Investigating the impacts of EU CAP reform 2014-20 and developments in sustainable olive farming systems

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Jel codes: C54, Q12, Q15, Q18

Abstract

In this paper, we investigate the adoption of sustainable olive growing practices in relation with the possible impacts of the recent EU CAP reform 2014-20 on diverse olive farming systems, taking Southern Spain as a representative case study. The analysis uses statistical methods and a Positive Mathematical Programming (PMP) model calibrated with the neutral procedure. The PMP model compares the situation of the average olive farm in the baseline year with its position in a simulated year considering two policy scenarios: 1) all production systems are under CAP green payments, 2) only organic and integrated systems are under CAP green payments. Simulations show that for scenario I there is no variation in the area under the different farming systems with respect to the baseline year, nor in the gross-margin-before-aid. Subsidies increase slightly because agricultural policy does not consider the reduction for modulation included in the baseline year. In contrast, in scenario II, areas under integrated and organic farming increase to the detriment of conventional farming. It can be concluded that the distribution rules for green payments set out in the new CAP do not incentivize the adoption of integrated and organic farming. However, alternative policy options, allowing the implementation in the olive sector of environmental measures equivalent to the green schemes implemented in annual crops, could bring about additional positive effects in terms of redistribution of aid from less to more environmentally friendly farming practices. This outcome would contribute to both better rewarding the public goods generated through this public aid and boosting the legitimacy of the CAP transfers.

***Keywords**: CAP reform 2014-20, PMP, policy impact analysis, sustainable olive farming.*

Résumé

Le but de ce travail est d'explorer la relation entre l'adoption de pratiques durables en oléiculture et les possibles impacts de la récente réforme de la PAC 2014-2020 sur les divers systèmes de production oléicole, en choisissant le Sud de l'Espagne pour une étude de cas représentatif. Dans cette analyse, seront utilisés des méthodes statistiques et un modèle de Programmation mathématique positive (PMP), calibré par la procédure neutre. Le modèle PMP compare la situation de l'exploitation oléicole moyenne dans une année de base avec sa position dans une année retenue pour la simulation, suivant deux scénarios politiques :1) tous les systèmes de production s'inscrivent dans les paiements verts de la PAC, 2) seuls les systèmes biologiques et intégrés s'inscrivent dans les paiements verts de la PAC. Les simulations montrent que dans le scénario 1, aucune variation n'intervient par rapport à l'année de base ni au niveau des superficies cultivées selon les différents systèmes de production ni au niveau de la marge brute standard. Une légère augmentation des aides est observée, car la politique agricole ne considère pas la réduction pour la modulation dans l'année de base. Par contre, dans le scénario 2, les superficies cultivées selon le mode de production intégré et biologique augmentent au détriment des systèmes conventionnels. Il est possible de conclure que les règles de distribution pour les paiements verts, établies par la nouvelle PAC n'encouragent pas l'adoption de systèmes de production intégrée ou biologique, Cependant, des options de politiques alternatives, permettant d'appliquer dans le secteur oléicole les mesures environnementales équivalentes aux schémas verts réalisés pour les cultures annuelles, pourraient produire des effets positifs en termes de redistribution des aides, des pratiques agricoles les moins respectueuses de l'environnement aux plus respectueuses. Un tel résultat impliquerait une meilleure rétribution des biens publics générés à travers ces aides publiques et un renforcement de la légitimité des transferts de la PAC.

Mots-clés: Réforme de la PAC 2014-2020, PMP, analyse d'impact des politiques, oléiculture durable.

1. Introduction

Andalusia (Southern Spain) is by far the most important olive-growing region in Spain and in the world (around 60% of growing area and 75% of olive oil production at national level, and 15% of growing area and 35% of olive oil production worldwide). Over the last decade it has experienced a significant development of sustainable olive farming, mainly integrated and organic production systems (Mili *et al.*, 2013). The expansion of these systems has largely occurred to the detriment of conventional olive production.

At the same time, a new Common Agricultural Policy (CAP) reform for the period 2014-2020 has been implemented (2015). As regards the reform application in Spain, negotiations have led to establish, among other things, that all olive farming systems (conventional, integrated and organic) comply *de facto* – i.e. without further obligations – with the greening conditions that determine eligibility to receive direct payments.

In this context, the present contribution aims to explore the adoption patterns of integrated and organic olive farming systems in Andalusia over the last years and how this process could be affected by new CAP scenarios. The basic motivation is the need to gain a better understanding of the policy measures implemented in the heavily supported olive sector in the EU. The effects of these policy measures on production, farming systems and farm margins represent an important issue from the policy-making point of view and a relevant research question.

The adoption process of sustainable (integrated, organic) farming techniques is explored by means of regression procedures, while the probable impacts of the new CAP measures are assessed using a Positive Mathematical Programming (PMP) model calibrated with the neutral procedure, where the baseline year is 2011 – the last year for which all data needed are available. In practice, the PMP model evaluates the impacts of the new policy (olive farming is totally under greening) against the potential effect of an alternative policy, considering that greening conditions are fulfilled only by the integrated and organic farming systems, which, admittedly, are more environment-friendly and have already benefited from specific agri-environmental support under the previous CAP regime.

