatory standards and may be more resistant to new practices and technologies in order to meet increasingly stringent eco-environmental requirements, particularly if they have long relied on traditional methods and have deeply rooted farming habits and beliefs.

Overall, the findings reveal that the distribution of DP benefited farming systems based on larger farms run by younger farmers, producing olives, cereals, and cattle. Farmers growing fruit and vegetables, mainly located in *Ribatejo e Oeste* and *Algarve*, as well as goats and sheep producers, experienced restricted access to DP. This is consistent with the prior discussion of the challenges encountered by Mediterranean farmers in obtaining DPs.

Logit model

The results of the logit estimation are presented in Table 5. Regarding the model goodness of fit, a test of the full model against a constant-only model was statistically significant, indicating that the explanatory variables reliably predict "the increase in the percentage of farmers receiving DP" ($\chi^2 = 616.01$, $p < 0.000$). The Hosmer and Lemeshow, Pearson goodness-of-fit, and area under the ROC curve (AUC) tests, provided no serious reasons to think that the model does not fit well, and the prediction success overall was 70.5%. (The classification table is displayed in the Appendix—Table 9.)

Similar to the approach employed in the regression model, the estimation of the logit model involved conducting separate estimations for distinct groups and incorporating various control variables. The analysis revealed that the coefficients' sign and magnitude remained consistent across groups and model specifications, thereby indicating a high level of robustness in the model.

The findings indicate that the 2014–2022 CAP played a very different role in the redistribution of DP between farming systems and regions. All agrarian regions improved

[4] The data used in the present study show a moderately positive correlation (r = 0.3720; p-value = 0.000) between farmers' age and the absence of formal education or training in agricultural sciences.

Table 5 Estimation results—logit model

Variables	Odds ratio	z	P>|z|
LocEDM	0.1872***	− 6.83	0.000
LocTM	0.8328	− 0.74	0.460
LocBL	0.1459***	− 7.62	0.000
LocBI	0.5003***	− 2.89	0.004
LocRO	0.4339***	− 3.35	0.001
LocALG	1.4649	0.96	0.335
LocMD	0.4128*	− 1.76	0.079
LocAZ	3.7874***	2.91	0.004
Acreage	0.9979	− 0.91	0.363
Small	1.0024	0.66	0.508
Landownership	1.0046*	1.72	0.085
Fruit	0.9939	− 1.26	0.206
Olives	0.9740***	− 8.39	0.000
Vineyard	1.0055*	1.76	0.078
Cereals	0.9764***	− 5.44	0.000
Vegetables	1.0040	0.63	0.530
Cattle	0.8284***	− 3.89	0.000
Sheep	0.9448	− 1.29	0.198
Goat	0.9606	− 0.62	0.534
Young	1.0474***	2.66	0.008
Farms	0.9938	− 4.11	0.000
Constant	11.586**	2.15	0.031
	Wald $\chi^2 = 616.01$ Prob > $\chi^2 = 0.0000$ Hosmer–Lemeshow $\chi^2 = 15.65$; Prob > $\chi^2 = 0.058$ Pearson $\chi^2 = 3870.16$; Prob > $\chi^2 = 0.000$ Pseudo $R^2 = 0.1526$ AUC = 0.7585 Correctly classified: 70.50%		

***p-value < 0.01; **p-value < 0.05 *p-value < 0.1

their access to DP less than the baseline region (Alentejo), with the exception of the Azores and Algarve (which is not statistically significant). The probability of an increase in the percentage of farmers getting subsidies was higher in communes with a larger proportion of vineyards, while it was smaller in communes with higher weights of olives, cereals, and livestock, particularly cattle. One percentage point increase in UAA used for vineyards contributes to a 0.55% increase in the probability of higher DP access. One percentage point increase in UAA producing olives or cereals, on the other hand, reduces the odds of a higher DP access by about 2.5%, and a unit cattle density increase has a negative effect on the probability of DP access increase by 17.2%. These results suggest a redistribution of DP among farming systems, given that the probability of an increase in the percentage of farmers receiving DP declined mostly in farming systems that were more supported in 2009 while growing in vineyard farming systems.

