

## **A National PMP Model for Policy Evaluation in Agriculture Using Micro Data and Administrative Information**

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# **A National PMP Model for Policy Evaluation in Agriculture Using Micro Data and Administrative Information**

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## **Abstract**

*The purpose of this paper is to describe the principle characteristics of a model that aims to estimate the effects of agricultural policy measures at sub-regional, regional and national level. This model is based on the use of “positive” information contained in two different databases, FADN and IACS-AGEA (an Italian administrative databank), and theoretical tools, such as PMP (Positive Mathematical Programming), able to reproduce and properly simulate the entrepreneurial behaviour present in each region. The paper clarify in detail the procedure used for merge two different database in a new database useful for the propose of the regional model and the structure of the model too. In particular, is explain how different sub-regional models will constitute one single regional model able to simulate agricultural policy for the whole region. Some preliminary results concerning application of the regional model in respect the effects of the introduction of the MTR in Emilia-Romagna, are also presented.*

## **Keywords**

Positive Mathematical Programming, Regional Model, Policy Evaluation

## **1. Introduction**

The agricultural policies that have had the greatest impact on the organization of production at farm level in the past few years have been characterised by the adoption of measures to sustain farmers' income, in the shape of direct payments in coupled and decoupled form. On one hand, these payments aim to reduce the cost to the farmers themselves of an increasing liberalisation of agricultural world markets, and on the other hand, to avoid penalising some categories of farmer too far as a result of the change in payment methods or an excessive reduction in compensatory payments.

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However, the agricultural policy tools for sustaining income such as those used until now, have sometimes not seemed very efficient in terms of satisfying the needs and objectives for which they were created. For this reason, the *a priori* evaluation of the possible effects caused by these tools, using suitable models, represents a necessary step in the definitive classification of the future effective tools used in agricultural policies.

Concerning the objective of evaluating the effect of these policies by means of models, farm level analysis does not create particular difficulties, but the analysis at regional and national level, which also considers the characteristics of the farms, obliges the researchers to face more complex problems. In fact, in order to meet the objective of developing models able to analyse production and market aspects on a regional and national scale, all information must be available to describe the behaviour of the different typologies of farmers in their territory and suitable methodologies both for data management and economical representation of entrepreneurial behaviour.

The purpose of this paper is to describe the principle characteristics of a model that aims to estimate the effects of agricultural policy measures at sub-regional, regional and national level. This model is based on the use of “positive” information contained in two different databases, FADN and IACS-AGEA (an Italian administrative databank), and theoretical tools, such as PMP (Positive Mathematical Programming), able to reproduce and properly simulate the entrepreneurial behaviour present in each region.

The paper is presented in four sections: the first section review the models based on mathematical programming used for policy analysis first analyses, the second section the characteristics of the FADN and IACS-AGEA data bank, the third section analyses the characteristics of the PMP model and the fourth section illustrates some preliminary results concerning the effects of the introduction of the MTR in one Italian Region.

## **2. The mathematical programming models used for agricultural policy analysis**

The idea of evaluating the effects of the agricultural policy measures using mathematical programming models is not new, and a path has been clearly documented that leads first of all to the analysis of the farm planning problems, moving later to facing more general agricultural policy problems and only recently including also the analysis of Common Agricultural Policy (CAP) problems.

Consequently, many of these models have the same structure, which remains a microeconomic view of agricultural policy problems. In other words, at the centre of the model there is the farm, the farmer-entrepreneur or the family farm, and their ability to adapt to different agricultural policies or to different market conditions.

Moving on from these observations, the models can be classified according to two main elements. The first is the number of farms, or aggregates of farms, that constitute the sample and the second is the methodology used to solve the policy problem. In relation to the “dimension” of the model, it is possible to distinguish between farm models, regional models and sector models. In relation to the methodology that can be used, it is possible distinguish between Linear Programming (LP), Linear Programming associated with econometric estimation and Positive Mathematical Programming.

To better understand the characteristics of the proposed model, we need briefly to recall the methodological approach that has characterised the development of the regional and sectoral models.

### ***2.1 Linear Programming and regional model***

The first step that led to the creation of sectoral models was the development of farm models. Farm models, initially, were developed for technical assistance purposes, or to study the impact of price market variation or new agriculture policy measures, and have the undoubted advantage of being simple to construct and useful for showing the observed reality. They also provide the information necessary to construct the technical matrix for the farm under examination, and thus greatly reduce the possibility of error in assessing the farmer's behaviour. But these models do not represent an area or sector because it is not possible to apply statistical inference of the results to the whole universe of farms. In conclusion, the models that show case studies are extremely useful for technical assistance and for estimating the impact on individual farms, but they are much less useful for public decision makers who require information on the effects across an area or production sector.

While farm models present clear limits concerning the possibility to correctly represent a region or sector, the specifically regional or sectoral models aim to correctly represent the productive structure of a given region or agricultural sector in order to be able to analyse the effects of the market or of agricultural policies.

Using models very similar to farm models, the first attempt to make the models more widely applicable was made during the 1970s. At that time the mainstream was, for a certain region, to consider the  $n$  farms in the sample and reduce them to a single representative farm using weighted averages for the parameters needed to construct the model. The biggest problem is the criteria for aggregating farms into the sample compared to the area universe to be represented. It is especially difficult to assess how the sample performs with regard to farm statistics on structure, economics and output.

The following works describe such attempts: Heady (1978) on American agriculture, Hazell and Norton (1986) describing the techniques of constructing a model representing the area studied, Hazell and Scandizzo (in Hazell and Norton 1986) on the agriculture of North-East Brazil and Paris and Ester (1995) on Australian agriculture, Jayet (1990) on French and European agriculture and Reading University model (1995) on British agricultural system.

Clearly, the most delicate aspect and the biggest limitation of this group of models is obtaining parameters to describe the technology used by types of farms, corresponding to size or the main type of output, even if they are in the same geographical region. It also needs to be noted that if farms are aggregated solely on the basis of structural characteristics, their output orientation and the different degrees of specialisation the entrepreneur chooses tend to be overlooked.

So there tends to be a risk of developing models that do not correctly represent the technology used and thus the costs of the different production processes. This means that the estimate of the entrepreneurs' behaviour represented by the model does not

correspond fully to reality and may consequently provide policy makers with flawed indications.

Among the various different models developed in Europe over the past few years, particular interest has been noted in those dealing with the French and British experiences, respectively using the AROPAj<sup>2</sup> and LUAM<sup>3</sup> models, which represent significant examples of regional models based on the use of only Linear Programming and aiming to analyse agricultural policy scenarios.

### ***2.3 Positive Mathematical Programming and regional models.***

To consider the problems described above, (to make the linear programming model more able to represent the production choices made by homogeneous groups of farms), some of the theoretical and methodological aspects of mathematical programming and, in particular, linear programming, were developed to provide greater capacity to analyse the problems of agricultural policy.

In this way that *normative* LP model aimed at identifying the “best” production combination under the hypothesis that the initial situation is not binding in terms of production choices, has been left behind for the *positive* type model, where the main objective is to precisely reproduce the observed production situation in order to be able to simulate the best behaviour of the farmers in varying the parameters involved in the agricultural policy intervention.

This path began with the work of Heady (1964, 1978) and Howitt (1995) and continued thanks to the work of Paris and Arfini (1995) and Paris and Howitt (1998) who, precisely as a result of the stimuli from the development of EU agricultural policy problems, created a new methodological approach called “Positive Mathematical Programming” (PMP). In particular, thanks to PMP it has been possible to reduce the research phase concerning the estimation of technical coefficients allowing for the possibility to directly use the data contained in the agricultural accountancy databanks (such as the European or the UK-FBS) without any kind of manipulation or estimation that could, among other things, imply in some cases the subjective evaluation by the researchers. Since 1995 many works using PMP have been available, analysing the effects of the Common Agricultural Policy (CAP) reform at sub-regional, regional, national and European level. The success of this methodology is confirmed by the fact that two European Union-financed research projects (CAPRI and EUROTOOLS<sup>4</sup>) use PMP to develop CAP analysis models.

