The Agricultural Competitiveness of the Alqueva Irrigation Project under the 2003 CAP Reform and the Health Check

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Abstract

The main purpose of this paper is to assess the competitiveness of the Alqueva irrigation project in the Alentejo region, southern Portugal. This project will create 110 thousand hectares of irrigated land in the region. The latest developments of Common Agricultural Policy in 2003 and 2009 and the Water Framework Directive guidelines could have negative impacts on the project competitiveness. The selection of representative farms was made using farmers' interviews and multivariate methods. A multi-period mathematical programming model was developed to assess the farms competitiveness. The results show that the Common Agricultural Policy and the Water Framework Directive will have negative effects on farms. This can be overcome by the adoption of new technologies and more sustainable agricultural systems ensuring the future competitiveness of irrigated farms.

Key-words: Irrigation, multi-period programming, competitiveness, Common Agricultural Policy.

Résumé

L'objectif principal de cette étude est d'évaluer la compétitivité du projet d'irrigation d'Alqueva dans la région de l'Alentejo dans le Sud du Portugal. Ce projet permettra d'irriguer 110 mille hectares situés dans la région. Les développements récents de la Politique Agricole Commune, en 2003 et en 2009, et les nouvelles orientations de la Directive Cadre sur l'Eau pourraient avoir des impacts négatifs, notamment sur la compétitivité des exploitations agricoles qui bénéficieront du projet. On a sélectionné un ensemble d'exploitations représentatives en interviewant des exploitants et en utilisant l'analyse multi-variée. Pour évaluer la compétitivité de ces exploitations, un modèle de programmation mathématique multi-période a été mis au point. Les résultats montrent que la Politique Agricole Commune et la Directive Cadre sur l'Eau auront des impacts négatifs sur la compétitivité des exploitations agricoles irriguées. Cependant, ces effets peuvent être contournés en adoptant de nouvelles technologies et des systèmes agricoles plus durables assurant la compétitivité des exploitations irriguées à l'avenir.

Mots-clés: *Irrigation, programmation multi-période, compétitivité, Politique Agricole Commune.*

1. Introduction

The Alqueva project under construction in the Alentejo region, Southern Portugal, has multiple goals, namely agricultural irrigation, supply of water for public consumption, production of hydroelectric power, and tourist and environmental activities. The most important is the hydro-agricultural component that includes the implementation of 110,000 hectares of new irrigated land in the biggest Portuguese agricultural region, with Mediterranean agro-climatic conditions. The conversion of dry to irrigated land will create many opportunities, but it will also involve some challenges and risks. The most important opportunities are the potential for increasing the current level of productivity and the adoption of a new cropping pattern. Both will be possible because Alentejo farm's structure is, in general, composed of large farms having good potential for innovation (Dos-Santos, 2008). The principal challenges are the farmer's capacity in converting dry to irrigated land under the conditions of CAP 2003 Reform and Water Framework Directive.

During the last decades, Alentejo agriculture was based on dry extensive farming systems, mainly cereals and beef production. These systems were, partially, encouraged by past CAP policies that fostered subsidized agricultural activities and not free market competitiveness (Fragoso and Marques, 2007).

Following the 1992 Mac Sharry reform, direct payments to EU farmers were introduced and became an integral part of the CAP. In arable land and beef cattle sectors, farmers were directly and partially compensated for income losses from reduction on intervention prices; direct payments became an important source of income. The shift from price support to direct income support was further advanced in the Agenda 2000 Agreement. However, direct payments did remain coupled to production for arable crops, beef cattle and milk, though lately a progressive decoupling was observed (Breen *et al.*, 2005).

The Luxembourg Agreement on the 2003 CAP reform allowed for the decoupling of all direct payments. Since 2005, decoupling rules have been applied in Portugal to arable crops and partially to sheep. With decoupling, farmers receive a Single Farm Payment (SFP) regardless of their production decisions as long as land use is maintained in accordance with basic standards for the environment, food safety, animal health and welfare, and good agricultural and environmental conditions. Decoupling payments reduce the links between agricultural support and production, removing incentives to production intensification and giving to farmers increasing freedom on farming decisions.

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Following the 2003 CAP reform, the European Commission adopted, in 2008, the Health Check (HC) aiming to prepare the CAP financial framework for 2013. To achieve this, some adjustments in the 2003 CAP reform were made, such as an increase in modulation in the SFP which will lead to a progressive reduction of its value per farm by the end of 2013. This amount was transferred to the CAP second Pillar (Arfini *et al.*, 2008). This measure can have strong impact on Alentejo agriculture because this region receives about 43.3% of the total Portuguese CAP support measures.

Several studies analysing the EU agricultural reforms have been made, among others, Gohin and Latruffe (2006) and Matthews *et al.* (2006). In Portugal, Fragoso and Marques (2007), Dos Santos (2008), Dos Santos *et al*. (2009) have studied the impact of 2003 CAP reform in Alqueva irrigation project.

The increasing water demand in EU demonstrated the growing shortage of this natural resource and encouraged an intense discussion about the efficiency of water use. This led to the approval of Directive 2000/60/CE, which established a framework for EU action in the field of water policy, the Water Framework Directive (WFD). There is no doubt that one of the most important topics of this directive is article 9 related to water pricing, proposed as the main economic instrument for dealing with the scarcity of water in the EU. The WFD establishes the appropriateness of using water pricing in order to provide adequate incentives for users to use water resources efficiently, thereby contributing to the environmental objectives of this Directive (Riesgo and Gómez-Limón, 2006).

