In the European Union, the Farm Accountancy Data Network (FADN) collects data with the aim of determining costs and incomes and doing a business analysis of agricultural holdings. FADN is used to reach two objectives: on the one hand it is a basis for agricultural sector analysis and on the other it is a fundamental instrument for agricultural policy analysis. One of the problems of the FADN is the lack of an analytical book-keeping system: standard farm accounting information are limited to aggregate farm input expenditures, and production costs per unit of output are not collected at the level of production process. Their estimation is possible only applying specific allocation coefficients or using statistical methodologies. Unlike other EU Countries, in the Italian FADN (RICA) some costs are allocated to each production process by the surveyors at the end of the accounting year. This is, clearly, an arbitrary allocation procedure that can be subject to inaccuracies if the farmer does not record the costs separately or if there are aggregate costs or joint costs for which it is difficult to make an objective attribution.

This book presents some important results of the FACEPA project (Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture), a Small collaborative project (Grant agreement 212292) funded by the Seventh Framework Programme (KKBE-2007-1-4-14) which concerns the application of econometric (GECOM model) and mathematical programming methodologies (PMP) to estimate the cost of production in agriculture for the most important agricultural commodities. INEA was one of the involved partner and the leading partner of WP6 "Modelling farm technologies".

The book is structured in five chapters. Initially a theoretical framework of analysis of the production cost in agriculture is presented, together with a description of FADN dataset. The second chapter presents the structure of the econometric model (GECOM) and the application to the Italian FADN. The model has been adapted modifying some variables and taking into account the difference between areas and the characteristics of farm production at a local level. Three chapters are devoted to the PMP model application for arable crops in three northern regions (Lombardy, Piedmont and Veneto): unlike the econometric method, the PMP model produces information about the modification of farm technologies and farmer's behaviour in case of changes in agricultural policies and prices.

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ISBN 978-88-8145-294-1

THE USE OF RICA TO ESTIMATE THE COST OF PRODUCTION IN AGRICULTURE

INEA 2013

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ISTITUTO NAZIONALE DI ECONOMIA AGRARIA

THE USE OF RICA TO ESTIMATE THE COST OF PRODUCTION IN AGRICULTURE

APPLICATION OF ECONOMETRIC AND MATHEMATICAL PROGRAMMING METHODOLOGIES

edited by Luca Cesaro and Sonia Marongiu

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The Volume is the result of the research activity of INEA in FACEPA (Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture) project, a Small collaborative project funded by the Seventh Framework Programme (KKBE-2007-1-4-14)
The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement No 212292 (FACEPA).

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Chapter 5

Application of the PMP model with latent information

DESCRIPTION OF FACEPA PROJECT

FACEPA (Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture) was a Small collaborative project (Grant agreement 212292) funded by the Seventh Framework Programme (KKBE-2007-1-4-14). It extended over three years, starting in April 2008 and ending in April 2011. Nine Member States were involved in the project with Universities and National Research Institutes (Table A).

Table A: List of beneficiaries of FACEPA project

Beneficiary name	Short name	Member State
Swedish University of Agricultural Sciences	SLU	Sweden
Swedish Institute for Food and Agricultural Economics	SLI	Sweden
Institut National de la Recherche Agronomique	INRA	French
Université Catholique de Louvain	UCL	Belgium
Istituto Nazionale di Economia Agraria	INEA	Italy
Johann Heinrich von Thunen Institut	vTI	Germany
Landbouw Economisch Instituut	LEI	Netherland
Corvinus University Budapest	CUB	Hungary
Estonian University of Life Sciences	EMU	Estonia
Ministry of Agriculture and Food Supply	MAFS	Bulgaria

The project was divided into ten work packages. All of them include several sub-tasks in order to optimize the organization of the research and to ensure that the different partners work together (in brackets, the partner leading the WP). Nine of them deal with research activities and one refers to management activities:

- WP1 – Concepts (LEI)
- WP2 – Specification and development of a general production cost model (SLU)
- WP3 – Implementation and validation of the general production cost model (vTI)
- WP4 – Dissemination and valorization of the production cost model (INRA)
- WP5 – Applications and extensions of the production cost model: performance analysis (CUB)
- WP6 – Modelling farm technologies (INEA)

- WP7 – Production cost and environment (SLI)
- WP8 – Methodological applications and improvements (SLU)
- WP9 – Evaluation of public policies (UCL)
- WP10 – Project management (SLI)

The first four WPs deal with the development, implementation, validation and dissemination of an economic model for estimating the cost of production of various types of agricultural commodities using the FADN data. The next four WPs focus on applications and extensions of the cost model that are relevant for the study of performance, policy and farm structure in EU agriculture. The objective of WP9 is to evaluate public policies using cost estimates obtained in the previous work packages.

Every WP has been summarized in different deliverables (30 in total, see Annex 1) that describe the theoretical and practical framework of every task implemented by the partners. The objectives of the project can be summarized as follows:

- to address the usefulness and appropriateness of the present FADN (Farm Accountancy Data Network) system to measure cost of production for agricultural commodities;
- to study the feasibility of developing a "general" production cost model for EU agriculture, easy to use by practitioners and reliable in terms of generating relevant analysis for agricultural production and policy analysis;
- to test and implement this cost model in a European context with the idea of applying it on a large scale (several agricultural commodities in several European countries);
- to assess the relationship between cost structure and farm performance, farm technology, environmental quality and farm heterogeneity with FADN datasets;
- to provide methodological improvements to the "general" production cost model;
- to undertake the evaluation of agricultural policy measures using FADN indicators.

The FACEPA scientific coordinator was the
Swedish University of Agricultural Sciences (SLU, Prof. Yves Surry).

The project results are available on a website
http://www2.ekon.slu.se/facepa/

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INTRODUCTION

In spite of the trend towards increased specialization that has characterized farming in many European countries, most farms still have more than one production activity or enterprise. Standard farm-accounting information is typically restricted to aggregate farm input expenditure and, as a consequence, it is difficult to obtain indications about production costs per unit of each enterprise's output or activities.

Why is it important to have information on the cost of production at farm level?

First of all, because the estimation of product cost is useful in the decision-making process at farm level: knowing the profitability of the individual products can help in the planning of future production. Product cost can be used for investment justification, sourcing materials and services, new product introductions, market strategy and engineering process changes. Full costs and variable costs are also used to evaluate the profitability of a product, to determine the optimal production process to take pricing decisions. comparisons of product costs structure between farms (in the same region or in different ones) could also lead to greater efficiency in the production process of individual farms. The benchmarking process could also be used for different time periods.

Secondly, the importance of using farm costs calculation and estimation for policy purposes is increasing, especially in Europe where farming systems have undergone important changes. Over time, policymakers have used the cost of production as a basis for farm policy (either directly or indirectly), and especially to take decisions about price support levels.

All these raise concerns about farm accounting data and the need to improve the cost data concept and other farm indicators have forced researchers to develop appropriate tools (models) to estimate the cost of production for agricultural commodities in the European Union. The FACEPA project started in this context with the objective of implementing one approach to estimate cost of production using the FADN database (at the European or national level). As the FADN system is not based on analytical accounting, there is no separate recording of costs for the various activities or enterprises on the holding. The specific costs of crop products and livestock are recorded separately (not by product but by group of products) and all other costs are recorded with respect to the whole farm. Given that the direct collection of farm level information is difficult, as it requires costly farm surveys and is often subjective, tools based on econometric techniques may offer an alternative for obtaining estimates of unit costs of production at a relatively lower cost.

Another method that can be implemented uses Positive Mathematical Programming (PMP) techniques, which can represent farm technologies and relative cost structures on the basis of the FADN database. One of the advantages of PMP models is that they permit different farm technologies in diverse territorial contexts and their relative total variable cost at farm level to be considered.

These two methods have been tested and implemented in the FACEPA project. The econometric model (that follows the scheme initiated in France almost twenty years ago by the Agricultural Division of INSEE and the research economists of INRA) was tested and developed in WP3, while the PMP model implementation was the main task of WP6. INEA has been involved in both WPs and as leading partner of WP6 Modelling farm technologies.

This book presents some important results of the FACEPA project. They concern the application of econometric and mathematical programming methodologies to estimate the cost of production in agriculture for the most important agricultural commodities in Italy. With respect to the original scheme of the models (structured to run with the European FADN dataset), further efforts have been made to adapt them to the Italian FADN dataset (RICA), which has a different variables aggregation. With respect to the European FADN dataset, the Italian FADN system includes information about the specific costs per production process. The allocation is made by the surveyors every year on the basis of farmers' indications or their experience. These observed costs have been compared with the estimated costs resulting from the implementation of both models.

The book is divided into five chapters.

In the first one, a theoretical framework of analysis of the production cost concept is provided, describing the different approaches to calculate and estimate production costs in agriculture. In fact, there is a lack of analytical accounting in the agricultural sector that makes cost allocation very difficult and subjective. This is due to the presence of multiple activities or enterprises (so, many indirect and common costs) and to the presence of mixed farms where some costs are connected to one product (directly attributable) while others must be allocated using appropriate allocation keys. The FADN dataset is, consequently, characterized by the same lack: the costs are recorded but not allocated to different crops.

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Knowledge about the FADN dataset is important to determine how these data should be used in the choice of the allocation approach. This choice is the main problem of every methodology and many studies have attempted to solve it. Some of them are widely described in the literature and are based on the application of allocation keys to the FADN dataset, determined in different ways depending on the cost structure and final objectives of the analysis. Others are based on the use of the FADN dataset to run econometric and mathematical programming models, more accurate from a statistical point of view, applicable on a large scale, and which can also be used to carry out scenario analyses. The last section of the chapter deals with the International Accounting Standard 41 Agriculture, indicating some studies and analyses concerning the adoption of these standards in FADN. The chapter summarizes the contents of Deliverable 1.1.2 (Cost of production. Definition and contents) issued by INEA.

The second chapter presents the structure of the econometric model, named GECOM (General Cost Estimation Model). This model, tested and implemented in WP3, has initially been applied on the FADN dataset to estimate cost of production of several agricultural commodities in several European Member States. Its flexibility has permitted a specific application to some national cases, such as the Italian FADN. The model has been adapted modifying some variables (input aggregation) and adding the most important Italian crops, taking into account the difference between areas and the characteristics of farm production at a local level.

The chapter summarizes the contents of Deliverables 3.1 (Implementation, validation and results of the production cost model using national FADN databases) and 3.2 (Implementation, validation and results of the production cost model using the EU FADN databases) of the FACEPA project and presents the results of the adaptation to the Italian FADN dataset.

The second part of the book deals with production cost estimation by means of Positive Mathematical Programming techniques. The activities have been carried out by INEA in WP6 (INEA was the leading partner). The objective of the work is the estimation of the cost for different production processes but also to offer a methodological framework that can analyze the impact of an environmental perturbation (market price or agricultural policy) in terms of farmer's technological adjustment. The traditional PMP models, in fact, provide results on the effect of alternative scenarios in terms of land allocation and farm economic performances; the model presented in this book also produces information about the modification of farm technology.

The general framework of the approach is described in chapter 3, where the difference between the standard and dual approach is explained in detail. The application of the model to the Italian FADN dataset and the validation procedure is described in chapter 4: the analysis has been restricted to arable crops (Farm Type 1) in three northern regions (Lombardy, Piedmont and Veneto) considering different levels of aggregation. In order to validate the procedure the estimated accounting costs are compared with the observed accounting costs through the t-test. Chapter 5 discusses application of the PMP model with the latent information, not revealed by the accounting books but considered a very important component of the farmer's decision-making process. Different simulation scenarios (agricultural policies and prices) have been hypothesized in order to analyze changes in technology and farmer's behaviour. The model has been applied only for farms specialized in arable crops in Veneto region, simulating the introduction of sorghum as latent crop for biomass production in the regional production plan.

The chapters summarize the contents of Deliverables 6.1 (Methodology to assess farm production costs using PMP farm models), 6.2 (Methodology for the definition of case study farms and model structure for each case study) and 6.3 (Effects of the single farm payment on cost function and production function) of FACEPA projects.

The book ends with the conclusions.

