AN INTEGRATED TERRITORIAL SIMULATION MODEL TO EVALUATE CAP REFORM ON MEDITERRANEAN AGRICULTURE. METHODOLOGICAL PROPOSAL AND FIRST APPLICATIONS IN APULIA REGION (SOUTHERN ITALY)

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Abstract

The implementation of most recent CAP and water policy reforms calls for simulation analytical tools able to quantify socio-economic and environmental impacts that can be different in terms of regions and farm type. This work proposes a territorial mathematical programming model that integrates hundreds of farm models clustered in a single meta-model at regional level that can be easily standardized having the FADN as the main data source. The tool has been experimentally applied to Apulia region and several simulations have been conducted in scenarios differing in terms of agricultural policies (total decoupling, increase of the modulation rate and introduction of a flat rate system for the Single Farm Payment), price of the water resource, market conditions (price of products and cost of inputs).

For each simulation, farmers' choices - cropping patterns and techniques-, the economic assessment of the effects of such choices -revenue, costs and incomes- and environment impacts -use of factors and resulting pressures on natural resources- have been analysed. The results of the analysis show that agricultural policies measures do not affect land use pattern or the agricultural pressure on water resources. But can have major income redistributive effects. On the contrary, water policy and market conditions impact on farmers' choices, economic performance and environmental pressure.

Keywords: Agricultural policies, Water policy reforms, territorial mathematical programming model.

JEL: Q18, Q25, Q51.

Introduction

The economic, social and environmental sustainability of the agricultural sector in a globally changing scenario is an increasingly pressing challenge and is the objective of numerous environmental and agricultural policy measures designed at the community level and applied regionally (Berbel and Gutierrez, 2005). Decision-support tools (Bazzani, 2007a) capable of quantifying the socio-economic and environmental impacts and supporting complex and participatory decision processes are largely applied to define such measures (Gohin, 2006).

This work is aimed at introducing a simulation model for the economic analysis of the agriculture sector under different agricultural policies, water policy and market conditions scenarios. Such a tool can easily fit to different local situations and time scales and can catch the complexity and multiplicity of the local production systems. To this end, the major sources of data, among which Farm Accountancy Data Network (FADN) in particular, which can provide standardized, homogeneous and accessible data were used.

Methodology

Generalities

The adopted methodology is based on mathematical programming farm models widely applied in the economic-agricultural analysis and in the analysis of irrigated agriculture for the evaluation of the possible effects of the new regulatory framework (Arfini and Donati, 2008; Blanco Fonseca et al., 2005; Borresh et al. 2005; Buisson, 2005; Butault and Delame, 2005; Casado and Gracia, 2005; Chatellier, 2007; INRA, 2003; Marchand et al, 2008; Scardigno and Viaggi, 2007) in specific irrigation areas (Bartolini et al., 2005 and 2007; Bazzani, 2005b; Dono and Severini 2005; Jùdez et al, 2007**;** Lezoche and Severini, 2007), focusing especially on the application of the full cost principle established in the WFD (Dono and Severini, 2006; Massarutto 2003a and 2003b), and on the use of irrigation water in the post-reform 2003 scenarios (Chinnici et al, 2006). The analysis of the studies carried out so far shows that territorial models better fit to the integrated management approach of water resources at watershed scale as recommended by the WDF (Bazzani, 2005a; Dono, Liberati and Severini, 2007). The approach we propose is a linear territorial model that - avoiding the assumptions and elaborations required when adopting representative farms - can take into account the multiplicity of the production systems though preserving the numerousness of the FADN sample.

The regional FADN[1] database, which is the primary source for the structural and economic farm data, was combined with the data from the Ministry of Labour and Social Security on labour requirements for the different crops, the monthly and total irrigation

[1] FADN is a network to gather accountancy data from farms for the determination of incomes and business analysis of agricultural holdings. It is the most widely used database in micro-economic research of agricultural policies for programming and evaluation purposes since it represents the only harmonized source at the European level.

requirements data resulting from agronomic studies and experimental research carried out in the concerned area and estimated through the use of water response curves by the "Land and Water Resources Division" of the Mediterranean Agronomic Institute of Bari, and the data provided by the reclamation and irrigation boards present in the Region. All the data used were adequately integrated and checked both with experts and stakeholders and basing on the scientific literature during the preparation and calibration of the model.