The WFD suggests the application of a full cost recovery policy for water services, considering environmental and social issues. This policy asks for the introduction or an increase in water prices. According to neoclassical economic theory, farmers will reduce water demand taking into consideration their agricultural water-derived demand. The consequences for the Alqueva irrigation scheme could be a reduction in farms competitiveness. Bartolini *et al.* (2007), in Italian less intensive irrigated systems, concluded that water pricing, though appearing to be an effective instrument for water regulation, has in most cases less impact than agricultural markets and policy. Moreover, Riesgo and Gomez-Limon (2006) highlighted that water pricing and agricultural policy need to be closely coordinated in order to meet the EU's policy objectives for the irrigation of the agricultural sector.

Taking into account what was stated above, the main objective of this paper is to analyse the competitiveness of farms in a sub-system of the Alqueva project, the irrigation scheme of Monte Novo (ISMN). This analysis uses a multi-period programming approach to measure the impact, at farm level, on resource allocation and profitability, of the scenarios under the 2003 CAP reform, the HC and the WFD.

The paper is structured as follows: section 2 describes the selection of the farms type used, section 3 presents the multi-period programming model utilized, section 4 discusses the results, and finally the main conclusions are reported in section 5.

2. Farms Typologies in the Irrigation Scheme of Monte Novo

The ISMN project, part of the Alqueva project, covers around 25,000 hectares where 7,100 have irrigation potential. The number of total farms is 112 with an average utilized agricultural area (UAA) of 229 hectares which is 4.1 and 18 times the Alentejo and the national average area, respectively. The agro-climatologic characteristics are Mediterranean, characterized by water shortages in summer, a high number of daily hours of sunshine and soils with good conditions for irrigation.

Data collection was conducted through interviews applied to a sample of 30 farmers. The classification and identification of the ISMN farms typologies was done using multivariate techniques, cluster and discriminant analysis. Cluster analysis was used to form homogeneous groups of farms and discriminant analysis to identify and characterize the representative farms.

The cluster analysis identified three groups of homogeneous farms or clusters. The factors that most contributed to distinguish farms were structural and farmers' characteristics and production orientation. Structural variables included the UAA, the utilized irrigated area per farm (UIA), the private UIA per farm, the number of tractors and agricultural labour force (ALF). For the farmer, the relevant characteristics were age, education and farmers information sources. Relatively to production orientation, irrigation systems and the relative economic importance of livestock were considered.

Cluster I, called smaller farmers, includes farms with a UAA varying from 50 to 450 ha. Farmers are less skilled and older when compared to the other clusters, with an average of 8 years of formal education and 59 years of age. Irrigated production systems consist mainly of crops and oilseeds, with a small number of farms having irrigated maize and vineyards.

Cluster II, named entrepreneur farmers, includes farms ranging from 450 to 1400 ha of UAA. Farmers are moderately skilled and relatively young. On average, farmers have 13 years of education and are 47 years old. The irrigation systems of production include cereal crops and oilseeds, vineyards, olive groves and beef cattle activities.

Cluster III, called consolidated agricultural companies, is formed by the largest UAA farms, more than 1400 ha. These companies have a complex and solid organizational structure. The managers are the youngest and the most skilled; on average they are 46 years old and have a bachelor degree. When compared with the other clusters, irrigated production systems have more investments in vineyard (1.7%) and in irrigated olive groves (0.3 %) and smaller areas of irrigated wheat and cattle production.

A discriminant analysis was performed to select the representative farms for each one of the clusters. The discriminant functions, Z1 and Z2, are:

$$Z1 = -3.469 + 0.026X_2 - 0.273X_9 - 0.574X_{10} + 0.035X_{13} + 0.044X_{14} - 0.026X_{16} + 0.043X_{18}$$
$$Z2 = -1.067 + 0.088X_1 - 0.186X_2 - 0.300X_9 + 0.158X_{10} - 0.021X_{16}.$$

The variables with higher discriminatory power, in Z1, are the UIA per farm (X_9), the number of livestock (X_{10}), the surface of irrigated wheat (X_{13}), the surface of irrigated vineyard (X_{14}), the long-term loans (X_{16}) and farmer's training level (X_{18}), while for Z2 the variables are farmer's age (X_1), farmer's education level (X_2), the UIA per farm (X_9), the cattle number (X_{10}) and long-term loans (X_{16}).

The Mahalanobis Squared Distance was used to identify the farm types, A, B and C, representing each one of the clusters. Table 1 shows the principal characteristics of each of the farm types selected.

Table 1 – *Characteristics of the three farms selected A, B and C.*

Farms characteristics	Cluster I Farm Type A	Cluster II Farm Type B	Cluster III Farm Type C
UAA/farm (ha)	350	1334	1775
UIA/farm (private) (ha)	116	250	477
UIA/farm (Alqueva) (ha)	50	150	615
Land tenure	owner	owner	owner
Farm organization	individual farmer	individual farmer	company (firms)
Farmer age (years)	59	45	44
Formal education of farmer (years)	9	12	17
Irrigation production systems (% UAA)	sunflower (18); wheat (33); maize (5.7)	sunflower (6.7); wheat (18.7); fodder (1.1); vineyards (3)	sunflower (8.8); wheat (13.4); maize (4.4)
Beef cattle (animal unit)	120	250	-

Source: Discriminant analysis results.

3. The multi-period mathematical programming approach

Mathematical programming models are widely applied in agricultural economics (Hazell and Norton, 1986; Howitt, 2005; López-Baldovín *et al.,* 2006). This study uses a multi-period mathematical programming model (MMP), which allows accommodating the long-run effects of investments and the policy trends on farms. Usually, structural changes occur gradually and the effects on agricultural competitiveness can be better evaluated if the model includes the inter-temporal decision making process (Henriques, 1997; Dos-Santos, 2008).