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The PMP is a technique widely used to investigate the impacts of public policies on the agricultural sector[1]. However, it does not allow apprehending changes in the distribution of the crop surface area which are not ascribable to policy changes, like price, yield or cost moves. Therefore, it cannot be used to assess crop evolution resulting from the adoption of technology, such as the integrated and the organic olive growing systems in our case study.

This article is organized as follows. Section 2 provides a background of the study. Section 3 presents, on the one hand, the data used to analyse the evolution in the last years of integrated and organic olive production systems as well as the variables (prices, yields and costs) that can account for this evolution and, on the other hand, the baseline year data and the policy scenarios for the simulations performed with the PMP model. Section 4 describes the methodology applied in this research, by detailing first the statistical methods used to analyse the evolution of sustainable olive farming systems, and then, the characteristics (objective function, equations and calibration procedure) of the PMP model applied. Results are illustrated in section 5 and conclusions are drawn in section 6.

2. Background of the research

Olive cultivation represents a major agricultural activity in Andalusia in terms of contribution to regional economy and rural development. From 2000 to 2014 Andalusian oil olive production came to about five million tons, ranging from almost three million in 2012 to over seven million in 2013 (Ministry of Agriculture, Food and Environment - MAGRAMA, 2015). Since the growing area has not changed significantly, these oscillations prove to be mainly the result of yearly yield fluctuations which are, in turn, largely due to weather variation. Olive yield in Andalusia is over 30% higher than the Spanish average, even though the introduction of modern production technology all over the country seems to counterbalance to a certain extent the natural advantages of Andalusia for olive production.

As regards the production structures, according to the last Agricultural Census published by the Spanish National Statistics Institute (INE, 2011), small farms (less than 10 ha) prevail in both dry and irrigated farming systems. In general, irrigated farms tend to be smaller than dry farms, except for the largest stratum (more than 100 ha) in which irrigated farms are on average 18 ha larger. The other source of structural and economic and financial data on olive holdings is the Spanish National Farm Accountancy Network database (annual farm-level survey integrated into the Community Farm Accountancy Data Network). Data are obtained from a representative sample of farms participating in the network. Farms are stratified according to production system, size measured in Economic Size Units (ESU, with one ESU representing €1,200 of standard gross margin) and region. The aggregates for all farms in the different regions and at national level are also presented. In the case of Andalusia, the 2014 sample contains 283 olive holdings. Cost analysis of the whole sample reveals that, on average, the most important entries are, in a decreasing order, wages and related social expenses (€8,124), plant cultivation (€7,823), depreciation (€4,683) and energy (€3,185). Analysis of production ratios by farm size shows that land productivity decreases in the 50-100 ESU farm stratum to €1,052/ha, with a sample average of €1,566/ha. As for the labour productivity, the lowest Net Value Added per Agricultural Work Unit is noticed in the stratum for smallest farms (8-25 ESU): €18,185 being the sample average €22,568.

There has also been a significant development of integrated and organic production paralleled with a slight decrease in conventional farming in the region (section 3.1 shows the evolution of the growing area of different olive farming systems in the period 2002-2011 considered in this research). Integrated and organic olive production systems display significant differential features that are worth highlighting. Integrated production uses less aggressive cultivation method and chemical processes compared with the conventional system. It seeks a balance between environment preservation and economic profitability. Introduction of this production system requires a well-developed extension service and the adoption of practices like soil, water and plant analysis, insect trapping and certification. An important policy feature is that there is no European legal framework for integrated production but many national and regional regulations (Narro, 2014), creating legislative confusion.

In contrast, organic production uses very strict limits on chemical synthetic pesticides and synthetic fertilisers. Organic production allows for some cost reductions, however higher costs appear in the form of reduced yields. There is a European regulation and a European quality label for this farming method. Organic production was recognised at European level by EC regulation 2092/91 (in Spain it has been regulated since 1989), and it represents a priority among the measures covered by the EU and the Spanish rural development programmes.

Besides, for economic, social, cultural and environmental reasons, in Europe the olive sector has traditionally benefited from strong public support. Our estimates of the Producer Subsidy Equivalent (PSE) – an indicator designed by the OECD to measure total monetary transfers from consumers and taxpayers to agricultural producers (OECD, 2010), indicate that, for the period 2006-2012, it reaches on average 42% of the gross olive producer receipts in Spain as measured at farm gate, 45% in Italy and 49% in Greece. This level of support confirms the exceptional status of this production in the Mediterranean agriculture in terms of protection compared with other Mediterranean products like wine and fruit and vegetables (Mili, 2009).