The current version of the model is static and a scenario analysis approach is adopted. The simulations performed provide data and estimates on the most efficient strategies of agents in response to the variations of the production factors in terms of availability and costs, of prices of products, and to the changes of specific agricultural and environmental policy measures.

The aggregate model

The macro level corresponds to the regional scale, disaggregated per province and altimetrical zone. Other forms of aggregation, at the watershed or irrigation district scale, that can better respond to specific purposes of the analysis are still possible. The model is linear in structure and is subdivided into blocks referred to different farms present in the area. These farms are differentiated by location within the study area (province and altimetry), by cropping pattern and source of water for irrigation. The adopted approach allows analysing the macro area-related farm constraints though highlighting the differences and the specificities of the farms indicated by index *f*, and their territorial distribution. The analysis of the agricultural system is always performed by pursuing efficiency, which leads to identify the optimal solution for the system as a whole. The total farm income *Z* is equal to the summation of the farm income INC_f of all the considered farms:

$$MAX\ Z = \Sigma_f\ INC_f \qquad (1)$$

The previous one is, thus, a simple accounting equation that aggregates the incomes calculated in the farm sub-models. Since the production factors are assigned on the basis of farm marginal productivity that differs between farms, by maximizing the aggregate farm income the increment in income of more performing farms can coexist with reductions in income of less performing ones.

The farm models

The farm models represent the micro components of the territorial model. Each model can be expressed in a compact analytical form by an income function and by a set of constraints.

$$INC_f = \Sigma_h\ m_{fh}\ X_{fh} + SU_f \qquad \vee f \qquad (2)$$

sub

$$\Sigma_h\ a_{fhk}\ X_{fh} \leq b_{fk} \qquad \vee f \qquad (3)$$

$X_{fh} \geq 0$ (4)

where:

f = 1,…, F farms

h = 1,…, H activities

k = 1,…, K production factors

The farm income function (equation 2) includes the economic data (costs and revenues, including subsidies coupled to production factors) relative to each of the possible production processes (activities) as coefficients - vector m -, and the corresponding activity levels representing the hectares for each on-farm activity or production process as unknowns - vector X. The INC_f variable represents the farm income, equal to the summation of the incomes resulting from different farm activities and the possible decoupled single farm payments (SFP). Income is quantified by respecting the constraints (equation 3) represented by the quantity of each factor required for the production of each final good (matrix A) and the total availability of factors (vector b), and by the condition of non-negativity of the activity levels of the variables (equation 4).

The solution of the aggregate problem provides the activity levels of the different production processes and the amount of production factors used per farm and, in the presence of scarce factors or special territorial constraints, it doesn't coincide with farm income maximization.

All the technically possible and area-relevant combinations between the crops grown in the farms falling in the sample, the presence or absence of irrigation, and two irrigation methods – drip and sprinkler – with different field efficiency were considered.

For each farm *f* the farm income INC is given by the difference between the value of production and the variable costs. The value of production refers to the production sold for final consumption or being processed and it includes subsidies coupled to the crop quantity or surface and the single farm payment. Variable costs are given by the specific cropping expenses, the expenses for water and those for labour.

Formally:

$$INC_f = \Sigma_{s,c,s,i,j} (q_{f,s,c,s,i,j} * p_{f,c} - vc_{f,c,i,j} + q_{f,s,c,s,i,j} * su\_qu_{s,c} + su\_ha_{s,c}) HA_{f,s,c,i,j} + DEC\_PA)_{f,} - c\_lab_{f,s} * LAB_f - c\_wat_{d,s} * WAT_{f,d} \quad (4)$$

Where the meaning of the indexes is as illustrated above, and the parameters stand for: q, quintals of production (q/ha); p, prices of sale (€/q); vc specific variable costs (€/ha); su_qu, subsidies per unit quantity of product (€/q); su_ha, subsidies per unit surface (€/ha); c_lab, labour cost (€/hour); and LAB quantity of employed labour. Decoupled payments (DEC_PA) (€), instead, are a variable whose quantification requires respecting specific rules introduced into separate constraints (for instance, the respect of the minimum cultivated surface with eligible crops). The cost, if any, related to the use of water, WAT (m^3) an endogenous variable, is given by the volume of water use multiplied by the price/cost per cubic meter, and differentiated per source of supply. Index *d* allows considering both the supply from irrigation boards paid on a consumption-base fee, and self-supply from wells that implies pumping-related costs. Prices and costs for the unit use of the water resource are expressed by the economic parameter c_wat (€/m^3). Since no data concerning water consumption per crop are available in the FADN, in this preliminary elaboration two conditions were identified – dry and full irrigation[2] - on the basis of the data supplied by MAIB experts.