The MMP model follows the assumptions of Hazell and Norton, (1986) and is based on Blanco (1996), Henriques (1997), Fragoso and Marques (2006) and Dos-Santos (2008). The objective function considers the farmers' preferences between present and future consumption, representing the initial situation of the farmers and including the final conditions which reflect the net assets value at the end of time horizon. So, the model solution provides the adjustments on crop patterns and resource allocation, and on farm's net assets under the CAP 2003, the HC and WFD scenarios.

The goal is to determine the optimal crop patterns, investments and financial flows, and resource allocation that maximize the farmer's wealth at minimum risk. All decisions are taken considering the annual cash-flow variability and the perception of having or not enough water to put into practice the production plan. Farmer's strategies comprise not only irrigated crops, but also the replacement of irrigated crops by rain-fed crops and the reinforcement or cessation of agricultural farming activities.

3.1. The objective function

The objective function (Z) maximizes the net present value of the producer consumption plus the final value of net assets (A) and minimizes the present value of standard deviation of annual cash-flows (equation 1). The annual producer consumption depends on annual cash-flows (C_n) and on marginal propensity to consumption (β). According to Henriques (1997), the marginal propensity to consumption was fixed in 60% of the annual cash flow value. Thus, 40% of annual cash flow goes to accumulated savings. The risk is given by the coefficient of risk aversion (f) and by the standard deviation of annual cash flow (σ_n). The discount rate used to calculate the present value was 2%, which represents the opportunity cost of capital into a market without risk. For the length of time horizon, it was considered a period of ten years (n=1,..,10) from 2004 to 2014. This period is close to the useful life of most of investments and its beginning coincides with the availability of data used for the model validation.

$$Max\ Z = \sum_{n=1}^{N} \frac{\beta C_n + A - \phi\sigma_n}{(1+i)^{n-1}} \qquad (1)$$

3.2. The risk

The coefficient f is usually interpreted as a risk marginal rate and the variable σ_n is calculated in (2) as the annual negative deviations of cash-flow by state of nature. Five states of nature (t) refer to technical, soil and climate production conditions and the remaining three states of nature (f) to the market conditions. Together, the outputs and the probability (p^t_f) of fifteen states of nature were considered.

$$\sigma_n = \sum_{t=1}^{T}\sum_{f=1}^{F} p_t^f \sqrt{\sum_{t=1}^{T}\sum_{f=1}^{F}(C_n - C_n^{f,t})^2} \qquad (2)$$

Another source of risk in ISMN is water availability. Equation (3) shows that water consumption must be less than or equal to water availability. Water consumption is calculated according to the crop demand for water (h_j) and crop area (X^j_n), where j is crop type by irrigation system. Annual water availability comes from private irrigation schemes in farms (Q) and from the project of Alqueva (w).

$$\sum_{j=1}^{J} h_j X_n^j \le Q + w \qquad (3)$$

The sources of water in private irrigation schemes are small dams, which have high annual variability levels. This implies that there is high probability of producers not having enough water to meet their average annual demands. To overcome this, the method of probabilistic constraints (Varela-Ortega et al., 1998; Fragoso and Marques, 2006) was used. This method assumes that farmers will choose the most feasible production plan.

The normal stochastic parameter Q is calculated in (4), on the basis of expected annual water availability from private irrigation schemes $E(q)$ and on its deviations ($K_\alpha ' \sigma_q$). The α coefficient is the probability of having water availability below the mean value, σ_q is the standard deviation of annual water availability and K_α is the percentile of the standardized normal distribution. According to the relative frequency of water availability, a value of 0.60 was used for α.

$$Q \leq E(q) - k_\alpha \sigma_q \qquad (4)$$

3.3. Decision variables

The decision variables of the model includes crop area and beef cattle heads, investments, loans and resource transfers activities between the different annual periods. Crop activities include dry-land activities such as cereals, oilseeds, fodder and pastures, and a wide range of irrigated activities like industrial and horticultural crops (tomatoes, peppers and sugar beet, melons, onions and potatoes), orchards (apple and plum), Mediterranean crops (olive, vineyards and grapes), cereals and oilseeds. In addition, for most of the crops a set of environmental technologies, such as the direct seeding, was considered.

Investment is a variable related with the structural investments that have influence on farmers' strategy. Investment includes equipment and machinery, irrigation equipment, orchard and Mediterranean crops and beef cattle.

According to expression (5), the initial assets capacity (ia), the investment made in the previous n-k years (I_{n-k}) and the investment made in the same year (I_n) should satisfy the requirements of the farmers' production strategy, which are given by crop area and beef cattle activities (X^j_n) and by technical coefficients ni_j.

$$\sum_{j=1}^{J} ni_j X_n^j \leq ia + \sum_{j=1}^{n-k} I_{n-k} + I_n \qquad (5)$$

Loans and resource transfer activities depend on financial resources allocation in the short and long term, which means that the modelling process takes into account liquidity (6) and solvability (7) of the farm. In the short term, cash balance from the previous period (B_{n-1}) and short-term loans (SL_n) guarantee the payment of operational expenses with crops and beef cattle activities, the repayment and interest of previous year short-term loans at a rate tx, and other expenses (OE_n), like the annuity payment of long-term loans and the farmer's wage.

$$B_{n-1} + SL_n \geq \sum_{j}^{J} e_j X_n^j + (1+tx)SL_{n-1} + OE_n \qquad (6)$$

In the long term, investments are funded by savings (SC_n), long-term loans (LL_n) and investment subsidies (SI_n). Savings available to investments are calculated each year as the difference between accumulated savings and savings used in the previous years.

$$\sum_{n=1}^{n-k} C_n (1-\beta) - \sum_{n=1}^{n-k} SC_{n-1} + LL_n + SI_n \geq IC_n \qquad (7)$$

3.4. Model constraints

The MMP model considers a set of constraints in order to represent technical, institutional, economic, and environmental conditions of the ISMN farms. This includes arable and irrigated land, labour force and herd nutritional requirement constraints. In addition, the model includes agronomic, market and CAP constraints, which bound some crop areas.