Regarding farm size, probably due to Portugal's decision to forgo implementing the redistributive payment, the farm size-related variables (*Acreage* and *Small*) are not statistically significant. Even though it is important to note that, if statistically significant, the negative impact of *Acreage* on the probability of an increase in the percentage of farmers receiving DP would mean that some transfers were made from larger farmers to small farmers, most likely because of the simplified procedures for small farmers that followed the implementation of the Small Farmers Scheme.

On the contrary, the proportion of young farmers in the communes (*Young)* had a positive and statistically significant influence on the dependent variable. One percentage point increase in the proportion of farmers under the age of 35 is associated with a 4.7% raise in the odds of an increase in the proportion of farmers receiving DP, suggesting that the Young Farmer Scheme enhanced young farmers' access to DP and contributed to increasing the probability of a better distribution of DP.

Although within the limits of statistical significance, *Landownership* also contributes to explaining the changes in farmers DP access between 2009 and 2019. In communes where more UAA was owned by farmers, the probability of an increase in the proportion of DP beneficiaries was higher. The probability of greater DP access increases by 0.46% for every 1% increase in the proportion of land owned by farmers.

In summary, young farmers growing vineyards and exploring their own property in the Alentejo and Azores agrarian regions were better able to capitalise on the benefits of CAP DP modifications between 2009 and 2019. On the other hand, the changes have resulted in a detrimental effect on the accessibility of DP for olive, grain, and cattle producers.

Comparative analysis of the models

Relating the two models estimated in the preceding sections can yield significant insights regarding the determinants of farmers' access to DP in the baseline year and the extent to which these determinants contributed to the observed change in access over the period 2009–2019. This facilitates the recognition of prevalent factors that consistently impacted the accessibility of subsidies, as well as factors that exhibited varying degrees of significance in clarifying the dynamics of DP access in the post-2009 period.

Looking at Table 6, it becomes evident that a redistribution of DP took place between the years 2009 and 2019, at both regional and farming system levels. In most cases, the location in regions that were the primary beneficiaries of DP in 2009 led to a subsequent decrease in their access to subsidies, and the other way around. Likewise, the structural factors that hindered the accessibility of subsidies in 2009 have, on the whole, played a positive role in facilitating greater access to subsidies from 2009 to 2019. A similar pattern was observed in the case of crops. Crops that impacted negatively on the access to DP in 2009 were found to contribute to an increase in access to DP, and vice versa. It should be noted, however, that not all of the coefficients were statistically significant.

The region of *Ribatejo e Oeste*, which had the lowest proportion of farmers accessing DP, deviate from the overall trend as it experiences a further decline in the proportion of farmers receiving subsidies after 2009. In the same direction, the adverse effects of the presence of sheep and goats in 2009 were further emphasised in the following years, albeit without reaching statistical significance. A similar pattern, but in the opposite direction, was observed in the context of land ownership, wherein there was an observed positive effect on farmers' eligibility for subsidies in 2009, and this positive effect persisted in the subsequent period.

Table 6 Coefficient signs and significance in the linear and logit models

Variables	Linear model	Logit model
LocEDM	+	-
LocTM	+	-
LocBL	+	-
LocBI	+	-
LocRO	-	-
LocALG	-	+
LocMD	+	-
LocAZ	-	+
Acreage	+	-
Small	-	+
Landownership	+	+
Fruit	-	-
Olives	+	-
Vineyard	-	+
Cereals	+	-
Vegetables	-	+
Cattle	+	-
Sheep	-	-
Goat	-	-
Young	+	+

Positive effect statistically significant
Negative effect statistically significant
Positive effect not statistically significant
Negative effect not statistically significant

It is highly probable that this redistribution has been facilitated by the new the redistributive CAP schemes introduced in 2013, namely degressivity, the Young Farmers Scheme, and the Small Farmers Scheme.

Conclusions

The literature has demonstrated that CAP DP has a significant impact on agricultural resource use efficiency, on farmers and other rural actors' income, and more broadly on the sustainability and resilience of agriculture and rural communities. However, as shown by the current research, it is evident that the inverse relationship holds true as well, whereby the capacity of farmers to get CAP subsidies is influenced by several structural factors.