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<sup>2</sup> The AROPAJ model (Jayet, 1990) was developed by the INRA Agricultural Research Centre at Grignon in order to use linear programming to analyse the effect of the CAP in France and, with an adequate database, the rest of Europe. It can be considered a regional model, because every model focused on the NUTS 2 area and became national by adding together different regions

<sup>3</sup> LUAM was developed by the University of Reading, and is an acronym of Land Use Allocation Model. It was created in 1985 at the Farm Management Unit at Reading University and was gradually implemented with the help of the Ministry of Agriculture in order to assess the effects of the CAP at regional levels.

<sup>4</sup> CAPRI and EUROTOOLS are acronyms relating to two research projects. The first (Common Agriculture Policy Regionalized Impact Analysis) coordinated by the University of Bonn, and the second (Tools For

These models, which use the same basic PMP methodology and the same FADN databank, show in reality some differences, stemming from the different ways of “interpreting” the PMP as developed in the initial works by Howitt and Paris. Among the works developed using PMP we should mention the models of INRA-Nancy (Barkaoui, Butault and Ruosselle, 1999)<sup>5</sup>, University of Madrid (Judez 2000)<sup>6</sup>, University of Galway (Garvey and Steele, 1998)<sup>7</sup>, University of Bonn (Hackeley and Britz, 2001)<sup>8</sup>, the FAL model (Kleinhanss, 2002)<sup>9</sup> and the CAPSET model (Paris, Arfini and Donati, 2003)<sup>10</sup>.

All these models have the common characteristic of using the FADN as the sole source of data, and of constructing models by region and farm type. The farm type is made from an average farm, “representative” of a group of farms with the same production orientation and reproduced using PMP models; or rather, a model for each considered type. It is only in the work of Paris and Arfini (1999 and 2000), thanks to the “self-selection” approach, that the behaviour of every single farm present in the same FT class is reproduced in all its specificities, adding greater value to the information concerning the characteristics of the farms included in the FADN sample.

The biggest problem common to all the models described is however their representativity with respect to the regional universe, and the fact that this is strictly linked to the representativity of the FADN sample. The latter should be guaranteed at regional level for each FT, but is obviously reduced when passing from level NUTS2 to NUTS3, and further reduced if a further subdivision of the farms is made, such as for example, size class. The biggest risk is therefore that of using models that do not provide a correct picture of the real situation, by reproducing instead a blurred image of the effects of the agricultural policy measures for a whole region.

## ***2.4 The FIPIIM model***

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Evaluating EU Agricultural Policies At Different Decision Level), coordinated by the University of Bologna.

<sup>5</sup> This model is based on FADN data for 12 EU countries subdivided by region (NUTS2) and by FT class. Also in this case we find an “average” representative farm whose production specialisation is described using the FT class. Allows for the simulation of the land use policies and considers a technical progress function

<sup>6</sup> The model is based on the construction of a “representative” farm respect the Farm Type of a given region. Data are taken from the mean of those farms with the same FT present in the FADN sample of the region

<sup>7</sup> The model applies fully the PMP to single representative farms chosen according to technical orientation (FT) and physical size.

<sup>8</sup> The model aim to develop a regional supply model for each EU member state based on expected prices where, in contrast to Howitt and Paris’ initial structure, they use an historic series of observations providing a stronger statistical base for the estimation of the parameters that constitute the technical matrix and the cost function

<sup>9</sup> The model is useful for regional estimation, is based on the use of the FADN database to and define the representative farms in each single FT at regional level

<sup>10</sup> The model is based on the EU-FADN data and aimed at estimating the effects of the agricultural policy measures including the effects of the Mid Term Review. The main characteristic of this model is the estimation of the totals cost and the inclusion of an output supply function separated from the land demand function, offering the possibility for the model to identify the optimum production volume according to economic convenience

According to the above picture, we need to develop a model able to simulate possible agricultural policy scenarios at regional level, guaranteeing on one hand, good statistical representativity, and on the other hand methodological correctness in describing the behaviour of the farmers. For these reasons the objective of the model proposed in this work is to overcome some limits which stem from the separate use of different sources of data (such as the FADN and IACS databanks), increasing the potential of the PMP to estimate and reproduce the cost function for each farm type in every single region, obtaining an agricultural policy tool that is at the same time flexible and complete.

Concretely, the creation of the proposed regional and national model of agricultural policy (called FADN IACS PMP Integrated Model – FIPIM) requires a specific database able to unite and integrate different statistical sources, and a methodology able to estimate the cost functions of the farms, calibrate the models with respect to the observed reality and carry out agricultural policy analysis at regional level.

More specifically, the statistical sources used are the IACS and FADN databanks, integrated between them using a procedure of aggregation (known as PMP Input Procedure – PIP), which foresees: a) the extraction of the data from two databases; b) the control of the data quality; c) the organisation of a new integrated database; d) the organisation of the input data in an adequate form for the PMP software model. On the other hand, the methodology used to estimate the cost function, the calibration and the simulation of the agricultural policy scenarios is represented by the PMP in accordance with the approach used by Paris and Howit (1998).

In contrast to the models described above, the FIPIM model does not need an extension to the universe, allowing a direct evaluation at regional level of the effects of the different agricultural policy measures. This result, as illustrated in more detail in the following paragraphs, is achieved by subdividing a region into many sub-regions, and then developing a PMP model able to estimate the cost function of the farm types present for each one of these, and to calibrate them with respect to the observed reality.

Schematically, each sub-region is defined by splitting the regional territory into: a) administrative provinces, b) altimetric levels and c) macro-farms. The latter are defined by aggregating all the farms registered under Regulation 1251/99 (and registered in the IACS database) according to size. In this model we considered 10 farm size classes (0-5 ha; 5-10- ha; 10-20 ha, 20-30 ha; 30-40 ha; 40-50 ha; 50-70 ha; 70-100 ha; 100-300 Ha; > 300 ha), each of which constitutes a “macro-farm” containing all the production and economic data relating to the processes actually present in the territory in question. These farm types will then be further aggregated in “IN-franchise” farms, meaning they are excluded from the modulation scheme, and “OUT-franchise” farms, which are obliged to apply the modulation scheme to the volume of received aid. This level of aggregation represent the “sub-region” reproduced by the model and can be considered an important territorial unit because is homogenous respect the level of direct payment.

Within each macro-farm identified in each homogeneous area, all processes present will be considered once they have been organised – for the sake of simplicity – into the following groups of processes: a) COP crops: cereal, corn, split and waxed corn, protein

cereals and flax; b) Other open field crops: horticultural, industrial crops, tobacco; c) Fodder: alfalfa, fodder plants, grass meadows; d) Animal production: cows, beef, sheep.

Essentially, the FIPIIM model refers to 10 types of farms ( $T=10$ ), each representing one “virtual” macro-farm with a maximum of 15 activities ( $J=15$ ), where: a) FADN supplies yields, output price and input cost; IACS provide surfaces and number of heads. This model is also integrated with other data concerning the level of subsidies, such as the compensatory payments for each individual process the farm has the right to, or any possible measures for production reduction, such as set-aside.

The following phase of agricultural policy evaluation is done by gathering together every calibrated sub-regional model into a single regional or national model, where the objective function is the sum of the objective function of every single sub-region, linked to the connected sub-regional technical matrices. The maximisation process of the aggregated objective function provides us with an “optimal” solution for the entire model, which is also “local optimal” for each sub-region. Organised in this way, in the policy scenario analysis phase the FIPIIM model will lead to an overall representation of the behaviour of the farmers represented in the individual types of macro-farms present in the region.

The characteristics of each databank, the means of aggregation and control, and the formulation of models are all described in the following paragraphs.

### **3. The FADN, IACS Integrated Database.**

As argued in the previous paragraphs, behind the regional simulation models there must be a set of data able to guarantee a suitable level of coverage of the information with respect to the needs of the model, and of representativity with respect to the observed reality. However the data needed cannot always be found in one single database, and when this happens, as in the case of FADN, a suitable level of representativity cannot always be guaranteed. From here, we need to use different statistical sources, using the information that is best suited to both the construction of the model and the policy objectives followed.

