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PRESSURE FACTORS AFFECTING LOMBARDY AGRICULTURAL SYSTEM: THE ENVIRONMENTAL CONSEQUENCES OF THE FISCHLER REFORM

Claudia Bulgheroni and Guido Sali

University of Milan, Italy
Department of Agricultural, Food and Environmental Economics and Policy

Contact: claudia.bulgheroni@unimi.it

European Association of Agricultural Economists

Università degli Studi della Tuscia

Istituto nazionale di Economia Agraria

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Abstract

This paper presents a regional model, based on Positive Mathematical Programming, which aims to evaluate the consequences of Fischler reform on the agricultural sector of the Lombardy irrigated lowland (Northern Italy). The model main focus is to quantify the agricultural land use changes due to the farmers reaction to the CAP reform main issues, such as single payment, and to simulate possible scenarios for the future. The model takes into account also the Water Frame Directive principles, in order to combine the assessment of both CAP issues and the potential irrigation water supplies reduction, which could deeply affect the area. The model input are obtained by means of the integration between FADN and SIARL (Agricultural Information System of Lombardy Region) information, in order to fit the territorial dimension. The simulation results of 11 different scenarios are discussed.

Key words: CAP modelling, Fischler Reform, Positive Mathematical Programming, Regional model, Water Frame Directive

JEL Classification: Q18, Q15, C61

Introduction

This paper expounds the application of a mathematical programming model to evaluate the implementation of adjustment measures of the agricultural sector in the irrigated Lombardy plains in the presence of economic and environmental events. Economic situations are a direct consequence of the strong re-orientation of the market determined by the Fischler reform. The elimination of direct payments is in fact linked to the serious upheaval in the European agricultural products market during recent years.

The vast availability of water has always been a main feature of this area and this environmental characteristic has, over the centuries, led to a flourishing agriculture based on dairy cattle breeding, forage and rice crops.

In recent years, and especially since 2003, water crises have often taken place. This reflects on the availability of water for irrigation, especially during the summer. On these occasions, farms in Lombardy have been forced to deal with conditions of water shortage that in some cases have caused decline in production. The repetition of periods of water shortage has moved regional authorities to take political initiatives in the management of the water resources in order to contain consumption.

The planned and implemented actions include an improvement in the efficiency of the distribution network, the conversion of the irrigation systems to spray irrigation, the adjustment of the water concession fees that also involves the introduction of a “price by use” and the reduction of water concessions to irrigation consortia.

The latter provision in particular is closely linked to the recent tendency of water management regional policy to safeguard the integrity of the waterways, as demonstrated by the will to maintain the so-called *Low Flow Limit* to preserve the aquatic ecosystems. The possibility that the availability of agricultural water supplied by the irrigation consortia could be reduced makes it necessary to study what changes to make in the production sector.

The objective of this paper is to relate the dynamics of agricultural prices with the possible restrictions of the availability of agricultural water. It is within this framework that this analysis shall verify whether the production structure of the Lombardy irrigated plain derived from the Fischler reform is compatible with the scenarios of water availability reduction for agriculture.

Theoretical Framework

Positive Mathematical Programming (PMP) has shown considerable versatility in recent years, being used in both sectorial and regional analyses to evaluate the effects of both the agricultural policies and those of the application of environmental policies to agriculture (Rhom and Dabbert, 2003, Schmidt and Sinabell, 2005 and 2006).

The reason of PMP diffusion are the advantages due to its *positive* approach. First of all, the main contribution that PMP brings to the policy modelling and, more in general, to agricultural economics problems, is the capability of maximizing the information of

agricultural data banks, available at European level, such as FADN, REGIO, etc (Arfini et al., 2003, Paris and Howitt, 1998). As a matter of fact, PMP methodology requires a lower bulk of information in respect to other mathematical programming techniques and provides useful results to policy makers even in presence of a limited set of information, as it generally happens when European agricultural databases are adopted. Furthermore, using PMP it is possible to exactly represent the situation observed: the total variable cost estimation makes possible the reproduction of the observed farm allocation plan and the decision variables (total specific variable costs) that drive farmers in selecting such production plan (Paris, 2001). Another important advantage is the PMP results continuous change (depending on farmers' reaction), as a consequence of changing exogenous variables (Buysse, Van Huylenbroeck, and Lauwers, 2006). Hence, PMP can responds with flexibility to a large spectrum of policy issues, typically concerning the land use change, production dynamics, variation in gross margin and in the other main economic variables (costs, subsidies, etc.).

