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AGRICULTURAL WATER MARKETS: EXPLORING LIMITS AND OPPORTUNITIES IN ITALY AND SPAIN

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AGRICULTURAL WATER MARKETS: EXPLORING LIMITS AND OPPORTUNITIES IN ITALY AND SPAIN

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Abstract

Agriculture is the main water-using sector in Southern European Countries, such as Spain and Italy. Innovative institutional solutions for reducing water use or increasing its efficiency are pursued by recent legislation concerning water, in particular by the Water Framework Directive (WFD). Even if not explicitly considered by the directive, water markets may be seen as a kind of instrument responding to the guiding principles of the upcoming water regulation.

The issue of water markets is very much debated in the water economics literature and particularly in the agricultural water literature.

Water markets refer to a mechanism of water allocation based on the exchange of rights on water use. Water markets are proposed and supported by economic theory on the ground that they produce an efficient allocation of water resources. Criticisms to water markets may derive both on the ground of economic efficiency itself (for example due to higher transaction costs and expenditure for wider water transport systems) and on equity considerations (for example the concentration of water on the more efficient farms that would specialise in intensive production, while the others would retain less intensive crops).

The objective of this paper is to test to what extent water markets may contribute to the improvement of the efficiency of water use.

The analysis is based on a linear programming model applied at basin level, comparing the situation with and without market and including transaction costs proportional to the amount of water exchanged. The model simulates the behaviour of different farm types, derived from cluster analysis on a sample of farms in each area.

The model is tested in two areas in Southern Italy and Spain. The paper confirms that water markets have the possibility to improve water use efficiency. However, the exchanges are very much affected by the amount of transaction costs, even for transaction costs relatively low. In the case of Lower Ter, gross margin increase due to markets may be as high as 30% which is rather a considerable amount. Instead, the highest increase in Foggia is only about 10%, a result that may be regarded as hardly relevant.

In Foggia the benefits of the water market collapse only when transaction costs are between 0,1 and 0,2 EUR/m^3 (that may be regarded as a fairly high amount). On the contrary, Lower Ter is more sensitive to transaction costs and 0,075 EUR/m^3 are enough to cause the market to shut down whatever the water quota.

When potential improvements occur, an additional issue arises, i.e. the institutional acceptance of market criteria for water allocation purposes. The general attitude in Europe still appears against such a solution. However, the changing economic context (agricultural markets, demographic trends) tend to decrease rigidities about water exchange, particularly among farmers.

1. Introduction

Agriculture is the main water-using sector in Southern European Countries, such as Spain and Italy. The sector of water regulation is undergoing strong changes due to the increasing perception of the issue of water scarcity. Innovative institutional solutions for reducing water use or increasing its efficiency are pursued by recent legislation concerning water.

The legal framework in the EU is today faced with the application of the Water Framework Directive (WFD) (OJ, 2000). The WFD introduces the principle of Full Cost Recovery (FCR) and the Polluter Pays Principles (PPP). It also proposes economic instruments as recommended tools for the regulation of water use and pollution (WATECO, 2003). Even if not explicitly considered by the directive, water markets may be seen as a kind of instrument responding to the view that water may be considered as an economic good, or, at least having an economic component that requires as much as possible an efficient use.

The issue of pricing policy and water markets is very much debated in the water economics literature and particularly in the agricultural water literature (Lee, 1997; Schiffler, 1997; Easter et al., 2004).

The objective of this paper is to test to what extent water markets may contribute to the improvement of the efficiency of water use. The analysis is based on a linear programming model applied at basin level. The model is tested in two areas in Southern Italy and Spain.

The paper has the following structure. Section 2 shortly describes the theoretical background for water markets. Section 3 describes the methodology adopted. Section 4 illustrates the characteristics of the study areas. Section 5 summarises the main results for the two study areas, followed by a brief discussion in section 6.

2. Theoretical and policy background forwater markets

Water markets refer to a mechanism of water allocation based on the exchange of rights on water use. Water markets are proposed and supported by economic theory on the ground that they produce an efficient allocation of water resources (Milliman, 1956; Lee, 1997; Schiffler, 1997; OECD, 2003; Easter et al., 2004).

Criticisms to water markets may derive both on the ground of economic efficiency itself and on equity considerations.