In particular, in this model two different databanks that operate at regional level, the FADN and the IACS, have been used. Obviously each databank introduces characteristics that influence or limit their use. For this reason the main characteristics of both are illustrated in the following paragraphs.

#### ***3.1 The FADN databank***

FADN represents the most important source of information on the structural, economical and productive characteristics of European agriculture. This databank has the great merit of recording, for each farm, information that links it to the Farm Type, to the Economical size (Class of ESU), the physical size (Class of AAU) and to the region in

which the firm is located<sup>11</sup>. For every farm all the information relating to the use of the land, productivity, production cost and income is also recorded.

From a theoretical point of view, FADN is “the ideal” instrument for all researchers, because it contains all the necessary information for the construction of an agricultural policy analysis model. Unfortunately, from a practical point of view, FADN in fact presents great limits that influence its use<sup>12</sup>.

In detail, the FADN information considered for the construction of the FIPIM model for each farm process and type (represented by the macro-farm) present in each sub-region, are those that best reflect the behaviour of the farmer, including:

- the value of the yield for each process;
- the unit output prices for the goods sold on the market;
- the unit cost (per hectare) of the inputs used for each process.

The data processing procedure<sup>13</sup> includes a phase for the processing and quality control of the data, and in particular:

- the yield is calculated for each crop at individual macro-farm level using weighted averages with respect to production volumes. The yield is therefore based on the ratio between the production of each crop and the relative cultivated area;
- the prices are calculated as the ratio between the output value of a given crop and the relative quantity produced at individual macro-farm level.
- the costs are calculated as the ratio between the value of the total variable costs for a given crop and the relative surfaces used at individual macro-farm level.

The control procedure adopted exclude from the database all the farms where the individual observations (yield, prices, costs) show an absolute deviation value of 30% with respect to the mean value of the region.

A particularly delicate step in preparing the data is the identification of the sold output processes and the processes destined for use within the farm as animal feed for the farm’s livestock. This step allows the model to consider the zootechnical production by relating it to fodder needs.

### **3.2 The IACS databank**

The IACS databank is considered an administrative databank, because its function is to record the characteristics of the farmers who join in the Common Market Organisations under the CAP. These data banks are created with a twofold objective: to facilitate the bureaucratic aspects for the farmers and to facilitate the control of the data and the payment of subsidies for the public bodies (mainly the Regions Administration).

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<sup>11</sup> Further information may be found in the websites <http://europa.eu.int/comm/agriculture/rica/index> and <http://www.inea.it/rica/index.html>

<sup>12</sup> The most important limits can be considered as: it is not a constant sample; a) the sample cannot be considered representative at sub-regional level; b) the variable costs related to single input are not recorded; c) the amounts of inputs related to single process are not recorded.

<sup>13</sup> This is done using a series of algorithms set in the PIP.

With reference to the FIPIM model, the Italian Minister of Agriculture (MIPA) has created a specific administrative data bank (called IACS-AGEA<sup>14</sup>) that collects all the data related to the farmers who are registered in the Reg. 1251/99. In other words the information contained in the “so-called” IACS-AGEA databank have the characteristic of being:

- Reliable, because the farmers are obliged to tell the truth;
- Detailed, because they contain precise details of the farms’ land use practices;
- Statistically correct, because based on surveys of all the farmers universe;
- Timely, because they are updated annually.

A significant example is given by the comparison of the IACS-AGEA databanks for 1999 and the ISTAT data for the same year (Table 1). From this simple analysis we can see how annual crops that are mostly involved with the land use (cereals, oil seed and beet), show a level of representativity that is close to, if not greater than, the observed universe. The discrepancy with respect to the ISTAT data should be read as greater precision with respect to ISTAT, which is carried out on a sample basis.

TABLE 1: Spread of soil use according to the IACS-AGEA database and ISTAT (values in ha, year 1999)

Crop	National survey ISTAT	IACS-Agea database	% variation
Cereals	3,959,132	4,028,678	101.8
Annual fodder crops	2,306,114	1,071,119	46.4
Permanent fodder crops	4,409,971	827,467	18.8
Sugar beet	283,025	232,657	82.2
Oilseeds	507,818	558,707	110.0
Tobacco	46,265	21,221	45.9
Oil	1,174,135	131,824	11.2
Vineyards	908,229	201,552	22.2
Fruits	490,085	92,307	18.8
Vegetables	470,322	124,922	26.6
Citruses	181,660	9,394	5.2

For these peculiar characteristics, the IACS-AGEA databank can be useful for overcoming the main gap of the FADN: the low level of representativity of the farm typologies at sub-regional level and especially of the land use between different crops. The IACS-AGEA databank therefore has the important task of providing the FIPIM model with the data of the surfaces of each activity. In other words, thanks to this reliable databank it is possible to obtain a reliable image, at sub-regional and (by combining the data) national level of the use of the land between different crops.

The use of the information in the IACS-AGEA databank requires specific software able to elaborate all the records related to every farmer for all sub-regions and for the whole of Italy. For reasons of privacy it is not possible to recognise the single farmers. On the other hand, it is possible to know the physical size of the farm and to aggregate

<sup>14</sup> The AJAX-AGEA databank owes its name to the Italian Agency created by the Italian Ministry of Agriculture, AGEA, which makes payments to farmers and carries out the necessary controls.

this in homogeneous size classes on the basis of the total AAU. The maximum level of the sub-regional desegregation is represented by the municipality, while the number of farm types can be selected at the discretion of the researchers, on the basis of the objectives of the analysis. In this case a subdivision into 10 classes has been chosen. The result of this operation is to create "macro-farms" (as show before, 10) at municipal level, where the surfaces used by every process are recorded.

It should be underlined that the data contained in the database comes from the paper forms filled in by the farmers when presenting their applications, and provides a detailed description of the size (in Ha) of the crop processes actually practiced at the farm, and assigns a code to them.

The main characteristic of the IACS-AGEA databank is at the same time also its main limit, because it does not provide any indication of crop yields, prices and costs.

Combining the FADN and IACS-AGEA databanks provides more complete information on the characteristics of the macro-farms, supplying precise information on the participation in European programmes with the estimation of the overall compensatory payments received. Furthermore these farms can be considered to be those with the greatest awareness of the agricultural policy measures involved in the individual sub-regions, simply because they have taken part in the Community programmes.

Within the same sub-region, the integration of information between the two databanks is carried out at macro-farm level, thanks to the presence of the common variable represented by the crop process identification code used in FADN and IACS-AGEA.

### 3.3 The FIPIM databank

The final result of the union of the two databanks is the construction of a single database able to produce input matrices in the form required by the PMP model. More precisely, the type of matrix used in the two databanks and generated through the process of combining the databanks can be schematised as follows (table 2):

TABLE 2 – Type of matrix used and generated by the FIPIM model

Name.	Data Input for crop	Source	Unit of measure	Operation	Data Output for crop	Unit of measure
St	Structure	IACS-AGEA	Ha and Head		Structure	Ha and Head
Y	Yields	FADN	t./Ha	St * Y	Total output	t.
Op	Output prices	FADN	Euro / t.		Output prices	Euro/t
Ip	Input prices	FADN	Euro / ha	St * Ip	Total cost	Euro
Sub	Subsidy	IACS-AGEA	Euro / ha		Subsidy	Euro

It should be noted that the FIPIM databank pays great attention during the construction phase to solving the problem of the “missing values” of yield, price and cost referred to processes that are not in the FADN database but are present in the

IACS/AGEA database. For this reason, two databanks have been constructed: a) the first refers to the sub-region under examination containing the information on the area of specific interest, and b) the second is a “support” referring to the Administrative Region to which the sub-region of specific interest belongs. The function of this second databank is to provide the missing value in the area of specific interest. The values are obtained from FADN and are shown as mean values of yield, output price and cost of each process in the administrative region to which the area of specific interest belongs.