A large variety of literature and EU research projects can be mentioned in order to prove the wide use of PMP in developing models able to assess the CAP reforms effects.

Many of them are based on "classical" three-phase PMP procedure, consisting in (Howitt 1995a): (i) differential cost recovering, (ii) non-linear cost function estimation, (iii) setting of a non constrained production model, with non-linear (mainly quadratic) objective function (*calibration* phase). In other words, the method assumes a profit maximizing equilibrium in the *baseline* situation and uses the observed production level as a basis for the appraisal of the third step non-linear objective function coefficients.

Among all the PMP models developed to forecast the farmers' behaviour as a consequence of Common Agricultural Policy reforms, at regional level, it is worth mentioning: (i) AGRISP (Arfini et al., 2005); (ii) CAPRI (Heckelei, 1997; Heckhelei and Britz, 2000); (iii) FARMIS (Offermann et al., 2005), (iv) Madrid University model (Judez et al. 1998, 1999, 2000). All of them share the assessment of the CAP impact through the forecast of the changes in the productive system, due to the new conditions imposed by the policy. Arfini et al., 2005, in particular, investigate the effects of CAP first pillar strategies on Italian farms, taking into account their own territorial context, with an approach which is similar to the one explained in this paper.

At the same time, in recent years, especially after the approval of the so-called *Water Frame Directive* (2000/60/CE), many PMP models have also been implemented, particularly at regional level, in order to assess the impact of new principles introduced by the normative, on irrigated agriculture. (e.g. Bartolini et al., 2007, Bazzani et al., 2005 and 2008; Cortigiani and Severini, 2008). Main WFD novelties refer to the Full Cost Recovery, the Polluter Pays Principle (PPP) and the use of pricing of water. Since all of them aim to reduce water use and water pollution, it is reasonable to think that these instruments will deeply influence the irrigated agriculture, one of the main water-consuming sectors.

The final goal of this paper is to combine in a unique PMP model the assessment of both CAP issues and the potential irrigation water supplies reduction, due to the WFD policy, by linking the latter with the agricultural prices dynamics.

Materials and Methods

The Model

The model is based on the traditional phases of positive mathematical programming:

1. Definition of a linear programming model where the land allocated to each production process is the only constraint adopted. The marginal cost values of the soil factor in each activated production process are obtained from the dual structure.
2. Use of marginal costs of the soil factor, returned in the first phase, for the estimate of the marginal cost curve of the entire system. This curve is hypothesised as a quadratic function with respect to the quantities produced and its integral expresses the total variable cost of production.
3. The construction of a non-linear model (in this specific case it is a quadratic function) that has as its optimal solution the same apportioning of land among the various production processes set in the first phase.
4. Use of a non-linear model, accordingly constrained on the basis of the availability of the resources and the characteristics of the system to prefigure scenarios of production choices and consequent land use.

This model is based on experience gained on a sample group of farm holdings, with a number of innovative factors summarized as follows:

- The production units assumed includes agrarian regions rather than farms. This choice was based on several considerations. Firstly, the structural conditions that influence production costs depend to a great extent on the conditions of the farmland: the pedo-climatic conditions, the quality of the soil, the water availability and methods of distribution, services, etc. This fact leads to note that in agriculture, the contextual conditions are important at least as much as the conditions of the organization of the farm. Furthermore, taking into account that in the models based on optimisation systems, such as the one in this paper (linear programming, quadratic programming), only the variable costs are considered, and the fixed costs that are mostly due to structure are ignored, the contextual conditions become the prevailing ones. Secondly, the assumption of a homogeneous land that includes all the relative farm holding factors considerably reduces the distortions of the model due to the specificity of the analysed farm samples and the choices made by the farmers. In fact, a territorial analysis, like this one, carries a strong risk that the sample farm holdings are not sufficiently representative of the production trends prevalent in the area of study, especially in the case where the sample (FADN) is already set. On the contrary, the assumption of a real use of agricultural land highlights

exactly which crops are more suitable or simply possible on that land on the basis of the contextual conditions.