The results align with previous studies, indicating that the regional significance of arable crops (namely cereals) and cattle farming practices, together with the prevalence of larger farms and younger farmers, all lead to enhanced accessibility to DP. In contrast, traditional Mediterranean farming systems have generally faced obstacles in obtaining access to DP, especially in the case of olive groves. However, some redistribution appears to have occurred between 2009 and 2019, from larger to smaller farmers, from older to younger farmers, and from olives, cereals, and cattle to other types of production, particularly vineyards.

The study's findings can be a useful tool for policymakers in improving and working towards a fairer and more effective agricultural support system by identifying the particular groups of farmers who suffer disproportionately from the unequal distribution of CAP direct payments. This issue holds particular significance in the current context, as the CAP has shifted towards a more adaptable and contextually responsive approach, enabling each MS to determine and execute its own national objectives and strategies by means of National Strategic Plans. The utilisation of the entire population of farmers in Portugal presents a significant opportunity for elucidating disparities in the access to DP at the national level.

Although this study provides a better understanding of the structural conditions that affect farmers access to DP as well as their ability to react to changes in the agricultural policy, the results are, however, restricted to a single European country, making extrapolation to other locations unwise. It is important to contextualise the results within specific geographic and institutional settings to avoid overgeneralisation. Besides, the unequal distribution of CAP payments is influenced by various factors, including agro-ecological local characteristics, farm size, production type, land ownership, and policy options. Isolating the impact of individual factors and determining causality is challenging, and the models used in the present study may not have been able to capture the full complexity of the system. Furthermore, the study's findings reflect the distribution patterns within a specific policy framework and time period. As CAP evolves, the DP distribution may also change, potentially affecting the relevance and applicability of the study's conclusions to future policy contexts. Another constraint of the research pertains to the temporal scope of the data. Using 2009 as the reference year instead of 2013 may have introduced a potential limitation in the analysis, as it could have concealed any changes that have place during this period and their subsequent influence on the outcomes. Furthermore, the current study quantifies CAP support in aggregate form, without making distinctions between different kinds of DP. A separate examination of each type of payment (decoupled, coupled, agri-environmental and less favoured area payments) will allow for a better understanding of disparities in DP access at the local level and to promote more effective policy decisions.

Given the limited amount of information gathered by the AC on DP, it is recommended that the data collection mechanisms be improved. This improvement would allow for the collection of accurate and comprehensive data on the recipients of these payments as well as each type of subsidy. As a result, it would make it easier to implement more effective monitoring and evaluation processes, as well as evidence-based decision-making, in anticipation of future CAP reforms. Qualitative research methods could be useful to examine how farmers perceive the fairness and effectiveness of payment distribution mechanisms, as well as their suggestions for improving equity, to supplement quantitative research, improve our understanding of farmers' perspectives, and facilitate a more efficient evaluation. It would be beneficial to expand the research to additional European countries that have implemented comparable CAP schemes in order to gain a more comprehensive understanding of policy effectiveness and identify potential areas for policy improvement.

Appendix 1

See Tables 7, 8 and 9.