All the unit farm coefficients, yields, variable costs, use of the factors explicitly considered (water and labour) and prices of sale of the products were calculated as the average of the 2004 and 2005 values and, in the case of 2004 economic values, they were discounted at the ISTAT inflation rate.

The subsidies reducing impact of modulation isn't included in the income equation since it is assumed that farmers do not consider the cut in subsidies at the planning phase. The impact of modulation is quantified *ex post* to assess the income variation for the different farms.

As for the extension of the frontier of production opportunities for each single considered farm, it was assumed that for the crops not grown in the farm, the average production processes of the area of belonging of the farms, namely of a given altimetrical zone and province, could be used and, accordingly, the average zonal coefficients were calculated. Further extension was subsequently obtained by attributing the possible adoption of the average processes calculated in an altimetrical zone of a neighbouring province to each zone.

The constraints adopted by the model include:

- Total land constraint: imposes that the set of crops grown, including uncultivated land and no-tillage, doesn't exceed the available land; it is defined on monthly basis through setting up a production schedule that specifies the land use per crop.

- Irrigated land constraint: imposes that irrigated surface be smaller than the farm irrigable surface.

- Agronomic constraints: ensure that crop rotations respond to some good practices rules capable of preserving soil fertility; specific constraints ensure that some crops or groups of crops do not exceed certain levels so that they are not repeated on the same plots but only after an adequate number of years.

- labour constraints: impose that the use of labour be smaller than or equal to the availability of the period, both at the farm and territorial level; availability is given by family labour and

[2] When the main surface used for the crop was partially irrigated, a specific attribution procedure was adopted.

external labour; the latter is constrained by area-based labour availability in each period.

- Water constraints: verify that water uses be smaller than or equal to the availability of the period, both at the farm and territorial level. The possibility of self-supply through wells is taken into consideration. The characteristics of the irrigation techniques, of the pumping stations and the resulting energy requirements are adequately considered.

- Market and policy constraints: establish upper limits to the variation of the cultivated area, per crop or per groups of crops, as compared with what is observed in relation to the absorption capacity of markets of sale of the agricultural production in specific areas; in the case of olive trees, they also fix lower limits to the variation of the area grown with different crops as set out in a regional regulation.

The study area and the sample

The model was experimentally applied to Apulia region, a region "with serious environmental problems related to the peculiar hydrogeological system of the territory and to the unsustainable use of natural resources; soil and water in particular" (AA.vv., 2001). Apulia region has an agricultural area of about 1.25 million hectares, equal to 62.5% of the territorial surface, 54% of which grown with arable crops, 39% with tree crops and the remaining 7% with meadows and pastures. Among tree crops, olive trees cover about 375 thousand hectares, vineyards about 158 thousand hectares totally, two thirds of which for wine production and one third for table grape, then followed by smaller surfaces of almond trees, cherry trees and citrus orchards. Among field crops, cereals play a major role and durum wheat prevails, with about 390 thousand cultivated hectares. Vegetable crops cover about 100 thousand hectares, differentiated into numerous species and varieties (artichoke, cauliflower, salads, cabbage, fennel, broccoli, pepper, tomato, potato, carrot, garlic, onion) and are grown all the year around; tomato stands out with 35 thousand hectares and artichoke with about 18 thousand hectares. Industrial crops extend over 20 thousand hectares and sugar beet prevails with about 17 thousand hectares (Regione Puglia- Inea, 2008). Farms are about 250,000 (Istat 2001), with an average size of 4.9 ha. Total employment is constantly decreasing and in 2005 it was equal to 130 thousand units. In 2005, the value of regional agricultural production exceeded 3.8 billion euros, 45% of which is represented by tree crops products (mainly olive trees and vineyards) and 35% by herbaceous crops (potatoes and vegetables 66%, followed by durum wheat 15%.)