Finally, it should be remembered that in assuming the agrarian region, the rigidity of determining the production alternatives in each farm is greatly diminished. The main rigidities are due on one hand to the needs for rotation that impose certain sequences in the choice of crops, and on the other hand the feeding needs of the livestock, that restrict the allocation of part of the farm land. In both cases, the assumption of the agricultural region considerably reduces the rigidity.

- The FADN sample farms located in the agrarian regions are fundamental for the acquisition of a number of economic quantities. This is true for production costs and for sales prices. The former are calculated by crop and compared with the cultivated area within the agrarian region. The latter are calculated as the average prices taken at the farm level.
- Production unit N+1 is also present in the model and represents the entire area of study.

With reference to phase 4, given the non-linear function *f(x)*, the problem consists in the search for the unknown values of vector *x* in order to optimise *f(x)* given the constraints assigned to the system. In this case, the function to maximise is the gross income of each agrarian region, expressed as follows

(1) $$f(x) = \sum_{j=1}^{J} \left(p_j - \frac{1}{2} \Theta_j x_j^{'} - \varepsilon_j \right) x_j$$

$$\text{s.t. } Ax \geq b$$

$$x \geq 0$$

where p_j is the price of the product relative to the j_{th} crop gross of single payment, x_j is the productions vector, Θ_j is the coefficient matrix, and ε_j the distance from the border solution. $Ax \leq b$ is a set of linear inequalities representing the equations of the constraints, and $x \geq 0$ is the non-negative constraints of the variables.

In this model, a number of constraints have been introduced on vector *x* to make allowances for both the structural and land characteristics of the production system and the analysis of the effects of a possible reduction of agricultural water availability should the regional sector authorities introduce concession restrictions to the irrigation consortia.

The constraints introduced in the model are described below:

- The area of study is specialised in dairy production. The diet is strictly based on locally produced forage and this must be guaranteed even in the case of economic instability that may affect other plant productions. Furthermore, the breeding of livestock shows a strong stability even when there are strong fluctuations in the milk and meat prices. On the one hand, the current system of milk quotas does not allow adjustments for

increasing the number of livestock. On the other hand, in the presence of possible drops in prices, reduction in the number of livestock is only possible in the long term, after an examination of the structural and not economic aspect of the price trends. For this very reason, a constraint has been introduced that allows for the production quota (QL), present in every agrarian region n and of the forage requirements necessary to feed the present livestock. The restriction for forage corn is as follows:

$$\left| \frac{QL_n (mv + mr)}{\gamma} - x_{nj_M} \right| \leq r \cdot q_{nj_M} \tag{2}$$

where *mv* and *mr* are the average annual feeding requirements of cows and other livestock respectively, γ is the average annual milk production per cow, x_{nj_M} is the current production of ground corn and *r* is the percentage that indicates the allowed deficit or surplus level of production activated with respect to the feeding requirements. In this paper *r=0.20*.

- Similarly to corn, medicinal herbs represent feed that is usually used in the feeding rations of milk cows. For this reason, the production constraint is as follows:

$$\left| \frac{QL_n ev}{\gamma} - x_{nj_E} \right| \leq r \cdot q_{nj_E} \tag{3}$$

where *ev* is the average annual requirement of alfa alfa per head in production, x_{nj_E} is the production of alfa alfa activated by the model in agricultural region *n* and q_{nj_E} is the current production of alfa alfa. *r* = 0.20 for this constraint too.

- With regard to grassland, we need to consider the characteristics of the agricultural land of many areas of the Lombardy lowland. Here, the fertile layer is extremely fine and the gravel subsoil does not allow the cultivation of arable land. Hence permanent grassland is the only possible land destination. For this reason, a destination constraint has been introduced for grasslands where the surface assigned to this cultivation, h_{nj_P}, is not lower than quota r of surface SUP_{nj_p}, currently used:

$$SUP_{nj_P} r \leq h_{nj_P} \tag{5}$$

In this case *r=0.80*.

- Finally, a restriction relative to the water resource has been introduced for each agrarian region n, and a reduction of 20% of the current availability of agricultural water as follows:

$$\sum_j F_{jn} q_{jn} \leq G_n \cdot r \tag{4}$$

where F_j is the water requirement of the j_{th} crop of G_n and the current availability of water in the n_{th} agrarian region.