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Chapter 1

ESTIMATION AND CALCULATION OF THE COST OF PRODUCTION IN AGRICULTURE

1.1 Some general concerns about cost estimation in agriculture

The last four decades have witnessed a major increase in research investigating product costing practices and production cost estimations. Starting from the industrial sector, the different methodologies have also been applied in other sectors, including agriculture (Ahern, Vasavada, 1992; Brierley et al., 2001). In the agricultural sector, the need to measure and estimate the cost of production had its roots in the agronomy discipline, with the emergence of farm management specialists. The aim was the measurement of cost of production at farm level to improve farmers' decisions by providing a means to assess their management strategies and achieve greater efficiency and higher profits. Over time, the measurement of farm costs has also been used for other purposes such as agricultural policies, comparisons between sectors, comparisons between countries or regions, etc.

Today's agricultural inputs and outputs are more complex than in the past, so economic theory has become more sophisticated and precise. Although farms have usually been excluded from cost accounting research and since the procedures of record keeping and accounting appeared not to be necessary, empirical evidence has been found on the usefulness of accounting when aiming for a high performance level in farm management (Argilés and Slof, 2001; Argilés and Slof, 2003).

Notwithstanding the importance of collecting information on the cost of production, the accounting methods for agricultural activities have received little attention from accountants and regulators in many countries. Instead, some countries have developed sophisticated tools for specific accounting in the agricultural sector. For instance, the Agricultural Resource Management Survey (ARMS) conducted by the United States Department of Agriculture is the primary source of information on the financial condition, production practices, resource use and economic situation of America's farming households. This survey is sponsored by the Economic Research Service and the National Agricultural Statistics Service and is the only national survey that provides observation at a farm level. Survey data used in estimates prior to the ARMS were collected as part of the annual Farm Cost and Returns Survey (FCRS) from 1984 to 1995 and the Cost of Production Survey (COPS) prior to 1984. In Canada, the Farm Level Data Project (FLDP) provides data for monitoring the financial and economic conditions on farms. An essential component of this is the Whole Farm Database (WFDB), which integrates all the available agricultural data (physical and financial).

In the European Union, the Farm Accountancy Data Network (FADN), established by the European Commission in 1965, has developed general procedures and detailed guidelines for farm accounting. FADN collects data from farms with the aim of determining costs and incomes and doing a business analysis of agricultural holdings. This has produced a highly structured body of data collection rules and procedures designed to produce aggregated reports that are similar to a balance sheet and an income statement. FADN is the only source of microeconomic data for agriculture that is harmonised within the European Union: data are collected in every Member State following a common standardised guideline. FADN is used to reach two objectives: on the one hand it is a basis for agricultural sector analysis and on the other it is an instrument for agricultural policy analysis. It has also been used to make cross-country comparison (FADN-ARMS database) of cost of production estimates (Bureau et al., 1992).

One of the problems of the FADN dataset (and, in general, of the whole agricultural sector) is the lack of an analytical book-keeping system: standard farm accounting information is restricted to aggregate farm input expenditure, without revealing production costs per unit of output of each enterprise. Obtaining them is possible only applying specific allocation coefficients or using statistical methodologies.

The methodology that tracks, studies and analyzes all the costs accrued in the production and sale of a product is named product costing. The application of product costing methodologies in the agricultural sector presents some difficulties. Today, despite a higher specialization level, the fact that there is more than one enterprise on a farm makes it difficult to allocate all the costs among them. So, costs known at a farm level must be shared among the enterprises or recalculated using estimation norms. Briefly, the difficulties of product cost estimation and calculation in the agricultural sector can be summarized as follows:

- in the agricultural sector, there are multiple activities and enterprises;
- the common costs subject to allocation are usually a considerable component of total costs;
- the determination of farm uses is complex;
- crop yields can change from year to year depending on the weather: a consequence is a change in the indirect costs and, so, a variation of the stock values;
- on dairy farms, there are difficulties in the evaluation of stock and activities connected with the animals born on the farm. In this case, it is necessary to take into account the expenses of purchasing breeding cattle and other general costs (veterinary fees, etc.);
- on farms there is usually not a developed use of book-keeping practices.

There are, consequently, different methods to calculate or estimate production costs, depending on the costs, farm type, accounting approach, final objectives and uses, etc.. Each methodology follows a specific theoretical framework and has a justification within a specific modelling context. The way in which costs are analyzed depends on the final objective and on the use of the analysis. Measurement of the cost of production at farm level can improve farmers' decisions by providing a mean for assessing management strategies in order to achieve greater efficiency and a high profit. Moreover, the use of production cost estimates has been extended and today regards not only farm management specialists, but also the policymakers who use the estimates to set prices, subsidies, agricultural policies, etc.. Cost estimating is a precursor to cost accounting: it is done prior the production of goods and services while cost accounting is done after their production. In the next paragraphs both aspects will be analysed in detail.

1.2 Approaches to estimate and calculate cost of production

There are different methodologies to estimate and calculate cost of production. In general the approaches may be grouped into three categories (French, 1992).

The first one is the *descriptive analysis approach* based on accounting data, which mainly involves combining point estimates of average costs into various classes for comparative purposes. The descriptive approach was the first method used to study farm marketing efficiency. The computational procedures involved in this approach are very simple, being based on average accounting cost records for a particular time period obtained from a sample of crops farms. This approach is very popular because it is relatively cheap (compared to the other approaches) and easily understood by managers, providing a means to relate their own cost experience to the experience of others. The limitation is that it needs a high standardization of the book-keeping system among farms. Moreover costs are influenced by different factors that cannot be separated. It provides no quantitative measures of parameters and few general clues regarding the types of functional relationships between costs and production factors.

The second is the *statistical analysis approach* (survey approach), which attempts to estimate functional relationships by econometric methods starting from the accounting data. This approach uses the same data as descriptive analysis but develops quantitative estimates of production and cost functions. Differently from the previous approach, data defects may be of great importance because of the potential for biasing quantitative functional estimates. The most important limitation of this approach is connected with the data because, even with uniform accounting systems, it is impossible to eliminate every degree of distortion. The estimates can be made using cost functions from time-series data, average regressions from cross-section data, frontier function and so on. However, lengthy time series may reflect variations in the farm physical structure and in this case, it is necessary to have some measure of the nature of this change. A problem also arises in the presence of arbitrary and variable systems for allocating common costs among enterprises.

Lastly, the *economic-engineering approach* represents production and cost relationships from engineering data or other estimates of the components of the production function. This method requires much greater familiarity with technical aspects of production than the typical analysis of accounting data. It is necessary to understand the production system, the nature and sequence of operations, the links among them, etc. The input-output relationships may be determined by engineering formulas and studies of the different processes. For example, the specification of requirements per hour of machinery operation. This approach encompasses studies ranging from simple descriptive comparisons of labour time requirements to detailed estimates of short- and long-term cost functions. Once the production functions have been specified, the cost functions are determined by applying factor prices. The economic-engineering approach avoids many problems highlighted for statistical studies. Moreover it can be applied in cases where accounting data are not available. It is usually the only approach possible when the objective is to compare operating methods or develop improved methods. A major limitation is the high research cost: the amount of technical data required to synthesize cost functions can be very expensive compared with the analysis of accounting data. Another shortcoming is the use of constant input coefficients that makes it impossible to measure or account for coordination problems such as crop farm increases in scale.

Obviously, two or more approaches are frequently combined. For example, economic-engineering studies may rely on statistical estimation based on accounting data for some components. Moreover, many descriptive comparisons of costs rely mainly on data generated by quasi-engineering types of measurement.

Generally speaking, there are separable objectives which are achievable only using a particular approach. For example: if the analysis focuses on the description and comparison of costs on farms that operate in different ways and with different practices, the descriptive and statistical analysis of accounting data could be sufficient. If the objective is to measure the short-term cost function to provide managerial tools for decision-making, then the statistical and economic-engineering approaches can be combined. Other purposes of cost estimation are: budgeting, measurement of performance efficiency, preparation of financial statements, estimation of the sale prices of products, etc..

1.3 Principles and methodologies for cost accounting

While cost estimation is the process of pre-determining the cost of a certain production, cost accounting is the process of determining costs on the basis of actual data and it is done after the production of goods and services.

Cost accounting[1] is defined as the methodology by which all elements of cost incurred in an activity are collected, classified and recorded. These elements are summarized and analyzed to determine a selling price or to discover where savings are possible. Cost accounting is one of the main aims of analytical accounting.

With respect to general accounting, where elementary costs are collected

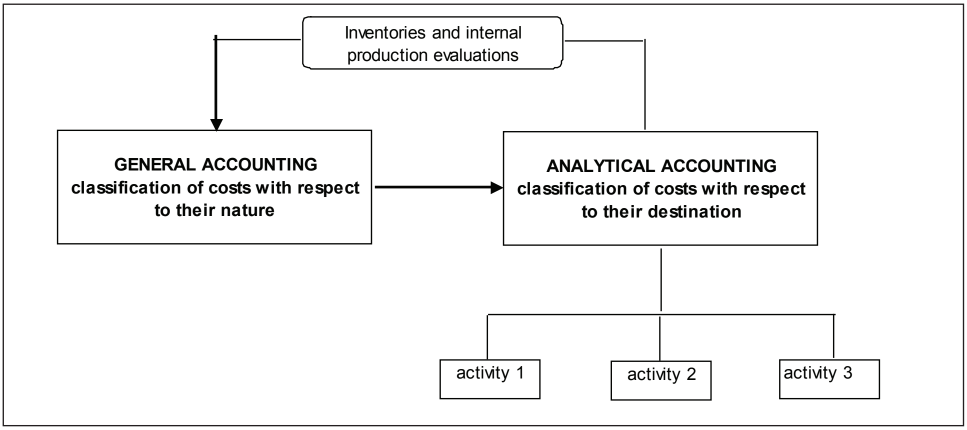
1 Cost accounting methodology originated during the industrial revolution in the 19th century when the complexity of business led to the development of a system for recording and tracking costs in order to help owners and managers in the decisional process. Initially, most of the costs were variable costs, varying directly with the amount of production and not difficult to allocate. Over time, overheads and fixed costs became more important, especially in the cost accounting practices of American industry where different cost accounting systems were formulated (over all the standard costing). Many of these concepts are used today (including the cost opportunity) together with a large literature concerning the aspects of cost behaviour. With the increase of complexity in cost accounting, new tools and quantitative methodologies have been developed to solve planning and control problems. For example: linear regression techniques, linear and non-linear programming, Bayesian estimation techniques, probability theory, and so on. However, the problems are the same as in the past: determination of fixed and variable costs, assessment of profitability, allocation to costs, etc.

and classified according to their nature or origin, in analytical accounting the costs are allocated to the different enterprises, according to the destination when consumed or used.

What is a production enterprise? Following the report of the AAEA (American Agricultural Economics Association) Commodity Cost and Returns Estimation Handbook (2000), a production enterprise is any portion of the general input-output structure of the farm business that can be separated and analyzed as a distinct entity. This entity uses inputs (and incurs costs) to produce an output (returns) or some fixed set of resources. So, a farm can be divided into enterprises in several different ways, depending on the production, technology, etc. A common delineation of enterprises is made considering the commodity lines (i.e. the barley enterprise, dairy enterprise, etc.) but in many cases, a neat division is not possible or not desirable. In other cases, it is necessary to estimate the detail of the costs of some enterprises.

Considering this definition, the aim of analytical accounting is to determine the costs of every farm activity or enterprise, to define the right evaluation rules for the different elements of the balance and to verify the correspondence between the estimated and realised values. Figure 1.1 summarizes the links between general and analytical accounting: cost accounting is an analytical methodology that uses the original information coming from general accounting and returns the inventories and internal production evaluations to general accounting.

Figure 1.1 - Links between general and analytical accounting systems



The allocation of costs to the activity or products can be made in different ways.

The *Direct Costing (DC)* procedure considers only variable costs and permits an easy determination of the final product cost. It is the preferred cost estimation procedure because it does not require any assumptions about prices or quantities: the majority of costs are direct and traceable. However it works well when the farmer has commodity specific records or can recall the amount spent for the commodity. For example: in the case of crop fertilizer and chemicals, it is sufficient to take into account how much was paid per hectare for the inputs used to produce the crop. In the case of other costs, such as livestock customs services, it is necessary to define how much of the total farm expenditures for each input was for production of the livestock commodity.

