Evaluating the Impacts of Policy Reforms under Changing Market Conditions on Olive Farming Systems in Southern Spain

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Abstract

This contribution explores the impacts of alternative policy reform and market scenarios on different olive farming systems (conventional, integrated and organic) in the Spanish region of Andalusia, by far the most important olive-growing region in Spain and in the world. It simulates the possible consequences of policy schemes such as decoupling, modulation and agri-environmental measures, using a representative farm Positive Mathematical Programming (PMP) model calibrated with the neutral procedure. Selection of this calibration procedure is based on its better predictive power compared to two other procedures also tested: the average cost procedure and calibration with exogenous elasticities. The impact analysis focuses primarily on the distribution of different farming systems over the production area and on farms' gross margins. The analysis compares the results of a base year 2002, in which all subsidies are coupled, with those of scenarios entailing decoupled non agri-environmental support and complementary subsidies for integrated olive farming. Input costs and positive and negative price variations with respect to the base year are considered. Results show inter alia that the recent agricultural policy changes favour the growth of integrated olive production. They also show that while decoupling has a small impact on land distribution in an increased price context, it might trigger an abandonment of part of the cultivated area in a decreased price context. This study opens up a new research avenue for the olive sector as it is the first time that farm modelling is used to investigate the impacts of olive agricultural and environmental policies on different market price and input cost settings.

Keywords: *Olive farming systems, agricultural policy reforms, PMP, representative farm model, Andalusia.*

Résumé

Dans cet article, nous allons explorer les effets de différents scénarios de réformes politiques et de marché sur les divers systèmes de production oléicole (conventionnel, intégré et biologique) en Andalousie, la région oléicole la plus importante en Espagne et dans le monde. Une simulation est proposée des possibles conséquences des dispositifs politiques tels que le découplage, la modulation et les mesures agro-environnementales, au moyen d'un modèle de Programmation mathématique positive PMP) d'exploitation type, calibré par la procédure neutre. Le choix de cette procédure de calibrage est basé sur sa meilleure capacité prédictive par rapport à celle des deux autres procédures également testées: le calibrage avec les coûts moyens et avec les élasticités exogènes. L'analyse d'impact est principale ment centrée sur la distribution superficielle des différents systèmes de production ainsi que sur les marges brutes des exploitations. L'analyse compare les résultats d'une année de base, 2002, pendant laquelle toutes les subventions sont couplées, avec ceux des scénarios comportant des soutiens non-agri-environnementaux découplés et des subventions complémentaires pour l'oléiculture intégrée. Les coûts des intrants et les variations positives et négatives de prix par rapport à l'année de base sont pris en considération. Les résultats montrent *inter alia* que les changements récents des politiques agricoles favorisent l'expansion de l'oléiculture intégrée. Ils montrent également que, bien que le découplage ait une faible incidence sur la distribution des terres dans un contexte de prix élevés, il pourrait provoquer l'abandon d'une partie de la surface cultivée dans un contexte de prix à la baisse. Cette étude ouvre une nouvelle voie de recherche pour le secteur oléicole, puisque c'est la première fois que ce type de modélisation est utilisé pour étudier les impacts des politiques agricoles et environnementales de l'olivier dans différents contextes de prix de marché et de coûts des intrants.

Mots-clés: Systèmes de production oléicole, réformes politiques, PMP, modèle d'exploitation type, Andalousie.

1. Introduction

World olive oil production takes place mostly in the Mediterranean basin, with Spain being the leading producer country and having the largest olive-growing area in the world (45% of world production and 25% of world olive-growing). Within Spain, Andalusia is the region harbouring the largest production, with 75% of national olive oil production and 62% of the growing area. Moreover, in many parts of Andalusia olive cultivation constitutes the basis for almost all economic activities. Andalusia is therefore the most representative region for performing studies on the olive sector from a regional perspective.

The economic performance of the olive sector is strongly dependent on the regulatory environment in addition to market variables. In Spain, the most important norm by far is the European Union (EU) regulation on the Common Market Organization (CMO) for olive oil. This body of rules, which was first established 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. The recent modifications in the Common Agricultural Policy (CAP) on decoupling and modulation of direct payments have been central to such changes.

The main objective of this study is to explore the likely impacts of policy schemes like decoupling and modulation and of specific agri-environmental measures under different price and cost scenarios, both on different olive farming systems (conventional, integrated and organic) and on farms' gross margin in Andalusia. Section 2 provides background information on the main recent developments in the olive sector in Andalusia. It briefly describes production areas and yields under both dry and irrigated farming, producer and input prices, farm structure and the situation of integrated and organic olive farming in the region. An analysis of the changing agricultural policy in the sector is also presented in this section. Section 3 presents the methodology used – the positive mathematical programming (PMP) model, to simulate the impacts of policy, price and cost variations. The approach followed allows comparison of the results for

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the average olive farm in Andalusia in the base year (2002) with simulations for policy and market conditions for 2008 and 2009. Section 4 evaluates the model calibration procedures tested and analyses the impacts of different scenarios on the representative farm. Finally, some conclusions are drawn in section 5.

2. Background

According to the Spanish Ministry of the Environment and Rural and Marine Affairs (MARM, 2011), the olive growing area in Andalusia represents around 62% of the total Spanish olive growing area. It increased from 1,150,000 ha in 1996 to 1,412,000 ha in 2009. Approximately 80% of this area is under dry farming. Irrigated olive area was 129,000 ha in 1996 and reached 281,000 ha in 2009. Andalusia has a higher percentage of irrigated olive groves than the rest of Spain.

Andalusian production of oil olives from 1996 to 2009 was around four million tons (80% of the Spanish total), ranging from two million in 1999 to almost six million in 2003. Since the growing area did not change much, these oscillations were essentially the result of yearly yield fluctuations which in turn are largely due to weather variations. Olive yield in Andalusia is 30% higher than the Spanish average, even though the introduction of modern production technologies all over Spain seems to counterbalance to a certain extent the natural advantages of Andalusia for olive production. Average olive yield in Spain is around 2.2 tons/ha and in Andalusia around 3 tons/ha, with greater dispersion in Andalusia. Dry farming yields in Andalusia are approximately 2.7 tons/ha and in Spain approximately 2 tons/ha. The yield gap for irrigated olives is much smaller: 4.4 tons/ha in Andalusia *versus* 4.2 tons/ha in all of Spain.

Olive producer perceived prices showed steady increases in nominal terms during the last two decades with peaks in 1996 and 2005. In these two years, drought caused a drop in yields with a marked reduction in production and a rise in prices. Regarding input prices, labour is the major cost item in the production process (Mili, 2009). According to the indexes of agricultural input prices in Spain, labour costs increased by 183% (permanent labour) and 188% (seasonal labour) between 1985 and 2006. This is especially high considering that they account for 40% to 70% of total production costs, depending on geographic location and production system. Hence it is not surprising that new, intensive olive groves adopt plantation layouts for mechanical harvesting to lower such high labour requirements. Similarly, the price of olive land increased during the 1986-2005 period above the average price for agricultural land as a whole. Measured in constant euros, the consolidated price increase in this period was 16.42% for total agricultural land and 127.84% for olive growing land (García et. al., 2008).