Table 7 Correlation coefficients

	LocEDM	*LocTM*	*LocBL*	*LocBI*	*LocRO*	*LocALG*	*LocMD*	*LocAZ*	*Acreage*	*Small*
LocEDM	1.0000									
LocTM	− 0.2801	1.0000								
LocBL	− 0.2945	− 0.1956	1.000							
LocBI	− 0.2305	− 0.1531	− 0.1610	1.0000						
LocRO	− 0.2147	− 0.1426	− 0.1499	− 0.1174	1.0000					
LocALG	− 0.0989	− 0.0657	− 0.0691	− 0.0540	− 0.0503	1.000				
LocMD	− 0.0884	− 0.0587	− 0.0617	− 0.0483	− 0.0450	− 0.207	1.0000			
LocAZ	− 0.1448	− 0.0962	− 0.1011	− 0.0792	− 0.0737	− 0.0340	− 0.0304	1.0000		
Acreage	− 0.1087	− 0.0692	− 0.1426	− 0.0209	− 0.0139	− 0.0121	− 0.0558	− 0.0227	1.0000	
Small	− 0.1618	− 0.2570	0.0390	− 0.0314	− 0.0324	− 0.0077	0.5405	0.2801	0.1859	1.0000
Landowner	− 0.1128	0.3066	0.1506	0.0050	− 0.0394	0.0026	0.0985	− 0.3669	− 0.1527	− 0.0475
Fruit	− 0.1120	0.0080	− 0.0804	− 0.0043	0.1718	0.2227	0.3307	− 0.0423	− 0.1097	0.2018
Olive	− 0.3707	0.2222	0.1210	0.1987	0.0698	− 0.0188	− 0.0814	− 0.1334	− 0.0756	− 0.0011
Vineyard	0.1845	0.0783	0.0298	− 0.1179	− 0.0063	− 0.0877	0.0519	− 0.1492	− 0.2034	0.1173
Cereals	0.1954	− 0.1361	0.2463	− 0.1510	0.0026	− 0.1020	− 0.1129	− 0.2010	− 0.0748	− 0.1355
Vegetables	− 0.0952	0.0887	− 0.0014	− 0.1052	0.2794	− 0.0113	0.4412	− 0.0642	− 0.0734	0.2286
Cattle	0.3778	− 0.2163	− 0.0886	− 0.1736	− 0.0853	− 0.0796	0.0221	0.2750	− 0.0938	0.0096
Sheep	− 0.0183	− 0.0832	0.2355	0.0899	− 0.0209	− 0.0665	− 0.0083	− 0.1902	− 0.1232	0.0415
Goat	− 0.0815	− 0.1098	0.2585	0.0556	− 0.0301	− 0.0355	0.1493	− 0.0750	− 0.1262	0.2075
Young	0.0004	− 0.0164	− 0.1730	− 0.0922	0.0117	− 0.0589	0.0273	0.4138	0.0960	0.0863

Table 7 (continued)

	Landow	***Fruit***	***Olive***	***Vine***	***Cereals***	***Vegetab***	***Cattle***	***Sheep***	***Goat***	***Young***
Landow	1.0000									
Fruit	0.0536	1.0000								
Olive	0.3387	− 0.0537	*1.0000*							
Vineyard	0.1783	0.0293	− 0.0255	1.0000						
Cereals	− 0.0555	− 0.1463	− 0.2388	− 0.0065	1.0000					
Vegetables	− 0.0640	0.1569	− 0.1523	− 0.0281	0.0999	1.0000				
Cattle	− 0.4007	− 0.0968	− 0.3021	− 0.1517	− 0.0403	0.0114	1.0000			
Sheep	0.1453	− 0.0763	0.0619	− 0.0514	0.0920	− 0.0145	− 0.1954	1.0000		
Goat	0.1785	− 0.0062	0.1556	− 0.0826	0.0137	0.0657	− 0.0861	0.1939	1.0000	
Young	− 0.2873	0.0436	− 0.1513	− 0.0578	− 0.1352	0.0486	0.2176	− 0.1452	− 0.0885	1.0000

Table 8 Variance inflation factor (VIF)

	VIF	*1/VIF*
LocEDM	7.41	0.134924
LocTM	4.77	0.209464
LocBL	5.24	0.190974
LocBI	3.44	0.290316
LocRO	3.38	0.295942
LocALG	1.65	0.605534
LocMD	2.54	0.393298
LocAZ	2.90	0.345054
Acreage	2.35	0.424733
Small	2.38	0.419989
Landowner	1.69	0.590568
Fruit	1.34	0.744037
Olive	1.61	0.622874
Vineyard	1.47	0.681980
Cereals	1.41	0.707908
Vegetables	1.56	0.642384
Cattle	1.77	0.565142
Sheep	1.25	0.799897
Goat	1.26	0.792082
Young	1.33	0.754693
Mean VIF	2.54	