The result of this information processing is a series of matrices of  $N$ ,  $J$  size (where  $N$  is the macro-farm and  $J$  are the processes), which represent the input matrices for the PMP model. Each matrix includes the data relative to a variable for all the considered processes present in the different macro-farms. More precisely, for each sub-region we will have the following series of matrices:

- 1) Matrix of the surfaces covered by crops destined for sale;
- 2) Matrix of the surfaces covered by crops destined for re-use;
- 3) Matrix of the number of head of each species;
- 4) Matrix of the production of processes destined for sale;
- 5) Matrix of the production of processes destined for re-use;
- 6) Matrix of zootechnical production;
- 7) Matrix of the prices of vegetable products;
- 8) Matrix of the prices of livestock;
- 9) Matrix of the costs of sold processes;
- 10) Matrix of the costs of reused processes;
- 11) Matrix of the costs of zootechnical processes;
- 12) Matrix of the compensation for sold processes;
- 13) Matrix of the compensation for reused processes;
- 14) Matrix of the compensation for zootechnical processes;

Despite contributing to the requirements of the model in a suitable manner, the FIPIM databank still has some limits. The greatest advantage is that it provides a much more realistic picture of the agricultural system, and above all allows for a more precise evaluation of the effects that the agricultural policy measures could have on the territory in terms of farms, the market and the costs of the policies. On the other hand, its limits can be summarised in the following aspects:

- it requires an appropriate data-warehouse and software to decode and organise the original farm-records.
- the structure of the data records may differ over the years.
- every IACS databank information record relates to only one measure (in this case only annual crops) and therefore the observed sample does not represent the universe of the farms present in the region.
- the destination of re-used fodder on the farm is not considered.

For these reasons the FIPIM databank can be considered a very good policy analysis tool only as far as annual crops and animal production is concerned, but needs to be further developed in order to be able to consider also other types of production.

#### 4. The mathematical structure of the FIPIM model

As mentioned above, the FIPIM model uses the PMP methodology described in the works of Paris and Howitt (1998) and Paris and Arfini (2002), as a mathematical process to analyse the behaviour of the farmers, therefore considering at the same time the presence of  $N$ -farms in a data sample, giving them the opportunity to not carry out processes that are not economically convenient thanks to the self-selection technique. Briefly, the PMP methodology consists of three steps.

The first is defined by  $N$  linear programming (LP) models, one for each macro-farm, and by an additional LP model for the entire sub-region. The  $n$ -th individual macro-farm model ( $n=1, \dots, N$ ), uses all the available information pertaining to the  $n$ -th farm in order to derive the vector of shadow prices of the limiting allocable inputs,  $y$ , and the differential marginal cost vector corresponding to the vector of realized output levels,  $\mathbf{I}$ . The  $n$ -th farm LP model has the following structure:

$$(1) \quad \max_{x_n \geq 0} (p'_n x_n - c'_n x_n)$$

subject to

$$(2) \quad A_n x_n \leq b_n$$

$$(3) \quad x_{nj} \leq x_{Rnj}, \quad \text{for } x_{Rnj} > 0, \quad j = 1, \dots, J_n$$

where  $p_n$  is the vector of output prices faced by the  $n$ -th farm,  $c_n$  is its vector of accounting costs per unit of output,  $A_n$  is the matrix of fixed technical coefficients involving limiting allocable inputs,  $b_n$  is the vector of availability of limiting allocable inputs, and  $x_{Rn}$  is the vector of realised output levels. The vector  $x_{Rn}$  is nonnegative. Each farm exhibits  $I$  allocable inputs and  $J_n$  products. The vector of realised land allocation decisions is indicated by  $H_{Rn}$ . In this study, land is the only limiting input. The  $n$ -th matrix  $A_n$  of technical coefficients is defined as  $A_n = [a_{nij}]$ , where  $a_{nij} = h_{Rni} / x_{Rn} J_n$ .

Constraints (2) are called structural constraints while constraints (3) are called calibration constraints. The vector of shadow prices,  $y_n$ , is associated to the allocable input constraints (2). The vector of differential marginal costs,  $\mathbf{I}_n$ , corresponds to the calibration constraints (3). It is important to recall that the sole purpose of this first stage of the PMP methodology is to obtain an accurate and consistent measure of the marginal cost associated with the vector of realised level of activities,  $x_{Rn}$ . From the above specification of primal and dual LP models, the marginal cost vector of the  $n$ -th farm is given by  $(\mathbf{I}_n + c_n)$ , while the marginal cost vector for the entire sample is  $(\bar{\mathbf{I}} + \bar{c})$ .

The second step of the PMP approach deals with the reconstruction of the marginal cost function using a specification that is linear in the parameters. The linearity aspect of the model becomes important when the number of farms is large. The integration of the

marginal cost function with respect to the output variables within the admissible domain will produce the desired total variable cost function.

As shown by Paris and Howitt (1998), the cost function is assumed to be a quadratic functional form in output quantities (input prices are not available from the farm survey and are assumed to be fixed):  $C(x) = x'Qx/2$ , where the  $Q$  matrix is symmetric and positive semi-definite. Given the LP specification discussed above, the associated marginal cost function for the FT can be represented as  $mc(x) \equiv \bar{I}_{LP} + \bar{c} = Q\bar{x}_R$ .

The requirement that the  $Q$  matrix of the quadratic cost function be symmetric positive semi-definite is achieved using the Cholesky factorisation:

$$(4) \quad Q = LDL'$$

where  $L$  is a unit lower triangular matrix,  $L'$  is its transpose, and  $D$  is a diagonal matrix whose elements are nonnegative. It can be shown that  $LDL'$  is a positive semi-definite matrix if and only if all the diagonal elements of  $D$  are nonnegative (Lau, 1978). In order to recover the marginal cost function is used the approach base on the maximum entropy principle.

Whether using the estimates of  $Q$  derived from either the least-squares or the maximum entropy specifications, the third step of the PMP methodology consists in assembling a non-linear model that uses the recovered variable cost function and is capable of reproducing the primal and dual solutions of the first stage LP models. There are  $N$  quadratic programming models,  $n = 1, \dots, N$ , one for each macro-farm in the sub-region. For the entire sub-region the following quadratic programming model will reproduce the total output and allocation decisions:

$$(5) \quad \max_{x \geq 0} (\bar{p}'x - x'\hat{Q}x/2)$$

subject to

$$(6) \quad Ax \leq \bar{b}$$

This model exactly reproduces the base period allocation and output decision of the  $n$ -th macro-farm and of the entire sub-region. That is, the primal and dual solutions of this quadratic programming models is exactly equal to the primal and dual solution of the initial LP model which, in turn, reproduces the realised results of the base period. This is the meaning of calibration within the PMP methodology. This model is analogous to the model specification and selection of econometric studies. The prediction step of PMP exploits the calibrated model to generate responses in the endogenous variables induced by the variation of some relevant parameters, assimilated to the exogenous variables of econometric models and can be used for analysing various scenarios of agricultural policy with changes in output prices, and limiting resource availability.

The PMP procedure used in FIPIM model may be able to face the problems of the animal farms, where the ( $J_v$ ) marketed crop processes are considered together with the ( $J_r$ ) feeding crops re-used for breeding and ( $J_z$ ) animal processes such as meat and milk production. Starting from the FIPIM database, the PMP model in the first step, corresponding to the linear programming (LP) model, is structured as follows:

$$(7a) \quad \sum_{J_v} A_v x_v + \sum_{J_r} A_r x_r \leq b$$

$$(7b) \quad \sum_{J_z} A_z x_z - x_r \leq 0$$

$$(7c) \quad x_v \leq x_{Rv}$$

$$(7d) \quad x_r \leq x_{Rr}$$

$$(7e) \quad x_z \leq x_{Rz}$$

$$(7f) \quad \sum_{J_v} A_v x_v - x_{Hv} = 0$$

$$(7g) \quad \sum_{J_r} A_r x_r - x_{Hr} = 0$$

$$(7h) \quad \sum_{J_z} DA_z x_z - x_{Na} = 0$$

$$(8) \quad \max Obj = \sum_{J_v} [(x_v p_v) - (x_v c_v)] + \sum_{J_z} [(x_z p_z) - (x_z c_z)] + \sum_{J_r} [(x_r p_r) \quad ] + \\ + \sum_{J_v} (x_{Hv} s_v) + \sum_{J_r} (x_{Hr} s_r) + \sum_{J_z} (x_{Na} s_z) + \sum_{J_v} \frac{1}{2} (x_{Hv} s a_v) + \sum_{J_r} \frac{1}{2} (x_{Hr} s a_r)$$

that is a constrained maximisation problem where the function (8) is the profit function to be maximised under the constraints (7a)-(7h)<sup>15</sup>.