As for production structures, according to the last Agricultural Census published by the Spanish National Statistics Institute (INE, 2002), small farms (less than 10 ha) predominate in both dry and irrigated farming systems. By area, however, medium-sized farms (10 to 100 ha) are the most representative. In general, irrigated farms tend to be smaller than dry farms, except for the largest stratum in which irrigated farms are on average slightly larger (plus 2 ha). The other source for structural and economic and financial data on olive holdings is the Spanish National Farm Accountancy Network (RECAN from the Spanish acronym) database[1]. 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 2004 sample contains 171 olive holdings. Cost analysis of the whole sample reveals that on average the most important entries are, in decreasing order, wages and related social expenses (€4,505), capital investment (€3,322), plant protection (€1,313), fertilizers (€1,218) and depreciation (€1,183). Analysis of production ratios by farm size shows that land productivity decreases as farm size increases (from €2,283/ha to €783/ha, with a sample average of €1,793/ha). The opposite happens with labour productivity, with net value added increasing from €10,748/AWU (Agricultural Work Unit) to €57,026/AWU and the sample average being €16,383/AWU.

There has also been a significant development of integrated and organic production paralleled with a slight decrease in conventional farming in the region. Table 1 shows the evolution of the growing area of different olive farming systems in the period 2002-2009 considered in this research. The goal of integrated production is to obtain high quality produce based on the rational use of production factors and environmentally-friendly procedures. Other elements of integrated production are to reach biological equilibrium and to optimize the use of natural resources. 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. According to MARM (2010a), most of the integrated production area in Spain grows olives (269,000 ha, 44.1% of total integrated production area in Spain in 2009). The vast majority of integrated olive groves (253,316 ha, 94% of total) are located in Andalusia. The current regulation for integrated production in the olive sector which covers both olive oil and table olives is dated July 18th 2002, and the conditions for granting subsidies

[1] The RECAN is a farm-level survey provided by the Spanish MARM. It provides the only detailed farm-level data available on an annual basis for Spain. Since 1986 the RECAN has been integrated into the Community Farm Accountancy Data Network (FADN), adopting its methodology so that results obtained are, *a priori*, comparable to those from other EU countries. Nevertheless, the FADN does not consider all the information collected by the RECAN. In particular the differentiation between irrigated and non-irrigated cultivated areas is included in the RECAN but not in the FADN.

to environmentally-friendly agricultural production are established in Royal Decree 1203/2006. Support is paid per hectare, and for each crop a minimum surface must be managed under this system. In the case of olive groves, the Decree established a premium of €147.25/ha, with one hectare being the minimum surface area.

Table 1 - *Olive growing area by production system in Andalusia (ha).*

	Conventional farming		Integrated farming		Organic farming	Total olive groves
	Dry	Irrigated	Dry	Irrigated	Dry (total)	
2002	1,097,403	237,475	31,412	6,798	31,517	1,406,605
2003	1,033,981	261,734	46,597	11,795	37,588	1,391,695
2004	1,015,266	256,041	62,730	15,820	40,868	1,390,725
2005	1,009,438	261,895	72,329	18,766	41,516	1,403,944
2006	957,768	248,641	128,258	33,296	42,148	1,410,111
2007	924,174	238,748	154,010	39,786	42,336	1,399,054
2008	895,497	234,753	186,068	48,777	41,557	1,406,652
2009	882,689	229,010	201,133	52,183	46,648	1,411,663

Sources: Authors' calculations based on 1) MARM (Agriculture Statistical Yearbook 2003-2010) for total area (dry and irrigated), 2) MARM (Organic Agriculture Statistics in Spain 2002-2009) for organic olive area, and 3) Junta de Andalucía (Annual Report of Agriculture Department 2002-2007) and MARM (Integrated Agriculture Statistics in Spain 2008-2009) for integrated olive area. Conventional olive area is obtained by subtracting the sum of integrated and organic area from total area. Note that due to the non availability of separate dry and irrigated data for conventional and integrated olive groves, we assume for both systems the same percentage distribution of dry and irrigated as is registered for the total area, which is given in the official MARM statistics. On the basis of yearly absolute data, this percentage distribution of dry and irrigated is, respectively: 82.21% and 17.79% (2002), 79.80% and 20.20% (2003), 79.86% and 20.14% (2004), 79.40% and 20.60% (2005), 79.39% and 20.61% (2006), 79.47% and 20.53% (2007), 79.23% and 20.77% (2008), 79.40% and 20.60% (2009).

With regard to organic production, the rules are much more stringent than for integrated production and are not only established at regional and national level, but also at European level. Synthetic agrochemicals for pest and disease control and fertilization are prohibited in organic production, while integrated production allows controlled application of certain quantities of these products. Even though organic production allows for some cost reductions –no agrochemicals–, higher costs appear in the form of reduced yields. These are compensated by public monetary support. For olive production, according to the Rural Development Plan 2007-2013 (MARM, 2009), support for organic production may reach €329/ha.

Spain is currently the second country in the world for organic olive-growing area. Worldwide, 409,000 ha of olive groves are cultivated organically. Spain has 101,275 ha, just behind Italy with 109,992 ha. Moreover, olive is the second organic crop in Spain (21.6% of the registered organic area), behind cereals. Andalusia has 41,500 ha (41% of Spanish organic olive groves) and 97 oil mills and bottling plants operating under organic regulations. Organic farming has been regulated in Spain since 1989 when the "Organic Agriculture" regulation was passed. It was recognized at European level by EC regulation 2092/91. Measures on organic agriculture have priority among the measures covered by the Spanish Rural Development Programme. Under the Rural Development Plan 2007-2013, adopting organic production methods entitles farmers to apply for the abovementioned support. A farmer that decides to produce organically must engage for at least five years in order to obtain subsidies. In the case of integrated production, the engagement is only for one year.

In addition, the olive oil sector is heavily dependent on the regulatory environment. EU regulation for the olive oil sector started out with regulation 136/66/CEE in 1966 which established a mixed regulatory system: an intervention regime based on target price, intervention price, import levies and export refunds, on the one hand, and a system of direct aid to production and consumption, on the other. The system was designed as compensation for Italy, then the sole olive oil producer in the early European Community, for having liberalised its markets for a range of other agricultural products from European partners. This explains why the intervention price for olive oil was much higher than the price fixed for competing oils. The European Commission decided to progressively apply the same scheme, first to Greece and then to Spain and Portugal, when they joined the European Community. Profits obtained through this system prompted production increases throughout the Community and mostly in Spain, the largest world producer and also the country with the largest production growth potential (Mili and Rodríguez Zúñiga, 2001).

Relevant regulatory changes started to be introduced after the World Trade Organization (WTO) Uruguay Round trade agreement in 1994. This agreement had important effects on the olive oil sector, both in Spain and other EU producer countries where this product had traditionally enjoyed a high level of protection, through both the CMO for olive oil and complementary actions undertaken by Member States. Important changes were introduced after the 1995-96 crop year especially concerning the regulation of trade with non-member countries. Thus, the EU export subsidies based on the difference between EU and world prices started to be modulated until their *de facto* elimination in 1998. On the import side, levies on imports were replaced by fixed import tariffs which were decreased by 20%. In addition, the EU is allowed to apply additional tariffs if the CIF import prices drop below trigger prices (prices established by the Commission that trigger the application of such complementary duties), or when the imported quantities surpass a certain threshold that might lead to alterations in the EU's internal market.