In Apulia conditions, irrigation is an indispensable and increasingly widespread practice to increase the quality of high value crops and irrigated agriculture represents 54% of the regional agricultural production. The total number of irrigated farms in the region is about 100,000 for a total surface of 248,000 hectares (equal to 64% of the approximately 390,000 equipped hectares) in 2001 with a quite different percentage according to the farm type. 69% of farms are supplied with water from groundwater, 19% from water systems and the remaining part from rain harvesting and other sources. 39% of farms are self-supplied, 27% of farms receive water from reclamation and irrigation boards, 13% from other farms and the remaining 21% from different sources. The public collective network is the one managed by the “Reclamations Boards” present in the region that run more than 1.7 million hectares with only 75,500 hectares as operating surface. In addition to the public collective network farmers’ associations are also present and manage small private collective networks and an unspecified number of private farm wells: it is estimated that, in Apulia, to each hectare irrigated from public source do correspond 2.3 hectares irrigated from private wells. This ratio differs between zones depending on the capacity of the public network to respond to farmers’ requirements and obviously tend to decrease significantly in the periods when public resources are particularly scarce. Finally, as for the irrigation methods, about 52% of the surface is irrigated by drip, 37% by sprinkler or micro-irrigation, and 5% by surface and furrow irrigation (ISTAT, 2001).

The FADN Inea data used cover the two-year period 2004-2005. The sample, originally consisting of 1,179 farms, reduced to 878 farms after screening to exclude those farms not present in all the considered years, the livestock farms[3], organic farms and micro-farms of a size smaller than 1 hectare (Table 1).

Tab. 1 Major sample characteristics

	Farm	**Total area**	**Agricultural Area**	**Irrigable area**	**Irrigated area**
	n	*Ha*			
Foggia	187	4,601	4,483	2,115	1,192
Bari	195	3,061	2,855	663	1,328
Brindisi	74	1,168	4,013	939	2,051
Taranto	174	4,453	1,136	2,991	608
Lecce	248	4,512	4,232	2,297	1,043
APULIA	878	17,796	16,718	10,006	6,223

Source: our elaborations

Globally, the analysis was performed on 17,796 hectares of total agricultural area, 16,718 hectares of Agricultural Area, with an irrigated area of 6,223 hectares over an irrigable area of 10,005 hectares. The irrigated area is equal to about one third of the cultivated one and only slightly more than half of the irrigable one.

[3] The choice of eliminating the livestock farms results from the fact that they are scarcely important in the regional agricultural system.

Scenarios

The simulated scenarios refer to:

- The observed cropping pattern in 2005 (SC1)
- The optimized cropping pattern in 2005 (SC2)
- The implementation of Fischler reform at 2011 (SC3)
- An increase in water supply costs at 2011, assuming that public source becomes more expensive than private one (SC4); or a considerable increase in water supply cost for private source (SC5)
- The implementation of the Health Check at 2013 (approximation SC6, regionalization SC7)
- Variation in costs and prices of inputs and products at 2013 (SC8/11)

As for the Health Check at 2013, in the approximation scenario (SC6) only those farmers who held entitlements in the past would receive subsidies. The amount received is quantified on the basis of the number of entitlements at 2013 and a unique value for payment entitlements, calculated as the average of the total subsidies amount in SC3. In the regionalization scenario (SC7) 30% of the previous amount is paid to all farmers, including the ones with no previous entitlements, on the basis of the cultivated area; the other 70% is calculated as before, being the value of the entitlements lower in this case. In the market scenarios (SC8-11) variable costs increase by 15% and product prices by 10% thus reducing agricultural margin. Only for cereals two distinct patterns are considered: in the SC8 and SC9 cereal prices increase more than costs whereas the opposite occurs in SC10 and SC11.

Tab. 2 Scenarios

<table>
<tr><th rowspan="2">SC</th><th rowspan="2">CAP</th><th colspan="2">Water price per source:</th><th rowspan="2">Price of products</th><th rowspan="2">Variable costs</th></tr>
<tr><th>public</th><th>private</th></tr>
<tr><td>SC1</td><td>2005 observed</td><td>0.1</td><td>0.2</td><td colspan="2" rowspan="4">average 2004/05</td></tr>
<tr><td>SC2</td><td>2005 optimised</td><td>0.1</td><td>0.2</td></tr>
<tr><td>SC3</td><td>2011 (historical model)</td><td>0.1</td><td>0.2</td></tr>
<tr><td>SC4</td><td>2011 (historical model)</td><td>0.25</td><td>0.2</td></tr>
<tr><td>SC5</td><td>2011 (historical model)</td><td>0.1</td><td>0.3</td><td colspan="2"></td></tr>
<tr><td>SC6</td><td>2013 (approximation)</td><td>0.1</td><td>0.2</td><td colspan="2" rowspan="2">average 2004/05</td></tr>
<tr><td>SC7</td><td>2013 (regionalization)</td><td>0.1</td><td>0.2</td></tr>
<tr><td>SC8</td><td>2013 (approximation)</td><td>0.1</td><td>0.2</td><td rowspan="2">Cereals +30%
Other crops +10%</td><td rowspan="2">+15%</td></tr>
<tr><td>SC9</td><td>2013 (regionalization)</td><td>0.1</td><td>0.2</td></tr>
<tr><td>SC10</td><td>2013 (approximation)</td><td>0.1</td><td>0.2</td><td rowspan="2">Cereals +0%
Other crops +10%</td><td rowspan="2">+15%</td></tr>
<tr><td>SC11</td><td>2013 (regionalization)</td><td>0.1</td><td>0.2</td></tr>
</table>