The model has the same methodological structure described by Howitt and Paris (1998) and the Maximum Entropy formulation is used to obtain the estimation of the

<sup>15</sup> The notation is the following:

v	is the index for the process of marketed crop production;
r	is the index for the process of crop production re-used for breeding;
z	is the index for the process of animal (milk and meat) production;
x (v,r,z)	are the unknown quantities for each process;
$x_H(v,r)$	are the unknown surfaces for marketed processes and re-used feeding crops;
$x_{Na}$	is the unknown number of animal heads for species, expressed in livestock units (LU)
$x_R(v,r,z)$	are the known outputs for each process;
p (v,z)	is the known vector of prices;
c (v,r,z)	is the known vector of costs;
s (v,r,z)	is the vector of compensatory payments according to EC-Regulation 1765/92
sa (v,r)	is the vector of compensatory payments for Set-aside
A (v,r)	are the matrices of the technical coefficient for the marketed and re-used crop ( $H_v/x_{Rv}$ and $H_r/x_{Rr}$ )
A (z)	are the matrix of the technical coefficient for feeding crops consumption ( $x_{Rr} / x_{Rz}$ )
DA(z)	is the matrix of the technical coefficient for the animal production (LU / $x_{Rz}$ )

Total Variable Cost matrix “ $Q_R$ ” (three in this model, one for each process typology: marketed, reused, animal production), allowing first the model calibration and then the agricultural policy analysis.

For the purposes of this paper, the FADN data concerning costs, yields and sale prices were added to the structural data taken from the 1990 Italian agricultural census. For each of the 41 provinces of Northern Italy, a model was generated taking into account of the existing processes in terms of surface and animal heads as reported by the census. More specifically, in order to consider the actual structural and productive characteristics, in each province, 4 farm typologies for each altimetric class were detected.

#### **4.2 – Regional aggregation of PMP models**

The FIPIIM model is therefore a regional model in which information on the farms is aggregated at sub-regional level and, using the PMP procedure, held in a simulation phase in order to provide responses to agricultural policy change that are as representative as possible of the characteristics of each sub-region and the farms within it.

From a methodological point of view, the particularity of this model lies in the means of aggregation of the single sub-regional models and the way in which the problem of maximisation is resolved during simulation: each simulation is carried out simultaneously for all sub-regions, allowing for the introduction of constraints at regional level.

In many regional models based on the use of PMP for which literature is available, as previously examined, the simulation process involved the resolution of a problem of optimisation for each single sub-region, without therefore considering the complex constraints set at regional level and the profitability expressed by the other sub-regions within the same region. In the FIPIIM model, on the other hand, the simulation phase includes the maximisation of an objective function aggregated by group of sub-regions that comprise the region under examination.

For this reason, the FIPIIM model appears as a “concatenated” model. A model in which during the policy scenario simulation phase, the decisions taken by each sub-region are linked to the decisions taken by the bordering sub-regions through the definition of a problem of simultaneous optimisation. The FIPIIM model described in this study is constructed on a regional base, but there is no reason why it could not be based on a national model, including in the system all the national sub-regions constructed by the size classes in the different provincial altimetric areas.

In the phase concerning the reproduction of the effects of the agricultural policy measures at regional level, the relevant aspects of the FIPIIM model are therefore the aggregation of the cost functions into a single regional model, and the construction of a suitable set of constraints able to correctly simulate the policies for the whole region.

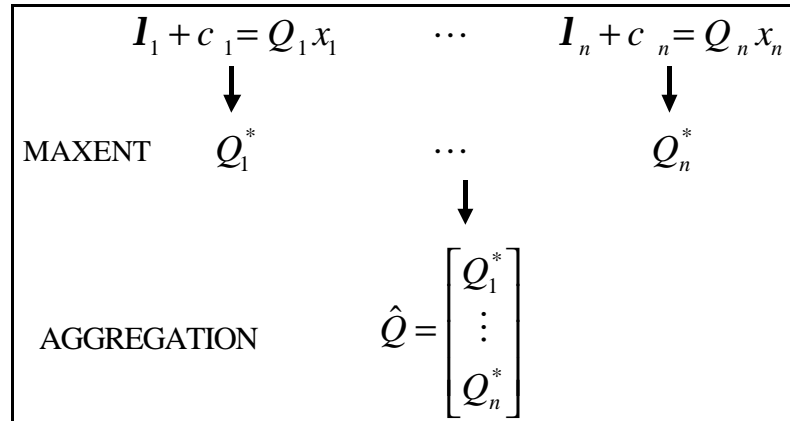
As illustrated in the previous section, the estimation of the cost function for each sub-region has the specific aim of estimating the parameters comprising the matrix  $Q$ , which incorporates all the information concerning the relations of substitution and complementarity between the processes, and represents the total cost function of the sub-region. Very concisely, we can express the  $Q$  matrix in the following way:

$$(9) \quad Q = \begin{bmatrix} q_{11} = [w_{11}^1 \cdots w_{11}^s] \begin{bmatrix} p_{11}^1 \\ \vdots \\ p_{11}^s \end{bmatrix} & \cdots & q_{1n} = [w_{1n}^1 \cdots w_{1n}^s] \begin{bmatrix} p_{1n}^1 \\ \vdots \\ p_{1n}^s \end{bmatrix} \\ \vdots & \ddots & \vdots \\ q_{n1} = [w_{n1}^1 \cdots w_{n1}^s] \begin{bmatrix} p_{n1}^1 \\ \vdots \\ p_{n1}^s \end{bmatrix} & \cdots & q_{nn} = [w_{nn}^1 \cdots w_{nn}^s] \begin{bmatrix} p_{nn}^1 \\ \vdots \\ p_{nn}^s \end{bmatrix} \end{bmatrix}$$

where, as shown by Paris and Howit (1998), the parameters of the  $Q$  matrix are estimated through the distribution of probability  $p_{mn}^s$  ( $s=1, \dots, S$ ) associated to the interval with the support weighting  $w_{mn}^s$ .

In the second phase of the PMP procedure the FIPIM model will therefore estimate the same number of cost functions as there are sub-regions in the referred region. Estimated in this way, the cost functions will represent the specific economic structure of each homogeneous area and will be used during the agricultural policy measure simulation phase. More precisely, the cost functions area aggregated among themselves using a specific aggregation routine that can be summarised according to the following scheme (Fig. 1.)

FIGURE 1: Aggregation of the cost matrices  $Q$  in the sub-regions



As can be seen, the information on the estimated cost functions for the sub-region ( $Q^*$ ) using Maximum Entropy (MAXENT) are gathered in a parameter indicated by  $\hat{Q}$ , which joins the single  $Q^*$  matrices in one single vector. The same aggregation procedure is developed also for the other information needed for the construction of the policy model, such as output price, yield and compensatory payments.

The information reorganised into vectors is included in the regional model and allows for an efficient definition of the problem of maximisation, as the overall group of vectors joins all the components concerning the objective functions of the  $n$  sub-regions in the referred region in one single matrix. The aim of the regional model is therefore to reproduce the initial production situation for the entire referred region without any calibration constraints, then to calibrate the model for the entire region once more.

More precisely, the objective function of the regional model sums the single objective functions of each sub-region, maximising the overall gross income for the region.

$$(10) \quad \sum_{n=1}^N PROF^n = PROFT$$

where  $PROFT$  represents the gross regional income, while  $PROF^n$  represents the gross income of each sub-region.