In addition to modifications of the CMO as a consequence of the WTO agreement, other changes in the sector's regulatory setting were introduced. In 1998 EC regulation 1638/98 established a 32% increase in the quantity eligible for support, a national guaranteed quota system, a subsidy system for private storage to replace public intervention, the elimination of consumer subsidies and of the special regime for small producers, and the granting for the first time of support for table olives. During the period 1998-2005, the unitary (per kg) amount of direct support was €1.32 multiplied by a coefficient obtained by dividing the national guaranteed quantity allocated to the Member State by actual production.

Subsequently, further changes were adopted in 2004 as part of a deeper CAP reform covering Mediterranean products (European Commission, 2003). The new regulation, which came into effect in 2006, introduced essential innovations in the way the sector is protected. A large proportion of aid to the sector is no longer linked to production incentives (quantities produced), but is granted through decoupled payments to farmers (De Graaff *et al*., 2011) where quality is at a premium over quantity. This change means that farmers' production decisions depend mostly on market conditions, becoming more independent from subsidies as decoupling levels rise. It was also determined that farms larger than 0.3 ha should receive at least 60% of the average support obtained during 2000-02 as a single decoupled payment. Payments for smaller farms are 100% decoupled. The amount is estimated according to a reference period for the four crop years from 1999-00 to 2002-03. These single payments are limited to plantations existing before May 1st, 1998 and new ones approved under EU programmes. The remaining 40% at the most are national funds for additional payments linked to objective criteria of sustainability and environmental goals.

The 2004 reform was first established under EC regulation 865/2004 that derogated regulation 136/66/EEC and was later substituted by EC regulation 1234/2007, creating a CMO for all agricultural sectors and special provisions for certain agricultural products (the single CMO regulation). The single payment system in Spain (Royal Decree 1618/2005) has been in force since 2006. From that year up to and including 2009, 93.61% of support was decoupled and the rest was coupled. Coupled payments are linked to environmental and landscaping measures. Up to 2009 they amounted to €103.4 million.

Moreover, since the 2006/07 crop year, farmers have been allowed to claim single payments for areas planted after May 1st, 1998 and also to plant olive trees on any surface area that may generate payment rights. Nevertheless, this measure was not extended to coupled support which has been maintained only for groves planted before May 1998. The first year of application of the programme was positively evaluated, as growers received large complementary payments. 495,034 olive producers out of a total number of 854,016 (58%) obtained support in Spain (MARM, 2010b). In Andalusia the percentage was 86%.

As from 2010, according to the provisions approved within the CAP health check of November 2008 (EC regulation 73/2009), all coupled support is granted as a single payment, i.e. 100% decoupled from production. Under certain circumstances, Member States are granted large flexibility margins for cross-compliance. Member States also decide on the measures to be adopted to spend additional modulation funds on their rural development programmes. The measures are co-financed up to 75%, or up to 90% if adopted in regions covered by convergence objectives.

The current regulation is also designed to anticipate further international liberalizing pressures that might arise from prospective multilateral trade agreements. It should be recalled that, before the 2004 reform, most of the public support for EU olive oil (estimated at 50% of producers´ gross revenue by means of the Producer Subsidy Equivalent –an indicator designed by the OECD to measure total monetary transfers from consumers and taxpayers to agricultural producers) was included in WTO's 'amber box', hence it was subject to reduction because of its distorting effects for international trade. The 2004 reform largely avoids this potential reduction of internal support because, under the new system, most decoupled production support can be assigned to WTO's 'green box' as it is not considered to distort international competition (Mili, 2006). As a result, in many cases it is possible to continue producing with production costs above selling prices, with the difference being covered by decoupled subsidies.

In addition, there are other effects of decoupling apart from minimizing the international pressure associated with support to agricultural production. While in theory fully decoupled measures are production and trade neutral as they have no link with input or output quantities or prices, ex-ante assessments suggest that decoupling always has some effect, though mostly an indirect one, on production, land use and investment decisions as well as on farmers' expectations and tolerance of risk (OECD, 2006). The implications of decoupling also vary across countries, activities and the decoupled-support scheme being implemented (Roselli et al., 2009).

Moreover, decoupled payments are more likely to influence production decisions when market failures exist, including inefficiencies, rigidities, or incomplete information in factor and product markets. Testing for the presence of market failures is an indirect way of determining whether decoupling might influence production decision (USDA/ERS, 2004).

Admittedly, it will take some years before farmers fully adjust to the new decoupled support schemes, and it will consequently take time to evaluate the ex-post, real outcomes in terms of farmers' behaviour and their implications for farm activities. However, in the short term it seems that there is likely to be relatively little change in the status quo resulting from introducing decoupling (Tranter *et al*., 2007).

3. Materials and methods

As stated earlier, the possible impacts of different agricultural policy, cost and price scenarios on the different olive production systems in Andalusia are assessed using a PMP model. In the model a single representative farm is considered to represent the whole Andalusian olive production sector. One of the main problems when using PMP is the choice of the calibration procedure. In this study, three calibration methods are tested: average cost procedure, calibration using exogenous elasticities and neutral calibration procedure. A comparative analysis of the three procedures is performed in order to choose which best suits the needs of this research. This kind of analysis recommended in recent papers (Kanellopoulos *et al*., 2010) is not usual in PMP applications.

3.1. Definition of the representative farm

The characteristics in the base year (2002) of the representative farm on which this analysis is based are shown in Table 2. The area, prices and yields for the different olive farming systems are obtained based on the total olive area, prices and yields collected by the RECAN for 2002 for the average farm under type of farming 3300 (olive cultivation) in Andalusia, which represents a total of 128,256 farms in the region. Only the characteristics that are relevant for olive producing farms were taken into account, because it is safe to assume that in the short and medium term olives do not compete in any significant way for surface area with other crops on the farm. In addition to RECAN, other information sources were used as indicated below.

Table 2 - *Characteristics of the representative farm in the base year (2002).*

Farming system	Area (ha)	Yield (Kg olives/ha)	Prices (€/Kg olives)	Variable costs (€/ha)
Dry farming	6.30			
Conventional	5.96	2.873	0.40	565.03
Integrated	0.17	2.873	0.44	593.28
Organic	0.17	2.873	0.48	621.53
Irrigated farming	2.63			
Conventional	2.56	4.905	0.43	827.49
Integrated	0.07	4.905	0.47	868.86

With respect to surface area, it is assumed that the values provided by RECAN for olive groves under dry-farming (6.30 ha) and under irrigation (2.63 ha) correspond to the total dry and irrigated areas, respectively. The breakdown of the dry farming area is 94.58% conventional, 2.71% integrated and 2.72% organic. Under irrigation, 97.22% is conventional and 2.78% is integrated. These proportions are estimated based on data obtained from the Agriculture Statistical Yearbook 2003 (MARM) and Alarcón and Saavedra (2003), applying the same percentages for dry and irrigated farming as in the total (see explanatory note in Table 1). Irrigated organic olive groves were not taken into account due to their extremely small weight in the total organic area. In June 2003 Andalusia had 2,892 ha of organic olive groves, i.e. 0.2% of the total olive area of Andalusia (Casero Rodríguez, 2003).