The constraints considered take into account the trade-off between model predictive power and model adherence to reality as highlighted by Howitt (2005). If too constrained, the model shows a higher adherence to reality, but its predictive power is lower while a less constrained model does not exhibit such a fine adherence, but its predictive capacities are further enhanced.

3.5. Model calibration and validation

The parameterization of the coefficient ϕ was done in order to reflect the farmer's behaviour towards risk. For the three farms studied (A, B and C), ϕ assumed the values of 0.20, 0.50 and 1.00, which represent different levels of risk aversion. The parameterization results showed that 0.20 was the best value for the coefficient ϕ.

According to McCarl and Apland (1986), the results of the three farm models were compared with the base year data, 2004, in order to test their robustness. For this purpose, the percentage absolute deviation (PAD) was calculated for crop and livestock activities, main economic results and resource allocation of land, labour, capital and irrigation water. The results showed that the model presents a good adherence to reality. The average PAD was 1.4%, 0.8%, and 9.4% for A, B and C farms, respectively. According to Hazell and Norton (1986), the three models can be considered calibrated and accepted as a valid instrument for performing further economic analysis.

3.6. Model scenarios

In order to analyse the competitiveness of the three farms of the ISMN, the scenarios described below were studied.

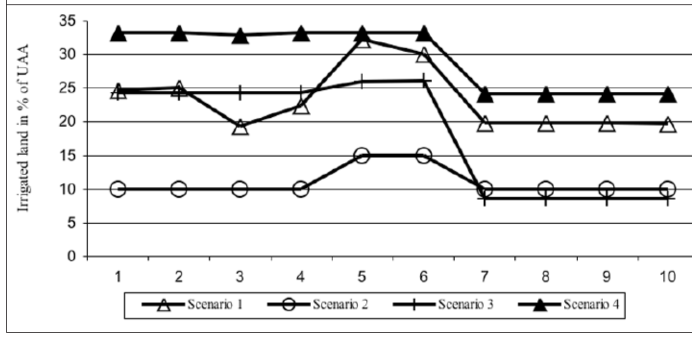
Scenario 1 - Represents the baseline situation in which the farms operate under the institutional framework of Agenda 2000; water supply is only from the private irrigation schemes; production is limited to traditional crops such as oilseeds, cereals, fodder and pasture.

Scenario 2 - Introduces the middle term CAP reform of 2003 and the Health Check; water supply and production conditions are similar to scenario 1.

Scenario 3 - Introduces water from the public Alqueva irrigation project; production conditions are similar to scenario 1; policy conditions are equal to scenario 2.

Scenario 4 - Introduces alternative crops and technologies (like industrial horticultural crops, fruits, Mediterranean crops, cereals and oilseeds, as well as environmental friendly technologies); policy conditions are equal to scenario 2; water supply from private and public sources.

Figure 1. *Evolution of irrigated land in farm type A by model scenarios.*



Source: Model results.

4. Results and discussion

For each one of the three farm types, the model was run under the four scenarios presented above. The results were analysed, first in terms of cropping mix patterns and use of resources, and then in terms of economic performance. The evolution of irrigated land and cropping pattern are discussed over the time horizon. The farms' economic performance is measured using the present value of producer consumption and net assets (PVNA), the annual net income (ANI), the total agricultural investment (TAI), the long-term loans (LTL) and the ratio subsidies/revenue.

4.1. Cropping mix patterns and use of resources

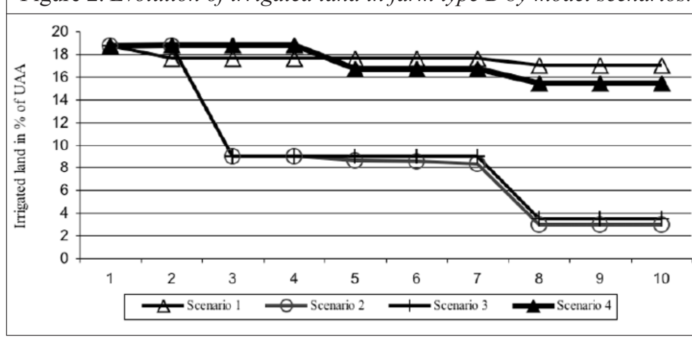
The evolution of irrigated land over the time horizon, on farm types A, B and C for each one of the four scenarios studied can be seen in Figures 1, 2 and 3 and in Tables A1, A2 and A3 in the appendix. In scenario 1, the irrigated land represents 33%, 19% and 27% of utilized agricultural area (UAA) on farm types A, B and C, respectively. However, in farm type A this percentage is only 24% at the end of the time horizon due to a reduction in sunflower area. Irrigated land is occupied mainly with wheat, maize and sunflower and with a small area of vineyards in farm type B. In farm types A and B, dry land is fully occupied with pasture and fodder which are utilized by beef cattle, 120 and 250 heads, respectively. In farm type C, dry land is cultivated exclusively with wheat and oilseed.