Indirect Costing (IC) also considers indirect costs. It is used to allocate these costs among the farm enterprises. As previously stated, farms are characterised by the presence of different productive processes and an allocation of common and fixed costs (recorded as a whole) among them is required. In this case it is important to define the right cost allocation rule in order to make the product costs truly representative of the production factors used to obtain them. there are no problems for direct and traceable costs because quantity and prices are clearly identified. For indirect costs it is more difficult. Usually, it is assumed that there is a relation between the rate of indirect costs allocated for a product and its quota on the whole production. Another way to allocate overhead costs is the volume-based allocation method: the costs are allocated to the enterprises in accordance with the volume of direct labour hours, direct labour costs or contract amount. So, a percentage of direct costs is considered.

Activity Based Costing (ABC) applies an attribution of all costs to the activities, depending on the amount of activities that are needed to produce that product. Traditional cost accounting reports fail to report the cost of activities and processes. In particular, the methodology to allocate the indirect costs (overheads) using an arbitrary percentage of expenses deriving from the consideration of direct costs, causes distortions. For example: let us suppose that the direct cost taken into account is the direct labour and materials and there are two products with different needs for a particular machine. In this case the amount of direct labour and materials is the same and this causes distortion in the allocation of fixed cost of machinery between the two products. So, when multiple products share common costs, there is a danger of one product subsidising another. ABC is an approach useful to solve the problems of traditional cost management systems, that appears to be inaccurate in the case of multiple products. ABC seeks to identify cause and effect relationships to assign costs. Once costs have been identified, the cost of each activity is attributed to each product to the extent that the product uses the activity. Because this method needs a lot of information (for example, hours of labour and machines used for different activities) that is not collected in FADN, this method is not possible using this network.

Standard Costing (SC) is the system in which actual costs are compared to predetermined costs in order to generate cost variances, whose analysis is useful to improve control of the business and increase efficiency. It provides the basis for the concept of accounting control. different studies have been done on the efficiency of the standard costing system and its ability to provide effective managerial control. Initially (from the late 18th to the late 19th century), cost information was used for a wider range of planning and control decisions and standard costs were used in the form of norms or targets. The standards represented actual results that had been obtained for similar activities or in prior periods, so they were the results of an archive-based research (deriving from an objective view of historical knowledge). Cost variances from the standard were neither computed nor used to evaluate managerial performance: for example, individual employees were evaluated according to quality, quantity and other criteria but cost data were not taken into account in the calculation. Anyway, in the past, this system was largely used to measure waste and inefficiency: the traditional environments with clear goals and stable product lines made the firms able to use currently attainable standards as a benchmark to evaluate performance. Standard costs were used to set the prices. Over time, things have changed as international competition forces to innovate, improve quality and reduce costs. Today, the ultimate objective of a firm is not to make a cost control because global competition and customers demand much more, such as for example, greater value and better performance. There is a shift from cost control to cost reduction: standard costs better serve as long-term targets of cost reduction rather than as static benchmarks for cost control. This new role derives from the intense competition as well as from the inability of firms to use cost-based pricing strategies. The new concept of standard is the value-added standard that will not be achieved immediately but represents a longer-term goal that may be flexible and only achieved through continuous improvement and cost reduction. Value-added standards are the norm in Japanese accounting systems and are the antithesis of past American and British practices.

Historical Costing (HC) is a method that uses historical costs for direct materials and direct labour while overheads and indirect costs are charged using a predetermined overhead rate per activity measure. The amount of overheads is obtained multiplying this rate by the quantity of activity measure.

1.4 The allocation of joint costs and overheads: a literature review

As previously mentioned, one of the main problems in cost accounting is to allocate the cost among different enterprises or productions. The analytical accounting system enables specific costs for every single activity or enterprise to be separated and provides some parameters to allocate overhead costs. There are different methods for this and they depend on the management information used on the farm. If a farmer keeps detailed records of the use of various farm resources, those records will likely form a sufficient basis for allocation. However, it is difficult to record and track data in agricultural holdings and, so, other allocation indicators must be used.

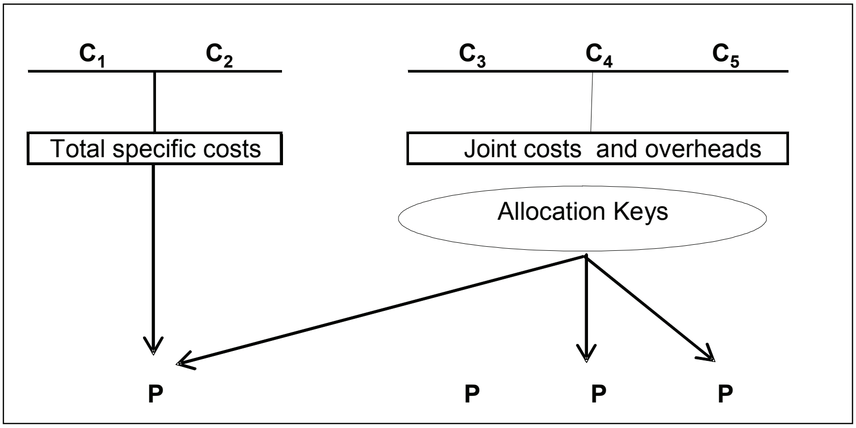
An important distinction in agricultural accounting is made between direct and indirect costs on the basis of the relation and reference to the final objective. The direct costs are traceable, specific and directly attributable to the final objective. The indirect costs require an arbitrary procedure to be allocated, being common to different objectives.

In the agricultural sector, the presence of more than one enterprise leads to the recording of the joint production costs, which are incurred on groups of products rather than on individual and separate ones (AAEA CAR Estimation Handbook, 2000). Joint production costs exist in three different situations:

- expenses incurred in the production of joint products;
- expenses for inputs that affect the production of more than one independent enterprise (capital inputs or fixed inputs: for example the allocation of fertilizer total cost among several different crops or the division of the total number of tractor hours between crop and livestock activities);
- expenses that are incurred on the farm as a whole (general farm overheads).

These three cases may give rise to joint costs that occur as either direct or indirect costs. In the case of joint direct costs, when there is a need to estimate costs for individual enterprises, the allocation may be made on an objective basis and using objective data (for example, land allocation, hours of use, etc.). For indirect joint costs (overheads) there are different procedures that, in any case, are implemented in an arbitrary manner. The following scheme (Figure 1.2) explains the methodology. Choosing a specific activity or enterprise, the production cost will be the sum of specific costs and farming overheads, allocated using appropriate allocation keys.

Figure 1.2 - Allocation of joint costs and overhead costs



There is not just one allocation key. The existence of different kinds of joint costs makes the choice of the appropriate allocation key necessary.

1.4.1 The allocation of indirect production joint costs (overheads)

Generally speaking, the methods developed to allocate overheads are referable to two common methodologies (AAEA CAR Estimation Handbook, 2000):

- allocation on the basis of gross value of farm production
- allocation on the basis of other allocated costs

With regard to the first methodology, enterprises are impacted relative to their importance to overall farm profit. Moreover, decisions about enterprise selection and management are neutral to general farm overhead expenses. However, when an enterprise has a negative margin, this method creates a mathematical problem. In this case, it is recommended that an allocation is made on the basis of long-term expected gross margins or other allocated costs.

This can lead to a relatively low profitability of products with relatively high (variable) costs already allocated (for instance, on a farm with cereals and pigs, cereals have relatively low variable costs with respect to pigs. Following this method, the profitability of the pig sector could result as relatively low).

To solve this problem on mixed farms, there is a method that takes the cost of fully specialized farms and uses the level of those costs to divide the costs of the mixed farms between the products. Obviously, this is possible only if there are enough specialized farms for the different products produced in a mixed farming system. The criticism is that the cost per product on the specialized farms differs from the cost of that product on mixed farms because of economies of scale and the results will consequently just be approximations.

A mix of these two approaches has been used by the LEI Wageningen Research Unit, which has developed two simple methods to allocate overheads. The first one assumes that in the long run every product has the same profitability (expressed as revenues/costs) because otherwise the farmer would change his product composition. So, the common costs are allocated in such a way that every product has the same profitability. This method can be a reasonable approximation of production costs only if based on several years and for fairly specialized farms. Otherwise, the approximation would be too rough. The second method can be used for products which are necessarily produced together and it supposes that the by-product is only produced because of the main product. So, the by-product forms only a small part of the total production (for example, milk and beef on farms specialized in milk production). This scheme is similar to the theory of Proni (1940), used in different Italian analyses. Following this approach, the production cost of the prevalent output can be calculated in two steps:

- first of all, the whole farm costs are calculated, without distinction among the different productions. The total cost can be obtained simply using the farm balance sheet.
- in the second step, the by-product cost is subtracted from the total cost and the difference is the cost of the main production. The cost of secondary production can be assimilated to the market price in the hypothesis of a perfect competition market.

Ghelfi (2000) also proposes two kinds of procedures to allocate the costs to the different farm enterprises or activities. In the case of predominance of specific costs, the direct costing procedure may be adopted: the cost of the final product is obtained summing all the specific costs of the single activity. The simplest cases are monocultures and farms with one kind of livestock rearing. When the farms have more than one production or continuous production (so a predominance of common costs) the allocation is made using indirect costing methods. Following this procedure, the costs are distributed in intermediate cost centres and then allocated among the single products of every centre. The cost centres are basic accounting units which are defined depending on the technical and productive function of the farm. In the agricultural sector, they usually correspond to the main production activity of the farm: for example, milk and meat production on a livestock farm or crop and milk production on a mixed farm.

Another way to allocate overheads is described in research done in the UK by Drury and Tales (1995) concerning the accounting systems used by a sample of firms in the manufacturing industry. The authors did a pilot survey to examine what kind of allocation processes are used by the sample. Some organizations simplify the allocation process by not assigning manufacturing overheads to cost centres but calculating an overhead rate for a factory:

$$Overhead\ Rate = \frac{Indirect}{Direct}$$

This rate becomes the basis for allocating overheads to all products produced, regardless of the production department where the products were made. Obviously, the overhead rate is suitable for allocating overheads among products that consume resources in the same proportions. It is not suitable when these proportions differ. So, in the case of the agricultural sector, this method could be used to allocate overheads among activities with similar technical coefficients. To calculate overhead rates, direct labour hours and volume-based allocation procedures could be adopted: direct labour cost, direct labour hours, machine hours, material cost, units produced, production time, selling price, etc.

It is important to highlight that the volume of production can be used but it cannot be the only allocation key. The cost is also influenced by structural (size and vertical integration of the farm, experience, technology and complexity of the production process) and operative variables (management quality, production type, etc.). This is the reason why it is necessary to understand the behaviour of the costs by also considering other variables. Moreover, the use of volume-based methods to allocate the indirect costs causes an overcharge of a product with higher volumes in favour of those with low volume or those with highly complex production.

1.4.2 The approach of the Directorate General of Agriculture (European Commission)

A study concerning analysis of the costs allocation system comes from the Directorate General of Agriculture of the European Commission. As regards arable crops, a program named ARACOST for estimating the costs of production has been developed (EC DGAGRI, 1999). This program defines some rules for allocating costs to different enterprises using a volume-based allocation model. All costs (joint costs and overheads) are allocated on the basis of the percentage of the specific crop output on the total output of arable crops. For instance, seed and seedlings purchased, fertilizers, crop protection, motor fuel, lubricants, farming overheads, depreciation are allocated considering

$$\frac{\textit{Output of the crop X}}{\textit{Total output of arable crops}}$$

While motor fuel, lubricants, farming overheads and depreciation

$$\frac{\textit{Output of the crop X}}{\textit{Total output of the farm}}$$

With regard to the milk sector, the study focuses on the development of a methodology that takes into account the co-existence of beef production on farms for which costs of milk production are estimated (EC RI/CC 1342, 2001; EC RI/CC 1331, 2001; EC RI/CC 1436, 2006; EC G3/EL, 2007). In particular, the methodology defines the allocation key for farming overheads, depreciation and other non-specific inputs of specialized dairy farms at EU level (TF 41). The aim is to estimate the cost of production for milk on farms with different levels of specialization in milk production.