Economic criticisms to market efficiency can be based on the argument that market transaction costs may be higher than those produced by other mechanism of water allocation. Transaction costs include all costs made necessary by the carrying out of a transaction; they may emerge ex ante (for the collection of information, negotiation, contracts writing, etc.) or ex post (for contract enforcement, etc.) (Williamson, 1985).

The functioning of water markets requires farmers to find out partners in the transaction and some process for contract negotiation, that may be implemented in various ways. In many cases, the present system of water distribution already causes high transaction costs (e.g. irrigation boards costs for water management, definition and enforcement of property rights). It is not clear to what extent water markets would actually increase such costs. At the moment, data available are very limited and transaction costs would, in any case, change very much from case to case and over time.

One major issue may be the cost of water transport, necessary for a market to exist, where possible traders are not already connected by water infrastructures (canals, pipes).

From the analytical point of view, both the amount and the structure of market costs (transaction plus transport costs) may be relevant. In principle they may be fixed or proportional to water exchange. They can also be differentiated between vendors and sellers, and depend on the size of the farm and its location.

Markets may be criticised also on the ground of equity considerations. Chan (1989) emphasizes this problem, which increases the more unequal are the participant agents in the market.

Another problem is the possible existence of negative externalities or third-party effects. Howe et al. (1986) emphasize as market deficiencies the changes in the amount and quality of the return water volumes, although they raise solutions to mitigate these effects.

In addition, it is likely that water markets would produce a concentration of water on the more efficient farms that would specialise in intensive production, while the others would retain less intensive crops. This phenomenon has been observed in Australia, Chile and the United States. While this implies an increase of heterogeneity across farms, it also contributes to the increase of the total agricultural production and the number of agricultural jobs (Sumpsi et al, 1998).

The contribution to efficiency is a relevant point for agriculture. Most of European agriculture is undergoing major changes with abandonment by some farmers and an attempt by others to recover competitiveness in the global market. Hence there are a number of farms that do not fully use they rights on water, while others are incurring high costs to gain (more or less legally) access to additional water resources.

Water markets may be implemented only when a legal basis exists. In this sense, Spain adopted a normative that allows for the exchange of water rights. In Italy the legal basis for proper water markets is usually considered not to exist. However, there is evidence of formal or informal markets for water in the south and, to a lesser extent, in the north, even if their size is almost impossible to assess.

A key issue for the setting of water markets is the existence of well defined property rights on water and the availability of low cost water transport infrastructures. On the other hand, water markets may be simply represented by transfers of rights, without real movement of water in excess with respect to the situation without market.

Existing experiences around the world (USA, South Africa, Australia) also show that water markets are acceptable in a mature legal system and in communities with high degree of trust. This is made necessary by the fact that the selling of the right may be associated to expectations of losing the right. In addition, water exchanges need to be supported by trustable systems for contract enforcement.

3. Methodology

The methodology is based on the use of a linear programming model at basin level. The reference model is given by well established basin level modelling such as those illustrated by Tisdell (2001) and may be seen as the transposition at basin level of widely used farm level linear programming models (see for example Gomez-Limon et al., 2000; Berbel and Gutierrez, 2005; Bazzani et al. 2005). Similar models have already been used in seminal analysis of water markets in Italy and Spain (Arriaza et al., 2002; Bazzani, 2004). The main contribution of this paper is to enrich such models by explicitly taking into account transaction costs.

The model, when water market is not allowed, has the following structure:

$$Max \sum_j \lambda_j \left(\sum_i GM_{ij} \ x_{ij} \right) \tag{1}$$

s.t.

$$\sum_i x_{ij} \ c_{iz} \le v_{zj}$$

$$\sum_i x_{ij} \ w_i \le a_j$$

where:

λ_j = surface proportion of the *j* farm typology (weight);

GM_{ij} = gross margin for crop *i* on farm j;

x_{ij} = crop surface for crop *i* on farm *j*;

c_{jz} =technical coefficient for crop i, on farm *j*, for constraint *z*;

v_{jz} = other resources availability on farm *j*, for constraint *z*;

w_i = water use for crop i (m^3/ha);

a_j = water quota available on farm j.

The model runs per hectare of land, so that the land used for each crop is expressed as a fraction of 1.

This kind of model is relatively simple and often used for the economic analysis of irrigation at basin level. It allows to identify optimal solutions and reactions of farmers to water policy changes. The basic structure illustrated in the model refers to the hypothesis of different water endowments in different farms; with no water exchanges allowed.