There are several public policies affecting the olive market in Andalusia and in Europe overall: the EU CAP, and the en-

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[1] A recent study using PMP to assess the impact of CAP reform 2014-20, with a focus on the Italian tomato sector, is reported in Solazzo *et al.* (2014).

vironmental, fiscal, commercial, competition, health and consumer and research and innovation policies. The most relevant regulation for olive oil is by far the CAP. This body of rules, which was first established in regulation 136/66/CEE in 1966, has been more or less substantially modified over the years, in line with more comprehensive changes in commercial and agricultural policies at national, Community and international levels. Relevant regulatory changes started to be introduced following the World Trade Organization (WTO) Uruguay Round trade agreement in 1994, affecting particularly trade regulation with non-member countries.

Subsequently, further changes were adopted in 2004 as part of a deeper CAP reform covering Mediterranean products (European Commission, 2003). The 2004 CAP reform pursued the same objectives of the previous MacScharry reforms in 1992 and 1999, in the framework of Agenda 2000: strengthen the competitiveness of European agriculture, guarantee farmers' incomes, integrate the new Member States, preserve the environment, and increase compliance with WTO rules. However, the 2004 reform has brought fundamental changes. The modifications concerning decoupling and modulation of direct payments have been central to such changes (according to modulation provisions, all direct payments -coupled and decoupled- were reduced after the first €5,000 by 7% in 2009, 8% in 2010, 9% in 2011 and 10% in 2012; these percentages are increased by 4% for amounts above €300,000). In the olive sector, total decoupling (100%) has been applied leading farmers' production decisions to depend further on market conditions. Under certain circumstances, Member States are also granted large flexibility margins for cross-compliance, i.e. receiving payments in return for respecting environmental regulations. Decoupled payments to olive producers are notified to WTO as green box, i.e. support considered as minimally or non-trade-distorting and not subject to any ceiling or reduction commitments in the WTO (Mili, 2006).

The new CAP reform 2014-2020, which started to be applied in 2015, is also in line with previous reforms and more broadly with "Europe 2020 Strategy" and its objectives in terms of employment, innovation, education, social inclusion and energy. However, it brings new measures to (1) improve aid redistribution and internal (in-country) and external (between countries) convergence, (2) introduce greening of aids, (3) support young farmers, (4) increase support for sustainability, provision of public goods and rural development, (5) strengthen the bargaining power of producers in the food chain. The implementation of these measures depends decisively on the practical modalities adopted at national level, given the great flexibility granted to the Member States for their enforcement.

As far as sustainable farming systems are concerned, the new CAP 2014-2020 sets out incentives for the inclusion of integrated farming in new equivalence systems related with the green payment. Indeed, this is what has happened in the olive sector, leading to considering both conventional and integrated production methods as equivalent to greening conditions. Member States decided in fact to adopt these two production systems as equivalent of the greening basic measures established in the reform which maintain permanent grassland, crop diversification, and an Ecological Focus Area. Organic farming methods comply *per se* with greening measures. Thus, in the CAP 2014-2020, and like other perennial crops, in Spain application modalities establish that all these olive farming systems comply *de facto* and without further obligations with greening conditions that determine eligibility to direct payments.

3. Data and policy scenarios

3.1. Data to analyze the development of the integrated and organic farming systems

Table 1 shows the olive producer prices, yields and costs per hectare from 2002 to 2011 in Andalusia. Prices and yields are provided by MAGRAMA (2013). Costs are those estimated for the year 2000 in Andalusia by Garcia *et al.* (2008), updated for the following years using the MAGRAMA index of prices paid by farmers. It should be noted that the olive oil yield is obtained by multiplying the olive yield by 0.213 (transformation coefficient from olives into olive oil).

Table 1 - *Prices, yields and costs of olive production in Andalusia, 2002-2011.*

Year (t)	Prices (€/100 kg): p	NON-IRRIGATED		IRRIGATED	
		Yields (100kg/ha): yd	Costs (€/ha): cd	Yields (100kg/ha): yi	Costs (€/ha): ci
2002 (2)	39.93	20.86	565.68	40.69	828.64
2003 (3)	45.58	39.21	583.18	62.02	857.54
2004 (4)	50.12	25.39	600.59	44.12	881.90
2005 (5)	63.41	17.01	621.54	34.52	909.10
2006 (6)	77.57	27.85	646.31	49.23	949.88
2007 (7)	54.06	30.02	680.20	52.39	998.95
2008 (8)	49.67	25.72	804.95	44.77	1155.12
2009 (9)	39.55	35.69	772.45	53.75	1117.99
2010 (10)	39.81	34.94	761.35	56.01	1113.00
2011 (11)	37.72	40.16	816.66	57.76	1189.11

With respect to farming system areas, Table 2 shows the series from 2002 to 2011 for irrigated and non-irrigated area of the integrated system, and the non-irrigated area of the organic system. The conventional irrigated and non-irrigated area is obtained by subtracting the sum of organic and integrated area from the total area (irrigated and non-irrigated) grown with olive. It should be underlined that the sources of original data for conventional and integrated areas do not differentiate between irrigated and non-irrigated. Consequently, we assume for both systems the same percentage distribution of dry and irrigated as it is stated for the total area.