Results

The Fischler reform

The decoupling of subsidies and the increase in the modulation rate of subsidies cause a small reduction of the cultivated area at the regional level (-1.2%), and even of -5.7% in the province of Brindisi. A quite sharp drop in industrial crops as a consequence of the reforms of the sugar beet and tobacco sector, a significant decline of tomato grown areas and an increase in grass land only in the provinces of Bari and Taranto - where they replace cereals and uncultivated land, and cereals and tomato, respectively - are observed[4].

Further details on the province-based situation are available in the above table.

Tab.3 Cropping pattern variation in SC3

	Cereals	Industrial	Vegetable	Tomato	Fruit	Olive	Vine	Grass land	Uncultivated area	Total area
Apulia	-3.2	-81.1	0.7	-38.5	-	-	-	124.3	-2.1	-1.2
FG	9.4	-7	1.4	-45.0	-	-	-	-	-46.4	0.4
BA	-9.3	-	0.1	-	-	0.2	-	332.0	-94.4	-
TA	-55.2	-	1.8	-80.8	-	-	-	92.7	4.9	-1.3
BR	-72.3	-	-	-	-	-	-	-	55.4	-5.7
LE	-16.4	-10-	0.1	-	-	-	-	-	14.0	-2.7

Here we simply highlight that in the province of Foggia, which is a suitable area for durum wheat, contrary to the rest of the region, cereals increase by 9.4%. Variations in vegetable crops are concentrated in the province of Foggia and Taranto and uncultivated surfaces markedly decrease in the provinces of Taranto, Brindisi and Lecce.

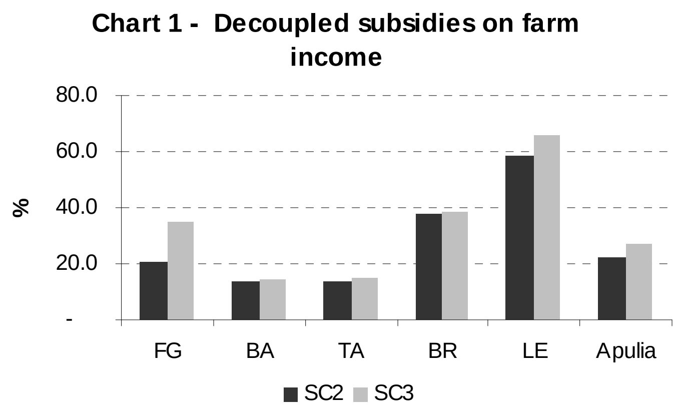
As a result of the changes in cropping pattern the irrigated surface decreases by 1.1% and in the post-reform scenario it is equal to 37.7 % of the regional Agricultural Area: the irrigated surfaces decrease especially in the province of Foggia (-3%), because of the substitution of cereals by tomatoes, and of Lecce (-1%), due to the reduction of tobacco; they remain stable in the other three provinces. Water use reduces by 4% at the regional level, but in the province of Foggia alone the reduction is equal to 13%, and consumption per hectare decreases from 2,710 to 2,630 m^3.

The completion of Fischler reform leaves the regional income basically unchanged. It increases on average by 0.28%, with a peak increase of 2.8% in the province of Lecce and a decrease of 1.5% in the province of Brindisi. The percentage of subsidies on income increases by 0.3% at the regional level, with increments of 1% in the provinces of Taranto and Brindisi, of 0.5% in the provinces of Bari and Lecce, whereas in the province of Foggia the subsidy rate to the formation of the farm income decreases by 1.5%

As a result of Fishler reform, inevitable changes are observed in the weight of

[4] Wine keeps stable in all the scenarios being an high profit cultivation with an upper bound that limits its expansion

decoupled subsidies with respect to the subsidies coupled to cultivated surface or quantities produced, with some province-based differences as shown in the following chart.