When water trading is allowed, the models changes in two ways. On one side, water availability in each farm is given by the initial quota, plus the water purchased, minus the water sold. This have to be connected to an additional complementary constraint saying that water purchased must be equal to water sold by farms. Secondly, market likely would imply (additional) transaction costs. In the present model only transaction costs proportional to water exchanges are assumed to exist.

The resulting model has the following structure:

$$Max \sum_j \lambda_j \left[\left(\sum_i GM_{ij} \; x_{ij} \right) - \left(t^p \; w_j^p + t^s \; w_j^s \right) \right] \tag{2}$$

s.t.

$$\sum_i x_{ij} \; c_{iz} \le v_{zj}$$

$$\sum_i x_{ij} \; w_i \le a_j + w_j^p - w_j^s$$

$$\sum_j \lambda_j \; w_j^p = \sum_j \lambda_j \; w_j^s$$

$$x_{ij} \ge 0$$

$$w_j^p \ge 0$$

$$w_j^s \ge 0$$

where:

w_j^p = water purchased by farm j;

w_j^s = water sold by farm j;

t^p = transaction cost of purchasing water;

t^s = transaction costs of selling water.

The gross margin accounts for gross revenues minus all variable costs, including eventual costs related to the acquisition of water. In the case with water market, the gross margin of each farm typology changes further as a function of revenues or payments due, respectively, to water selling or purchasing.

A key factor in determining the profitability of water markets is the actual level of transaction costs. In absence of reliable estimates of such costs, a sensitivity analysis has been carried out in order to quantify the thresholds above which the market is not economically feasible.

There are some main assumptions of the model that need to be clarified. First the sequence of actions: the farmer knows his water quota, then decides about water rights exchange, then takes all his farming decisions after knowing water availability. All farmers act in a context of perfect information about the technical possibilities (cost, production) given by the total water available after exchange, but is not fully informed free of costs about other farmers actions and purposes. This give rise to the possibility of transaction costs, both *ex ante* and *ex post.*

The contract consists in the engagement by a farmer not to use its right on water (seller) and in gaining the possibility to use the same amount of water by the counterpart (buyer). A system of water distribution reaching all farmers is supposed already to exist, so water distribution does not have any implication in terms of transport costs.

4. The study areas and model validation

The models (1) and (2) have been constructed for two case studies. The main features of the two study areas are illustrated in table 1.

Table 1 Main features of the two areas

	Lower Ter	Foggia
Water supply	Dams, Ter river , private wells	Dams, Ofanto river, private wells
Water distribution system	Canals, pipes and drains (not pressure)	Pressure pipes
Irrigation system	Superficial irrigation	Drip irrigation
Water price	Variable from 6.18 to 59.77 EUR/hectare	0.09 EUR/m3
Prevailing tariff system	Area payment based on irrigated surface	Volumetric
Agricultural surface in the RIB (ha)	7100	143000
Area in the sample (ha)	1373.4	1258.6
Number of farms in the sample	60	131
Average farm size in the sample (ha)	22.89	9.6
Methodology for the identification of farm types	Cluster analysis	Cluster analysis
Number of typologies modelled	4	3

The first one is the Community of Irrigants of Lower Ter in Catalonia (in the Northeast of Spain). A Community of Irrigants is a grouping of all the owners of a same irrigable zone, who are united by law for the independent and common administration of public waters. The area is characterised by the cultivation of corn, fruit trees, alfalfa and other minor crops. In addition in the zone there are bovine farms with cultures for animal feeding.

The sampling was within the irrigation community by quotas. The parameter used in the definition of the quotas was the farm's surface. The sample consists in 60 farms, divided in 4 farm types. It was chosen in such a way as to reflect the same distribution of farm surface as in the whole area.

The second case study is located in the South of Italy (Puglia), in the Reclamation and Irrigation Board (RIB) of Capitanata (Province of Foggia)[1]. The RIBs (Consorzi di Bonifica e Irrigazione) are public bodies managed as associations of landowners, that control land reclamation and the distribution of water over a certain area. Agriculture in the study area is based on the combination of high income industrial tomato and highly subsidised locally traditional crops, such as rainfed durum wheat. The development of high value added crops, such as tomato and other vegetables is counterbalanced by a high impact on the environment and is dependent upon a sufficient water availability. The sample consists in 131 farms, divided in 3 farm types, one based on tomato-durum wheat and the other two cultivating a more wide range of vegetables.