As for yields (Table 2), the hypothesis adopted is of similar yields under dry and irrigated farming for conventional and integrated olive groves (GuzmánCasado *et al*., 2002), and for dry conventional and organic (Alonso Mielgo and GuzmánCasado, 2004; Alonso *et al*., 2008). Yields for both dry and irrigated farming are obtained from RECAN, dividing total production by the olive-growing area. The average Andalusian oil yield for the 2002/03 crop year (21.3%) is applied. This is the average yield from homogeneous Spanish olive oil-producing areas approved by the Commission and classified according to the municipalities included in the EC regulation 2138/97.

Prices are obtained from RECAN information. These, under both dry and irrigated farming, are unit values resulting from dividing total production value by produced quantity. In order to estimate the prices for each type of olive farming, it is assumed that prices for integrated olive are 10% higher than conventional olive, and that organic olive prices are 20% higher than conventional. These assumptions are based on Alonso Mielgo and Guzmán Casado (2004) and Alonso *et al*. (2008). Moreover, the breakdown of surface area by farming system, as established above, is taken into account in the estimations.

Variable costs for conventional olive groves for 2002 (Table 5) are obtained by applying the index of prices paid by producers in 2002, with base 2000 provided by MARM (Table 4), to the costs reported for 2000 by García *et al.* (2008). Family labour costs, included among total variable costs by these authors, have been subtracted. Variable costs for integrated and organic groves are estimated according to the above-mentioned studies by Alonso Mielgo and Guzmán Casado (2004) and Alonso *et al*. (2008). These calculations establish that variable costs for integrated and organic groves are, respectively, 5% and 10% higher than for conventional systems.

3.2. Scenarios

The simulations produced by the model described in section 3.3 show the effects of switching from completely production-coupled support – the situation in 2002 – to decoupled direct support in two different price and cost situations, one representing an increasing price scenario and the other a decreasing one with respect to the base year. Instead of establishing arbitrary hypotheses about policy, price and cost changes with regard to the situation in 2002, we consider the real situations of 2008 and 2009 to represent these variations. The situation in 2008 corresponds to a context of increasing prices, and 2009 reflects declining prices. In both years non agri-environmental support to olive groves was largely decoupled. Furthermore, considering both situations has the advantage that it provides a first assessment of the predictive quality of the model. It is also worth noting that establishing these scenarios allows the analysis of the impact due exclusively to changes in agricultural policy or in prices and costs. For instance, in order to examine the impact of agricultural policy, it is sufficient to compare the results of the model for the base year with those of a scenario for a year –e.g. 2009- in which agricultural policy is considered while 2002 prices and costs are kept constant.

3.2.1. Agricultural policy scenarios

Table 3 shows the agricultural policy measures considered for the base year 2002 and for the simulation years (2008 and 2009).

Table 3 - *Agricultural policy measures included in the model.*

Type of support	Base year	Simulation years	
		Coupled support	Decoupled support
Production-driven support	103.43 €/100 Kg olive oil	48.87 €/ha	715.91 €/ha
Agri-environmental support for organic olive groves	266.85 €/ha	266.85 €/ha	-
Support for certification and implementation of integrated olive groves	–	49.14 €/ha	-

Total support for oil production was €103.43/100 kg in 2002. It is assumed that total support for the simulated years would be the same amount that the representative farm received in the base year (€6,829.49), equivalent to €764.78/ha. The total support figure is obtained as follows: considering that one kilogram of olives produces 0.213 kilogram of olive oil, the total production support received by the representative farm in the base year would be: €1.0343 * 0.213 * (2,873 * 6.3 + 4,905 * 2.63) = €6,829.49. 93.61% of this is decoupled and the rest is coupled to production level.

Environmental support for organic olive groves was €266.85/ha in 2002 (AriazaSeguín et al., 2002) and stayed at the same level in 2008 and 2009.

Public subsidies for integrated olive plantations mostly serve to pay the wages of the technical advisors needed to implement integrated production rules and to cover certification expenses. This support was given in 2008 and 2009, but not in the base year. There are no records for 2002 showing this kind of payment because the environmental support foreseen (€147.25) was not applied in Andalusia (AriazaSeguín et al., 2002). Nor are there any payment records for system implementation and certification for that year.

Later, however, support payments started to be granted under the agri-environmental programme, and also for implementation and certification. In 2009 (the last year with available information), public support for olive production under integrated systems is estimated at €49.14/ha. This average estimation is based on total support for environmental measures of this type of €7,800,000 allocated to 253,316.18 ha of olive groves that year. The result is €30.79/ha. To this the subsidy for implementation and certification of €18.35/ha must be added. This amount results from applying the proportion of integrated olive groves in the total integrated surface area of Andalusia (66.42%) to the total sum granted for that purpose (implementation and certification) for the whole Andalusian integrated production surface area (€7,000,000); i.e. 66.42% of €4,649,400 divided by 253,316.18 ha. Moreover, the amount of €7,800,000 for agri-environmental support was granted for integrated production in river basins leading to water reservoirs for human consumption or other specific areas. Note that both agri-environmental subsidies (the CAP second pillar) and support for integrated production implementation and certification are not subject to modulation.

3.2.2. Cost and price variation scenarios

Variations of different cost components between the base year 2002 and the simulation years 2008 and 2009 are obtained on the basis of estimations for 2002 and on the paid price indexes for 2008 and 2009 with 2002 being the base year (Table 4).

Table 4 - *Variable cost components for dry and irrigated conventional olive farming and indexes of prices paid by the growers.*

Item	Cost dry farming €/ha 2000 (1)	Cost irrigated farming €/ha 2000 (1)	Index 2002 2000=100 (2)	Index 2008 2002=100 (3)	Index 2009 2002=100 (3)
Fertilizers	110	128	106.90	207.11	171.75
Plant protection	59	82	105.30	111.22	114.71
Machinery	68	31	108.40	125.52	127.77
Processing	24	55	102.90	138.97	123.27
Labour	259.11	464.29	110.73	124.12	125.85

Sources: (1) García et al. (2008) excluding family labour costs, (2) MARM index of prices paid, (3) Authors' estimations based on MARM index of prices paid.

The variable cost levels and variations between the base year and the simulated years, shown in Table 5, are based on the data given in Table 4.

Table 5 - *Variable costs for conventional olive cultivation and cost changes (indices) of the simulated years compared to the base year.*

	Costs €/ha 2002	Costs 2008		Costs 2009	
		€/ha	Index 2002=100	€/ha	Index 2002=100
Dry farming	565.03	795.58	140.80	758.92	134.31
Irrigated farming	827.49	1,138.35	137.57	1,093.75	132.18

Price variations are estimated based on average prices for oil olives published by MARM for 2002, 2008 and 2009. These prices show a 19.38% increase in 2008 compared to 2002 and a 12.62% decrease in 2009. It should be pointed out that even though we refer, respectively, to increased and decreased price scenarios in 2008 and 2009, market conditions for both scenarios also envisage input cost variations. In 2008 price and cost variations led to a gross margin net of subsidies (GMNS) increasing between 1% and 9% approximately, with the exception of conventional olive where GMNS dropped by 0.45%. In 2009, the GMNS reduction ranged between 40% and 59% for different types of olive farming

3.3. The PMP model

The impact of changes in costs, prices, and agricultural and environmental policy measures on the Andalusian olive sector between 2002 and 2008-2009 has been analyzed using the PMP model explained below. This model allows consistent treatment of the set of heterogeneous sector information collected in this study.