The reform of the single farm payment scheme

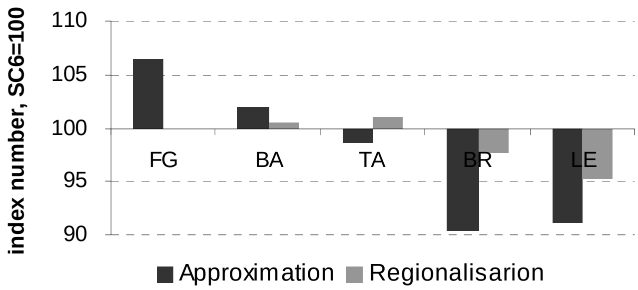
Comparing the cropping patterns in the two simulated reform hypotheses of the Single Farm Payment (SFP), farmers' choices remain unchanged, with the single exception of a rather limited displacement from cereal cultivation to grass land moving from the approximation to the regionalization hypothesis. Accordingly, also the percentage of the irrigated Agricultural Area and water use, total and per hectare, remain unchanged in the three scenarios.

Tab. 4 Cropping pattern variation in SC6 and 7

	Cereals	Industrial	Vegetable	Tomato	Fruit	Olive	Vine	Grass land	Uncultivated area
SC6/SC3	0.1	-25.1	-	0.8	-0.1	-	-	-	-
SC7/SC3	-0.7	-25.1	-	0.8	-0.1	-	-	-	2.2

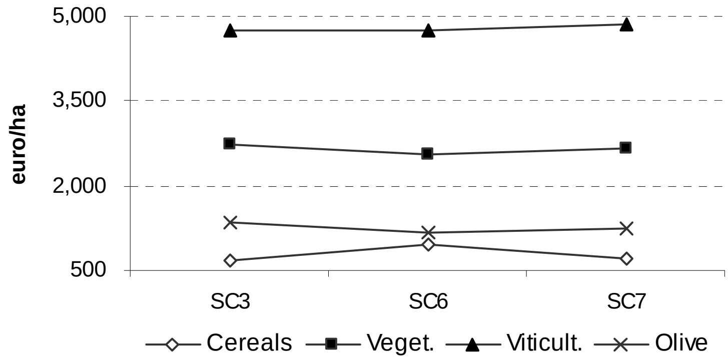
The average estimated income for the whole area declines from 1,880 euro/ha in SC3 to 1,872 euro/ha in SC6 and to 1,875 euro/ha in SC7 with an apparent zero impact of the two reform options. Conversely, at the provincial scale, Foggia and Bari would benefit from both the reform hypotheses of the SFP but more so in the approximation scheme. The southern provinces of Brindisi and Lecce would be penalized in both options but more so in the approximation hypotheses, and the province of Taranto would be in an intermediate position, with an income decline per hectare in SC6 (approximation) and an income increase in SC7 (regionalization).

Chart 2 - Income per hectare



Such dynamics could be partially explained by the prevailing cropping pattern in the different provinces as illustrated in the following chart where the levels of income of the main types of farming show the redistribution effect of the different reform options of the SFP: the viticulture cropping pattern would continue to be the most profitable one, followed by vegetables, olive trees and cereals that, despite the increment in SC6 (approximation) is the least profitable type of farming in the regional agriculture.

Chart 3 - Income per farm type



The same redistribution effect can be analysed when considering the pattern of subsidies per farm and per hectare in the various provinces and for the major types of farming.