Farm typologies in each study area were selected on the basis of Cluster Analysis on a data set derived from a representative sample of farms, validated through interviews with local experts. For each cluster we considered different constraints such as crop rotation, labour

[1] The models used in the case of Foggia where based on data collection and validation carried out during the project WADI "Sustainability of European Irrigated Agriculture under Water Framework Directive and Agenda 2000" (EVK1-2000-00057) (Berbel and Gutierrez, 2005).

availability, land, etc. that refer to specific characteristics of each farm typology. Four clusters where identified for Lower Ter and three for Foggia (table 2).

Table 2 Types of farms identified by means the cluster analysis

Zone	Short name	Farm typology
Lower Ter	LT.1	Productive orientation extensive- mixed crops ('Mixed')
	LT.2	Productive orientation fruit ('Fruit')
	LT.3	Productive orientation livestock ('Livestock')
	LT.4	Productive orientation extensive-corn ('Corn')
Foggia	Fg.1	Small farm - Productive orientation extensive-tomato ('Small extensive')
	Fg.2	Small farm - Productive orientation vegetables ('Small vegetables')
	Fg.3	Large farm - Productive orientation extensive-tomato ('Large extensive')

Models were calibrated using primary data collected from the surveyed farms. Constraints include standard constraints such as land, labour, commercial constraints and rotations. Labour constraints have been constructed by period (table 3).

Table 3 Main features of the models

	Lower Ter				Foggia		
Model	LT.1	LT.2	LT.3	LT.4	Fg.1	Fg.2	Fg.3
Average farm size (ha)					7,52	7,71	31,36
Objectives							
* Gross Margin	X	X	X	X	X	X	X
Constraints:							
- Land	X	X	X	X	X	X	X
- Water	X	X	X	X	X	X	X
- Labour					X	X	X
- CAP (set-aside)	X	X	X	X			
- Market		X					
- Rotations	X	X	X	X	X	X	X
- Specific type of soil	X			X			
- Cattle feeding			X				
Cluster weight	0,34	0,19	0,12	0,35	0,365	0,361	0,274

Models were validated against the actual crop mix seen as a combination of farming activities (tables 4 and 5).

Table 4 Deviations between real and simulated values of the percentage crop surface (Lower Ter)

	LT.1	LT.2	LT.3	LT.4
Corn	-6,00	-0,97	0,98	-1,00
Sunflower	4,00	0,93	0,00	0,14
Other grain cereals	3,00	-1,90	1,00	-0,07
Winter forage	0,00	1,85	-0,45	0,07
Alfalfa	0,00	2,94	0,30	2,00
Fruit trees	0,00	0,02	0,00	0,00
Poplars	2,91	0,00	0,00	0,30
Set-aside	-1,00	-1,88	-0,82	-1,52
Other grain cereals (non irrigated)	-3,00	0,00	0,00	0,00
Total deviation	19,91	10,49	3,54	5,11

Table 5 Deviations between real and simulated values of the percentage crop surface (Foggia)

	Fg.1	Fg.2	Fg.3
Tomato	6,70	6,93	2,22
Durum wheat	-2,58	-9,36	-2,22
Durum wheat and broccoli	-0,39	2,72	0,00
Asparagus	-3,72	-0,28	0,00
Total deviation	13,39	19,29	4,45

5. Results

Gain from markets for different levels of transaction costs and quota in the two areas are reported in figures 1 and 2, expressed as a percent increase of total gross margin of the area.

In the case of Lower Ter benefits may be as high as 30% which is rather a considerable amount. Instead, the highest increase in Foggia is only about 10%, a result that may be regarded as hardly relevant. In both cases, the advantages in terms of increase of gross margin appear limited to low levels of transaction costs and intermediate levels of water availability.

In Foggia the benefits of the water market collapse only when transaction costs are between 0,1 and 0,2 EUR/m^3 (that may be regarded as a fairly high amount). On the contrary, Lower Ter is more sensitive to transaction costs and 0,075 EUR/m^3 are enough to cause the market to shut down whatever the water quota.

The quotas corresponding to the higher increase in gross margin are respectively 2000 m^3/ha for Lower Ter and 1000 for Foggia. Both amounts are actually very close to real amounts distributed in the drought years. Particularly in the Lower Ter, however, the volumes provided in the last years has been enough higher. Also, in the case of Lower Ter restrictions to water availability or, possibly, intersectoral water exchanges, may derive from a strong intersectorial competition on the use of the resource, for example by the neighbouring golf courses or the close tourist zones (Costa Brava).