The allocation of the charges to milk production is based on three criteria depending on the kind of costs taken into account:

- specific costs (purchased feed for grazing livestock)
- other specific livestock costs (e.g. veterinary fees)
- all other costs (farming overheads, depreciation, external factors)

The share of dairy livestock units on the grazing livestock unit is used to allocate grazing livestock feed costs, while for the other livestock specific costs the share of dairy livestock units on the total livestock units is used. In the analysis the dairy livestock units are defined as dairy cows and a share of total breeding heifers and young females. This share is equal to the proportion of dairy cows in the total number of cows (dairy cows, cull dairy cows and others).

The specific costs of the crops (seed and seedlings, fertilizers and soil improvers, crop protection products) are shared according to the percentage of fodder crops, forage crops and temporary grass in the total Utilizable Agricultural

Area (UAA). This method permits an estimation to be made of the value of fodder plants, which is necessary because in some European Union countries (especially in the north), the value of fodder areas is not indicated in FADN.

A similar analysis was done of production costs for the beef sector (EC RI/CC 1342, 2001). Using the same methodology, the model has been limited to farms with suckler cows, making a distinction between those who just rear the young calves and those who fatten the animals on the farm. European typology does not allow a beef production system to be precisely identified, so the analysis uses an INRA study that created a Typology of Grazing Livestock System in the European Union. Table 1.1 displays the allocation keys used for every kind of cost used in the analysis:

Table 1.1 - Allocation keys used for the milk and beef sector costs.

Kind of costs	Allocation keys Milk sector	Allocation keys Beef sector
Specific costs (purchased feed for grazing livestock)	$\frac{\textit{Dairy livestock units}}{\textit{Total grazing livestock units}}$	$\frac{\textit{Beef livestock units}}{\textit{Total grazing livestock units}}$
Other specific livestock costs	$\frac{\textit{Dairy livestock units}}{\textit{Total livestock units}}$	$\frac{\textit{Beef livestock units}}{\textit{Total livestock units}}$
Other indirect costs (farming overheads, depreciation, ext. factors)	$\frac{\text{Milk and milk pr . output \& subs.}}{\textit{Total output \& subsidies}}$	$\frac{\textit{Beef livestock subsidies}}{\textit{Total output \& subsidies}}$
Specific forage costs (farm-use of forage crops)	$\frac{\textit{Dairy livestock units}}{\textit{Total grazing livestock units}}$	$\frac{\textit{Beef livestock units}}{\textit{Total grazing livestock units}}$
Seeds and seedlings	% area of fodder crops, other forage crops and temporary grass in the total UAA	
Fertilizers and soil improvers	% area of fodder crops, other forage crops, temporary grass and meadows in the total UAA	
Crop protection products	% area of fodder crops and other forage crops in the total UAA	

Source: DG Agri – European Commission

In the past, the indirect costs were allocated taking into account only the output. Due to the increasing importance of direct subsidies compared to market price support in beef production, the previous key has been replaced by the one in the table, which also considers subsidies (EC RI/CC 1331, 2001).

1.4.3 The Integrated Direct Costing approach

An interesting contribution to the application of analytical accounting systems in the dairy sector is provided by Arfini (1997). His analysis starts with the definition of the Cost Centre (CC) as a unit in which costs can be segregated and allocated. More specifically, using the principles of an analytical (or industrial) accounting system, Arfini breaks up the farm activity of a specialized dairy farm into more CCs in order to allocate the costs in the single enterprises, using various allocation keys. the methodology is thus not completely different from the one previously described. One difference is that there is greater detail concerning the division of the livestock farming activity, depending on the age and functions of the different kinds of animals. The division of farm activities has been made following a "functionality criteria", on the basis of the role of every CC in the farm production and the links between them (Figure 1.3).

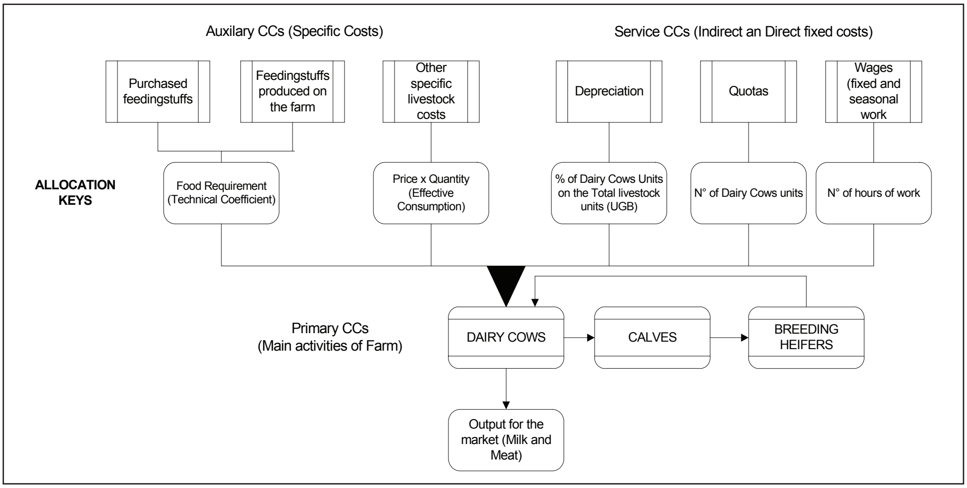
Three kinds of CC have been distinguished for the specialized dairy farm:

Primary CCs: bring together all the activities that represent the final step of farm production and that generate an output, in part sold on the market and in part used to guarantee internal continuity (remount). Following this scheme, the animals are divided into three Primary CCs. The most important one is the Dairy Cows, which includes the females that produce two kinds of output: one destined for the market (milk and non-dairy cows) and one used for the internal remount (calves for farm use). This last output originates the Calves Cost Centre in which the animals stay until they become Breeding Heifers, in the next Cost Centre. Both of these CCs produce output for the market (male calves and heifers), with most heifers destined for the Dairy Cows CC.

Auxiliary CCs: this group includes the specific costs of livestock farming whose output constitutes the input for the Primary CCs. Three CCs are distinguished: Purchased feedstuffs, feedstuffs produced on the farm and other specific livestock costs. All the costs are allocated using specific allocation keys. feedstuffs are allocated on the basis of a "consumption criteria" considering the food requirement of every kind of animal in the Primary CCs. So, the methodology uses a technical coefficient to express consumption; multiplying prices and quantities consumed it is possible to have an indication of the feed costs. For the specific livestock costs (veterinary, products for cleaning livestock equipment, etc.), the supply services invoices are taken into account

Service CCs: are fictitious CCs useful to allocate the costs of the fixed assets, in particular the depreciation of agricultural land, farm buildings, machinery and equipment, and milk quotas. this group also includes the cost of labour (wages of fixed and seasonal workers). With regard to the fixed assets cost (depreciation), the allocation among the three primary CCs is in proportion to the use of the production factor by the animals. To do this, a technical parameter (LSU)[2] has been used to obtain a homogeneous measure of the entire livestock. Labour costs are allocated taking into account the hours effectively dedicated to the activities of primary CCs. The quotas are linked only with the Dairy Cows CC and the allocation is made on the basis of the number of cows.

Figure 1.3 - Arfini's scheme for dairy farms



The scheme shows the application of the method for the Dairy Cows Cost Centre. The same scheme is applied to obtain the cost for calves and breeding heifers.

The methodology follows a "cascade scheme": the output of Auxiliary and Service CCs is the input for the Primary CCs. With regard to the Auxiliary CCs and Services CCs it is necessary to identify the produced (or available) quantities and the production (or purchase) costs, while for the Primary CCs it is necessary to define the input requirements (that depend on the technologies). The methodology is

2 LSU = Livestock Unit. This is a system used to compare or aggregate animals of different species or categories. Equivalences are based on the food requirements of animals. LSU = 1 dairy cow; calves < 6 months = 0.25 LSU; calves 1-2 years = 0.60-0.70 LSU; breeding heifers > 2 years = 0.70-0.90 LSU. The ranges depend on the sex of animals and the function (for fattening or calving).

named Integrated Direct Costing *(IDC) and considers the variable direct costs and specific fixed costs, both directly imputable to the single activities or enterprises. This makes it possible to calculate the margin of profit and the capacity to generate revenues of each single activity on the farm.*

1.4.4 Calculation of production cost in organic farming

Public financial support for organic farmers was introduced in many European countries at the end of 1980s to cover economic losses incurred during the conversion period. During the 1990s, political interest in organic farming moved to the European Union level with the EU Reg. 2092/91, which introduced a common set of production standards for organic plant production. In 1999 this regulation was supplemented by common standards for livestock production (EU Reg. 1804/99). In the following years Member States implemented various organic farming policies according to this legislative framework, receiving further support under the agri-environmental programmes granted under the rural development regulations. Over time, the number of organic farms and organic production areas have increased and today this sector has become very important. Notwithstanding this, before 2000 none of the most important statistical surveys at farm level in European Union (Eurostat Farm Structure Survey and FADN) provided an explicit identification of organic holdings. During the preparation of the Agenda 2000 Reform, new issues were taken into account: reinforcement of the Rural Development aspects of CAP, sustainable and environmentally-friendly agricultural practices, food quality and food safety. As a result, organic farming acquired increasing importance and an identification code was implemented in FSS (Farm Structure Survey) and FADN. Moreover, the quality of data collected for organic farms was improved with an action named EISfOM (European Information System for Organic Markets), developed under the key action 5 (Sustainable agriculture) of the 5th Framework Programme for Research and Technological Development.

FADN began to collect information on organic farming from 15 Member States in the accounting year 2000/01, following the recommendation of a study concerning the modernisation of farm returns (LEI, 1999). The following codes were added:

- non-organic farms
- purely organic farms
- converting to organic or mixed farms

Although FADN is one of the key instruments for evaluating the income of farm holdings, some studies have underlined its limitations for the analysis of organic farms (Gleirscher, 2005). First of all there are problems with the correct identification of organic farms. Where organic holdings are 100% organic (certified according to EU Reg. 2092/91) there are no problems, although there is still a need to separate the holdings in conversion. Many problems arise where holdings have mixed organic, conventional and in conversion management.

The second problem concerns the classification based on the European Size Units derived from the Standard Gross Margins for agriculture in general. For agriculture with different prices and gross margins and with a high presence of mixed farms, this basis for the classification may lead to the exclusion of smaller organic holdings, because they fall below the inclusion threshold.

Generally speaking, the cost structure in organic farming differs from the conventional one. In crop production, soil fertility and biological activity should be maintained by the use of green manure (fertilization), leguminous plants and an ample crop rotation scheme. For crop protection against diseases and pests, besides ample crop rotation schemes, natural enemies are used. Livestock production focuses on animal welfare and health care and organic feeding. For each animal, minimum indoor and outdoor room should be available. Natural and homeopathic medicines have preference and the feedstuffs should be organically produced (only a restricted number of additives is allowed).

These characteristics of organic farming management lead to a different costs and incomes modelling and structure with respect to conventional farming (Offermann, 2004; Acs et al., 2005; Anderson, 1994; Firth, 2002). On the costs side, there is an increase due to the need for special soil improvement and special propagation material during the change of production system. So, the costs of plant protection and artificial fertilization decrease. Moreover, organic farming requires more intensive labour. There are more expenses for certification and administration and for activities on organic markets. On the income side, organic premiums and subsidies play an important role in the compensation for lower yields and lower marketable volume.

Notwithstanding some limitations in the FADN database, the inclusion of information about organic farming in FADN permits the database to be used to analyze economic results of organic farms and makes possible a comparison with conventional farms or between organic farms in different countries.

An EU research project named EU-CEEOFP (Further Development of Organic Farming Policy in Europe with particular emphasis on EU Enlargement) sets the guidelines for harmonization of income comparison between organic and conventional farms. The approach is to select a group of similar conventional farms to compare with organic farms in order to minimise differences in management ability. Organic and conventional farms must have similar natural production conditions, the same type of location, similar production factor resources and similar farm types.

With regard to the analysis by country, the FADN database has been used in two important studies in ten countries:

- DG Environment commissioned a study in 2002 to analyze the effect of the CAP on environmentally-friendly farming systems using organic farming as example (analysis on direct payments based on data 2000)
- European Environmental Agency commissioned a study on the IRENA[3] indicator Organic price and incomes (analysis on income indicators based on data 2001)

Considering the second analysis on financial performance, the study made a comparison between the Farm Net Value Added per unit of farm labour (FNVA/AWU, Agricultural Work Units) and Farm Family Income per Family Work Unit (FFI/FWU) of organic and conventional farms. On average, the two kinds of farms achieved similar incomes. In six out of ten countries FNVA/AWU was similar or slightly higher on the organic farms. Overall, 56% of organic farms had higher incomes than their comparable conventional farm group.