Table 2 - *Area under different farming systems in Andalusia (hectares), 2002-2011.*

Year (t)	Conventional		Integrated		Organic
	Dry	Irrigated	Dry	Irrigated	Dry (total)
2002 (2)	1097403	237475	31412	6798	31517
2003 (3)	1033981	261734	46597	11795	37588
2004 (4)	1015266	256041	62730	15820	40868
2005 (5)	1009438	261895	72329	18766	41516
2006 (6)	957768	248641	128258	33296	42148
2007 (7)	924174	238748	154010	39786	42336
2008 (8)	895497	234753	186068	48777	41557
2009 (9)	882689	229010	201133	52183	46648
2010 (10)	867307	234735	219164	59316	46902
2011 (11)	840688	232987	242479	67201	56023

3.2. Data for the PMP model

In order to measure the impact of the new CAP 2014-2020 independently from other variables (in particular prices, yields and costs) on the different olive farming systems, the results of the representative PMP farm model described below for the baseline year 2011 will be compared with the results obtained by simulating new agricultural policies, keeping the other variables constant.

3.2.1. Characteristics of the modelled farm in the baseline year

Table 3 summarizes the characteristics of the average olive farm in Andalusia in 2011. The total irrigated and non-irrigated areas of the average farm correspond to those of the average farm growing olive grove (table olive area is excluded) in Andalusia according to the last Spanish agricultural census of 2009 (INE, 2011). The distribution of the irrigated and non-irrigated land in the different farming systems has been estimated as equal to the proportion of these systems in the irrigated and non-irrigated total area of olive groves in Andalusia, as can indicated in Table 2. Prices, yields and costs/ha in conventional farming are reported in Table 1 for 2011. The yields of integrated and organic productions are considered the same as in conventional production (Guzman Casado *et al.,* 2002). The olive price is assumed to be, for organic, 1.2 times and for integrated ,1.1 times the conventional, according to Alonso Mielgo and Guzmán Casado (2004) and Alonso *et al.* (2008). Their studies demonstrate that the variable costs per hectare of organic and integrated are respectively 1.1 and 1.05 times the conventional[2].

Table 3 - *Characteristics of the average farm.*

Farming system	Area (ha)	Yields (100 kg olives/ha)	Prices (€/100 kg olives)	Variable costs (€/ha)
Dry farming	*5.811*			
Conventional	4.288	40.16	37.72	816.66
Integrated	1.237	40.16	41.49	857.49
Organic	0.286	40.16	45.26	898.33
Irrigated farming	*1.966*			
Conventional	1.526	57.76	37.72	1189.11
Integrated	0.440	57.76	41.49	1248.57

3.2.2. Agricultural policy scenarios

Table 4 shows the agricultural policy measures taken into account to compare their impacts on the average olive growing farm in Andalusia. The basic source of measures for the baseline year 2011 is Mili *et al.* (2013). For this year a reduction of 9% of the total direct payments exceeding 5000 € is applied to the farm in concept of modulation, according to the regulation in force in 2011. The suggested scenarios I and II consider the general rule established in the new CAP reform (European Commission, 2013a, 2013b), where only 70% of the total decoupled direct payments existing in the baseline year are kept in all cases while the remaining 30% are received when greening practices are implemented. The first scenario considers that – as approved in the new CAP for permanent crops including olive production – all olive farming systems comply with the greening conditions. In contrast, the second scenario assumes that only organic and integrated farming obtain systematically 30% of the direct payments intended for greening practices.

Table 4 - *Agricultural policy measures in baseline year and scenarios.*

Type of support	Baseline year (2011)	Scenario I: all systems are under green payments	Scenario II: Only organic and integrated are under green payments
Decoupled direct payments	764.78 €/ha	535.35 €/ha	535.35 €/ha
Greening suport			
Conventional production		229.43 €/ha	0.00 €/ha
Organic production		229.43 €/ha	229.43 €/ha
Integrated production		229.43 €/ha	229.43 €/ha
Agri-environmental support (coupled)			
Organic production	266.85 €/ha	266.85 €/ha	266.85 €/ha
Integrated production	49.14 €/ha	49.14 €/ha	49.14 €/ha

4. Methodology

4.1. Methods to study the adoption of integrated and organic farming

The methods used to study this aspect mainly imply the use of plots, moving averages and regression models to analyze trends in prices, yields and costs, and to investigate whether there is any relationship between them and the trends observed in the evolution of the surface area of the integrated and organic farming systems.

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[2] These characteristics highlight the advantage (higher gross margin per hectare) of organic and integrated systems with respect to the conventional system even without considering the agri-environmental aid received by the former two systems.