Figure 1 Gain from markets for different levels of transaction costs – Lower Ter

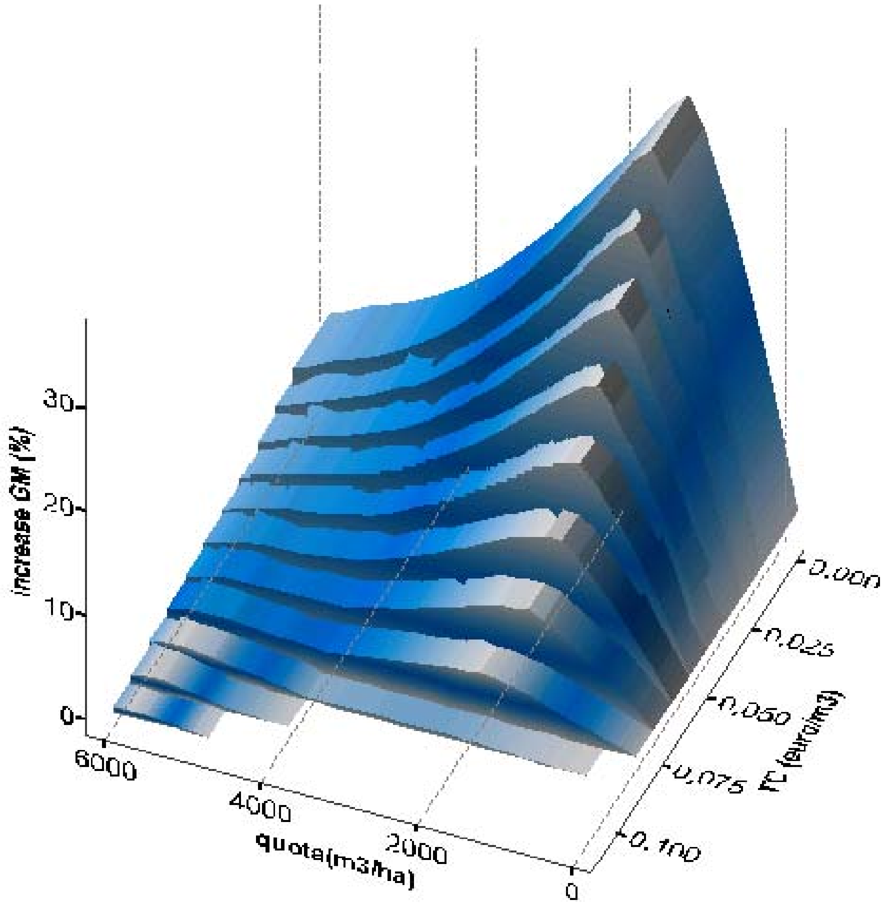


Figure 2 Gain from markets for different levels of transaction costs – Foggia

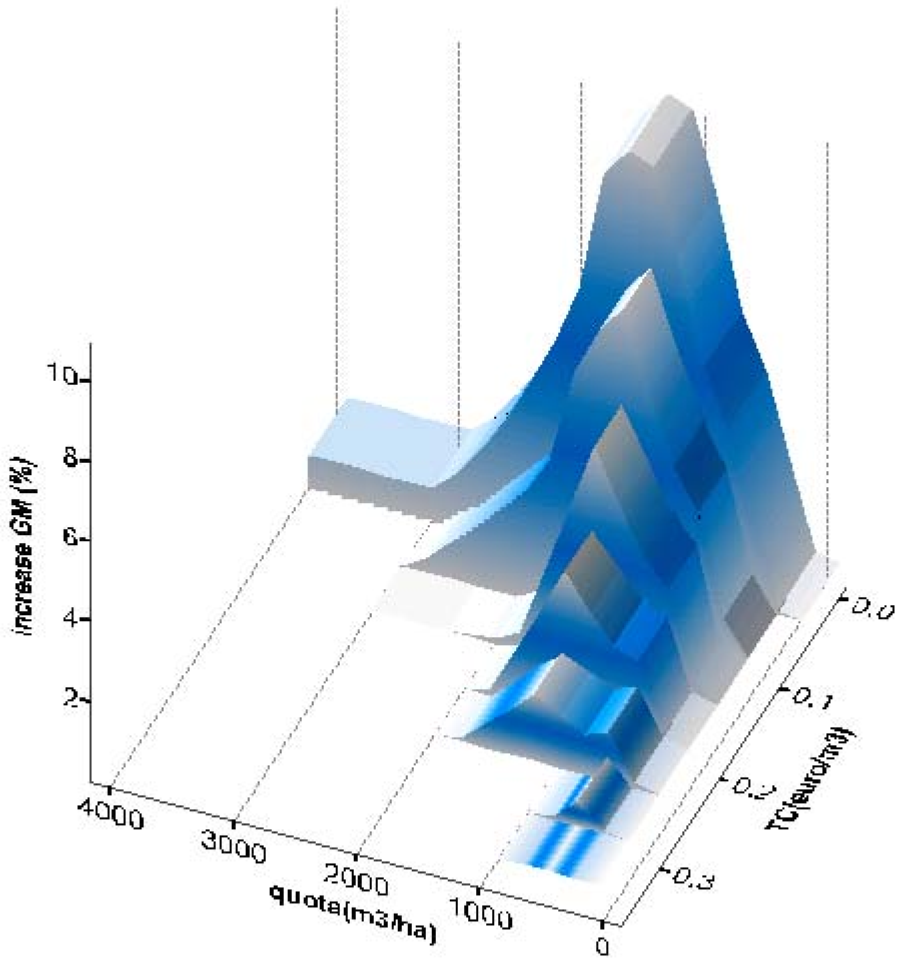


Figure 3 and 4 show the total water exchange among clusters as a