Table 9 Probit model classification table

Classified	**D**	**~D**	**Total**
+	974	388	1362
−	471	1079	1550
Total	1445	1467	2912
Classified + if predicted Pr(D) > = .5			
True D defined as aumentosub ! = 0			
Sensitivity	Pr(+ |D)	67.40%	
Specificity	Pr(− |~ D)	73.55%	
Positive predictive value	Pr(D| +)	71.51%	
Negative predictive value	Pr(~ D|−)	69.61%	
False + rate for true ~ D	Pr(+ |~ D)	26.45%	
False—rate for true D	Pr(− |D)	32.60%	
False + rate for classified +	Pr(~ D| +)	28.49%	
False—rate for classified -	Pr(D|-)	30.39%	
Correctly classified		70.50%	

Abbreviations

CAP	Common agricultural policy
DP	Direct payments
SPS	Single payment scheme
BPS	Basic payment scheme
MS	Member(s) state
FADN	Farm accountancy data network
EU	European Union
AC	Agricultural census
UAA	Utilised agricultural area

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Declarations

Competing interests
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References

Alfaro-Navarro JL, Andrés-Martínez ME (2021) A longitudinal and cross-sectional analysis of the distribution of Common Agricultural Policy aids in European countries. Agric Econ Czech Republic 67(9):351–362. https://doi.org/10.17221/87/2021-AGRICECON
Barral S, Detang-Dessendre C (2023) Reforming the Common Agricultural Policy (2023–2027): multidisciplinary views. Rev Agric Food Environ Stud 104(1):47–50. https://doi.org/10.1007/s41130-023-00191-9
Bartolini F, Viaggi D (2013) The common agricultural policy and the determinants of changes in EU farm size. Land Use Policy 31:126–135. https://doi.org/10.1016/j.landusepol.2011.10.007
Becvarova V (2011) Economic and regional consequences of direct payments under the current CAP philosophy. Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis 59(4):19–26. https://doi.org/10.11118/actaun201159040019
Beluhova-Uzunova R, Hristov K, Shishkova M (2019) Small farms in Bulgaria: trends and perspectives. Agric Sci J Agric Univ Plovdiv 11(25):59–65. https://doi.org/10.22620/agrisci.2019.25.008
Biagini L, Antonioli F, Severini S (2023) The impact of CAP subsidies on the productivity of cereal farms in six European countries: a historical perspective (2008–2018). Food Policy 119:102473. https://doi.org/10.1016/j.foodpol.2023.102473
Bohlmann C, Rauch A, Zacher H (2017) A lifespan perspective on entrepreneurship: perceived opportunities and skills explain the negative association between age and entrepreneurial activity. Front Psychol 8:1–11. https://doi.org/10.3389/fpsyg.2017.02015
Boinon JP, Kroll JC, Lepicier D, Leseigneur A, Viallon JB (2007) Enforcement of the 2003 CAP reform in 5 countries of the West European Union: Consequences on land rent and land market. Agric Econ 53(4):173–183. https://doi.org/10.17221/860-agricecon
Bojnec Š, Fertő I (2022) Do different types of Common Agricultural Policy subsidies promote farm employment? Land Use Policy. https://doi.org/10.1016/j.landusepol.2021.105823
Brady M, Hristov J, Hojgard S, Jansson T, Larsson C, Nordin I, Johansson H (2017) Impacts of Direct Payments Lessons for CAP post - 2020. AgriFood Economics Centre
Buitenhuis Y, Candel JJL, Termeer KJAM, Feindt PH (2020) Does the Common Agricultural Policy enhance farming systems' resilience? Applying the Resilience Assessment Tool (ResAT) to a farming system case study in the Netherlands. J Rural Stud 80(March):314–327. https://doi.org/10.1016/j.jrurstud.2020.10.004
Cagliero R, Arzeni A, Cisilino F, Monteleone A, Borsotto P (2021) Ten years after: Diffusion, criticism and potential improvements in the use of fadn for Rural Development assessment in Italy. Economia Agro-Alimentare 23(3):1–24. https://doi.org/10.3280/ecag2021oa12769
Ciaian P, Kancs D, Espinosa M (2018) The Impact of the 2013 CAP Reform on the Decoupled Payments' Capitalisation into Land Values. J Agric Econ 69(2):306–337. https://doi.org/10.1111/1477-9552.12253
Ciaian P, Kancs D, Gomez S (2015) Income distributional effects of CAP subsidies: micro evidence from the EU. Outlook Agric 44(1):19–28. https://doi.org/10.5367/oa.2015.0196
Ciliberti S, Frascarelli A (2018) The CAP 2013 reform of direct payments: redistributive effects and impacts on farm income concentration in Italy. Agric Food Econ. https://doi.org/10.1186/s40100-018-0113-5
Cisilino F, Zilli G, Zanuttig G (2021) FADN data to support policymaking: the potential of an additional survey. Economia Agro-Alimentare 23(3):1–22. https://doi.org/10.3280/ecag2021oa12756
Cong RG, Brady M (2012) How to design a targeted agricultural subsidy system: Efficiency or equity? PLoS ONE. https://doi.org/10.1371/journal.pone.0041225
Cross M, Franks J (2007) Farmer's and advisor's attitudes towards the environmental stewardship scheme. J Farm Manag 13:47–68
Cunha A, Swinbank A (2011) An inside view of the CAP reform process : explaining the Macsharry, agenda 2000, and Fischler reforms. Oxford University Press