In Italy, an important analysis of the organic farming sector based on the use of the Italian FADN dataset was carried out by INEA in the SABIO project (Carillo, 2008), the main aim of which was to estimate the added value generated by the organic farming system in different political and market scenarios. More specifically, the FADN data were used to analyze the income and profitability of organic farms.

1.4.5 Other approaches

De Roest et al. (2004) refer to the calculation of milk production costs. The procedure is based on analytical accounting and uses data from a farm survey, according to a scheme formulated by the European Dairy Farmers.

The costs are divided into specific costs (exclusively concerning dairy production) and general costs (sustained for different activities on the farm). Both cost

3 Indicators reporting on the integration of environmental concerns in agricultural policy. There are 35 indicators and two of these (no.5 and no.7) specifically address organic farming.

types can be implicit or explicit. In this study, the overheads allocation is made using these coefficients:

$$\frac{\textit{Fodder Crop Surface}}{\textit{Utilised Agricultural Area}}$$

$$\frac{\textit{Revenues from milk}}{\textit{Total Revenues}}$$

$$\frac{\textit{Revenues from meat}}{\textit{Total Revenues}}$$

These coefficients may also be used with FADN but it can be difficult to obtain the fodder crop surfaces in some European Union countries.

Another analysis was done by Pretolani (2004), who started from the FADN data related to specialized dairy farms to make a comparison between Italy and other European Regions. In this analysis, all farm costs are referred to the main production (milk), including the costs of other activities, considered as joint production. The total cost is the sum of implicit and explicit costs and is compared with the Equivalent Milk Production to obtain the unitary cost:

$$\frac{\textit{Total Cost}}{\textit{Equivalent Milk Production}}$$

The Equivalent Milk Production is obtained dividing the total farm revenues (without subsidies) by the price of milk produced on the farm. So, the value of milk is equal to the selling price. With this method, the farm is considered as one activity (milk) and all the secondary productions are "translated" into milk. So, the total farm cost coincides with the milk cost.

Salghetti and Ferri (2005) use the previously described theory of Proni to compare a conventional and an organic dairy farm. The total cost includes explicit and implicit costs. The former are costs effectively incurred by the farm so they derive from the accountancy, while the latter concern the holder's own production factors and need an estimation procedure, generally conducted with cost opportunity estimation methods.

To determine the secondary production costs, the sales invoices are taken into account, under the hypothesis of a perfect competition on the market that makes the costs equal to the income. Subtracting this cost from the total costs, an estimate of the total cost of principal production is obtained (in this case, milk). The unit cost is obtained dividing by the quantity of production.

Specific studies of the economics of milk production have been done by Colman et al. (2004). These authors use the record of a representative sample of dairy units to generate estimates of the factors that influenced the economics of milk production in England and Wales. As concerns the cost allocation, the fixed costs are divided into two categories: direct costs (directly attributable to the dairy herd) and indirect costs (i.e. overheads). This latter category has been calculated using known levels of these costs on dairy farms from the Farm Business Survey, following a costing procedure adopted by the Department for Environment Food and Rural Affairs (DEFRA) in its studies. This study is interesting because it applies a procedure to record and allocate the forage variable costs, taking into account grassland and fodder crops. These costs are allocated to the dairy enterprise on the basis of Livestock Unit Grazing Weeks (LUGWs). The LUGWs are calculated taking into account the total number of weeks that different classes of livestock were at grass during the year (additionally, quantities of conserved grass made during the year are converted into LUGWs).

Boone and Wisman (1998) refer to the calculation of production costs in the pig sector and the methodological problems encountered when comparing production costs within an international perspective. They start with FADN data and make some integrations with Eurostat prices. More specifically, in FADN, only the value of the purchases and sales of pigs is given. There is no information on the number of pigs or the weight of pigs traded. Moreover, FADN does not indicate technical data and so nothing can be said about the costs per kilogram. To solve this problem, they use the Eurostat price, in particular the price per kg live weight of fattened pigs to obtain the amount sold in terms of kilograms:

$$Amount\ sold\ (kg) = \frac{total\ sales\ (€)}{Price\ (€/Kg)}$$

They only consider those farms with no sales other than fattened pigs and with no purchases of piglets. Moreover, on these farms the revenues from pig sales are at least 75% of the total farm revenue.

Overheads are allocated in two different ways that modify the farm results:

- assuming the equal profitability of all products: receipts/total costs is the same for every product
- as percentage of sales: costs are allocated using pork sales as a percentage of total sales

The second method leads to low pig trading profitability for the farm because the pigs have relatively high variable costs. Adding these costs to overheads that are allocated on a percentage of sales, leads to relatively high costs per unit for pigs and low costs for the other activities of the farm.

The cost of unpaid labour is calculated as the hours worked multiplied by the average gross hourly wage in all the industries of the country. The cost of equity is calculated considering the return on long-term government bonds less the inflation rate. The production costs of pork are obtained considering the classification of costs based on the time period, as shown in Figure 1.4:

Figure 1.4 - Production costs scheme for the pig sector (Boone and Wisman, 1998)

Feeding costs	Short-term costs
Other direct costs	
Overhead costs	
Paid interest	
Paid labour	
	Medium-term costs
Depreciation	
	Long-term costs
Calculated interest	
Calculated labour	
	Long-term costs incl. Subsidies
Subsidies	

1.5 The calculation of own resources: labour, capital and land

In a long-term perspective cost analysis, the need to estimate the cost of own resources seems to be very important. Many farm accounting systems (including FADN) do not identify the full cost of agricultural production, probably because of the difficulties in estimating explicit costs, in particular family labour, own land and own capital. These items should be estimated at their opportunity costs and be included in cost analysis. Opportunity cost is the value of the next best alternative use of the resources and is an important part of the decision-making process. Despite its importance, it is not treated as an actual cost in any financial statements. The consideration of opportunity costs is one of the key differences between the concepts of economic cost and accounting cost and between full and partial cost configuration. The AAEA Cost and Return Estimation Handbook gives recommendations useful to estimate the opportunity cost for own resources, typically labour, capital and land. Moreover the scientific literature recommends the estimation of these opportunity costs also in order to obtain further information on the efficient use of farm resources.

1.5.1 Own labour

Labour is one of the most important inputs in agricultural production. There are two categories: hired labour and unpaid labour. The cost of the former includes wages, salaries, benefits and other associated costs, while family labour is included in the latter. Despite the importance of this cost in the EU agricultural context (with a large number of small farms), FADN does not consider family labour as a cost.

There are several methods to evaluate family labour, the most important being the opportunity cost method.

Following the indication in the AAEA Handbook (2000), the opportunity cost of farm labour is the maximum value per unit among the alternative uses of that labour. Skills, location, period of use are generally important factors for determining the opportunity cost of labour. For hired farm labour, the compensation is the opportunity cost while for unpaid labour it is necessary to estimate an implicit compensation, based on the opportunity cost of off-farm work or on the return available in the next best alternative use of this labour. Without the consideration of transaction costs, the optimal allocation of the farmer's and his family's labour is reached when marginal labour product equals the wage rate, which represents opportunity costs of farm labour. But it is not clear which wage rate should be considered representative of labour opportunity costs.

There are different procedures.

In the first method, the marginal value of farm labour is obtained via shadow values from programming models while the value of the marginal product is obtained using econometric models. This approach could be a weak measure of the costs of farm labour because the value of labour is determined by a number of other farm decisions (other inputs, technology, etc.): farm operators who are very successful could have a marginal value of time in farming that exceeds their implicit wage for off-farm work[4].

The second method estimates the family labour using

- the wage rate of professional farm managers to approximate the cost of the hours used by a farm operator in decision making
- the wage rate of hired farm labour to approximate the cost of all other unpaid farm labour.

It is an apparently easy approach to apply but presents some problems that makes it appropriate only if no other estimates exist. First of all, on a farm it is very difficult to divide the farm operator's labour into decision-making work and other farm work. Generally, there is a joint product of field work and decisions and this may lead to errors in calculating the true cost of the work. Moreover, the quality of decision making by farmers and professional farm managers may be different. Experience and incentives also differ between family members and hired workers: a family worker is usually assumed to be more productive than a hired worker and his work is done better because of the expectation of a share in the net farm income. If these differences are important, it is necessary to adjust the calculation.

The third approach uses the off-farm wage rates of farming people as information about wage opportunities of family work. It is the simplest estimation method to calculate the opportunity cost. Following this method, the off-farm work is the best alternative to farm work. It is necessary to take into account that all farm labour does not have the same skills or productivity in farm work and, so, does not have the same opportunities in off-farm work. For example: older farm operators do not have prior off-farm work experience, so may not have good off-farm work opportunities. This method uses labour market information to evaluate personal and location characteristics.

4 Picazo and Martinez (2005) adopt an input distance function to derive input shadow prices of family labour on the citrus fruit farms of Valencia Region. The function has been parameterized as a translog function and calculated by goal programming techniques, under the hypothesis that observed market price of hired labour equals the absolute shadow price of family labour. The result of this analysis is that the shadow price of own labour on the investigated farms is lower than the market wage. There are different reasons to explain this: farmers may prefer working on their own farm rather than in an off-farm job (for example because they take transport costs or other expenditures associated with off-farm jobs into account).

1.5.2 Own capital

The cost of equity should be based on the market rate of return for investment with the same risk. However, it is not easy to find this rate of return and there is still no agreement in the finance literature about the trade-off between risk and return. The risk of an investment in a farm will be relatively low because a lot of money is invested in land (that does not readily depreciate) and buildings. An approximation could be found by using the average rate of return on long-term government bonds with some small premium for the extra risk of the equity.

1.5.3 Own land

Estimating the costs associated with the use of land in farm production is complex. In general there are three categories of costs and their sum is equal to the cost of agricultural use value:

- costs of owning land: opportunity cost (approximated by multiplying the current agricultural value of the land by an appropriate interest rate) and property taxes
- costs of maintaining land: user costs (to restore service capacity as a result of use) and time costs (to restore losses in service capacity as a result of the passage of time)
- overhead costs: general liability insurance, irrigation, etc.

In practice, it may be difficult to estimate these costs separately because land markets are sometimes not active and do not provide a sufficient number of observations to make reliable estimates. Moreover, different land tenures affect production cost calculations because there are different ways to share the risks, the rights, and returns of land use.

In FADN there are three types of land occupation of the Utilizable Agricultural Area (UAA) of the farm:

- UAA in owner occupation: the holder is owner;
- rented UAA: the holder is not the owner but a fixed rent is paid (in cash or kind).
- share-cropped UAA: land is farmed jointly by the owner and the sharecropper on the bases of a sharecropping agreement.

The AAEA Handbook refers to different alternatives for calculating the land costs in these three cases.

In the first, when agricultural land is worked almost exclusively by owners, an implicit annual rental fee can be obtained. In this case, the estimation of land cost is made taking into account the opportunity cost obtained multiplying the land market value for agricultural purposes by an interest rate. This cost is added to the annual maintenance cost and to the annual taxes.

In the second case, when a significant portion of the agricultural land is farmed under cash rental tenure, the cash rent paid for land is the best measure of the costs associated with the land's agricultural use value[5]. Cash rent reflects what tenants are willing to pay to avoid the payment of property taxes on the land, opportunity costs, time costs and user costs. So, it is the most reflective indicator of current market conditions. Obviously, some difficulties arise where the cash rental market represents a small portion of the agricultural land or where land markets are not active. In this case, a cash equivalent rental rate is calculated considering the annual net rents for every production.

A sharecropping rental agreement is more complicated: the cost sharing consists of cash costs for the landowner and both cash and non-cash costs for the tenant. In this case, there is not a cash rental payment but a cash-equivalent rental value: the sharecropper experiences a reduction in cash receipts and a reduction in cash operating costs.

1.6 FADN accounting system: general concerns

One of the aims of this project is to address the usefulness of the FADN system to measure the cost of production for agricultural activities, whether increasing the information on cost of production or analyzing the accountancy framework and cost items in FADN.