In scenario 2, irrigated land is drastically reduced and livestock production, namely beef cattle activities and pasture and fodder crops, are reinforced. In farm type A, irrigated crops account for only 10% of UAA while in farm type B the percentage decreases from 18% to 3% (just vineyard) at the end of the time horizon. In the case of farm type C, irrigated crops are completely abandoned.

The model scenario 3 represents an important increase in water and land available to irrigation and the results are not much different from the ones observed for scenario 2. For farm types A and B, irrigated land represents 24% and 19% of UAA at the beginning of time horizon, but these percentages fall to 8.6% and 3.5%, respectively, due to WFD dispositions on water prices increases. At the same time, pasture and fodder crop areas and beef cattle activities increase, though, this last activity is reduced at the end of the time horizon. This scenario has good structural conditions for irrigation, but it is not possible to profit from the economic potential of the Alqueva project and neither to promote farm competitiveness.

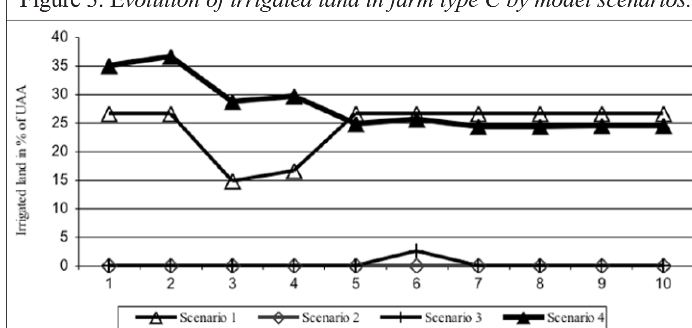
The model scenario 4 introduces the possibility of farmers to adopt new agricultural technologies. This is reflected in a positive economic impact with improved levels of agricultural resources use. In this scenario, irrigated land grows to 25%, 19% and 35% of UAA in farm types A, B and C, respectively, even with water price rising due to WFD dispositions. Traditional irrigation crop pattern composed by cereals and/or fodder crops is replaced by

Figure 2. *Evolution of irrigated land in farm type B by model scenarios.*



Source: Model results.

Figure 3. E*volution of irrigated land in farm type C by model scenarios.*



Source: Model results.

Mediterranean crops, orchard, and industrial and horticultural crops.

Mediterranean crops are vineyards, grapes and olive, occupying, respectively, between 0.7% and 3%, 3% and 7%, and 6% and 9% of UAA. In the case of industrial crops, the main areas are sugar beet (5% to 7% of UAA) and tomatoes (0.2% to 3.4% of UAA). The most important horticultural crops are potatoes and onions, representing 4% to 7% of UAA, and 0.2% to 2.5% of UAA, respectively. The technologies of reduced tillage and direct seeding are largely adopted. After the third year of the time horizon, industrial crop areas are replaced by horticultural crops due to decreasing CAP supports on sugar beet and tomatoes. Beef cattle still plays an important role on the economy of ISMN, but a reduction around 28% in farm types A and B is observed. These changes lead to duplication of agricultural employment in farm types A and B and tripling in farm type C.

4.2 Economic results

Figures 4, 5 and 6 and Tables A1, A2 and A3 in the appendix present the PVNA, the TAI and the loans in farm types A, B and C for each one of the model scenarios considered.

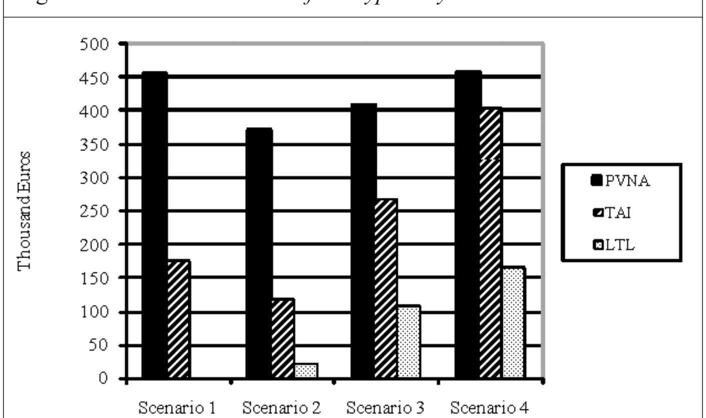
In scenario 1, the PVNA of farm type A is 456 thousand Euros and TAI, which is entirely financed with savings, is 174.5 thousand Euros. The ANI over the time horizon is between 49.7 and 46.2 thousand Euros and the current subsidies represent between 65% and 42% of revenues. In farm type B, PVNA reaches 1,284 thousand Euros, TAI is 818 thousand Euros and LTL represents 12% of the TAI. ANI varies between 116 and 133.7 thousand Euros, representing current subsidies more than 40% of revenues. In farm type C, PVNA is 641.4 thousand Euros, TAI is 1,816 thousand Euros and LTL represents 41% of the TAI. ANI is 386 thousand Euros in the first year of the time horizon, but decreases successively down to 200 thousand Euros.

In scenario 2, which introduces the SFP and the decoupling of agricultural supports, there is a general decline in the economic results, mainly due to the adoption of extensive crop patterns and the abandonment of irrigated crops. This scenario leads to a decrease in the PVNA by 18.5% and 47%, and in the TAI by 47% and 92% on farm types A and B, respectively. In farm type C, PVNA doubles, TAI is reduced to almost half of its value and LTL falls dramatically. At the end of the time horizon most revenues are mainly from SFP.