Chart 4 - Subsidies per farm per province

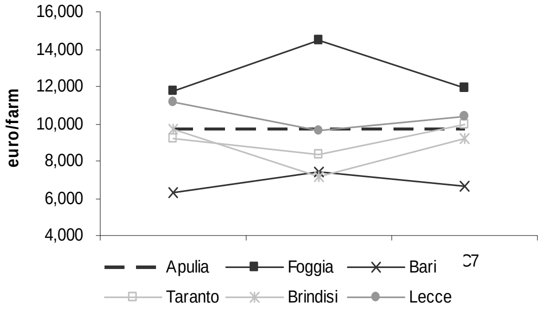


Chart 5 - Subsidies per hectare per province

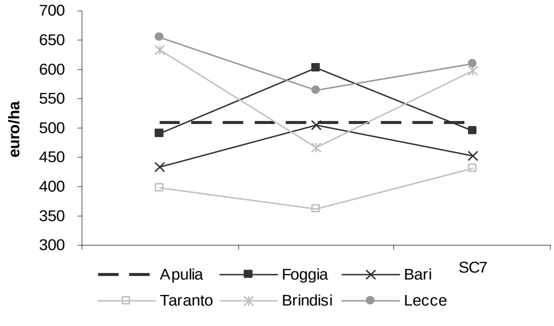


Chart 6 - Subsidies per hectare per farm type

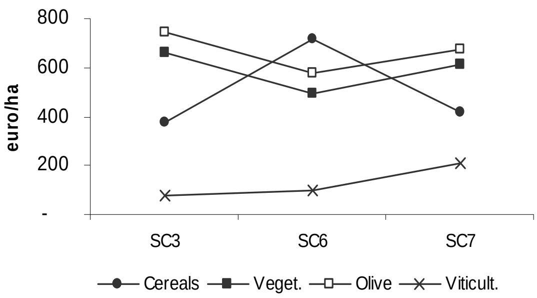
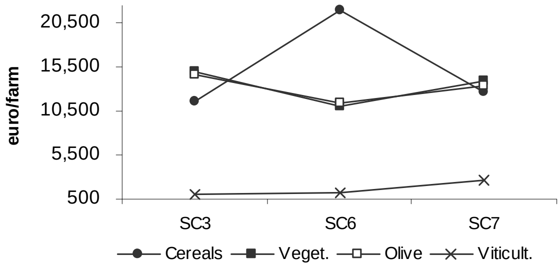


Chart 7 - Subsidies per farm type

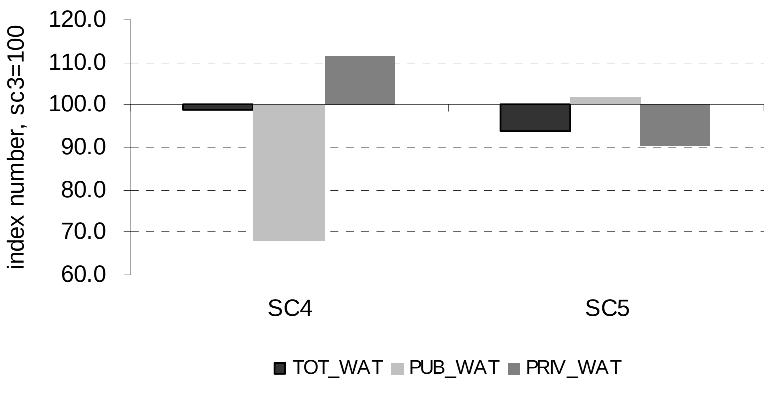


Water pricing policy

The main consequence of the increase in the price of public (SC4) and private (SC5) source of water is the reduction of the tomato grown surfaces only partly compensated by the increase in cereal-growing and the extension of grass land, whereas in both scenarios uncultivated land increases.

Globally, water consumption decreases by 1% in SC4 and by 6.2% in SC4 with different dynamics between withdrawals from the two sources (see chart 8): in SC4 water withdrawal from the public network decreases by more than 30% almost entirely compensated by an increase in the abstraction from private source (+11%). In SC5, abstraction from wells decreases by 9% whereas withdrawal from public network increases by 2%.

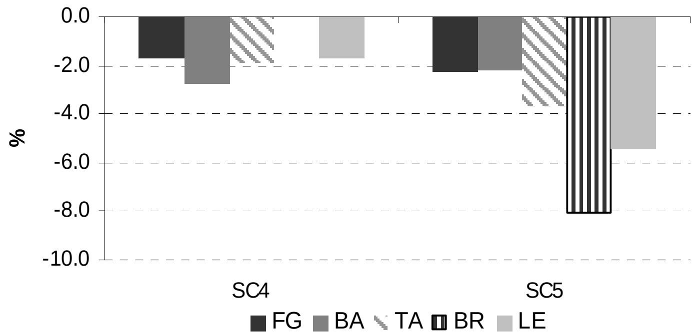
Chart 8 - Withdrawal of water per source



In SC5 for all the provinces, except the province of Foggia, the reaction to the increase in the price of water is definitely a reduction of irrigated surfaces rather than a reduction in the unit volume of irrigation water per crop: in the province of Foggia, together with the decrease in the tomato grown surfaces, a sharp change is evident in viticulture for wine production that turns almost entirely from irrigated to dry.

Income at the regional scale declines by 1.9% in SC4 and by 3.5% in SC5 with different values on a province-basis.