Czyzewski B, Smedzik-Ambrozy K (2017) The regional structure of the CAP subsidies and the factor productivity in agriculture in the EU 28. Agric Econ (czech Republic) 63(4):149–163. https://doi.org/10.1722/302/2015-AGRICECON

Davidova S, Bailey A, Erjavec E, Gorton M, Thomson K (2013) Semi-subsistence farming: value and directions of development. https://www.europarl.europa.eu/thinktank/en/document/IPOL-AGRI_ET(2013)495861

Davidova S, Kenneth T (2014) Family farming in Europe: challenges and prospects (in-depth analysis) (European P)

De Castris M, Di Gennaro D (2018) Does agricultural subsidies foster Italian southern farms? A Spatial Quantile Regression Approach. http://arxiv.org/abs/1803.05659

Delattre L, Debolini M, Paoli JC, Napoleone C, Moulery M, Leonelli L, Santucci P (2020) Understanding the Relationships between Extensive Livestock Systems, Land-Cover Changes, and CAP Support in Less-Favored Mediterranean Areas. Land 9:518. https://doi.org/10.3390/land9120518

Dinis I, Simões O (2021) Resilience in retrospective: the trajectory of agro-pastoral systems in the centro region of Portugal. Sustainability. https://doi.org/10.3390/su13095089

Espinosa M, Louhichi K, Perni A, Ciaian P (2020) EU-wide impacts of the 2013 CAP direct payments reform: a farm-level analysis. Appl Econ Perspect Policy 42(4):695–715. https://doi.org/10.1093/aepp/ppz021

European Comission. (n.d.). *Farming Income Support*. Directorate-General for Agriculture and Rural Development. Retrieved March 14, 2023, from https://agridata.ec.europa.eu/extensions/DashboardIndicators/FarmIncome.html

European Comission (2013) Report from the Commission to the European Parliament, the Council and the European Social Committee Agricultural Genetic Resources - from conservation to sustainable use. In *COM(2013)838 final*. European Comission

European Commission (2004) The 2003 CAP reform. In *Information Sheets* (Issue October 2004)

European Commission (2013) Overview of CAP Reform 2014–2020. *Agricultural Policy Perspectives Brief N.º 5*, *December 2013*, 10

European Commission (2016) *Direct Payments: The Young Farmer Payment under Pillar I of the Common Agricultural Policy* (pp. 1–6). https://ec.europa.eu/agriculture/sites/agriculture/files/direct-support/direct-payments/docs/young-farmer-payment_en.pdf

European Commission (2020) *Direct payments to agricultural producers - graphs and figures. Financial year 2019*. European Commission: DG Agriculture and Rural Development. https://ec.europa.eu/agriculture/sites/agriculture/files/cap-funding/beneficiaries/direct-aid/pdf/direct-aid-report-2017_en.pdf

European Commission (2021a) *Statistical Factsheet: European Union* (Issue June). European Commission: DG Agriculture and Rural Development

European Commission (2021b) *Statistical Factsheet: Portugal* (Issue June). European Commission: DG Agriculture and Rural Development

Garrone M, Emmers D, Lee H, Olper A, Swinnen J (2019) Subsidies and agricultural productivity in the EU. Agric Econ 50(6):803–817. https://doi.org/10.1111/agec.12526