function of the water quota. Again the exchanges are very much affected by the amount of transaction costs (TC), even for transaction costs relatively low.

Figure 3 Water exchanges among clusters – Lower Ter (TC=0 and TC=0,05 EUR/m^3)

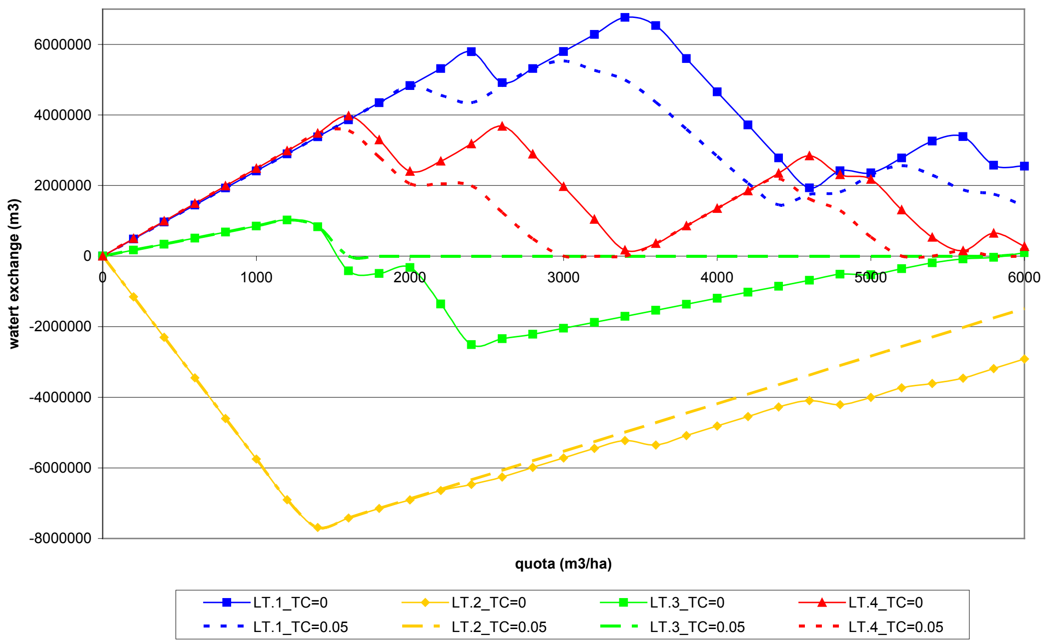
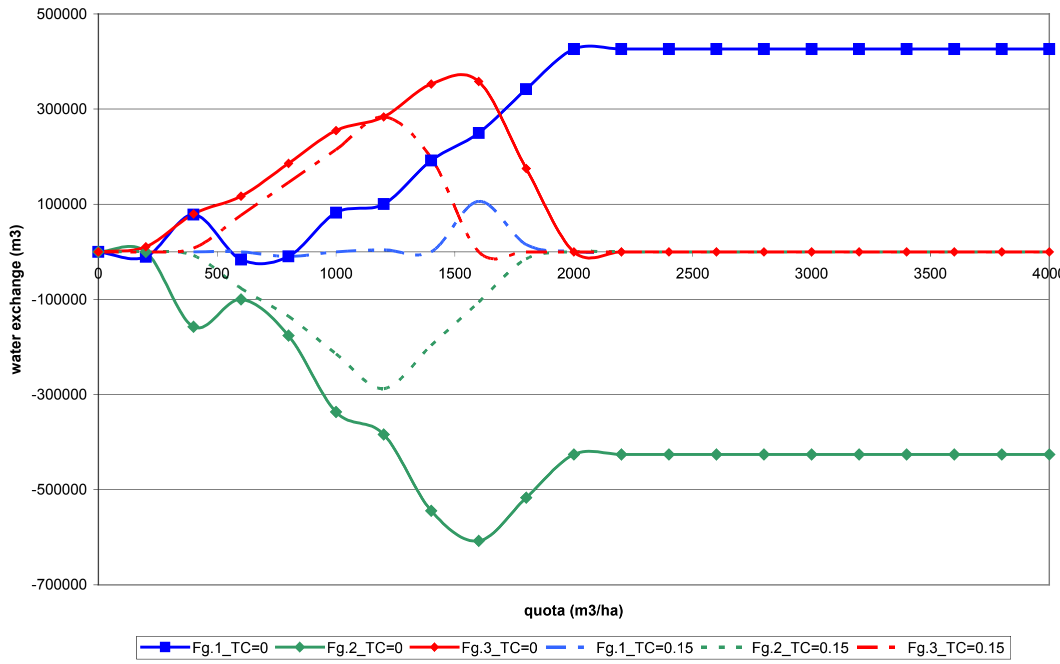