The PMP was formalised by Howitt (1995) though it was already in use before then. It has undergone a significant development in recent years and has led to numerous applications aiming at analyzing the effect on the agricultural sector of changing agricultural policy measures (mostly CAP measures). Reviews of PMP focusing on this topical context can be found in Heckeley and Britz (2005), and Henry de Frahan *et al.* (2007). Some PMP models like those used in this paper are built at farm level using FADN data (see for instance Osterburg *et al*., 2001; Buysse *et al.*, 2005; Judez et al., 2009). PMP essentials consist in estimation of certain parameters of a nonlinear (usually quadratic) programming model in such a way that the optimal solution of the model reproduces the real situation of the modelled unit (farm, region) in a reference year also called the base year. This process, called model calibration, also allows PMP to frequently substitute linear programming (LP), whose results do not usually fit with the observed reality or in which arbitrary restrictions must be introduced to achieve such a fit.

Parameter estimation of the PMP model can be carried out using statistical methods when there are multiple observations of the modelled unit. However, it can be also conducted with one observation i.e. with data on prices, costs, agricultural policy measures and crop area for one year, generally considered the base year. This procedure is often criticised for not providing parameters that allow the model to predict properly the behaviour of the modelized unit. Despite this criticism there is widespread agreement on using it when, as in our case, information is scarce and fragmented. Meanwhile new methodological proposals have been explored; for instance, Kanellopoulos et al. (2010) developed two new calibration procedures based on the standard calibration proposed by Arfini and Paris (1995); Júdez et al. (2011) propose a procedure to include in PMP models crops grown using production techniques not used in the base year.

Several procedures exist for model calibration using one observation though the simulations obtained for different scenarios depend on the calibration procedure used. Some authors (Kanellopoulos *et al.*, 2010) propose ex-post experiments and validation of the model predictions to determine the PMP variant that is most appropriate for each specific case. These authors consider the model valid if its predictions present a percentage absolute deviation (PAD) no greater than 15%. This value, in turn, is given on the basis of the value suggested by Hazell and Norton (1986) as a rough guideline for PAD obtained with the results for the base year. Another aspect to take into account in evaluating the predictive capacity of the model is whether the results capture changes in crop acreage in a sensitive fashion reflecting, for instance, increases or decreases with respect to base year of the acreage of main crops when these take place during the analyzed period.

Of the three calibration procedures compared, two of them – average cost procedure (see, for example, Buysse et al., 2007) and the procedure using exogenous supply elasticities proposed by Helming *et al.* (2001) – are among the most frequently applied. Gocht (2005) finds that calibration by exogenous supply elasticities gives lower PAD than other calibration procedures when comparing the observed land use of several groups of farms with the prediction generated using the different methods of calibration. The third procedure that we call the neutral procedure is proposed by Röhm and Dabbert (2003) and has scarcely been used. We call it neutral because these authors consider the objective function (1) in section 3.3.1 to be associated with this calibration, i.e. neutral in the sense that it is not explicitly based on increasing cost or declining yields. Admittedly this calibration procedure differs from the others which lead either to gross margin objective functions with increasing marginal cost functions with respect to the crop level (calibrations with average costs and with exogenous elasticities belong to this category), or to gross margin objective functions with decreasing marginal cost functions (Howitt, 1995). The neutral procedure brings about objective functions with decreasing marginal gross margins without specifying either cost or yield functions.

Estimation of the objective function parameters to calibrate the model requires a previous estimate of the opportunity costs of resources. In the traditional application of these three calibration procedures, this estimate is performed by means of an auxiliary LP with calibration constraints in the so-called first step in PMP (Howitt, 1995). The use of this first step has two weaknesses: i) the marginal crop (the crop with the lowest gross margin) has no quadratic term in the objective function (calibration with exogenous elasticities does not have this drawback), and ii) it is not possible to include *a priori* values for the opportunity cost of resources. In this study these problems are avoided by skipping the first step in PMP using only the Khun-Tucker necessary conditions to estimate the parameters (Buysse *et al*., 2004; Júdez *et al*., 1998, 2001).

The following sections present the objective function for the neutral calibration procedure and the restrictions of the model used in this study, as well as the detail for obtaining expressions to estimate the parameters of the objective function that calibrate the model. For the other two calibration procedures, the model has the same restrictions and its objective functions along with the expressions of calibration parameters are specified in Appendix 1.

3.3.1. Objective function for the neutral calibration procedure and constraints of the model

Let X_{ij} be the area in hectares for 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 results with different agricultural policies, prices and costs can be represented as follows:

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

$$\sum_{i} X_{ij} \leq A_j(\lambda_{2j})\forall j \quad (2)$$

$$-\sum_{j=1}^{2}\sum_{i} s_{ij} * X_{ij} - d * E + XP1 + XP2 \leq 0 \quad (\lambda_3) \quad (3)$$

$$XP1 \leq M \quad (\lambda_4) \quad (4)$$

$$X_{ij}, XP1, XP2 \geq 0$$

where the following variables are added to *Xij*:
*XP*1: amount, in €, of production support (coupled and decoupled) not liable to be reduced via modulation within the simulated years. In the base year no modulation is applied[2].
*XP*2*:* amount, in €, of production support above *XP*1, liable to modulation reductions of 5% in 2008 *(mod= 0.95)* and of 7% *(mod=0.93)* in 2009. In the base year there is no modulation at all and *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 premium for organic olive groves and support for certification and implementation of integrated olive groves), in €/ha; and costs, in €/ha, of crop *i* on land type *j*.
A_j,: area, in ha, of land type *j*.
s_{ij},: coupled payments subject to reduction for modulation, in €/ha.
d: entitlements per hectare, in €, for single payment. In the base year there is no single payment and *d*=0.
E: area, in hectares, eligible for single payment. In simulation years 2008 and 2009 $E=A_1+A_2$. In the base year $E=0$.
α_{ij} and β_{ij}: parameters to calibrate the model in the base year. Their expressions are shown below.

In the model, expression (1) to be maximized represents the farm's gross margin. It is made up of decreasing gross margin functions for each crop with respect to crop level. Equation (2) is the land area constraint, for both dry and irrigated farming. Equation (3) defines total production support to the farm: *XP*1+*XP*2, and equation (4) limits the amount of this support, *M*, free from modulation reductions. *M* amounts to €5,000 in simulation years 2008 and 2009 and is a positive real unrestricted number in the base year, when no modulation takes place. The lambdas in the right constraints represent their dual values.

[2] Note that, according to modulation provisions, all direct payments (coupled and decoupled) were reduced, after the first €5,000, by 7% in 2009 (that year, Spanish decoupling was still at 93.61%), 8% in 2010 (100% decoupling), 9% in 2011 (100% decoupling) and 12% in 2012 (100% decoupling). These percentages are increased by 4% for amounts above €300,000.