4.2. The PMP model

Let be the area in hectares for the crop *i* (*i*=1: conventional olive, *i*=2: integrated olive, *i*=3: organic olive) on land type *j* (*j*=1: dry land, *j*=2: irrigated land). The model to simulate the results with different agricultural policies, prices and costs can be represented as follows:

$$\text{(3)} \qquad \max:\ F = \sum_{j=1}^{2}\sum_{i}\left[p_{ij} * y_{ij} + a_{ij} - c_{ij} + \left(\alpha_{ij} + \beta_{ij} * X_{ij}\right)\right] * X_{ij} + XP1 + mod * XP2$$

$$\text{(4)} \qquad \sum_{i} X_{ij} \ \leq A_j \quad (\lambda_j) \quad \forall j$$

$$\text{(5)} \qquad XP1 + XP2 \quad \leq DP$$

$$\text{(6)} \qquad XP1 \quad \leq M$$

$$\text{(7)} \qquad X_{ij}, XP1, XP2 \quad \geq 0$$

Where the following variables are added to:

*XP*1: amount, in €, of decoupled direct payments not liable to be reduced via modulation.

*XP*2: amount, in €, of decoupled payments above *XP*1, liable to modulation reductions. In the simulation scenarios *XP*2 = 0.

And where:

$p_{ij}, y_{ij}, a_{ij}, c_{ij}$,: price, in €/kg of olives; yield, in kg/ha; coupled support not subject to reduction by modulation (agri-environmental aid for organic and integrated olive groves in the baseline year to which coupled direct payments are added in simulations), in €/ha; and costs, in €/ha, of crop *i* on land type *j*.

A_j: area, in ha, of land type *j*.

DP: Decoupled payments received by the farm. In the baseline year and in simulations these payments are: (A_1+A_2) x decoupled payments/ha shown in Table 4.

mod: (100-% of reduction via modulation). This parameter is 0.91 in the baseline year, where the reduction percentage is 9%, and 1 in the simulation scenarios where there is no reduction for modulation.

α_{ij} and β_{ij}: parameters to calibrate the model in the baseline year. Their expressions are reported below.

In the model, expression (3) to be maximized represents the farm's gross margin (including coupled subsidies) plus decoupled aid. It comprises the decreasing gross margin functions for each crop with respect to the crop level, as it corresponds to the neutral calibration procedure proposed by Röhm and Dabbert (2003)[3]. Equation (4) is the land area constraint, for both dry and irrigated farming. Equation (5) defines decoupled payments due to the farm before modulation: *XP*1 +*XP*2*,* and equation (6) limits the amount of these payments, *M*, free from modulation reductions. *M* amounts to €5,000 in the baseline year and is a positive real unrestricted number in the simulations, when no modulation takes place. Lambda in the right of the land constraints represents its dual values.

Estimation of parameters α_{ij} *and* β_{ij}.

The Kuhn-Tucker necessary conditions for the optimum solution of the model (3)-(7) at point $X_{ij} = \bar{X}_{ij}$ (with $\bar{X}_{ij}$ being the olive-growing area *i* on land type *j* in the baseline year) are verified if the following equation holds for all couple *i,j*:

$$\text{(8)} \qquad \left(\frac{\partial F}{\partial X_{ij}}\right)_{X_{ij}=\bar{X}_{ij}} = \bar{\lambda}_j$$

Where, $\bar{\lambda}_j$ is the value of λ_j in the baseline year.

The proof for a general model can be found in Jades *et al.* (1998), being the result subsequently used in Jude et al. (2001) and proved with greater detail in jades *et al.* (2002).

Developing $\left(\frac{\partial F}{\partial X_{ij}}\right)_{X_{ij}=\bar{X}_{ij}}$ from equation (3), equation (8) becomes:

$$\text{(9)} \qquad \bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} - \bar{c}_{ij} + \alpha_{ij} + 2\beta_{ij} * \bar{X}_{ij} = \bar{\lambda}_j$$

where $\bar{p}_{ij}, \bar{y}_{ij}, \bar{a}_{ij}$ and $\bar{c}_{ij}$ are the values of p_{ij}, y_{ij}, a_{ij} and c_{ij} in the base year and where $\bar{\lambda}_j$ is the opportunity cost of the land type *j* that year.

The estimate of the objective function parameters, using (9), to calibrate the model requires a previous estimate of the opportunity costs of resources (irrigated and non-irrigated land in this case). In the traditional application of the PMP, this estimate is performed by means of an auxiliary LP with calibration constraints in the so-called first step of the PMP (Howitt, 1995). The use of this first step entails two weaknesses: if) the marginal crop (the crop with the lowest gross margin) has no quadratic term in the objective function (the calibration with exogenous elasticities does not have this disadvantage), and ii) it is not possible to include *a priori* values of the opportunity cost of resources. In the present paper, these problems are avoided by skipping the first step of the PMP using only the necessary conditions of Khun-Tucker (equation (9) in this case) to estimate the parameters (see Buysse *et al*., 2004; Júdez *et al*., 1998, 2001), considering as the opportunity cost of land its yearly rental price in Andalusia for olive farming, which, according to MAGRAMA (2013), amounts to 301 €/ha in 2010 (last figure available) for the non-irrigated land. For the irrigated land, it has been estimated to 600.19 €/ha, taking into account the relationship between the yearly rental prices of irrigated and non-irrigated land reported by Mili *et al.* (2013). The yearly rental prices obtained are compatible with the necessary condition: $\bar{\lambda}_j \leq \min\,(\bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} - \bar{c}_{ij})$ to have decreasing marginal gross margin for crops in the objective function.