Data sources and model input

The input data for the territorial economic model worked out for this paper are drawn from two different data banks. They are the *Farm Accountancy Data Network* (FADN) and the *Agricultural Information System of Lombardy Region* (SIARL), which includes the land use statements presented by farmers to obtain subsidies. The model requires farm accountancy variables (FADN) as input and returns information about the area allocated to each type of agricultural land use, aggregated at the *sub-regional* level. This is made possible by the main innovations of this methodology, i.e. the two data sources integration, in different steps of the model.

First of all, it is necessary to highlight that the model runs on a territorial unit, called *agrarian region*, which represents the unit of the *sub regional* partition made by the National Institute of Statistics, to split out the Italian land into homogeneous areas, according to territorial and agricultural features. Hence, all the input data set have to be referred to this unit.

The elaboration starts from the SIARL database at local (municipality) level. The land use information is aggregated at agrarian region level and the results consist in a list of all the agricultural land uses (Ha) of each agrarian region.

At the same time, the FADN sample farms are aggregated in order to obtain a sort of *macro farm* for each agrarian region, **w**hich type of farming is obtained by the sum of the agricultural activities of all the farms included, while the accountancy results are drawn from the average of the correspondent variables of each farm incorporated.

The integration of the two sources is performed by linking each SIARL agricultural land use with the corresponding FADN agricultural activities, in order to attribute the territorial features characterizing each agrarian region.

Since the territorial connotation plays a key role in the agricultural policy analysis and considering that the agrarian region represents the minimum homogeneous unit, from the territorial viewpoint, the need of reproducing the real agricultural land allocation among the different production processes (and the associated techno-economic parameters) clearly appears. The use of the SIARL information about the agrarian region land use allows both to attribute the territorial dimension to the farm data aggregate and to enhance the significance of the FADN sample which, at sub-regional level, is rather poor, due to excessive sample fragmentation.

Table 1 shows the complete list of the model input variables and the respective source.

Table 1 - Model input variables

Input variables	Year	Unit	Source
Land uses	2008	ha/AR	SIARL
Sold and re-employed production	2007	t/AR	FADN
Variable costs for sold and re-employed goods	2007	€/AR	FADN
Sold goods prices	2007	€/AR	FADN
Milk quotas	2007	t/AR	SIARL
Subsidies and payments	2007	€/AR	FADN
Water requirements	1993-2005[1]	mm^3/AR	*Gandolfi et al. 2007*

Source: personal analysis.

Study area and FADN sample

The CAP analysis was carried out in a territorial fashion using the watered low land of a region[2] situated in the North of Italy, Lombardy, as the main focus. This part of the watered lowland (belonging to the Adda river basin) is a 888,243 ha area and represents one of the prominent agricultural districts in Italy. It houses a large part of the Italian farms (46,650 according to ISTAT, 2000), while the Utilized Agricultural Area (UAA) covers approximately the 87% of the surface.

According to the SIARL database, the agricultural land use in 2008 is ordered, as follows: 283,938 ha of *Grain Corn*, 93,255 ha of *Rice*, 76,831ha of *Soft Wheat*, 61,303 ha of *Forage Corn*, 55,244 ha of *Grassland*, 46,800 ha of *Alfa Alfa*, 27,259 ha of *Barley*, 21,386 ha of *Hard Wheat*, 11,473 ha of *Soya*, 6,995 ha of *Set Aside*, 6,657 ha of *Sugar Beet* and 5,692 ha of *Tomato*.

Furthermore, here are located several of the most productive farms of the country mainly devoted to cereal farming and milk cow breeding.

The study area is bordered by administrative regional limits on the East and West, while the northern and southern boundaries follows the limits of Irrigation districts which are the territorial base unit of the irrigation water management system of the region. The study area contains 814 Lombardy municipalities which belong to the 45 *agrarian regions*. Each of them includes 10-20 municipalities and the regional UAA rounds 15,000 ha on average.

Due to the difficulties in founding data, the work was carried out on sample of farms, extracted from the EU-FADN database and referred to the study area. It includes 413 farms

[1] These inputs are calculated on1993-2005 period, as the average of all period irrigation seasons average.
[2] According with NUTS 2.

fairly distributed in the 45 agrarian regions of the area. The sample is representative of the area as characterized by its main features described below.