Figure 4 Water exchanges among clusters – Foggia (TC=0 and TC=0,15 EUR/m^3)



The figures highlight the strongly different position of different kinds of farms with respect to water markets. In Lower Ter, cluster 1 and 4 are the main sellers, while cluster 3 and, to a lesser extent cluster 2 are the buyers. This denotes a clear polarisation for water towards livestock and fruit farms. In the same way, in the case of Foggia, cluster 2 is the main buyer, denoting a strong concentration of water resources towards intensive vegetable growers.

Positions, even the role as buyers and sellers, may reverse depending on the water quota available.

High transaction costs may cause some farms to exit the market (e.g. cluster 3 in Lower Ter). Water exchange tends to increase and then to decrease as a function of the quota. However, where the exit point from water use at price zero (lower point of the demand curve) is very different among clusters, a certain amount of exchange may be profitable even for plenty of water available.

The results illustrated here were complemented by a short survey carried out among farmers in Lower Ter and by interviewing the responsible of the irrigation boards in Foggia. The general attitude is clearly against market, partly for equity considerations, partly because a discussion about water market is perceived as being politically difficult and potentially able to produce conflicts. Where farmers where interviewed, they showed a general interest towards buying water, while they are less willing to sell water. One possible explanation is in the fear of loosing the right to water use over time, so that the expected gains from market would be only temporary, and markets would actually lead to a depreciation of their assets.

6. Discussion

The paper confirms that water markets have the possibility to improve water use efficiency. However it also highlights that this potential strongly depends on the institutional ability to allow exchange with reasonably low transaction costs. Part of the issue is to be connected to the actual nature of the transaction costs considered: are they actual costs (time spent by the farmers, true legal costs) or costs linked to risk perception and uncertainty about the future allocation of water rights? Are these costs due to the form of exchange and can be lowered by a revision of water institutions? Are limits and guarantees to the participants on the market the right ones, in order to avoid excessive risk perception and non-participation?

Answers to these questions may derive from further research on this field. They would particularly benefit from a more detailed modelling of the information asymmetries and from a combined approach linking more directly modelling with an institutional, and possibly a participatory, approach.

Also, farmers' attitudes and objective could be analysed more in detail trough multicriteria analysis, in order to improve the actual degree of participation and utility derived from water markets. Other likely issues of interest would be the degree of specialisation brought about by the market and the side effects on equity issues.

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