3.3.2 Estimation of parameters for calibration

The Kuhn-Tucker necessary conditions for optimum solution of the model (1)-(4) at point $X_{ij} = \bar{X}ij$ (with $\bar{X}ij$ being the olive-growing area *i* on land type *j* in the base year) are verified if the following equation holds for all *i,j*:

$$\left(\frac{\partial F}{\partial X_{ij}}\right)_{X_{ij}=\bar{X}_{ij}} = \bar{\lambda}_{2j} - \bar{s}_{ij} * \bar{\lambda}_3 \quad (5)$$

where $\bar{\lambda}_{2j}$, $\bar{s}_{ij}$ and $\bar{\lambda}_3$ are the values of λ_{2j}, s_{ij} and λ_3 in the base year.

The proof for a general model can be found in Júdez *et al*. (1998). The result is subsequently used in Júdez *et al.* (2001) and proved with greater detail in Júdez et al. (2002).

In the base year $\lambda_3 = 1$, thus equation (5) becomes:

$$\bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} + \bar{s}_{ij} - \bar{c}_{ij} + \alpha_{ij} + 2\beta_{ij} * \bar{X}_{ij} = \bar{\lambda}_{2j} \quad (6)$$

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 $\bar{\lambda}_{2j}$ is the opportunity cost of the land that year, which in this research is considered to be the yearly rental price of a hectare of land of type *j,* estimated to be € 895.36 for the dry land (*j=1*) and €1,785.33 for the irrigated land (*j=2*). The yearly rental price of land type *j*, b_j, is estimated on the basis of the price of a hectare of land *j* with olive, P_j, in 2002. The value of b_j. represents the annual equivalent for an infinite number of years of the price P_j considering discount rate *a*. Therefore $P_j = \sum_{j=1}^{\infty} \frac{bj}{(1+a)^t}$ and, consequently, $b_j = a * P_j$. It was considered that *a*=4%, P_1=22,384 € and P_2=44,633.34 €. P_1 is the average price of a hectare of olive land in Andalusia according to the Land Price Survey 2002 performed by MARM. P_2 is not provided in this survey and has been estimated using the average Spanish price of a hectare of irrigated olive land (€32,343) increased by 38%, which is the increase observed in the price of dry olive land in Andalusia with respect to the average price in Spain for this type of land. The yearly rental prices obtained are compatible with the necessary condition ($\bar{\lambda}_{2j}=\min_i (\bar{p}_{ij}, * \bar{y}_{ij} + \bar{a}_{ij} + \bar{s}_{ij} - \bar{c}_{ij}$) for decreasing marginal gross margin for crops in the objective function.

Equation (6) has two parameters to be determined, so there is an infinite number of values for α_{ij} and β_{ij} satisfying (6). To obtain a single solution for these parameters a new equation has to be added. In line with Röhm and Dabbert (2003), to recover the gross margin in the base year the added equation is:

$$\alpha_{ij} + \beta_{ij} * \bar{X}_{ij} = 0 \quad (7).$$

From (6) and (7) the expressions of α_{ij} and β_{ij} are:

$$\beta_{ij} = \left[\bar{\lambda}_{2j} - \left(\bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} + \bar{s}_{ij} - \bar{c}_{ij}\right)\right] / \bar{X}_{ij}$$

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

The expressions of the parameters to calibrate the model with the average cost procedure and with the calibration using exogenous elasticities are shown in Appendix 1.

4. Findings

As stated above, an essential aspect of PMP is the calibration procedure used in the model. In subsection 4.1 the tested calibration procedures are compared on the basis of the results obtained using each procedure under different scenarios (Appendix 2). Subsequently, in subsection 4.2 impact analysis is carried out with the results of the model calibrated with the selected neutral procedure. All results were obtained using GAMS/CONOPT (Brooke et al., 1992; GAMS, 2001).

4.1. Evaluation of calibration methods

Results show, first, that calibration with exogenous elasticities leads, unlike the other two procedures, to a calibration default in the economic function, which does not reproduce the real gross margin of the representative farm in the base year. Second, of the three olive farming types considered, organic farming sees the largest gross margin increase with regard to the base year with the policies of 2002 and prices and costs of 2008. This fact is only captured by the model increasing the organic olive area, when neutral calibration is used. Third, neutral calibration has the advantage of being more suitable than the other two calibration procedures for simultaneously including variations in prices and costs in the objective function for the simulated scenarios. Fourth, only the simulated results with prices and costs for 2008 using the model calibrated with the neutral procedure capture increases in the area of organic and integrated farming to the detriment of conventional farming. This is in line with reality, although the intensity of the variations is less than what is observed in the real data. This analysis resulted in selection of the neutral calibration procedure to carry out the impact analysis, after evaluating the PAD of the model using this same procedure. The PAD assesses the predictive quality of the model with this calibration procedure.

PAD estimation

The planting decision is a function of the expected income after a number of years (usually 4 to 6) separating planting from commercial production. Nevertheless, it is possible to know the consequences of the planting decision if we have data on the area of different olive farming systems during the years following the planting year. The calibration procedure of the model has been chosen in such a way that it not only calibrates for the base year but can also approximately reproduce the existing area for different olive farming systems in subsequent years[3].

Taking these observations into account, market trends in 2008 (a slight increase or stable GMNS resulting from price and cost increases in this scenario in respect to the base year) are those that allow the best fit by the model for the trend in the growing area for different farming systems. Thus, market conditions in 2008 could substitute, as a proxy variable, farmers' actual expectations, leading them to increase or decrease the olive growing area of the different farming systems.

The model's predictive capacity for different time spans can be evaluated by estimating the PAD of year t (t=2005, 2006, 2007 and 2008) using the expression:

$$PAD_t = \frac{\sum_{j=1}^{5} \left|Y_j - Y_{jt}^0\right|}{\sum_{j=1}^{5} Y_{jt}^0} * 100$$

where activity j is a type of olive farming in a type of land (irrigated or dry), Y_{jt}^0 is the actual area in year t of activity j and Y_j is the simulated area. The values of Y_{jt}^0 are the existing area in Andalusia of activity j in year t (Table 1) and Y_j is the result of multiplying the area in Andalusia of activity j in the base year 2002 by the variation in this area obtained from the model with the 2008 price and cost scenario.

The PAD values obtained for the different years considering policy measures either for the base year or for 2008 are not significantly different. For the latter case PAD values are 10.7% for 2005, 19.8% for 2006, 24.2% for 2007 and 28.8% for 2008. From these results it could be inferred, in a first approximation, that the predictive quality of the model is reasonable for a time horizon of three or four years.

4.2. Impact analysis

The impact analysis is based on simulated results for scenarios combining prices, costs and policy measures existing in 2002, 2008 and 2009. Tables 6 and 7 present these results.

Price and cost variations in the 2008 scenario favour the expansion of integrated and organic olive production at the expense of conventional farming. In addition, agricultural policy change in 2008 favours the expansion of integrated olive production. However, this increase is not due to the change from total coupling of support in 2002 to partial decoupling in 2008, but rather to the fact that the new policy brought specific, coupled support to integrated olive production of €49.14/ha, which does not exist in the base year.

The combined effect of agricultural policy, price and cost changes in the 2008 scenario trigger a significant increase in integrated olive production and a smaller increase in organic production, substituting part of the conventional growing area, both dry and irrigated. This change in the distri-

[3] This is somehow equivalent to selecting the specification in econometric models in such a way as to produce the best possible prediction.