In scenario 3, the Alqueva project did not bring the expected effects when compared with scenario 1. PVNA decreases by 10% and 1% in farm types A and B, respectively, due to the investment done in beef cattle and irrigation and which increases TAI and the dependence from LTL. For farm type C, the results are similar to scenario 2, with slight improvements on economic results and therefore on farm competitiveness. These results show that the removal of resource constraints, in this case water supply, is not enough to improve income and, as shown in scenario 4, new technologies and activities are required.

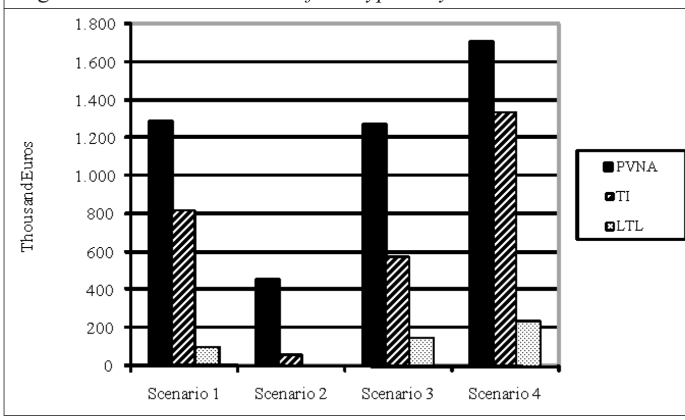
Model scenario 4 has important economic effects and a positive impact on farm competitiveness levels. Comparing with model scenario 1, PVNA is maintained in farm type A, grows 25% in farm type B and more than eleven times in farm type C. TI almost doubles in all farm types, increasing its dependence

Figure 4. *Economic results in farm type A by model scenarios.*



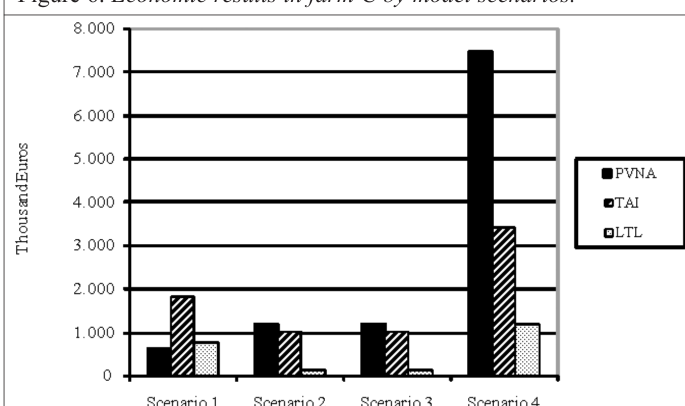
Source: Model Results.

Figure 5. *Economic results in farm type B by model scenarios.*



Source: Model Results.

Figure 6. *Economic results in farm C by model scenarios.*



Source: Model Results.

from borrowed capital as well as from the costs with interests. When compared to scenario 2, PVNA increases 23% in farm type A, almost 4 times in farm type B and more than 6 times in farm type C. When compared with model scenario 3, the adoption of alternative agricultural technologies provides an increase in PVNA of 12%, 34% and more than 6 times in farm types A, B and C, respectively.

5. Conclusions

The results allow to conclude that the introduction of the Single Farm Payment scheme, the reinforcement of the decoupling supports in the Common Agricultural Policy review of 2003 and in the Health Check in 2009, lead to an extensification on agricultural systems, reduction of the economic results and weakness on farm competitiveness levels. These results are similar to Coelho (2005), who refers this risk of arable land abandonment due to decoupling agricultural supports.

The new structures of the Alqueva irrigation project do not provide the needed stimulus to meet the new challenges of the evolution of the Common Agricultural Policy. Traditional activities of cereals, oilseed, pastures and fodder do not have the level of competitiveness able to give better returns to agricultural resources, particularly to water and irrigated land.

Otherwise, the adoption of alternative agricultural technologies, such as industrial and horticultural crops, orchards, Mediterranean crops and direct seeding and reduced tillage, could bring important positive economic effects such as higher returns and better resources allocation, which allow to maintain or increase the farm competiveness in the Irrigation Scheme of Monte Novo and in the Alqueva project.

Despite this enormous potential, the effects depend on resources and capital structure of farms. Smaller farms have more difficulties in adopting alternative technologies, due to their financial constraints and to the shortage of technical and management knowledge. Therefore, a review of financial policies and credit access for small and medium farmers, as well as the technical and management assistance policy is demanded**.**

The study concludes that Common Agricultural Policy trends to reinforce the decoupling of agricultural support have more influence on farmers' decisions than the Water Directive Framework guidelines. The negative effects of increases in water pricing can be accommodated with the adoption of more profitable irrigated systems with less demand for water, such as for vineyards and olives.

In this case, one of the main difficulties is related to the limitations of the microeconomic analysis to treat problems involving the management of common resources, such as water in public irrigation structures. Future developments should address the effects of water pricing on the competitiveness of farms considering alternative schemes of water rates for irrigation.

References

Arfini, F., Donati, M., Petricione, G.; Solazzo, R., 2008. An Impact Assessment of the Future CAP Reform on the Italian Sector. 109th EAAE Seminar. (Accessed on 16/ 09/2009). *ageconsearch.umn.edu/bitstream/44831/2/4.1.3_ Donati.pdf.*

Bartolini, F., Bazzani, G.M., Gallerani, V., Raggi, M., Viaggi, D., 2007. *The impact of water and agriculture policy scenarios on irrigated farming systems in Italy: An analysis based on farm level multi-attribute linear programming models,* Agricultural Systems, 93 (1), 90-114.