Now, Equation (9) has two parameters to be determined, so there is an infinity number of values of α_{ij} and β_{ij} satisfying (9). To obtain a unique solution for these parameters a new equation must be added. To solve this problem in the neutral calibration, the following equation (10) proposed by Röhm and Dabbert (2003)[4] is added:

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[3] This calibration procedure proved to be the most suitable after comparison with the cost average procedure and the use of exogenous elasticities (see Mili *et al.*, 2013).

[4] The main contribution of this paper by Röhm and Dabbert is not the proposal of neutral calibration, but the introduction of specific calibration constraints in the linear programming model for the first step

$$(10) \qquad \alpha_{ij} + \beta_{ij} * \bar{X}_{ij} = 0$$

From (9) and (10) the expressions of α_{ij} and β_{ij} are:

$$\beta_{ij} = [\bar{\lambda}_j - (\bar{p}_{ij} * \ \bar{y}_{ij} + \bar{a}_{ij} - \bar{c}_{ij})]/\bar{X}_{ij}$$

$$\alpha_{ij} = -\beta_{ij} * \bar{X}_{ij}$$

It is worth noting that equation (10) allows the results of the model for the baseline year to recover the gross margin plus the total aid actually existing in that year.

5. Results

5.1. Adoption of integrated and organic farming

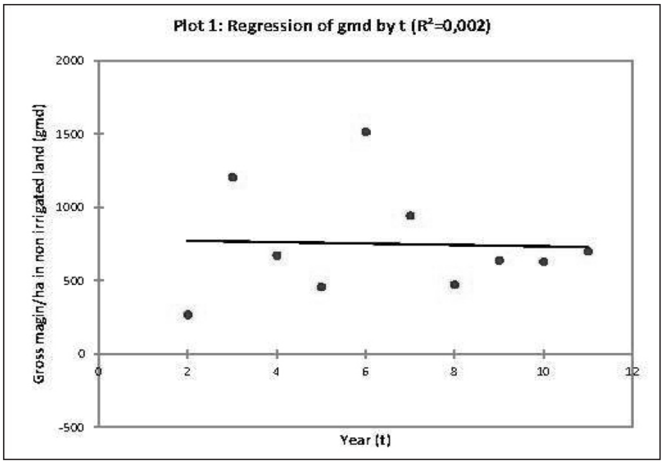
The results illustrated in this section were obtained using XLSTAT.

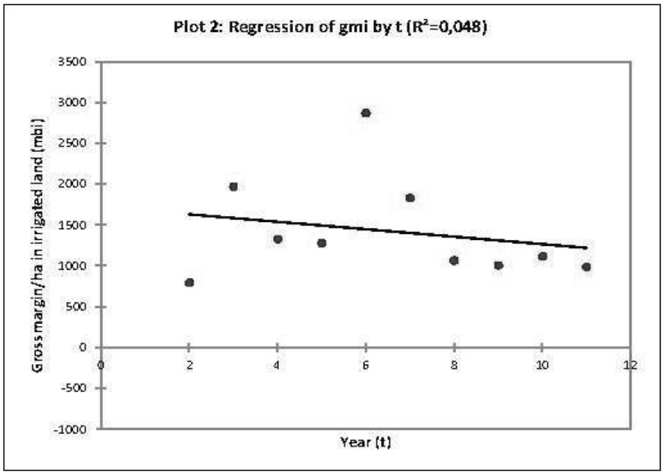
5.1.1. Price, yield and cost trends

Price, yield, and cost trends included in Table 1, as well as in the series of revenue per hectare without aid in non-irrigated (rd=p*yd) and irrigated (ri=p*yi) area, are illustrated in Plots A1-A7 in Appendix 1.

The 3-year moving average of prices and yields (Plots A1-A3) indicate that prices fall when yields increase and vice-versa. Also, it can be noticed that oscillations of prices and yields are transmitted to oscillations in revenue without aid (Plots A4 and A5). However, regressions of revenues by time show horizontal lines in accordance with a stable trend in the studied period. Meanwhile, in this period costs exhibit a constant increase as shown by the very good fit of the linear regression of costs by time (Plots A6 and A7).

Considering all these trends, it can be concluded that, overall, olive production in Andalusia takes place in a context of stable revenue (at current prices) and increased costs. Nevertheless, as illustrated in Plots 1 and 2, the gross margin per hectare (excluding policy aids) both in the non-irrigated (gmd=rd-cd) and in the irrigated (gmi=ri-ci) does not decrease significantly due to the huge revenue variation per hectare over time.





5.1.2.Trends in integrated and organic olive farming areas

Plots 3 and 4 represent the evolution of the organic and the integrated area, which corresponds to the series reported in Table 2, considering the dry and the irrigated area of the integrated farming as aggregated, as well as the linear models that fit this evolution.