The most diffused Type of Farming[3] are TF41 *Specialist dairying* and TF13 *Specialist cereals, oilseed and protein crops.* The former counts 144 farms of the sample (34.8%) which cover 40% of the sampled UAA, while the latter includes 119 farms (28.8%) and occupies the 25% of UAA. Also TF14, TF50 and TF 81 play an important role in the area and, together with the previously mentioned Types of Farming, cover more then 95% of the UAA of the sample.

Table 2 - Distribution of FADN sample farms according to Physical Size and Types of Farming

Physical size class (cod)	Physical size class (ha)	Farms (n)						
		TF41	TF13	TF 50	TF14	TF 81	Other TF[1]	Total
1	< 5	3	4	9	1	--	20	**37**
2	5-10	14	20	9	5	4	14	**66**
3	10 -20	39	29	5	10	5	11	**99**
4	20 - 50	42	33	5	10	5	11	**106**
5	> 50	46	29	7	5	5	13	**105**
Total		**144**	**115**	**35**	**31**	**19**	**69**	**413**

Note: It includes TF 31,32, 34, 42, 43, 44, 60, 72, 82

Source: personal analysis on FADN data.

As far as the Physical Size of the farms is concerned, they are fairly distributed in the medium – upper classes, with 105 farms belonging to the one which is larger than 50 ha. Analyzing the farm size together with the type of farming, the sample results distributed as shown in table 1.

Results and Discussion

Hypothesised scenarios and analysis of results

Considering, on the one hand, possible increases or decreases in the price of milk and cereals, and, on the other, the possible reduction of the water availability for agricultural, 11

[3] *TF 14 grouping classes (Reg. (CE) 2003/369).* According to it, TF41 = Specialist dairying; TF13 = Specialist cereals, oilseed and protein crops; TF50 = Specialist granivores; TF81 = Field crops-gazing livestock combined; TF14 = General field cropping; TF71 = Mixed livestock, mainly grazing livestock; TF82 = Various crops and livestock combined, *TF*31 = Specialist vineyards; TF32 = Specialist fruit and citrus fruit; TF34 = Various specialist crops combined; TF42 = Specialist cattle-rearing and fattening; TF44 = Sheep, goats and other grazing livestock; TF60 = Mixed cropping; TF72 = Mixed livestock, mainly granivores.

scenarios have been hypothesised The scheme of the examined scenarios is given in Table 3, while the results of the simulations are given in Tables 4.

In the absence of irrigation constraints, the analysis of price variation of agricultural products shows different effects.

Table 3 - Scheme of examined scenarios

Scenario	Price hypothesis	Reduction of agricultural water availability
SIM_01	20% milk increase	no
SIM_02	20% milk increase	yes
SIM_03	20% milk decrease	no
SIM_04	20% cereals increase	no
SIM_05	20% cereals increase	yes
SIM_06	20% cereals decrease	no
SIM_07	20% cereals decrease	yes
SIM_08	20% milk and cereals increase	no
SIM_09	20% milk and cereals increase	yes
SIM_10	20% milk and cereals decrease	no
SIM_11	20% milk and cereals decrease	yes

Source: personal analysis.

Table 4 - Land allocated to crop (current situation = 100)

CROPS	SIM_01	SIM_02	SIM_03	SIM_04	SIM_05	SIM_06	SIM_07	SIM_08	SIM_09	SIM_10	SIM_11
Beet	100.2	99.9	104.6	8.8	--	117.6	213.7	--	--	130.6	197.1
Alfa alfa	108.8	108.8	79.9	72.0	80.5	125.4	108.8	83.1	80.5	88.7	114.4
Durum	96.0	105.0	110.0	118.9	132.6	91.8	181.9	78.9	132.6	136.7	163.7
Soft wheat	93.8	104.8	109.2	80.3	174.1	96.0	131.4	138.5	174.1	128.7	129.0
Corn grain	95.8	94.0	103.4	120.9	106.8	97.8	72.6	121.8	106.8	91.0	52.4
Forage	107.9	107.9	107.9	97.9	107.9	104.4	107.9	98.1	107.9	97.9	103.0
Barley	93.0	105.3	110.0	98.1	113.2	79.4	189.4	45.2	113.2	139.4	171.9
Tomatoes	99.4	99.6	101.5	41.6	29.0	169.0	185.0	29.6	29.0	121.1	170.4
Grassland	135.2	123.3	80.0	80.0	80.0	89.1	118.7	80.0	80.0	80.0	135.9
Set-aside	--	--	2.9	--	--	157.4	--	--	--	283.8	639.4
Rice	98.4	96.7	99.9	105.8	54.2	86.5	44.1	75.1	54.2	72.9	64.9
Soya	95.1	93.1	104.4	--	--	161.1	444.6	--	--	203.3	415.8

Source: personal analysis.