Blanco, M.F., 1996. *Analyse des Impacts Socio-économiques et les Effets sur L´Environnement des Politiques Agricoles: Modélisation de L´Utilisation Agricole des Ressources en Eau Dans la Région Espagnole de Castille-Léon.* CIHEAM – Institut Agronomique Méditerranéen de Montpellier. Collection Thèses & Masters, 32, Montpellier.

Breen, J.P., Hennessy, T.C., Thorne, F.S., 2005. *The Effect of Decoupling on the Decision to Produce: An Irish Case Study*, Food Policy, 30, 129-144.

Coelho L.A.G., 2005. *Decisão em Contexto de Incerteza: O Comportamento dos Agricultores na Região de Sequeiro do Alentejo Face à Reforma Intercalar da Política Agrícola Comum.* Tese de Doutoramento. Universidade de Évora, Évora.

Directive 2000/60/EC. 2000. *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Directory Classification Code: Environment, consumers and health protection - Environment - Pollution and nuisances - Water protection and management*. Official Journal L 327 , 22/12/2000 P. 0001 - 0073 . OJ L 327/1, 22.12.2000, pp.1-72.

Dos-Santos, M.J.P.L.,2008. *Análise da Competitividade do Regadio de Alqueva: O Caso do Perímetro de Rega do Monte Novo*, Tese de Doutoramento, Universidade de Évora, Évora.

Dos-Santos, M.J.P.L., Henriques, P.D.S., Fragoso, R.M.S., Silva-Carvalho, M.L.P.V., 2009. *A competitividade do regadio de Alqueva: O caso do Perímetro de Rega do Monte Novo a Sul de Portugal*. XLVII SOBER - Congresso da Sociedade Brasileira de Economia, Administração e Sociologia Rural. Brasil.

Fragoso, R., Marques, C., 2006. *A Revisão da Política de Tarifas de Água no Uso Agrícola: Um Estudo de Caso no Sul de Portugal.* Proceeding Conference do XLIV SOBER. Brasil.

Fragoso, R., Marques, C., 2007. *A Competitividade do Regadio em Portugal no Contexto da Nova Política Agrícola Comum: O Caso de uma Exploração Agrícola no Alentejo*, Revista de Economia e Sociologia Rural, 45, (1), 49-70.

Gohin, A. Latruffe, L., 2006. *The Luxembourg common agricultural policy reform and the European food industries: What's at stake?,* Canadian Journal of Agricultural Economics, 54(1), 175-194.

Hazell, P.B.R.; Norton, R.D., 1986. *Mathematical Programming Economics Analyses in Agriculture*. McMillan Publishing Company, New York, U.S.A.

Henriques, P.D.S., 1997. *Technical Efficiency and Changes in Alentejan Farming Systems.* PhD Thesis, University of Reading, Reading, UK.

Howitt, R.E. 2005. *Agricultural and environmental policy models: Calibration, Estimation and Optimization.*

Available for download in pfd form from the author's webpage. (Accessed on 16/06/2008).

López-Baldovin, M.J., Gutiérrez-Martin, C., Berbel, J., 2006. *Multicriteria and multiperiod programming for scenario analysis in Guadalquivir river irrigated farming*, Journal of the Operational Research Society, 57(5), 499-509.

Matthews, K.B., Wright, I.A., Buchan, K., Davies, D.A., Schwarz, G., 2006. Assessing the options for upland livestock systems under CAP reform: Developing and applying a livestock systems, Agricultural Systems, 90 (1), 32-61.

McCarl, B.A., Apland, J., 1986. *Validation of linear programming models*, Southern Journal of Agricultural Economics, 18, 155-164.

Riesgo, L., Gomez-Limon, J.A., 2006. *Multi-criteria policy scenario analysis for public regulation of irrigated agriculture,* Agricultural Systems, 91 (1), 1-28.

Varela-Ortega, C., Sumpsi, M.J., Garrido, A., Blanco, M.; Iglesias, E., 1998. *Water Pricing Policies, Public Decision Making and Farmer's Response: Implications for Water Policy*, Agricultural Economics, 19, (1), 193-202.