Grochowska R, Pawłowska A, Skarżyńska A (2021) Searching for more balanced distribution of direct payments among agricultural farms in the CAP post-2020. Agric Econ (czech Republic) 67(5):181–188. https://doi.org/10.17221/417/2020-AGRICECON

Guastella G, Moro D, Sckokai P, Veneziani M (2018) The capitalisation of CAP payments into land rental prices: a panel sample selection approach. J Agric Econ 69(3):688–704. https://doi.org/10.1111/1477-9552.12258

Hansen H, Teuber R (2011) Assessing the impacts of EU's common agricultural policy on regional convergence: Sub-national evidence from Germany. Appl Econ 43(26):3755–3765. https://doi.org/10.1080/00036841003724395

Hejnowicz AP, Rudd MA, White PCL (2016) A survey exploring private farm advisor perspectives of agri-environment schemes: the case of England's Environmental Stewardship programme. Land Use Policy 55:240–256. https://doi.org/10.1016/j.landusepol.2016.04.005

Henke R, D'Andrea MR, Benos T, Castellotti T, Pierangeli F, Lironcurti S, De Filippis F, Giua M, Rosatelli L, Resl T, Heinschink K (2015) Implementation of the First Pillar of the CAP 2014–2020 in the Member States. European Parliament

Hennessy T (2014) CAP 2014–2020 tools to enhance family farming: opportunities and limits. Eur Parliament. https://doi.org/10.2861/56801

Heyl K, Döring T, Garske B, Stubenrauch J, Ekardt F (2021) The Common Agricultural Policy beyond 2020: a critical review in light of global environmental goals. Rev Eur Comp Int Environ Law 30(1):95–106. https://doi.org/10.1111/reel.12351

Jambor A, Szerletics A (2022) Regional impacts of direct payments on farm productivity and efficiency in the European Union. Agris on-Line Pap Econ Inform 14(1):59–68. https://doi.org/10.7160/aol.2022.140105

Kazukauskas A, Newman C, Clancy D, Sauer J (2013) Disinvestment, farm size, and gradual farm exit: the impact of subsidy decoupling in a European context. Am J Agric Econ 95(5):1068–1087. https://doi.org/10.1093/ajae/aat048

Kremmydas D, Tsiboukas K (2022) Redistribution and the abolishment of historical entitlements in the CAP Strategic plans: the case of Greece. Sustainability 14:735

Lévesque M, Minniti M (2006) The effect of aging on entrepreneurial behavior. J Bus Venturing 21(2):177–194. https://doi.org/10.1016/j.jbusvent.2005.04.003

Lipcsei J (2022) Territorial inequalities in vegetable plant payments in Hungary. Visegrad J Bioecon Sustain Dev 11(2):94–99. https://doi.org/10.2478/vjbsd-2022-0013

Long J, Freese J (2006) Regression models for categorical dependent variables using stata (Second Edi). Stata Press

Lososová J, Zdeněk R (2023) Simulation of the impacts of the proposed direct payment scheme: the case of the Czech Republic. Agric Econ 69(1):13–24. https://doi.org/10.17221/328/2022-AGRICECON

Matthews KB, Buchan K, Miller DG, Towers W (2013) Reforming the CAP-With area-based payments, who wins and who loses? Land Use Policy 31:209–222. https://doi.org/10.1016/j.landusepol.2012.06.013

Morkunas M, Labukas P (2020) The evaluation of negative factors of direct payments under common agricultural policy from a viewpoint of sustainability of rural regions of the new EU member states: evidence from Lithuania. Agriculture (switzerland) 10(6):1–14. https://doi.org/10.3390/agriculture10060228

O'Neill S, Hanrahan K (2016) The capitalization of coupled and decoupled CAP payments into land rental rates. Agric Econ 47(3):285–294. https://doi.org/10.1111/agec.12229