The Farm Accountancy Data Network (FADN) of the European Union was established with Council Regulation 79/65/EEC of 15 June 1965, modified and expanded over time and repealed by Council Regulation 1217/09/EC of 30 November 2009. Since then, the FADN system has gathered accountancy data from farms with the aim of determining their incomes and making business analyses of agricultural holdings possible. Today, FADN fulfils the role of a guideline and reference point for agricultural accounting in Europe, by doing a microeconomic analysis of

5 Cash rent does not include the value of anticipated gains (losses) due to inflation or potential future non-agricultural use of land. It does not include payments for financial capital, risk and management because, in general, the tenant is not acquiring them but only the temporary use of the land to produce an agricultural product.

agricultural activities of different farm types, sizes and regions. FADN can thus be considered one of the most important sources of statistics available in the European Union. Its analogue at aggregate level is the Economic Accounts for Agriculture (EAA) developed by Eurostat, which derived from the national accounts of Member States.

The data collected in FADN concern assets, liabilities, revenues and expenses of the farms and they are summarized in reports similar to Balance Sheets and Income Statements.

The variables taken into account in FADN refer to:

- physical and structural data (location, crop areas and yields, livestock, labour inputs, machinery and equipment, stocks and working capital, etc.)
- economic and financial data (value of production, crop and livestock sales and purchases, production costs, financial and interest charges, assets, liabilities, quotas, grants and subsidies, etc.)

FADN does not collect information on all European farms, but follows a method for classifying agricultural holdings established by the Commission Decision 377/85/EEC. Briefly, a sample is established with a sampling plan and the holdings in the sample and in the population are stratified according to region, economic size and type of specialization.

The economic size of farms, expressed in terms of European Size Units (ESU) was determined using the concept of Standard Gross Margin (SGM). The SGM of a crop or livestock item is defined as the value of output from one hectare or one animal less the cost of variable inputs required to produce that output. In other words, the SGM refers to the single farm enterprise and measures its contribution to the payments of overheads and farm profits. The SGM is also used to classify the different types of farming, defined in terms of the relative importance of each enterprise on the farm. The relative importance is measured quantitatively as a proportion of each enterprise SGM on the farm's total SGM. FADN permits an accurate and detailed classification of the different holdings, whether among specialized types of farming or mixed types of farming. The Commission Regulation 1242/2008/EC of 8 December 2008 introduced the concept of Standard Output (SO) in place of the SGM to calculate the farm size. It can be defined as the standard value of the gross agricultural production at farm-gate price. It excludes the direct payment and is measured in euros and not in ESU as the SGM classification. Regulation 1242/2008 repealed the Decision 377/85/EEC that, however, has been applied up to and including the accounting year 2009. The Regulation concerning the SO was applied from the accounting year 2010 for the FADN and also for the

Farm Structure Survey.

FADN data are collected through a questionnaire, the Farm Return, the content of which is specified in the Commission Regulation 2237/77/EEC of 23 September 1977 and subsequent amendments. Over time, the Farm Return has been modified to take into account the new variables resulting from the evolution of the Common Agricultural Policy. The updating is necessary to avoid the risk of obsolescence and to remove problems due to different accounting systems in the Member States.

These Regulations also contain detailed instructions on how the Farm Return is completed and provide definitions of the terms used. So, the FADN system has a very structured set of rules for data collection and aggregation, very close to an accounting plan. Table 1.2 shows the section of the Farm Return:

Table 1.2 - Contents of the tables in FADN

Table A	General information
Table B	Type of occupation
Table C	Labour
Table D	Number and value of livestock
Table E	Livestock purchases and sales
Table F	Costs
Table G	Land and buildings, deadstock and circulating capital
Table H	Debts
Table I	Value Added Tax
Table J	Grants and Subsidies
Table K	Production (crops and animal products, livestock excluded)
Table L	Quotas and other rights
Table M	Direct payments for arable crops and beef
Table N	Details of purchases and sales of livestock

The data collected in FADN give information on farm income, costs and returns of the farm operations, farm size and specialization. But they exclude the non-farm income that includes the off-farm activity of the holder or holder's family and the revenues coming from own resources (land, labour and capital). This means that FADN does not provide information on standard of living of farming households, except when those households derive their entire income from the holding. This is a limitation of the FADN system that makes it difficult to take into account a more comprehensive concept of farming household.

All the items included in FADN lead to various income indicators. The most important one is the Farm Family Income, which represents the remuneration for the family's production factors (work, land and capital) and the remuneration for the businessman's risks (loss/profit) in the accounting year. Another important income indicator is the Farm Net Value Added (FNVA), which is the remuneration for the fixed production factors (work, land and capital), whether they be external or family factors. As a result, holdings can be compared irrespective of their family/ non family nature of the production factors employed.

1.6.1 The costs accounted in FADN structure

In FADN, the different kinds of costs are listed in two tables:

- Table F: specific costs, farming overheads, total external factors
- Table G: depreciation (land and buildings, deadstock and circulating capital)

The specific costs for crops can be divided into three categories:

- seeds and seedlings, purchased and produced on the farm (bulbs, corms, tubers and seed preparation costs)
- fertilizers, soil improvers (lime, compost, peat, manure) and crop protection products
- other specific crop costs that are the general costs directly connected with crop production (packing and binding materials, soil analysis, plastic coverings, etc.).

The FADN scheme also includes specific forestry costs (fertilizers and crop protection products).

The specific costs for livestock include feedstuffs and other specific livestock costs (Table 1.3). In the first group the distinction is made between feed for grazing livestock (horses, cattle, sheep, goats) and feed for other animals (poultry, pigs and other small animals). Both headings include purchased feedstuffs and feedstuffs produced on the farm[6]: oilcake, compound feed, cereals, dried grass, dried and fresh sugarbeet pulp, fishmeal, meatmeal, milk and dairy products, minerals. They also include the cost of use of pasture land not included in the UAA (short-term rental), purchased litter and straw for bedding, additives for storage and preservation. The "other specific livestock costs" include veterinary

6 The feedstuffs produced on the farm include marketable farm products such as forage crops used as feedstuff.

fees, artificial insemination, milk tests, products for cleaning livestock equipment, etc.

Table 1.3 - Inputs – Specific costs

Specific crop	Seed and seedlings purchased, produced and used on the farm; fertilizers and soil improvers; crop protection products; other specific crop costs; specific forestry costs
Specific livestock	
Purchased feedstuffs	Concentrated feedstuffs for grazing stock; pigs, poultry and other small animals; coarse fodder for grazing stock
Feedstuffs produced on the farm	Feedstuffs for grazing stock, pigs, poultry and other small animals
Other specific livestock costs	

In FADN overhead costs are divided into two categories: labour and machinery, and general overheads (Table 1.4).

The overhead costs for labour and machinery include the costs of services provided by agricultural contractors, the purchase of small equipment or protective clothing, the purchase of detergents for general cleaning and general farm maintenance, the cost of running farm vehicles, etc. The general overheads include costs such as electricity, water (for all farm purposes including irrigation), insurance (all premiums covering farm risks), telephone and other farming overheads (secretarial office).

In FADN it is also possible to indicate the amount of insurance for farm buildings but this information is optional.

The total external factors account is composed of three headings that concern the remuneration of inputs (work, land and capital) which are not the property of the holder (Table 1.5).

Table 1.4 - Inputs – Farming overheads

Contract work and machinery hire Current upkeep of machinery and equipment Motor fuels and lubricants Car expenses	Labour and machinery
Upkeep of land improvements and buildings Electricity Heating fuels Water Other farming overheads	General overheads
Insurance (insurance for farm buildings)	

Table 1.5 - Inputs – Total external factors

Wages and social security	Labour and machinery
Rent paid	Land charges
Interest and financial charges	Interest paid

Wages and social security heading includes the wages and social security contributions (and insurance) of wage earners, i.e. all payments to employees in return for work done. THERE ARE DIFFERENT KINDS OF WORKERS ON A FARM:

- direct labour: includes farm wage earners (fixed and temporary) who carry out all the activities directly connected with the farm production process (tractor drivers, workers for pruning and harvesting, etc.)
- indirect labour: includes the technical workers who have an auxiliary role on the farm with respect to the direct workers (security, production supervisors, etc.)
- technical and commercial labour: includes salaried employees, for example
- holder's family work

While in the first three cases the farm records the real cost for workers, in the last case there are no remunerations and so the accounting system must take the cost opportunity for the family's work into account. But, while FADN offers data about the workers employed on the farm, it does not consider the non-family work as a cost. The only real cost could be the social security payments.

In general, the wage costs include:

- cash equivalent of payments in kind (e.g. rents, meals and lodging, etc.)
- productivity bonuses and profit share-outs
- recruitment expenses
- employee social security contributions, taxes and insurance.

In FADN, this account excludes the amounts received by workers considered as unpaid labour (wages lower than a normal wage, persons who do not receive a salary) and all the holder's and employer's costs. It excludes labour used for work under contract (recorded as contract work and machinery hire).

Rent (land charges costs) heading includes the net value of cash and payments in kind for renting of land, buildings, quotas and other rights for the farm business.

The heading Interest includes interest and financial charges on loans for the farm business (loans for purchase of land and buildings, purchase of land or working capital) are included. The subsidies on interest are not deducted and are entered under "grants and subsidies on costs".

In the FADN accounting system depreciation is calculated at replacement value (the new value at current price) before deduction of subsidies. It concerns plantations of permanent crops, farm buildings and fixed equipment, land improvements, machinery and equipment. There is no depreciation of land, forest land and circulating capital. The precise depreciation method and rates can be chosen locally. Generally speaking, all EU Member States use the linear depreciation method that diminishes the value of an asset by a fixed amount each period, until the net value is zero. It is the simplest calculation. Depreciation is usually calculated with different coefficients for buildings, technical equipment, machinery, etc.

1.7 The International Accounting Standard for the agricultural sector (IAS 41) and the FADN system

In spite of the undoubted importance of accounting, the agricultural sector has a low level of bookkeeping and accounting practice. This can become a problem especially if the accounting information is used to improve the farm management or when it is either directly or indirectly a basis for policymakers in the decision-making procedure. While accounting for farming activities has traditionally received little attention in many countries, in others different principles of agricultural accounting have been developed. For example, in North America, the American Institute of Certified Public Accountants (AICPA) and the Canadian Institute of Chartered Accountants (CICA) developed guidelines on income measurement and other agricultural reporting issues. In Europe, FADN developed general procedures and detailed guidelines for farm accounting.

Different kinds of initiatives therefore existed, but on a country-by-country basis. As a consequence, there were no comprehensive accounting standards for agriculture, applicable in all countries in a harmonized way.

In 2001, the release of the International Accounting Standard *IAS 41 Agriculture* by the International Accounting Standards Board (IASB)[7] changed agricultural accounting from a domestic issue dealt with by individual countries to a global issue. IAS 41 prescribes the accounting treatment, financial statement presentation and disclosures related to agricultural activity.

1.7.1 Some concerns about IAS 41 Agriculture and the Fair Value

The objective of IAS 41 is to establish standards of accounting for agricultural activity, which is defined as

the management of the biological transformation of biological assets (living plants and animals) into agricultural produce (harvested product of the enterprise's biological assets)… Biological transformation comprises the processes of growth, degeneration, production and procreation that cause qualitative and quantitative changes in a biological asset[8].

The pure reduction of biological assets (for example the deforestation of forest stands without former forestation or maintenance) does not constitute any agricultural activity. IAS 41 formulates three essential characteristics that identify an agricultural activity:

- capability to change: living animals and plants are capable of biological transformation;
- management of change: management facilitates the biological transformation, improving the necessary conditions for the process. As a consequence, harvesting from unmanaged resources (such as ocean fishing or deforestation) is not an agricultural activity;

7 IASB is a Board of the International Accounting Standards Committee (IASC), it is a private institution that sets out and disseminates international accounting principles. The aim of IASC is to coordinate drafting procedures and improve the communication of businesses' economic information.