Given that the structure of the constraints of each sub-region is independent from the others, the maximisation of the gross regional income is the result of the maximisation of the gross income of each sub-region,  $PROF^n$ , obtaining an optimum solution at regional level that is equally optimum at sub-regional level.

The maximisation of the regional objective function is subject to a series of constraints that, for each sub-region, fix the structural characteristics (the surface) and reproduce the agricultural policy scenarios. Specifically, the structural constraint (11) on the available resources obliges the land used for produce sold,  $xh_v^n$ , re-used,  $xh_r^n$ , the set-aside,  $xhs^n$  and the non-productive cultivated land respecting good agronomic practice  $xhb^n$ , to be at least equal to the total land availability at sub-regional level,  $b^n$ .

$$(11) \quad \sum_{v=1}^V xh_v^n + \sum_{r=1}^R xh_r^n + xhs^n + xhb^n \leq b^n$$

The structure of (11) allows us to determine the set-aside due to the variable  $xhs^n$ , (set-aside surface), which is also present in the constraint (12) concerning the sub-region set-aside:

$$(12) \quad \left( \sum_{v \in cop} xh_v^n + xhs^n \right) \mathbf{q}^n \leq xhs^n$$

where  $\mathbf{q}^n$  is the set-aside rate for each sub-region that multiplies the surface used for COP crops.

As well as the structural constraint of available land, there is another constraint (13) that defines the relation between the zoo-technical activities and the farm surface, linking the forage needs  $a_m^n x_m^n$ , and the availability with the sub-region  $x_r^n$ :

$$(13) \quad \sum_{m=1}^M (a_m^n x_m^n) - x_r^n \leq 0$$

As well as the structural constraints linked to land use, the model also includes other constraints, in respect of the CMO, concerning the production of some processes at sub-regional level: milk, beet and industrial tomatoes. For example, the milk production constraint is linked to the presumed referred quota equal to the observed level in the start year. If the base quota is exceeded, a fine corresponding to the excess collection is due, in accordance with the milk CMO regulations.

$$(14) \quad \begin{aligned} x_{LAT}^n &= xq_{LAT}^n + xf_{LAT}^n \\ xq_{LAT}^n &\leq \bar{x}_{LAT}^n \end{aligned}$$

where  $x_{LAT}^n$  is the quantity of milk in the objective function,  $xq_{LAT}^n$  and  $xf_{LAT}^n$  are respectively the quantity of the quota and the quantity of the excess milk produced, on which the excess collection is applied, and finally,  $\bar{x}_{LAT}^n$  is the observed milk quota in the calibration year for the relative sub-region.

In the same way constraints have been added for beet and tomato crops. Also in this case the production by sub-region has been divided into two quotas, the first relating to the quantity produced during the year of observation and the second the excess production with respect to the quota upon which the output price penalty is to be applied (15).

$$(15) \quad \begin{aligned} x_{ORT}^n &= xq_{ORT}^n + xf_{ORT}^n \\ xq_{ORT}^n &\leq \bar{x}_{ORT}^n \end{aligned}$$

where  $x_{ORT}^n$  is the variable associated to the production level of horticultural crops (ORT), while the other symbols have the same meaning as those used for the milk quota constraints.

For both the milk quota constraints and the horticultural crop constraints there is an objective function for each sub-region,  $PROF^n$ , introducing a negative income component for the part of the production that exceeds the quota.

This procedure can be replicated from regional to national level, replacing the sub-regional constraints with a single constraint that functions on national level. This process (which has not been used in this study) could allow for the introduction of agricultural policy system, such as the ‘‘Maximum Guaranteed Surface’’, maintaining the production particularities of each single sub-region thanks to the gathered information. This last aspect could represent a highly useful element for agricultural policy analyses, which are increasingly having to consider the technological, structural, production and economic characteristics of the individual European sub-regions.

## 5. An agricultural policy application

The FIPIIM model can be applied to many contexts for the evaluation of agricultural policy and the changes in the market variables that affect the farmers’ choice of

production. The recent proposal to review the Common Agricultural Policy offers many interesting ideas for the implementation of the FIPIM model. In fact, the new agricultural support mechanisms that make the Mid Term Review (MTR) a real aid system reform, can be integrated within the model through the formulation of suitable policy constraints. To this end, the main agricultural intervention tools – the principle of decoupling farm aid and dynamic modulation, have been introduced in the FIPIM model.

### 5.1 The scenarios and structure of the policy evaluation constraints

On the basis of the above information, the FIPIM model has been applied to an Italian region (Emilia Romagna) to evaluate the effects of the new EU support measures in the agricultural sector. In particular the following scenarios have been identified:

*Baseline.* The base scenario on which the comparison is carried out is represented by the situation recorded in 2003, obtained by updating the results obtained<sup>16</sup> using the 1999 calibrated models (applying the new levels of aid and the market price variation of agricultural produce according to the forecasts of the FAPRI-Ireland model).

1. *Modified CMO (Sim\_CMO).* The first real policy scenario is the updating of the compensatory payments for the COP crops on the basis of the indications included in the reform proposal. In this scenario the aid remains coupled to the processes, supposing that there are no changes to the type of support system.
2. *Decoupling (Sim\_D).* The aid recalculated according to the previous scenario is attributed to the macro-farms in each sub-region in a de-coupled manner, maintaining a part of the specific aid for those processes that have been expressly identified in the MTR.
3. *Decoupling and dynamic modulation (Sim\_DM).* This scenario foresees the full application of the Mid Term Review. The dynamic modulation and decoupling constraints of the aid have been activated.

As far as the decoupling of farm aid is concerned<sup>17</sup>, this is subordinate to the existence of admissible agricultural surfaces to which the due payment is linked<sup>18</sup>. The FIPIM model takes this intervention mechanism into account through the formulation of the following constraints:

$$(16) \quad \begin{aligned} ham^n &\leq hDIR^n \\ ham^n + hamd^n &= \sum_v xh_v^n + \sum_r xh_r^n + xhs^n + xhb^n \end{aligned}$$

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<sup>16</sup> The updating has been done by applying the new levels of aid and the market price variation of agricultural produce to the results of the 1999-calibrated model, as foreseen in the FAPRI-Ireland model.

<sup>17</sup> The MTR foresees the provision of aid to farmers who have historically benefited from direct support in the form of a single payment not bound to specific crops, which can be destined to all productive farm processes and is therefore independent from any allocational choice made by the farmer.

<sup>18</sup> Theoretically the number of hectares admissible for aid could be lower than the number of rights held by the farm.

where  $hDIR^n$  is the number of rights calculated by the sum of all the hectares benefiting from the specific aid during the year of calibration, including all the forage land;  $hamd^n$  is the deviation variable relating to the land admissible for aid but exceeding  $hDIR^n$  that will not receive any payment even although it is entitled to. The first constraint of (16) expresses the condition in which the number of hectares that can benefit from the single payment,  $ham^n$ , must not exceed the number of rights acquired by the farm. The second constraint, on the other hand, establishes the equivalence between the land admissible for aid and the surface allocated to farm processes, including the set-aside and fallow surfaces in accordance with the good agronomic practice. In the aid decoupling policy scenario the variable  $ham^n$  benefits from a bonus,  $aid^n$ , equal to the value of the right calculated according to the instructions in the MTR proposal. The single payment is part of the dynamic modulation process .

## 5.2 – Some results

The approach used in analysing the impact of the EU Mid Term Review allows us to isolate the single effects of the modifications to the intervention measures. In this case the FIPIM model has been applied to the farms of the Emilia Romagna region that applied the Reg. 1765/97 in 1999 with the aim of evaluating the impact of the MTR. This analysis concerned the 24 regional altimetric areas from which, using a process of separation according to the franchise threshold, 48 sub-regional models were obtained, which, during the simulation phase, were included in a single regional model according to the previously described procedure.

For reasons of brevity, the aggregated data is shown for the 9 provinces within the Emilia Romagna region concerning the effects on cereal surface, the overall size of the subsidies concerning the single measures and the variation in gross income.