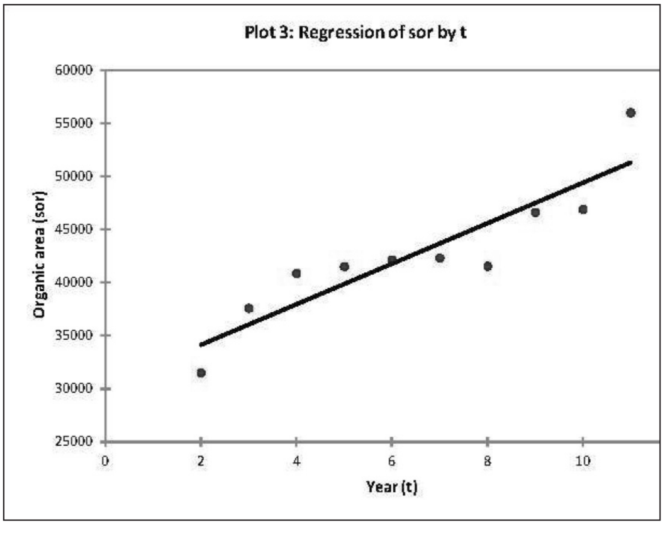
The following equations (1) and (2) are the expression of these models.

$$(1)\ sor_t = 30302.67 + 1908.87t + e_t \qquad R^2 = 0.82$$
$$(13.30) \qquad (5.95)$$

$$(2)\ sin_t = -26146.72 + 26488.13_t + 39609.42D_t + et \quad R^2 = 0.99$$
$$(-3.05) \qquad (13.07) \qquad (3.33)$$

Where: and are the area of organic and integrated systems, respectively, in the year, is the residual in the year, is the determination coefficient, and in brackets are the t-statistics. D is a dummy variable such as:

$$D_t = \begin{cases} 0 & if \quad t < 6 \\ 1 & if \quad t \geq 6 \end{cases}$$



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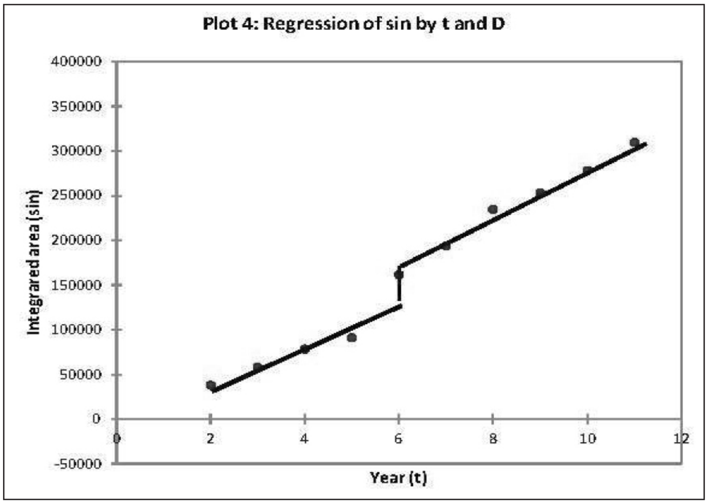
of PMP to achieve more realistic substitution between different variants (farming technologies) of a crop when other crops are present. The proposal cannot be applied in this research because the farm area can only be occupied by the different variants of olive growing.



These adjustments show the sustained increase over time of both type of farming. This increase seems to be independent of price and yield. It appears as if the more interesting gross margin per hectare of the organic and integrated farming compared with the conventional farming was resulting into a continuous increase of the two former production systems, probably reflecting the process of adoption of these two new production techniques replacing conventional farming.

Moreover, in the period under study no relevant new regulation has been adopted aiming to provide public support to the organic production system. However, the regulation in force for the integrated system has been modified following the implementation of the Royal Decree 1203/2006 governing subsidy allocation modalities for environment-friendly agricultural production systems. This could probably explain the step in the integrated production area between 2005 and 2006, described statistically by the dummy variable, D, in equation (2) (see Plot 4) and also demonstrate that the allocation of new aid, unlike prices and yields, significantly affect the trend in the adoption of a new production technology.

5.2. PMP model results

First, it should be recalled that the results of PMP models are obtained following the hypothesis that the unit modeled (the farm in this case) is in equilibrium in the baseline year, i.e. the distribution of crops will not change if prices, costs, yields and policy measures remain constant. In this respect, the sustained increase observed in section 5.1 in the area of integrated and organic farming during the period under investigation - which is independent of the over-mentioned parameters - is not taken into account in the result variations for different simulations with respect to the baseline year reported in Table 5. These variations only reflect the changes due to the implementation of agricultural policies simulated, i.e. prices, costs and yields are considered constant. All PMP results were obtained using GAMS.

Concerning scenario I (all systems benefit from the greening aid), Table 5 shows that no variation occurs in the area of different farming systems with respect to the baseline year. The gross-margin-without-aid does not vary. Subsidies increase slightly in so far as the agricultural policy for this simulation does not consider the reduction for modulation (€85.29) included in the baseline year.