8 *IASC does not take into account the land use as a fundamental requirement of agricultural activity. Moreover, in IAS 41, the assets that are not affected by a biological growth process are considered separately and included in other IAS: Agricultural LAND (IAS 16 AND IAS 40), INTANGIBLE ASSETS (IAS 38), GOVERNMENT GRANTS (IAS 20).*

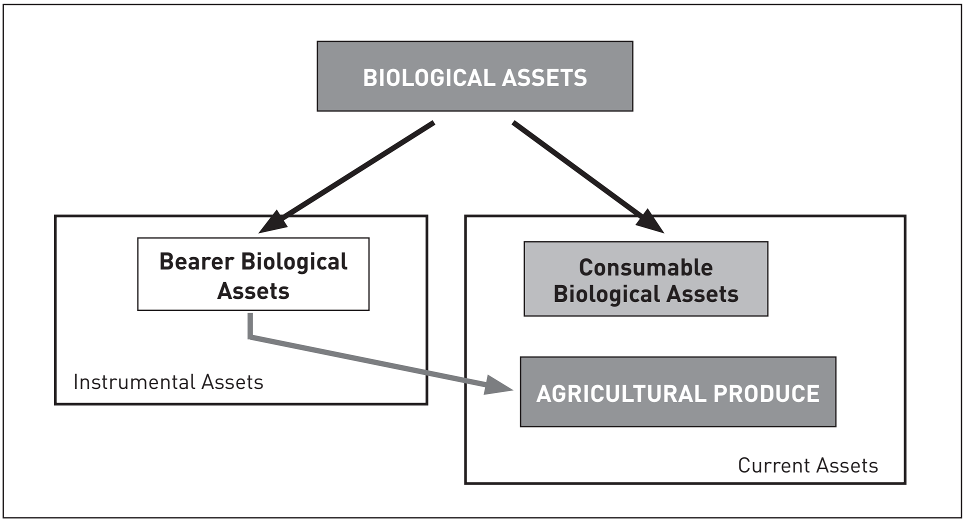
- measurement of change: the change in quality or quantity is measured and monitored.

Following the IAS 41 definitions, biological assets can be:

- consumable biological assets if they can be harvested and consumed as agricultural produce or sold as biological assets (livestock for meat, livestock held for sale, fish in farms, crops such as maize and wheat, etc.)
- bearer biological assets that are used to obtain derived agricultural products (livestock producing milk, grapevines, orchards, etc.) destined for the market, consumption or transformation.

Figure 1.5 summarizes this scheme: the bearer biological assets could be considered as instrumental assets used for the farm activity while consumable biological assets and farm produce could be considered as current assets, allocated on the market.

Figure 1.5 - Biological assets in IAS 41



The adoption of IAS 41 for the valuation of biological assets and agricultural produce constitutes a breach with the principle of original costs. In IAS 41 all types of biological assets and agricultural produce should be measured on initial and consecutive recognition at their *fair value* less estimated point-of-sale costs. Table 1.6 shows the method used by IAS 41 to define this value.

Table 1.6 - Definition of the value for biological assets and agricultural produce according to IAS 41

Market price (net price)
• transport costs
• other costs to get assets to a market
= Fair Value
• Point-of-sale costs
commissions to brokers and dealers
levies by regulatory agencies and commodity exchanges
transfer taxes and duties
= Valuation for biological assets and agricultural produce

As the table shows, the fair value is the market price less the transport costs and other costs necessary to get assets to the market. In other words, the fair value of an asset is based on its present location and condition.

Gains or losses on initial recognition are included in profit or loss for the period in which they arise. This is true for either the changes in fair value of biological assets or for agricultural produce harvested from a biological asset.

Fair value accounting provides more transparency than historical cost accounting, based on the amount of money paid to acquire the asset. This last criteria does not reflect the nature of farming because the quantity of assets on the farm does not depend only on the amount at a certain moment, but also on other processes (procreation, growth, death). So, the fair value approach reflects the effect of biological transformation in the best way.

Moreover, if the profit of a company is based on the historical expenditure, problems can arise during times of high inflation. In this case, if the profit is used to pay taxes and private expenses, the company would not have enough resources to buy the same fixed assets again because inflation would make them more expensive. So, historical cost is not objective and not very informative under this point of view.

If available, a market price on an active market[9] is the best evidence of fair value and should be used as the basis for measurement. Otherwise the estimation is made using other kinds of information: the most recent market transaction prices, the market prices for similar assets or sector benchmarks (for example, the value

9 An active market is a market where: the items traded are homogeneous; willing buyers and sellers can normally be found at any time; prices are available to the public.

of a cow expressed per kilogram of meat). If these prices are not available, the valuation is made considering the present value of the net cash flows that the assets would generate if they were used on the farm. Otherwise, the original costs are used.

In limited circumstances, cost is an indicator of fair value. If there has been little biological transformation or the impact of biological transformation on the asset price is low, cost can be used to approximate fair value. For example: the first few years of an asset such as a forest with a long-term production cycle.

1.7.2 Comparison between FADN and IAS 41 accounting system

Different studies have considered and analyzed the potential impact of IAS 41 on the European FADN system and, in effect, as stated previously, the two systems have different accounting and valuation methods (Argilès and Slof, 2001; Argilès and Slof, 2003; Elad 2004; IBH 2005; Herbohn and Herborn, 2006).

With regard to the evaluation of assets, FADN uses market prices:

- livestock is valued at prices prevailing at the end of the accounting period
- land is valued on the basis of market price for non-rented land with similar characteristics
- depreciable fixed assets are valued at replacement cost at the end of the accounting period
- depreciation is calculated on a replacement-cost basis

So, FADN is based on fair value and appears to be in accordance with IAS 41. But while IAS 41 requires that the assets should be measured at their fair value less estimated point-of-sale costs, FADN does not deduct these costs. Moreover, FADN uses current values for all non-monetary assets, while IAS 41 refers to the valuation of biological assets and agricultural produce and remands the other assets to other IASs.

The use of current cost accounting in FADN permits inter-business comparisons: the cost of two companies that have the same asset, bought at different times (so with different historical costs) will be calculated in the same way. In the calculation of current costs, problems can arise for assets which change only seldom or never or for old assets that have been a technical breakthrough.

Following FADN methodology and IAS 41, both sold and unsold production is considered as revenue. In FADN, this means that revenues derived from livestock and agricultural produce are computed as sales plus (minus) the increase (decrease) in value of inventories. IAS 41 considers that biological transformation should be recognized in net profit or loss in the period in which it occurs.

Both systems recognize unrealized gains or losses as revenue prior to sale. This inclusion reflects the efforts of management but also creates much uncertainty regarding the ultimate realization of revenues. This is the case for biological assets with a long production cycle (forests, grapevines): the recognition of profits that are not realized for several years may lead to unrealistic expectations of distributable profits for which no funds are available.

With respect to subsidies, contrarily to IAS 41, FADN considers subsidies fully earned once these have been granted.

As concerns expenses (specific costs, overheads, depreciation and external factors), FADN does not consider the remuneration paid to the farmer and his family as a farm expense. Given that the farmer's family is in many cases the major (or only) constituent of the workforce, this is of considerable importance. The exclusion could be due to the fact that the calculation of the real cost of family work would require some form of opportunity costing. Amounts paid to family members have more in common with dividends than salaries and do not represent their real cost.

1.8 Remarks

Although cost accounting and record keeping procedures are not usually practised by the farms, empirical evidence has been found on the usefulness of accounting when aiming for a high performance level in farm management. Some countries have developed specific tools for accounting in agricultural sector as European Union, that used the results of FADN survey to make cross-country comparison and cost of production estimates. The conceptual framework of FADN has been improved thanks to the IAS 41 rules.

One of the problems of FADN dataset is the lack of an analytical book-keeping system, that makes difficult to share the costs incurred at a farm level in the different enterprises or production processes carried out by the farmer. Moreover, the common costs are a considerable component of total costs and they can shared only using specific techniques or allocation keys or using econometric and statistical models. One of the purposes of FACEPA project was the use of FADN database (based on general accounting) to estimate the cost of production of the single farm enterprises in order to define an analytical accounting for selected production processes. The first method is based on an econometric approach while the second one is the application of PMP techniques.

Chapter 2
THE GENERAL ECONOMETRIC MODEL (GECOM)

2.1 Objectives

Production costs analysis in agriculture has always been of fundamental importance in helping to understand the structure of a specific production sector and improving the decision-making process at a farm level. In fact, knowledge of the profitability of every production process can help in planning future production and selection of the farmers' strategies. As stated in the first chapter, one problem of the agricultural sector is the lack of an analytical book-keeping accounting system. As a consequence, it is not easy to obtain a direct allocation of the production cost per farm, which is only possible applying specific allocation coefficients or using statistical methods. Even FADN (Farm Accountancy Data Network), one of the most important sources of information about farm costs at European level, is not based on an analytical account so the estimation of the production cost per unit of farm output needs other instruments.

Generally speaking, there are different methodologies to calculate and estimate the cost of every production process. One of these is based on a statistical analysis approach which attempts to estimate a functional relationship using econometric models. The GECOM model (general production cost model), developed in the FACEPA project (Seventh Framework Programme), tries to estimate all the farm costs for every production process using the FADN dataset. The testing and implementation of the model was the main task of WP3, coordinated by the von Thunen Institute (Germany).

The estimation is made for the traditionally aggregated costs (such as depreciation) and specific ones (fertilizers, seeds, etc.). The high flexibility of the GECOM model makes it applicable in many European countries and, at the same time, able to satisfy particular needs. In the FACEPA project, for instance, the model has been implemented to analyze specific national cases (using national FADN datasets). In particular, in the Italian FADN, differently from other countries, some costs are allocated to each production process by the surveyors at the end of the accounting year. The consequence is an arbitrary allocation procedure that can be subject to inaccuracies if the farmer does not record the costs separately or if there are aggregate costs or joint costs for which it is difficult to make an objective attribution. The implementation of an econometric model can help during this delicate phase.

In this chapter, after presentation of the general structure of the GECOM model, the characteristics of the Italian FADN dataset will be described. The model has been adapted to the specific dataset, changing the input and output aggregation when necessary and choosing the appropriate investigation level. The result of the estimation will be discussed and compared with the cost allocation made by the surveyors for the most important Italian productions: common and durum wheat, maize, apples, grapes and wine, cows' milk.

2.2 Description of the production cost model

The production cost model developed in the FACEPA project was applied for the first time by INSEE using the French FADN dataset (Aufrant, 1983) following the work of Divay and Meunier (Divay and Meunier, 1980). This first application covered 14 livestock and crop products. A contract between the European Commission and INSEE and INRA then resulted in the design of the first software adapted to the EU FADN and in an improvement of the model (Pollet, 1998). The same scheme has been used in other works (Butault et al., 1994; Pingault and Desbois, 2003; Desbois, 2006)

The model specification is well described in the work of Pollet (Pollet, 1998) and in deliverable 3.2 of FACEPA project (Implementation, validation and results of the production cost model using the EU FADN). It is composed by a system of linear equations in which the dependent variable is the input cost while the independent variables are the output values. Assuming that there are I inputs used by F farms to produce K outputs, the system of linear equations can be written as follows:

$$x_{if} = \sum_{k=1}^{K} \beta_{ik} y_{kf} + u_{if}$$

- x_{if} is the total cost of input i paid by farm f
- y_{kf} is the total value of output k produced by farm f

- β_{ik} is the unknown production coefficient (result of estimation), which is defined as the average (for all farms) expenditure on input i required to produce one unit of output value k (in euros)
- u_{if} is the error term specific to each input and farm

Assuming proportionality, the cost x_{if} ***is*** a linear function (β_{ik}) of the output k. On every farm, the observed costs differ from the theoretical costs by a random factor u_{if}. The factor ui are of zero expectation and independent from one farm to the next, which means that the consumption of input i by a given farm is not affected by another farm's consumption of the same input.

If p_k is the price of one ton of Y_k the unit cost of production per ton in x_i for y_k is

$$C_{ik} = \beta_{ik} * p_k$$

It is also possible to calculate costs per hectare or livestock referring to output per unit.

There is an equation for each cost item on each of the farms. There are several types of constraints, due to the general nature of the model. Aside from any other restriction, the sum of production coefficients for each output (product) must be equal to one

$$\sum_{i=1}^{I} \beta_{ik} = 1$$

Moreover, the coefficients relating to the expenditure for animals (feed and specific costs) are constrained to zero for all crop production (assuming no costs for animals in the selected crop processes) and the coefficients for specific crop costs are constrained to zero for animal production (only the home-grown feed costs are considered). Another limit of the model is that the size and technological level of each farm are completely disregarded.