Starting with the analysis of the allocational behaviour concerning cereal surfaces (table 3) we can see the dynamics in play in the different provinces of the region, subdivided according to the franchise threshold criterion.

These results show how the updating of compensation only (SIM\_CMO scenario) would have a very low impact at regional level both for small farms (in\_franchise farms), which would increase the overall cereal surface by 1.3%, and for large farms (out\_franchise farms), which would slightly reduce the surface for this category of processes. It should be underlined that the response of the farmers in the single provinces is not however uniform, with fairly diverse behaviour shown for both small farmers (Parma +3.1 %, Ferrara -0.8%) and large farmers (Parma and Reggio Emilia + 1.8%, Ferrara -2%).

The greatest impact on cereal farmers in the region seems to be due to the passage from a partially coupled aid system, to a fully decoupled one. In fact, the introduction of this scenario would cause an overall reduction of cereal surface by 15% for the in-franchise farms and around 10% for the farms subject to modulation. In absolute terms,

this data would mean a reduction of around 40,000 ha. of cereal surface for the whole region.

Also in this case, the application characteristics of the single provinces seem to be fairly diversified. In the small farms the reduction in production is between 18% (Ferrara and Bologna) and 10% (Piacenza and Forlì), while for the larger farms the cereal surface reduction would appear to be between 13% (Parma) and 5% (Reggio Emilia).

This scenario would not be modified by the introduction of modulation, (which involves only the large farms) showing how this measure would not prompt the farmers to modify their own production organisation.

The justification of the different behaviour in the single provinces is due precisely to the variability of process profitability that can be seen in each province, and above all to the profitability with respect to other “competitor” processes operating in the same farms, such as industrial crops and forage for cattle farming, which vary in size according to economic convenience, and in this study is not described for reasons of brevity.

TABLE 3: Variation of cereal surfaces following the application of the MTR scenarios  
(Value in Ha and in %)

Cereals									
Class	Provinces	Baseline	Sim_CMO	Sim_D	Sim_DM	Sim_CMO	Sim_D	Sim_DM	
				(ha)					(var. %)
IN	Piacenza	13821	14011	12393	12393	1.4	-10.3	-10.3	
	Parma	18684	19267	15613	15613	3.1	-16.4	-16.4	
	Reggio Emilia	14703	15097	12157	12157	2.7	-17.3	-17.3	
	Modena	17994	18250	15540	15540	1.4	-13.6	-13.6	
	Bologna	30939	31269	25213	25213	1.1	-18.5	-18.5	
	Ferrara	11696	11602	9512	9512	-0.8	-18.7	-18.7	
	Ravenna	19436	19566	16923	16923	0.7	-12.9	-12.9	
	Forlì	16638	16772	14914	14914	0.8	-10.4	-10.4	
	Rimini	6756	6778	5763	5763	0.3	-14.7	-14.7	
	<b>Emilia-Romagna</b>	<b>150666</b>	<b>152611</b>	<b>128028</b>	<b>128028</b>	<b>1.3</b>	<b>-15.0</b>	<b>-15.0</b>	
OUT	Piacenza	34126	34286	30096	30086	0.5	-11.8	-11.8	
	Parma	15391	15663	13325	13324	1.8	-13.4	-13.4	
	Reggio Emilia	11615	11827	10994	10996	1.8	-5.3	-5.3	
	Modena	23528	23640	21544	21544	0.5	-8.4	-8.4	
	Bologna	41294	41386	37252	37250	0.2	-9.8	-9.8	
	Ferrara	74486	72983	67234	67228	-2.0	-9.7	-9.7	
	Ravenna	18207	18305	16049	16048	0.5	-11.9	-11.9	
	Forlì	7074	7133	6232	6232	0.8	-11.9	-11.9	
	Rimini	2279	2283	1939	1939	0.2	-14.9	-14.9	
	<b>Emilia-Romagna</b>	<b>228002</b>	<b>227506</b>	<b>204665</b>	<b>204645</b>	<b>-0.2</b>	<b>-10.2</b>	<b>-10.2</b>	

The solutions of the FIPIM model provide the policy makers with a great amount of information concerning the variation of some important economic dimensions that guide the farmers’ choices, such as the amount of aid received, the gross saleable production,

the total production costs and gross margin. In this paper, the analysis concentrates on the changes in the levels of SGP, aid and the variation in gross margin at sub-regional level and the type of farm subject to modulation (table 4).

The analysis of regional SGP shows a generalised reduction starting with the aid modification scenario (Sim\_CMO) only. This result is justified by the change in market price of zootechnical products that, according to the GTAP forecasts used in this study, see a reduction in the price of milk with respect to 2003 of almost 16%. This effect can be particularly noted in the provinces of Parma and Reggio Emilia, which are the two provinces with the highest vocation for milk production, where above all for the in-franchise farms, the SGP is reduced by about 10% in Parma and as much as -13% in Reggio Emilia. The reduction in SGP value must therefore not be seen as a reduction in overall efficiency of the farms subject to the policy changes. By examining the progress of the gross margin, the reduction in SGP, in particular in the decoupling scenarios, this is justified precisely by the fact of having reached a higher level of efficiency, following the exclusion of those processes with low profitability.

At regional level, the adaptation of yields to the MTR leads to an increase in the cost of the CAP despite decoupling and modulation. As far as the “in-franchise” group is concerned, the subsidies are increased by about 20% with respect to the 2000 baseline. On the other hand, the results of the “out-franchise” farms show an increase in aid levels of about 15% in the first scenario (Sim\_CMO) and 12% in that with decoupling only, while for the third scenario (Sim\_DM) the model shows an increase of 3.3% with respect to 2003 following the activation of modulation constraints.

The generalised increase in subsidies is generated by the combined effect of the recalculation of the CMO aid according to the MTR regulation proposal and the introduction of new, complementary subsidies, such as those relating to the referred individual milk quotas. Among all the provinces, only the group of large farms in the province of Piacenza shows a reduction in aid in all scenarios.

On the basis of the IACS-AGEA data, the “out-franchise” group in the province of Ferrara uses 26% of overall aid received within the Emilia Romagna region, which demonstrates that this province is certainly the most specialised in the production of crops eligible for public support. The provinces showing the largest increase in support are Parma and Reggio Emilia, with variations of as much as 40%, which benefit large farms only. This result is due to both the variation in the level of aid and the introduction of extra bonus on the milk quota.

The effect of this aid has a direct impact on the sub-regional gross margin, which in this case can be interpreted as a variation in the added value of the territory as a result of the application of the policy measures. For the large farms, the cut in aid under the Sim\_DM scenario causes a modest reduction in gross margin (-0.2%), which is in contrast to the trends of the previous scenarios, where the gross margin increases. To this end, it is interesting to note how the highest growth in profit is recorded precisely in the decoupled aid scenario (+1.3%). This result is probably due to the increased production specialisation in those activities with the highest added value. The fact that there is no direct link between the production process and public support actually allows the model to transfer the aid to the most efficient farm processes.

The observed phenomenon is also reproduced in the small farms, where the gross margin undergoes a less consistent reduction in the decoupling scenario than in the coupled aid scenario, despite the fact that the overall aid is less. The in-franchise farms are generally those with a smaller average size than the out-franchise ones, and for this reason are considered less efficient because they are less specialised. This may explain the trend of the reduction in farm margins for these farms, even if the variations in the level of support are much greater than those for the group subject to modulation.