Table 6 - *Simulations associated with base year and 2008 conditions.*

	Base year 2002	Simulation (% variation with respect to base year)		
		2008 policies. Constant prices and costs (base year)	Base year policies. 2008 prices and costs	2008 policies, prices and costs
Conventional dry farming (ha)	5.96	-0.17	-0.08	-0.24
Integrated dry farming (ha)	0.17	5.89	1.32	7.20
Organic dry farming (ha)	0.17	-0.07	1.44	1.37
Conventional irrigated farming (ha)	2.56	-0.09	-0.05	-0.14
Integrated irrigated farming (ha)	0.07	3.22	1.72	4.94
Economic function (000€)	14.44	-0.57	1.96	1.39
Subsidies (000€)	6.87	-1.15	0.01	-1.14
Gross margin (000€)	13.98	-0.56	1.97	1.41
% support / gross margin	49.17	-0.60	-1.92	-2.51

bution of olive growing systems on the growing area brought a 1.41% increase in gross margin (olive sales – variable costs + subsidies) with respect to the base year, despite a 1.14% decrease in support because of modulation.

Conversely, for 2009 the price drop compared to the base year drove an increase in conventional farming at the expense of the integrated and organic areas existing in 2002. Moreover, the 2009 agricultural policy, being virtually the same as that for 2008 except for the modulation rate which increased from 5% in 2008 to 7% in 2009, had the same effect as in 2008, i.e. partial substitution of conventional by integrated farming while the organic farming area remained stable. In fact, the substitution rate between different types of production systems was the same in the 2009 and 2008 scenarios, despite the increase in the modulation rate.

Table 7 - *Simulations associated with base year and 2009 conditions.*

	Base year 2002	Simulation (% variation with respect to base year)		
		2009 policies. Constant prices and costs (base year)	Base year policies. 2009 prices and costs	2009 policies, prices and costs
Conventional dry farming (ha)	5.96	-0.17	0.17	-4.82
Integrated dry farming (ha)	0.17	5.89	-2.83	-0.74
Organic dry farming (ha)	0.17	-0.07	-3.10	-5.21
Conventional irrigated farming (ha)	2.56	-0.09	0.08	-0.02
Integrated irrigated farming (ha)	0.07	3.22	-2.62	0.60
Economic function (000€)	14.44	-0.83	-25.39	26.19
Subsidies (000€)	6.87	-1.68	-0.02	-1.92
Gross margin (000€)	13.98	-0.82	-25.41	-26.87
% support / gross margin	49.17	-0.87	34.04	34.11

The combined effects of agricultural policy, prices and costs in 2009 caused a decline in the growing area for all production systems – with the exception of a small increase in the integrated olive production area – and abandonment of 4.72% of the cultivated dry area. This change in land use structure came together with a 1.92% loss of support (due to modulation and a lower amount of coupled payments because of a smaller cultivated area), and a reduction in gross margin of 26.87% mostly due to lower olive prices and, to a lesser extent, to the abandonment of some of the cultivated area.

5. Conclusions

This is the first study in which the impact of agricultural and environmental policy changes on both the economic results of olive farms and land distribution among different farming systems, are investigated in different market price and cost conditions. A PMP model using data from several fragmented sources was used for this purpose. Analysis of the predictive performance of the model comparing different PMP calibration procedures –an aspect covered in fairly few PMP studies-shows that the best predictions are achieved using the neutral calibration procedure. This finding determined the choice of this procedure for the impact analysis conducted.

From the simulation results, it can be concluded that decoupling has a relatively small impact on farms' gross margins and on land use, when market conditions lead to constant or increasing prices for different olive farming variants with respect to the base year. Under increasing price conditions, payments linked to agri-environmental policies favour the growth of integrated and organic olive production at the expense of conventional farming, whether other payments are decoupled or not. The integrated system also increases under constant or decreasing prices -only in irrigated land in the latter case- due to the complementary subsidies for this system. Simulated results with respect to the base year also show that the decoupling policy might cause partial abandonment of the cultivated area.

This study opens up a new research line for the olive sector in Spain and in other producing countries. In a following stage the model could be used, for instance, to evaluate at regional level and/or for different farm sizes the options for the CAP 2020 recently proposed by the European Commission, which will inevitably involve changes in olive farming support. Methodologically, and prior to such applications, it would be necessary to more thoroughly investigate farmers' expectations regarding their production decisions and use theresults to improve the model and its predictive performance.

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Appendix 1

The PMP model with the average cost calibration procedure or with calibration using exogenous elasticities has the same constraints (2)-(4) shown in section 3.3.1, though the objective function (gross margin with a quadratic cost function) has the following expression in both cases:

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

Where v_{ij} is the cost variation index for olive groves *i* on land *j* (in the base year v_{ij}=1).

This function is the sum of the gross margins of each olive grove where the marginal cost functions are increasing regarding the crop level. The expressions of α_{ij} and β_{ij}, nevertheless, differ between the two calibration methods.

A.1 Estimation of α_{ij} and β_{ij} when usingthe average cost procedure

In this case, equation (5) in section 3.3.2 to calibrate the model becomes:

$$\bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} + \bar{s}_{ij} - \alpha_{ij} - \beta_{ij} * \bar{X}_{ij} = \bar{\lambda}_{2j} \qquad (2A)$$

And the added equation to determine the average cost of each olive grove *i, j* is:

$$\alpha_{ij} + \frac{1}{2}\beta_{ij} * \bar{X}_{ij} = \bar{c}_{ij} \qquad (3A)$$

From (2A) and (3A) the following is obtained:

$$\beta_{ij} = 2 * \left(\bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} + \bar{s}_{ij} - \bar{c}_{ij} - \bar{\lambda}_{2j}\right)/\bar{X}_{ij}$$

$$\alpha_{ij} = \bar{c}_{ij} - \frac{1}{2}\beta_{ij} * \bar{X}_{ij}$$

The average cost calibration procedure leads to the same results as the neutral procedure for the scenarios in which prices and costs are those of the base year 2002 (see results of all Tables in Appendix 2 for the base year 2002, and results for scenarios with constant prices and costs in the base year 2002 and policy scenarios for 2008 and 2009 (Tables A2.1 and A2.4 of Appendix 2). These equalities are coherent with those in the cases of objective function of the neutral (equation (1) and the objective function of the average cost (equation (1.A) procedures.