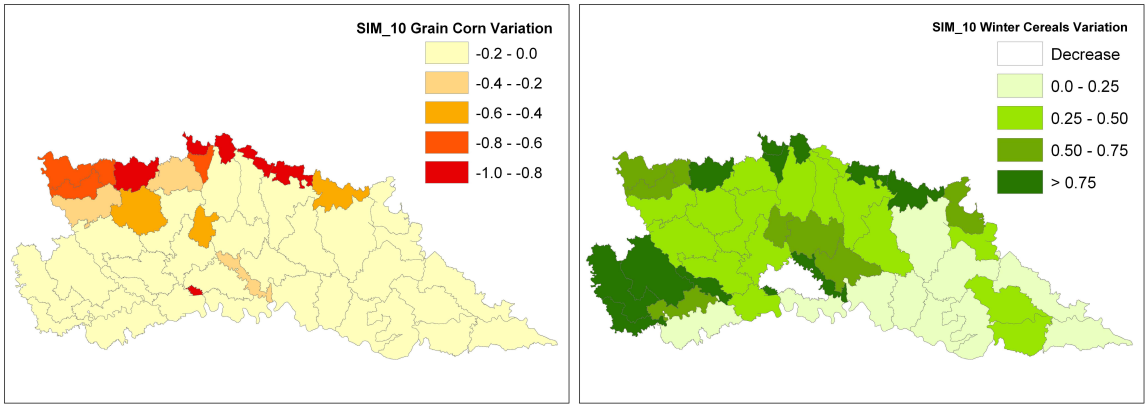
The variations in the price of milk produce an effect on the value of forage transformation (corn grain, dried alfa alfa and permanent grassland), without however strongly influencing final production. This depends on the stability of the animal husbandry production sector which is characterised by heavy fixed investments and therefore hard to change in the short-medium term (SIM_01). In particular, with a decrease in the price of milk (SIM_03), the effects are mainly evident in those agrarian regions where the forage production exceeds local requirements and consequently the production destined for sale is reduced (alfa alfa and grassland). In general in the study area the production of forage corn covers almost entirely the feeding requirements of farms, therefore even with the loss of competitiveness of the zootechnical products the surface necessary to guarantee supply self-sufficiency is maintained.

The variations in the price of cereals (wheat, barley, corn grain, rice) seem able to cause greatest changes in the production objective of arable land surfaces. In the case of price increase (SIM_04), corn (+21%) was the item most affected, followed by durum wheat (+19%) which has undergone an increase in the Lombardy plain since the introduction of the new aid regime based on the single payment. The surface used for rice also increased. Other cereals became relatively less competitive, due to a lower increase in gross income with the increase in price: this is the case for barley and soft wheat.

On the other hand, with the decrease in the price of cereals (SIM_01), we can see a diversified withdrawal of the cereal surfaces, greater for barley and durum wheat, less for corn and soft wheat. It should be noted that less widespread crops such as beet, soya and tomatoes are becoming more popular, despite the current difficulties following the change in the aid programme (this is the case for beet), or due to the fierce competition on the international market (soya and tomatoes).