Table 4: Results of the FIPIM model on economic sizes

CLASS	Province	Economic Variables	Economic Values						
			Baseline	Sim_OCM	Sim_D	Sim_DM	Sim_OCM	Sim_D	Sim_DM
			(000 Euro)			(Var. %)			
IN-Franchise	Bologna	GSP	117,180	115,171	108,037	108,037	-1.7	-7.8	-7.8
		Subsidies	11,993	13,415	13,387	13,387	11.9	11.6	11.6
		Gross Margin	66,824	66,495	67,913	67,913	-0.5	1.6	1.6
	Ferrara	GSP	31,322	31,308	28,666	28,666	0.2	-8.5	-8.5
		Subsidies	6,690	7,478	7,403	7,403	8.5	7.4	7.4
		Gross Margin	19,367	20,006	20,882	20,882	3.2	7.7	7.7
	Forlì	GSP	116,004	115,103	112,866	112,866	-0.8	-2.7	-2.7
		Subsidies	4,946	5,638	5,671	5,671	14.0	14.7	14.7
		Gross Margin	61,560	61,266	61,436	61,436	-0.5	-0.2	-0.2
	Modena	GSP	73,342	68,960	65,971	65,971	-5.9	-10.1	-10.1
		Subsidies	8,122	10,102	10,122	10,122	24.4	24.6	24.6
		Gross Margin	45,515	44,112	44,945	44,945	-3.1	-1.3	-1.3
	Piacenza	GSP	58,069	55,796	54,787	54,787	-3.9	-5.7	-5.7
		Subsidies	5,264	5,997	5,946	5,946	13.9	13.0	13.0
		Gross Margin	34,871	34,181	34,627	34,627	-2.0	-0.7	-0.7
	Parma	GSP	92,541	84,194	82,879	82,879	-9.0	-10.4	-10.4
		Subsidies	7,633	10,764	10,739	10,739	41.0	40.7	40.7
		Gross Margin	55,239	51,907	52,828	52,828	-6.0	-4.4	-4.4
	Ravenna	GSP	56,673	55,960	53,712	53,712	-1.3	-5.2	-5.2
		Subsidies	7,430	8,083	8,041	8,041	8.8	8.2	8.2
		Gross Margin	34,859	34,910	35,490	35,490	0.1	1.8	1.8
	Reggio Emilia	GSP	85,054	77,205	73,637	73,637	-9.2	-13.4	-13.4
		Subsidies	6,192	8,812	8,805	8,805	42.3	42.2	42.2
		Gross Margin	48,768	45,541	46,574	46,574	-6.6	-4.5	-4.5
Rimini	GSP	37,081	37,116	35,567	35,567	0.1	-4.1	-4.1	
	Subsidies	1,836	1,960	1,960	1,960	6.8	6.8	6.8	
	Gross Margin	19,652	19,767	19,877	19,877	0.6	1.1	1.1	
Emilia-Romagna	GSP	667,265	640,904	616,122	616,122	-4.0	-7.7	-7.7	
	Subsidies	60,305	72,250	72,074	72,074	19.8	19.5	19.5	
	Gross Margin	396,675	378,185	364,574	364,574	-2.2	-0.5	-0.5	

Table 4: Results of the FIPIM model on economic sizes

CLASS	Province	Economic Variables	Economic Values						
			Baseline	Sim_OCM	Sim_D	Sim_DM	Sim_OCM	Sim_D	Sim_DM
			(000 Euro)				(Var. %)		
JUT-Franchise	Bologna	GSP	240,102	236,440	229,842	229,835	-0.7	-4.3	-4.3
		Subsidies	19,354	21,243	21,239	19,530	9.8	9.7	0.9
		Gross Margin	135,180	135,387	136,186	134,478	0.2	0.7	-0.5
	Ferrara	GSP	271,325	271,754	268,905	268,479	0.2	-0.9	-1.0
		Subsidies	46,069	56,401	55,067	50,844	22.4	19.5	10.4
		Gross Margin	180,820	188,965	191,085	186,949	4.5	5.7	3.4
	Forlì	GSP	33,768	33,420	33,136	33,135	-1.0	-1.9	-1.9
		Subsidies	2,576	2,869	2,871	2,644	11.4	11.4	2.7
		Gross Margin	19,456	19,369	19,533	19,306	-0.5	0.4	-0.8
	Modena	GSP	100,095	97,740	96,940	96,927	-2.4	-3.2	-3.2
		Subsidies	12,447	14,255	14,175	13,088	14.5	13.9	5.2
		Gross Margin	63,211	63,008	63,676	62,591	-0.3	0.7	-1.0
	Piacenza	GSP	164,346	162,192	161,278	161,274	-1.3	-1.9	-1.9
		Subsidies	15,809	14,930	12,756	11,548	5.6	-19.3	26.9
		Gross Margin	100,261	100,256	100,047	99,840	0.0	0.2	-1.4
	Parma	GSP	121,635	117,067	111,435	111,435	-3.0	-8.4	-8.4
		Subsidies	7,188	9,031	8,822	8,386	25.6	22.7	16.7
		Gross Margin	68,243	66,185	66,430	65,995	-3.0	-2.7	-3.3
	Ravenna	GSP	106,542	105,954	104,150	104,146	-0.6	-2.2	-2.2
		Subsidies	8,409	9,149	9,116	8,269	8.8	8.4	-1.7
		Gross Margin	61,247	61,388	61,748	60,901	0.2	0.8	-0.6
Reggio Emilia	GSP	83,729	79,412	79,106	79,103	-5.2	-5.5	-5.5	
	Subsidies	5,599	7,373	7,439	7,025	31.7	32.9	25.5	
	Gross Margin	50,637	48,826	49,243	48,829	-3.6	-2.8	-3.6	
Rimini	GSP	16,904	16,408	15,750	15,750	-0.6	-4.6	-4.6	
	Subsidies	835	937	941	908	12.3	12.7	8.7	
	Gross Margin	8,776	8,755	8,815	8,782	-0.2	0.4	0.1	
Emilia-Romagna	GSP	1,138,045	1,122,386	1,100,542	1,100,083	-1.4	-3.3	-3.3	
	Subsidies	118,285	136,187	132,425	122,244	15.1	12.0	3.3	
	Gross Margin	687,831	692,150	696,762	686,672	0.6	1.3	-0.2	
Emilia-Romagna Total	GSP	1,805,311	1,763,291	1,716,664	1,716,205	-2.3	-4.9	-4.9	
	Subsidies	178,590	208,437	204,499	194,318	16.7	14.5	8.8	
	Gross Margin	1,074,505	1,070,335	1,081,336	1,071,245	-0.4	0.6	-0.3	

## 6. Conclusion

One of the greatest difficulties in constructing regional agricultural policy analysis models based on micro-economic information lies in the access to data able to correctly reflect the behaviour of the farmers, and the availability of suitable analysis methods. This difficulty is combined with the need to construct models that provide ever more detailed information at sub-regional level, as it is at this level that the value of compensation for many processes subject to EC aid is defined (cereals, oil and oleaginous crops, etc).

From this starting point springs the need to find alternative information sources to the classic statistical data, which can however reflect the characteristics and strategies of the farmers in terms of structure, adopted production organisation, production capacity and relations with the market. This information is easily available today thanks to the integration of the FADN and IACS databanks. Despite their creation for completely different purposes, after suitable data processing these databases are able to provide a precise picture of the agricultural system in a given territory, without jeopardising the information and the later universe return phase.

It is precisely the use of statistical sources with the above-described characteristics that allows us to apply specific methodologies such as PMP, which not only allows us to reproduce the characteristics of the companies in a region, but allows us to estimate the behaviour of the farmers faced with the variation in agricultural policy choices, starting at the smallest level of detail, the sub-region.

The integration of the two databases with the PMP methodology is an important step forward in the analysis of the effects of the agricultural policy measures, because it allows for the later aggregation of the models, moving the analysis from sub-regional, to regional and to national level.

The regional and national model is characterised by a high level of flexibility, which allows us to join together sub-regions with similar administrative and climatic characteristics. Moreover, the possibility to obtain “local optimal” solutions allows us to put regional and national constraints into the model, thus being able to predict more correctly the effect of the policies on every single region.

The agricultural policies that can be predicted are those relating to the variation of compensation, different methods of payment (coupled and decoupled), reductions in payment (modulation) and quota policies. The model allows us to measure the quantitative and qualitative effects in terms of: use of the soil, crop supply, amount of total income for farmers, total cost of the policies at regional and sub-regional level and value of the marginal cost of the soil factor.

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