Table 4 - *Agricultural policy measures in baseline year and scenarios.*

	Baseline year 2011	Simulations (% variation with respect to baseline year)	
		Scenario I: All systems are under green payments	Scenario II: Only organic and integrated are under green payments
Area			
Conventional dry farming (ha)	4.29	0.00	-5.51
Integrated dry farming (ha)	1.24	0.00	16.67
Organic dry farming (ha)	0.29	0.00	10.49
Conventional irrigated farming (ha)	1.53	0.00	-4.67
Integrated irrigated farming (ha)	0.44	0.00	16.17
Subsidies			
Coupled aid (€)	158.67	1124.55	341.89
Decoupled aid before modulation (€)	5947.69	-30.00	-30.00
Modulation reduction (€)	85.29	-100.00	-100.00
Decoupled aid after modulation (€)	5862.40	-28.98	-28.98
Total aid after modulation (€)	6021.07	1.42	-19.21
Gross margin and objective function			
Gross margin without aid (€)	6272.47	0.00	0.65
Gross margin plus aid (€)	12293.54	0.69	-9.08
Objective function (€) (1)	12293.54	0.69	-9.87
Ratios			
Total aid/ha (€)	774.22	1.42	-19.21
Gross margin plus aid/ha (€)	1580.76	0.69	-9.08
Total aid/Gross margin plus aid (%)	48.98	0.72	-11.14

(1) Gross margin plus aid with quadratic function.

Moreover, Table 5 shows that in simulation II (only integrated and organic systems receive greening aids) integrated and organic farming areas increase to the detriment of conventional farming area. This variation of the on-farm area distribution is associated with a total aid decrease of nearly 20%, resulting from a 30% loss of decoupled aid, being recovered as coupled aid in integrated and organic farming, but not recovered in conventional farming because in simulation II, this system is supposed not to benefit from greening aid. Hence, the gross margin plus aid decreases by 9%.

6. Conclusions

The present investigation shows that in Andalusia, the area under both integrated and organic olive farming continuously increased in the period 2002-2011. This growth was achieved to the detriment of the predominant conventional system and independently of the evolution of prices, yields and agricultural policy measures. In the case of an integrated farming system, it appears that new policy proposals cause a short-term boost. The evolution of the integrated and organic farming area can mainly be attributed to the adoption of these relatively new technologies (farming practices) that are more profitable than the replaced technology (conventional farming system).

The simulations performed show that with the new CAP, which establishes that all olive farming systems fulfill by definition the conditions to receive green payments, no change will occur in the distribution of the farm area for the three systems nor in the aid received. Conversely, if the organic and integrated farming systems are under green payments, while the predominant conventional farming cannot benefit from such support, the area under the integrated and organic systems could increase significantly with a resulting decrease in the area under conventional cultivation. This substitution between farming systems is associated with the losses in the total aid received, which in turn cause a decrease in the farm benefits.

Arguably, the distribution rules of the green payment established in the new CAP do not incentivize the adoption of integrated and organic farming systems. However, alternative policy options, allowing the implementation of environmental measures in the olive sector comparable to the green schemes implemented in annual crops, could bring about additional positive effects in terms of redistribution of aid from less (conventional) to more environmentally friendly farming practices (integrated, organic), which contribute to both rewarding better the public goods generated through such public aid (better environment and product quality) and boosting in the meantime the legitimacy of the CAP financial aid.

This policy scenario could become a realistic option in future revisions of CAP measures (Matthews, 2014). It would enhance the level of environmental additionality through new compulsory options for greening, focusing on alternative means for delivering improved environmental management in permanent crops including olive farming. Such policy orientation will depend on many factors, especially the prospective EU Multiannual Financial Frameworks and the evolution of the olive international market. It will also be related to the necessary balance between environmental added value, administrative burden and political acceptability of policy changes (Hart *et al*., 2016). The growing pressure on budget targeting in the EU and the increased societal demand in terms of food safety and environmental sustainability will presumably push in this direction.

At the same time, the above-mentioned budgetary, societal and political determinants are to be considered in the context of the broader debate to shape the CAP after 2020. Internally, some of the proposals for the CAP post 2020 point out the need for a shift away from direct payments to farmers towards greater support for innovation systems that could improve agricultural productivity and sustainability (OECD, 2016), while other suggestions include moving direct payments from a per ha basis to a per-person basis as a way to counteract outflow of labour out of the agricultural sector in Europe (Vogelzang *et al.,* 2016). Externally, it seems that much remains to be done to achieve further reduction of distortions on the international market (Tangermann, 2014). The various CAP reforms have certainly improved its compliance with the international trade rules, particularly those of the WTO, but the overall impact remains somehow unchanged since actual support changes formally but not in scope. This support generates disputes in non-EU competing countries, particularly in the Southern and Eastern Mediterranean region, where the olive industry barely receives public financial support. Therefore, an international rebalancing of EU support, based on a higher policy coherence at international level, with the resulting effects on the olive sector, would probably be another major challenge for the forthcoming CAP reforms. Finally, for future research, further comparative analysis might be conducted following this approach based on farm size strata, also in other producing countries using properly adapted policy scenarios.

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Appendix 1 - *Trends of prices, yields, revenues and costs.*