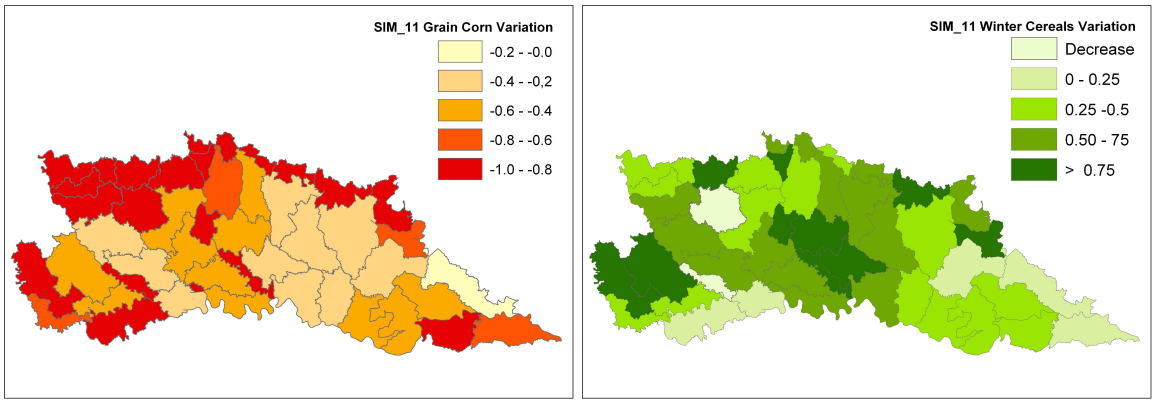
Finally, the allocation to set-aside, which in recent years has undergone a drastic decrease following the crisis of agricultural prices that hit the international markets. In the case of the joint increase of the price of milk and cereals (SIM_08), it can be observed a concentration of the production destination on corn and soft wheat while a corresponding decrease (SIM_10) shows an expansion of wheat and barley, characterised by a modest contribution of capital and work, besides industrial crops and set-aside.

Figure 2 - SIM_10 variation in *Grain Corn* and *Winter Cereals* area



The case of the introduction of the constraint of agricultural water availability highlights the trend to shift towards crops with lower water requirements. So, comparing the scenarios with the water constraint with respect to those without constraints (SIM_02 vs SIM_01, SIM_05 vs SIM_04, SIM_07 vs SIM_06, SIM_09 vs SIM_08 e SIM_11 vs SIM_10), the corn grain and rice crops show greater decrease, to the advantage of autumn-winter cereals and grassland (Fig.1 and Fig.2).

Figure 2 - SIM_11 variation in *Grain Corn* and *Winter Cereals* area



In some cases, the agricultural water constraint assumes a significance for the purpose of sowing, equal to or greater than the price effect. This means, for example, that the increase in the surface allocated to corn grain in case of price increase (SIM_03) tends to cancel out if introduced to the water constraint (SIM_04). Similarly, the modest decrease in surface due to the reduction in price (-2.2% in SIM_06), becomes considerably greater if we introduce the water constraint (-27.4% in SIM_07).

Both rice and corn lose approximately 50% of surface, especially in the presence of both price decrease and water constraint. Since both crops are widely distributed over the study area, a loss of approximately 170,000 ha is implied. Such loss can deeply change the production profile of the Lombardy watered lowland.

In fact, scenarios SIM_07 and SIM_11 show a production situation that if realized, would risk creating a significant impact on the economic balance of the farm holdings. The strong increase of the set-aside in the last two scenarios is also significant. Here, the set-aside land exceeds the surface it covered during the 2005-2006 period when the guarantee of EU aid and the stickiness of the market re-orientation process had triggered the resort to the set-aside.

Conclusions and Recommendations

The predictable scenarios due to price variations show a certain stability with regard to the zootechnical matrix of the production structure. The presence of animal husbandry makes farmers less willing to make sudden changes to the kind of crops they cultivate, especially

those crops used for forage. Cereal and industrial crops are more sensitive: the transfer from direct payments to a single payment makes the weight of EU aid on the choice production non-influential and the price variations may determine significant shifts in production choices.

It has to be underlined that the process of adjustment to price variations foreseen by the model has in reality certain forces that limit it and delays its occurrence. The price variations need to assume the characteristic of structural variations, and not simply seasonal or economic, at least as perceived by the operators of the sector. The time periods between the selection of the seeds and the sale of the product often exceed one year, hence even significant price dynamics not perceived as structural, such as those recorded between 2007 and 2008, did not cause equally significant variations in the distribution of arable land in the area of study.

On the contrary, the results of the model relative to the adjustments caused by a lower agricultural water availability are to be considered more reliable. In this case, the supply of water from irrigation consortia is quantified with certainty and will be available in the same quantities in the years to come. It would be necessary a long period in the future with few margins of uncertainty where the availability of water would be reduced with respect to the present time.

From the simulation results the possibility of a lower profitability in the agricultural areas, under examination due to greater recourse to winter cereals, grasslands and the re-emergence of the set-aside, emerges. In short, a lower water availability causes an enlargement of agricultural production.

From the methodological point of view, the PMP models like the one adopted in this paper allow to give support not only for the sector policies, but also for the environmental policies that interact with the agricultural production systems

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