Chart 9 - Income variation in SC4 and 5



The increase of the costs of inputs and the price of products

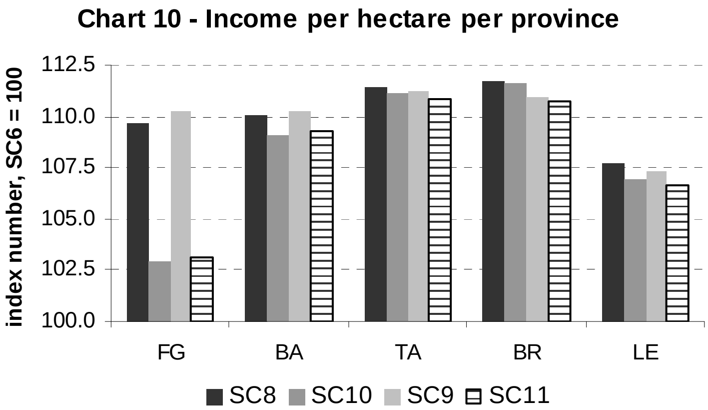
The simulations relative to the variations of costs and prices reveal a significant farmers' sensitivity to the market data. In the scenarios SC8 and SC9, cereals increase considerably followed by the increases in vegetable grown surfaces to the detriment of grassland and uncultivated land, whereas in SC10 and SC11 cereal-grown surfaces, whose price has remained unchanged, reduce but vegetable grown surfaces are still on the increase and their profitability seems not to be penalized by the increase in the costs of production.

Tab. 5 Cropping pattern variation in SC8, 9, 10 and 11

	Cereals	Industrial	Vegetable	Tomato	Fruit	Olive	Vine	Grass land	Uncultivated land
SC8/SC6	5.9	80.5	2.9	-0.3	-0.7	0.2	-	-7.3	-13.0
SC10/SC6	-3.9	110.6	2.9	-	-0.7	0.2	-	-	8.2
SC9/SC7	6.8	80.5	2.9	-0.3	-0.7	0.2	-	-7.3	-14.9
SC11/SC7	-4.2	110.6	2.9	-	-0.7	0.2	-	-	8.8

As a consequence of the increase in the surfaces of vegetable crops, water consumption increases to 2.8% in scenarios 8 and 10 and to 2.5% in scenarios 9 and 11.

At the regional level, the agricultural income increases by 10.2% in the assumption of the price of cereals and by 8.3% in the hypothesis of stability, but at the provincial level considerably different dynamics are apparent due to the different weight of the cereal sector with the province of Foggia that is penalized in scenario 10 and 11.



Conclusions

Decision support tools play a major role in dealing with and managing complex decision-making problems at the European, national, regional, local and farm level. Therefore, having tools capable of performing the economic analysis of agricultural production systems related to the use of resources and of water in particular, and analysing and assessing strategies and adjustment measures is a priority need the proposed model meets by providing a concrete response that consolidates the experiences acquired so far. The developed territorial mathematical programming model provides a comprehensive information framework including the farmers choices in terms of cropping patterns and techniques, an economic assessment of the effects of such choices on farm economic results (revenue, costs and incomes) and environment results (use of factors and resulting pressures on the system) under different possible future scenario.

The experimental application of the model to Apulia region highlighted that the agricultural policy measures simulated in SC3 result in the concentration of cereals in the plain of the province of Foggia - a suitable area for cereal cultivation -, and in lesser water demand from agriculture in the region that is mainly reflected by a reduction in the irrigated area..

The two simulated SFP reform hypotheses show to have strong income redistribution impacts at the territorial scale and farm type that need to be considered when indicating the option to be adopted.

Our results also show that water pricing policies are effective to reduce water demand but it is important to consider the presence of the two sources of water supply and the cross-elasticity of water demand: the price increase of the water supplied from public boards can indeed lead to increased abstraction from private wells with expectable worse environmental conditions over extensive areas together with a possible worsening in the public water agency balance.

Also, the performed simulations lead to conclude that the variations in market parameters, price of products and costs of inputs, undoubtedly have remarkable effects on the farm cropping patterns and, accordingly, on production results in terms of income, and on the pressure exerted on the resources in terms of water demand.

The plentiful data produced in our study are a valuable asset potentially available to all stakeholders for them to start a process of dialogue that can usefully contribute to design adequate measures of agricultural policy to facilitate response, adjustment and mitigation strategies based on environmental, economic and social sustainability criteria.

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