Appendix

Table A1 – *Results for form type A under scenarios 1, 2, 3 and 4.*

Years	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Scenario 1										
Producer consumption and net assets (€)										456,097
Total agricultural investments (€)										174,545
Irrigated land (% of UAA)	33.2	33.2	32.8	33.2	33.2	33.2	24.1	24.1	24.1	24.1
Cereals and oilseeds (% of UAA)	33.2	33.2	32.8	33.2	33.2	33.2	24.1	24.1	24.1	24.1
Dry land (% of UAA)	66.8	66.8	67.2	66.8	66.8	66.8	75.9	75.9	75.9	75.9
Scenario 2										
Producer consumption and net assets (€)										371,685
Total agricultural investments (€)										118,177
Irrigated land (% of UAA)	10.0	10.0	10.0	10.0	15.0	15.0	9.9	9.9	9.9	4.6
Cereals and oilseeds (% of UAA)					5.9	5.9				
Fodders and pasture (% of UAA)	10.0	10.0	10.0	10.0	9.2	9.1	9.9	9.9	9.9	4.6
Dry land (% of UAA)	90.0	90.0	90.0	90.0	85.0	85.0	90.1	90.1	90.1	95.4
Scenario 3										
Producer consumption and net assets (€)										407,543
Total agricultural investments (€)										267,893
Irrigated land (% of UAA)	24.3	24.3	24.3	24.3	25.9	26	8.6	8.6	8.6	8.6
Cereals and oilseeds (% of UAA)					15.8	15.8				
Fodders and pasture (% of UAA)	24.3	24.3	24.3	24.3	10.1	10.2	8.6	8.6	8.6	8.6
Dry land (% of UAA)	75.7	75.7	75.7	75.7	74.1	74	82.6	82.6	82.6	91.4
Scenario 4										
Producer consumption and net assets (€)										457,082
Total agricultural investments (€)										404,439
Irrigated land (% of UAA)	24.6	25	19.2	22.4	32.7	29	19.7	19.7	19.7	21.1
Cereals and oilseeds (% of UAA)	2.8	2.4	2.7	2.8	10.2	8.8	1.4	1.4	1.4	1.4
Fodders and pasture (% of UAA)	5.6	5.6	5.6	5.6	5.6	4.3	2.8	2.8	2.8	2.8
Industrial, horticultural and orchard crops (% of UAA)	8.0	8.0	1.6	4.7	7.6	6.6	6.2	6.2	6.2	7.6
Mediterranean crops (% of UAA)	8.2	9.0	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3
Dry land (% of UAA)	75.4	75.0	80.8	77.6	67.3	71.0	73.5	73.5	73.5	72.1

Source: model results.

Table A2 – *Results for form type B under scenarios 1, 2, 3 and 4.*

Years	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Scenario 1										
Producer consumption and net assets (€)										1,283,784
Total agricultural investments (€)										818,115
Irrigated land (% of UAA)	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7
Cereals and oilseeds (% of UAA)	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Fodders and pasture (% of UAA)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Mediterranean crops (% of UAA)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Dry land (% of UAA)	81.3	81.3	81.3	81.3	81.3	81.3	81.3	81.3	81.3	81.3
Scenario 2										
Producer consumption and net assets (€)										449,821
Total agricultural investments (€)										64,072
Irrigated land (% of UAA)	18.8	18.8	9.0	9.0	8.6	8.6	8.3	3.0	3.0	3.0
Cereals and oilseeds (% of UAA)	14.6	14.6	3.8	3.8	3.3	3.3	3.0			
Fodders and pasture (% of UAA)	1.2	1.2	2.2	2.2	2.3	2.3	2.3			
Mediterranean crops (% of UAA)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Dry land (% of UAA)	45.1	45.1	39.6	39.6	5.5	5.5	5.7	6.9	5.3	5.3
Scenario 3										
Producer consumption and net assets (€)										1,269,311
Total agricultural investments (€)										576,434
Irrigated land (% of UAA)	18.8	18.8	9.0	9.0	9.0	9.0	9.0	3.5	3.5	3.5
Cereals and oilseeds (% of UAA)	7.3	7.5			5.5	5.5	5.5			
Fodders and pasture (% of UAA)	8.5	8.3	6.0	6.0	0.5	0.5	0.5	0.5	0.5	0.5
Mediterranean crops (% of UAA)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Dry land (% of UAA)	81.2	81.2	91.0	91.0	91.0	91.0	91	96.5	96.5	96.5
Scenario 4										
Producer consumption and net assets (€)										1,701,404
Total agricultural investments (€)										1,334,031
Irrigated land (% of UAA)	18.7	18.8	18.8	18.8	16.6	16.6	16.5	15.4	15.4	15.4
Fodders and pasture (% of UAA)	3.4	2.6	2.8	2.8	0.4	0.4	0.3	0.1	0.1	0.1
Industrial, horticultural and orchard crops (% of UAA)	7.3	7.2	7.0	7.0	7.2	7.2	7.2	6.3	6.3	6.3
Mediterranean crops (% of UAA)	8.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Dry land (% of UAA)	44.8	49.1	39.1	39.1	5.8	5.4	5.3	6.5	6.5	6.5

Source: model results.

Table A3 – *Results for form type C under scenarios 1, 2, 3 and 4.*

Years	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Scenario 1										
Producer consumption and net assets (€)										641,358
Total agricultural investments (€)										1,816,500
Irrigated land (% of UAA)	26.6	26.6	14.9	16.6	26.6	26.6	26.6	26.6	26.6	26.6
Cereals and oilseeds (% of UAA)	26.6	26.6	14.9	16.6	26.6	26.6	26.6	26.6	26.6	26.6
Dry land (% of UAA)	73.4	73.4	85.1	83.4	73.4	73.4	73.4	73.4	73.4	73.4
Scenario 2										
Producer consumption and net assets (€)										1,197,897
Total agricultural investments (€)										997,236
Dry land (% of UAA)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	10.00	100.0
Scenario 3										
Producer consumption and net assets (€)										1,213,897
Total agricultural investments (€)										997,978
Dry land (% of UAA)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	10.00	100.0
Scenario 4										
Producer consumption and net assets (€)										7,474,177
Total agricultural investments (€)										3,405,211
Irrigated land (% of UAA)	35.1	37.1	28.8	29.8	25.1	24.8	24.5	24.5	24.7	24.7
Fodders and pasture (% of UAA)	5.7	6	5.2	5.2	0.4	0.2				
Industrial, horticultural and orchard crops (% of UAA)	18.3	18	10.5	11.5	11.6	11.5	11.4	11.4	11.6	11.6
Mediterranean crops (% of UAA)	11.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
Dry land (% of UAA)	64.9	62.9	71.2	70.2	74.9	75.2	75.5	75.5	75.3	75.3

Source: model results.