A.2 Estimation of α_{ij} and β_{ij} when usingcalibration with exogenous elasticities

The equation that calibrates the model is (2A), as when using the average cost calibration procedure. The added equation to obtain a single solution for α_{ij} and β_{ij}[4] is:

$$\beta_{ij} = \frac{\bar{r}_{ij}}{\bar{X}_{ij} * \epsilon_{ij}} \qquad (4A)$$

where: $r_{ij} = p_{ij} * y_{ij} + a_{ij} + s_{ij}$ ($\bar{r}_{ij}$ in the base year) represents the revenue and ε_{ij} the supply elasticity of olive grove *i,j*, respectively. Hence the expression of α_{ij} obtained from (2A) is:

$$\alpha_{ij} = \bar{p}_{ij} * \bar{y}_{ij} + \bar{a}_{ij} + \bar{s}_{ij} - \beta_{ij} * \bar{X}_{ij} - \bar{\lambda}_{2j}$$

[4] The expression of $\beta_{ij}$is obtained by considering from (2A): $r_{ij} - \alpha_{ij} - \beta_{ij} * X_{ij} = \lambda_{2j}$ and consequently $\beta_{ij} = \frac{\partial r_{ij}}{\partial X_{ij}} - \frac{\partial \lambda_{2j}}{\partial X_{ij}}$. Assuming, as usual in calibration using exogenous supply elasticities, that $\frac{\partial \lambda_{2j}}{\partial X_{ij}} = 0$ (Heckelei and Britz, 2005): $\beta_{ij} = \frac{\partial r_{ij}}{\partial X_{ij}}$. Taking into account that supply elasticity of olive grove *i,j* at $X_{ij} = \bar{X}_{ij}$ and $r_{ij} = \bar{r}_{ij}$ is: $\epsilon_{ij} = \frac{\partial X_{ij}}{\partial r_{ij}}\frac{\bar{r}_{ij}}{\bar{X}_{ij}}$, the expression of β_{ij} is that of equation (4A). The exogenous elasticity considered in this paper is 0.1, corresponding to the middle point of the elasticities interval estimated by Garcia Alvarez-Coque (1996) for the category "other crops" which includes olive.

Appendix 2: Impact of agricultural policy, costs and prices on olive grove structure and on economic results under different calibration methods.

Table A2.1 - *Simulation results under 2002 constant prices and costs and 2008 policy with different calibration methods.*

	Base year 2002	Variation in simulated year (%)		
		Average costs	Exogenous elasticities	Neutral
Conventional dry farming (ha)	5.96	-0.17	-0.01	-0.17
Integrated dry farming (ha)	0.17	5.89	0.25	5.89
Organic dry farming (ha)	0.17	-0.07	-0.01	-0.07
Conventional irrigated farming (ha)	2.56	-0.09	0.00	-0.09
Integrated irrigated farming (ha)	0.07	3.22	0.14	3.22
Economic function (000€)				
Neutral	13.98			-0.57
Average costs	13.98	-0.57	-	
Exogenous elasticities	109.02	-	-0.07	-
Subsidies (000€)	6.87	-1.15	-1.16	-1.15
Gross margin (000€)	13.98	-0.56	-0.57	-0.56
% support /gross margin	49.17	-0.60	-0.59	-0.60

Table A2.2 - *Simulation results under 2008 prices and costs and base year 2002 policy with different calibration methods.*

	Base year 2002	Variation in simulated year (%)		
		Average costs	Exogenous elasticities	Neutral
Conventional dry farming (ha)	5.96	0.26	0.02	-0.08
Integrated dry farming (ha)	0.17	-1.89	-0.08	1.32
Organic dry farming (ha)	0.17	-7.21	-0.48	1.44
Conventional irrigated farming (ha)	2.56	0.05	0.00	-0.05
Integrated irrigated farming (ha)	0.07	-1.78	-0.08	1.72
Economic function (000€)				
Neutral	13.98			1.96
Average costs	13.98	1.96	-	
Exogenous elasticities	109.02	-	34.62	-
Subsidies (000€)	6.87	-0.05	0.00	0.01
Gross margins (000€)	13.98	1.91	1.95	1.97
% support / gross margin	49.17	-1.92	-1.92	-1.92

Table A2.3 - *Simulation results under 2008 prices, costs and policy with different calibration methods.*

	Base year 2002	Variation in simulated year (%)		
		Average costs	Exogenous elasticities	Neutral
Conventional dry farming (ha)	5.96	0.14	0.01	-0.24
Integrated dry farming (ha)	0.17	2.29	0.10	7.20
Organic dry farming (ha)	0.17	-7.26	-0.48	1.37
Conventional irrigated farming (ha)	2.56	-0.02	0.00	-0.14
Integrated irrigated farming (ha)	0.07	0.56	0.02	4.94
Economic function (000€)				
Neutral	13.98			1.39
Average costs	13.98	1.39	-	
Exogenous elasticities	109.02	-	34.55	-
Subsidies (000€)	6.87	-1.20	-1.16	-1.14
Gross margin (000€)	13.98	1.35	1.38	1.41
% support / gross margin	49.17	-2.52	-2.51	-2.51

Table A2.4 - *Simulation results under 2002 constant prices and costs and 2009 policy with different calibration methods.*

	Base year 2002	Variation in simulated year (%)		
		Average costs	Exogenous elasticities	Neutral
Conventional dry farming (ha)	5.96	-0.17	-0.01	-0.17
Integrated dry farming (ha)	0.17	5.89	0.25	5.89
Organic dry farming (ha)	0.17	-0.07	-0.01	-0.07
Conventional irrigated farming (ha)	2.56	-0.09	0.00	-0.09
Integrated irrigated farming (ha)	0.07	3.22	0.14	3.22
Economic function (000€)				
Neutral	13.98			-0.83
Average costs	13.98	-0.83	-	
Exogenous elasticities	109.02	-	-0.11	-
Subsidies (000€)	6.87	-1.68	-1.69	-1.68
Gross margin (000€)	13.98	-0.82	-0.83	-0.82
% support / gross margin	49.17	-0.87	-0.87	-0.87

Table A2.5 - *Simulation results under 2009 prices and costs and base year 2002 policy with different calibration methods.*

	Base year 2002	Variation in simulated year (%)		
		Average costs	Exogenous elasticities	Neutral
Conventional dry farming (ha)	5.96	0.40	0.02	0.17
Integrated dry farming (ha)	0.17	-4.60	-0.19	-2.83
Organic dry farming (ha)	0.17	-9.57	-0.63	-3.10
Conventional irrigated farming (ha)	2.56	0.13	0.01	0.08
Integrated irrigated farming (ha)	0.07	-4.68	-0.20	-2.62
Economic function (000€)				
Neutral	13.98			-25.39
Average costs	13.98	-25.38	-	
Exogenous elasticities	109.02	-	25.86	-
Subsidies (000€)	6.87	-0.06	0.00	-0.02
Gross margin (000€)	13.98	-25.45	-25.40	-25.41
% support / gross margin	49.17	34.05	34.04	34.04

Table A2.6 - *Simulation results under 2009 prices, costs and policy with different calibration methods.*

	Base year 2002	Variation in simulated year (%)		
		Average costs	Exogenous elasticities	Neutral
Conventional dry farming (ha)	5.96	-16.36	-0.59	-4.82
Integrated dry farming (ha)	0.17	-13.33	-0.57	-0.74
Organic dry farming (ha)	0.17	-16.65	-1.11	-5.21
Conventional irrigated farming (ha)	2.56	0.06	0.00	-0.02
Integrated irrigated farming (ha)	0.07	-2.25	-0.1	0.60
Economic function (000€)				
Neutral	13.98			-26.19
Average costs	13.98	-25.68	-	
Exogenous elasticities	109.02	-	25.76	-
Subsidies (000€)	6.87	-2.49	-1.72	-1.92
Gross margin (000€)	13.98	-28.46	-26.31	-26.87
% support / gross margin	49.17	36.29	33.37	34.11