Ocean N, Howley P (2021) Using choice framing to improve the design of agricultural subsidy schemes. Land Econ 97(4):933–950. https://doi.org/10.3368/le.97.4.041620-0055R1
OECD (2004) Analysis of the 2003 CAP reform. OECD Pap 4(3):1–49
Ozili PK (2023) The acceptable R-square in empirical modelling for social science research. In: Saliya C (ed) Social Research Methodology and Publishing Results: A Guide to Non-Native English Speakers (Issue January 2023, pp. 134–143). IGIGlobal. https://doi.org/10.4018/978-1-6684-6859-3.ch009
Philippidis G, Hubbard LJ (2003) Agenda 2000 reform of the CAP and its impacts on member member States: a note. J Agric Econ 54(3):479–486. https://doi.org/10.1111/j.1477-9552.2003.tb00073.x
Sadłowski A, Wrzaszcz W, Smędzik-Ambroży K, Matras-Bolibok A, Budzyńska A, Angowski M, Mann S (2021) Direct payments and sustainable agricultural development—the example of Poland. Sustainability (switzerland) 13(23):1–20. https://doi.org/10.3390/su132313090
Segrelles JA (2017) Agricultural subsidies and their repercussions on family farming in the latest common agricultural policy reforms (2014–2020) in the european union: CHanging everything so that everything remains the same? Bol AGE 2017(74):161–184. https://doi.org/10.21138/bage.2449
Severini S, Tantari A, Di Tommaso G (2016) Do CAP direct payments stabilise farm income? Empirical evidences from a constant sample of Italian farms. Agric Food Econ. https://doi.org/10.11868/s40100-016-0050-0
Severini S, Tantari A (2013a) The effect of the EU farm payments policy and its recent reform on farm income inequality. J Policy Model 35(2):212–227. https://doi.org/10.1016/j.jpolmod.2012.12.002
Severini S, Tantari A (2013b) The impact of agricultural policy on farm income concentration: the case of regional implementation of the CAP direct payments in Italy. Agric Econ 44(3):275–286. https://doi.org/10.1111/agec.12010
Sinabell F, Schmid E, Hofreither MF (2013) Exploring the distribution of direct payments of the Common Agricultural Policy. Empirica 40(2):325–341. https://doi.org/10.1007/s10663-012-9194-7
Staniszewski J, Borychowski M (2020) The impact of the subsidies on efficiency of different sized farms: Case study of the common agricultural policy of the European Union. Agric Econ (czech Republic) 66(8):373–380. https://doi.org/10.17221/151/2020-AGRICECON
Statistics Portugal. (n.d.). *Agriculture census - historical series*. http://www.ine.pt
Statistics Portugal. (2019). Agricultural Census 2019. In *Destaque 24.October.2019*. Instituto Nacional de Estatística.
Svatoš M, Chovancová M (2013) The influence of subsidies on the economic performance of Czech farms in the regions. Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis 61(4):1137–1144. https://doi.org/10.11118/actaun201361041137
Trnková G, Malá Z (2012) Analysis of distribution impact of subsidies within the common agricultural policy on field production businesses in the czech REPUBLIC. Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis 60(7):415–424. https://doi.org/10.1111/actaun201260070415
Valenti D, Bertoni D, Cavicchioli D, Olper A (2021) The capitalization of CAP payments into land rental prices: a grouped fixed-effects estimator. Appl Econ Lett 28(3):231–236. https://doi.org/10.1080/13504851.2020.1749227
Viegas M, Wolf J, Cordovil F (2023) Assessment of inequality in the Common Agricultural Policy in Portugal. Agric Food Econ 11:13. https://doi.org/10.1186/s40100-023-00255-w
Volkov A, Balezentis T, Morkunas M, Streimikiene D (2019) Who Benefits from CAP? The way the direct payments system impacts socioeconomic sustainability of small farms. Sustainability (switzerland). https://doi.org/10.3390/SU11072112
Weltin M, Zasada I, Franke C, Piorr A, Raggi M, Viaggi D (2017) Analysing behavioural differences of farm households: an example of income diversification strategies based on European farm survey data. Land Use Policy 62:172–184. https://doi.org/10.1016/j.landusepol.2016.11.041
Žičkienė A, Melnikienė R, Morkūnas M, Volkov A (2022) CAP direct payments and economic resilience of agriculture: impact assessment. Sustainability (switzerland). https://doi.org/10.3390/su141710546

Publisher's Note

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