The model has been estimated using the Seemingly Unrelated Regression (SUR) methodology, a generalization of linear regression. It fits with the estimation of such a simultaneous system of equations, composed by multivariate linear regressions having no structural relationships between them. The dependent variable never enters the equation between the explanatory variables, but the equations are linked through the covariance of the errors. Each equation has its own dependent variable and its own set of explanatory variables, potentially different from the other equations. If the explanatory variables are the same for all equations and if there are no correlations of errors among the equations, the estimator obtained is the same as that of the ordinary least squares (OLS), equation by equation. But in this model, the equations have a different set of regressors and the correlations between the disturbances of the different equations appeared significant enough to justify the use of SUR method instead the OLS (Pollet, 1998). In fact, the correlation of errors generates a particular form of variance-covariance matrix.

2.2.1 Outliers analysis

As in any statistical analysis, the presence of outliers may affect the final results. So it is important to remove them from the dataset in order to achieve clearer and statistically significant results. The outliers' elimination was performed using a procedure specified in the FACEPA project. It is a fairly complex procedure that takes into account more variables simultaneously. The idea behind it is to consider the joint distribution of the considered variables and remove all the observations "far" from the centre of the distribution. The distance between each observation and the centre of the distribution has been measured considering the Mahalanobis distance. The Mahalanobis distance for each multivariate observation i (i = 1, ... n) is defined as:

$$M_i = \left(\sum_{i=1}^{n} (x_i - \bar{x}_n)^T \; V_n^{-1} \, (x_i - \bar{x}_n) \right)^{1/2}$$

Where $\boldsymbol{x_i}$ is the i-th observation vector ($\boldsymbol{x_{i1}, xi2, \ldots x_{ip}}$), is the mean vector for the total sample, $\boldsymbol{V_n}$ is [$\boldsymbol{p \; x \; p}$] the variance and covariance matrix and $\boldsymbol{M_i}$ is the analog of the square of the standard score of a single variable:

$$z_i = \frac{x_i - \bar{x}_n}{V_n}$$

Which measures the distance from the mean in standard deviation unit and $\boldsymbol{Z_i}$ is distributed as $\boldsymbol{\chi}^2$.

Given n observations in a dataset with p variables the variance and covariance matrix is:

$$V_n = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x}_n) \, (x_i - \bar{x}_n)^T$$

The consideration of the covariance matrix makes the Mahalanobis distance preferable to other methods that ignore the covariance and instead treat all variables equally. In many cases, the observations cannot be identified as multivariate outliers when each variable is considered independently of the others because they become important interactions between the different variables. It may happen that a variable considered individually falls in the middle of a distribution (e.g., UAA) and two variables for the same observation (e.g., UAA and income) could be placed far from the average distribution

2.3 FACEPA model specification

The production cost model defined in the FACEPA project has been planned to be implemented with the FADN dataset and to estimate the costs of production in several European countries. The flexibility of the model permits a different input and output variables aggregation, depending on the specific needs and characteristics.

The total output of each farm has been separated into 31 products, with 17 considered inputs (Table 2.1). The contribution gross margin is defined as the difference between the total output (including coupled subsidies) and the sum of inputs. Concerning subsidies, those decoupled and received by the farm as a whole (e.g., single payment, agri-environmental payments, etc.) are not taken into account in the model specification because they are not attributable to the single production process. Given that in the FADN accounting scheme, the output value does not include the coupled subsidies, they are considered as negative costs in the estimation of the net value added.

Table 2.1 - Inputs and outputs of the FACEPA model

Outputs:	**Inputs**
• Wheat (WHEAT)	• Purchased Feed (FEEDPC)
• Durum Wheat (DWHEA)	• Home-grown Feed (FEEDHC)
• Barley (BARLE)	• Vet costs (VETCOS)
• Maize (MAIS)	• (other livestock specific costs)
• Other cereals (OTCER)	• Seed (SEED)
• Dry Pulses (DRYPU)	• Fertilizer (FERTIL)
• Potato (POTAT)	• Crop protection (CRPROT)
• Sugarbeet (SUGAR)	• Contract work (CONWOR)
• Nurseries (VIVAI)	• Machinery (MACHUK)
• Sunflower (SUNFL)	• Other costs (OTHSIC)
• Soya (SOJA)	• Land rent (LANDCO)
• Fresh Vegetables(op.field) (OPENF)	• Interest rate (INTERE)
• Fresh Vegetables(mkt. gard) (OPENG)	• Wages (SALARI)
• Fresh Vegetables_und.glass (UGlas)	• Processing cost (TRASFO)
• Flowers (open and protected) (FLOWE)	• Depreciation (DEPREC)
• Apples (APPLE)	• Taxes (TAXES)
• Citrus fruits (AGRUM)	• Contribution margin (MC)
• Other Fruit (exc. Pome fruit) (OTHFR)	
• Grapes table (UVA_C)	
• Grapes quality (UVA_Q)	
• Table wine (TWINE)	
• Quality wine (QWINE)	
• Olives and oil (OLIVE)	
• Other crops (OCROP)	
• Cattle (CATTL)	
• Sheep (SHEEP)	
• Pigs (PIG_)	
• Poultry (POULT)	
• Cows' Milk (CMILK)	
• Other milk (OMILK)	
• Eggs (Egg)	
• Contract rearing (CONTR)	
• Other activities (OACTI)	
• Other livestock (OLIST)	

The model estimates a regression equation for each cost, which is placed in connection with the value of the generated output. For instance: considering purchased feed the estimated equation is as follows:

Purchased feed = β_{23}* *cattle production value* +β_{24}**sheep production value* +β_{25}* *pig production value* +β_{26}* *poultry production value* +β_{27}**cows' milk and milk products production value* +β_{28}*. *Other milks production value* +β_{29}* *egg production value* + β_{32}**other livestock production value* + *u (error term)*

The specification adopted in the FACEPA project provides that the cost of feed (and purchased products) and other specific farms expenses are regressed on relative farm output; subsidies are regressed on the products that have direct contributions, and other costs (seeds, fertilizers etc.), including the net added value, are regressed on all the outputs considered.

2.4 Specification of the Gecom model for the Italian FADN dataset

The production cost model described in the previous section has been applied to the Italian FADN. This has required an adaptation to the specific structural dataset characteristics and a different variable selection and aggregation to satisfy some information requirements coming from the agricultural research sector.

The input and output variables taken into account for the Italian case are listed in Table 2.2. On the output side, the main changes concern the separation of grapes and wine productions, the selection of some typical Mediterranean products (such as olive oil and olives, citrus fruits) and the consideration of a separate category for nurseries, which have very different production costs from other-crops.

With regard to the inputs, processing costs and wages have been added. Moreover, unlike in the original structure, the coupled subsidies are not explicitly considered in the model as a negative cost, because in the Italian FADN structure, they are included in the production value. Differently from the basic specificationof the model, the inclusion of wages among the inputs leads to the estimation of the contribution margin (and not the net value added), calculated in the same way, as the difference between the outputs value (including subsidies) and the inputs value.

Table 2.2 - Inputs and outputs of the Italian- FADN GECOM model

Outputs:	Inputs
• Wheat (WHEAT) • Durum Wheat (DWHEA) • Barley (BARLE) • Maize (MAIS) • Other cereals (OTCER) • Dry Pulses (DRYPU) • Potato (POTAT) • Sugarbeet (SUGAR) • Rape seed (RAPE_) • Sunflower (SUNFL) • Soya (SOJA) • Fresh Vegetables (op.field) (OPENF) • Fresh Vegetables (mkt. gard) (OPENG) • Fresh Vegetables_und.glass • (UGlas) • Flowers (open and protected) (FLOWE) • Apples (APPLE) • Other Fruit (exc. Pome fruit) (OTHFR) • Grapes table and table wine • (TWINE) • Grapes quality and quality wine (QWINE) • Forest products (FORES) • Other crops (OCROP) • Cattle (CATTL) • Sheep (SHEEP) • Pigs (PIG_) • Poultry (POULT) • Cows' Milk (CMILK) • Other milk (OMILK) • Eggs (Egg) • Contract rearing (CONTR) • Other activities (OACTI) • Other livestock (OLIST)	• Feed (FEEDPC) - *Concentrated feed for grazing livestock, coarse fodder, pig feed purchased and poultry and small animals feed* • Feed (FEEDHC) - *Feed for grazing livestock home-grown, pig feed home- grown, and poultry and small animals home-grown feed* • Vet costs (VETCOS) - *other livestock specific costs* • Seed (SEED) - *Purchased and home-grown* • Fertilizer (FERTIL) • Crop protection (CRPROT) • Motor fuel and lubricants (MOTFUE) • Electricity and heating fuels (OENERG) • Contract work (CONWOR) • Building (BUILUK) - *Upkeep and land improvement and building costs* • Machinery (MACHUK) - *Upkeep of machinery and equipment* • Other costs (OTHSIC) - *Car expenses, other costs crops, forestry specific costs, water, insurance, other farming overheads and insurance of farm buildings* • Land rent and taxes on land and buildings (LANDCO) • Interest rate (INTERE) - *Total interest on all loans* • Depreciation (DEPREC) • Taxes (TAXES) • Subsidies (SUBSID) • Net value added (NETVAL)

As previously mentioned, a system of equations is simultaneously estimated for every farm and each cost is linked to the production value of the outputs that use that cost (Table 2.3). Some general costs are allocated in all the productions, such as depreciation, other costs, mechanization, and wages. Other costs can be directly or indirectly related to specific production processes. Rearing costs are related only to livestock production. The costs for seeds, fertilizers, pesticides and rents are not directly attributed to livestock production. They are indirectly accounted in the livestock production process as farm-used fodder.

Table 2.3 - Relationship between outputs and inputs

Dependent variable	Independent variables
Purchased Feed (FEEDPC)	Livestock production
Home-grown Feed (FEEDHC)	Livestock production
Vet costs (VETCOS)	Livestock production
Seed (SEED)	Vegetable production (permanent crop excluded)
Fertilizer (FERTIL)	Vegetable production
Crop protection (CRPROT)	Vegetable production
Contract work (CONWOR)	Vegetable production
Mechanization (MACHUK)	All the outputs
Other costs (OTHSIC)	All the outputs
Land rent (LANDCO)	Vegetable production
Interest rate (INTERE)	All the outputs
Wages (WAGES)	All the outputs
Depreciation (DEPREC)	All the outputs
Processing cost (TRASFO)	Table wine, quality wine, olives and olive oil, cows' milk other milk, other activities
Contribution margin (MC)	All the outputs

2.5 Description of input and output variables of the Italian FADN dataset

The Italian FADN dataset used for the cost estimations is a balanced panel of farms selected from the Italian FADN database that covers the period 2005-2007 and includes 8 tables, 5 of them used for the definition of input and output variables:

- AZI: general and structural information about the farm
- ALL: input and output from livestock production process
- COL: input and output from crop production process

- FAM: information about the family
- ENT: revenues from other activities

The high level of disaggregation in the Italian FADN dataset has led to the input variables of GECOM model being defined as a sum of more cost items, as shown in Table 2.4.

Some costs have simply been added together from the same source file: for instance, the cost of purchased feed (FEEDPC) is obtained by adding the variables SPE_MANGI and SPE_LETTI accounted in the table AZI. The variable WAGES includes wages paid, social security contributions and severance pay (TFR found). Wages refers to the wage earners, while social security contributions and severance pay refer also to family labour.

Other variables have been obtained processing the cost items. One of these is the variable SEED on costs for seeds, which requires additional clarifications. Analysis of the table COL showed that the costs of buying and planting seeds for permanent crops correspond to the cost incurred for integrating the existing plantation. Given the nature of this type of expenditure, not comparable to the cost of seed for crops or vegetables, it has been considered separately (SPE_SEME for permanent crops) and included in the general item OTHSIC. To summarize: the cost of seeds (or plants) attributed to permanent crops have been aggregated to the variable OTHSIC (SPE_SEME for permanent crops) while the costs of seed crops, vegetables, flowers (including nurseries of fruit, grapes, olives and forestry), have been treated as expenses on arable crop (SPE_SEME within the variable SEED, which also includes farm-used seeds RE_SEME). An additional clarification is required for the variable TRASFO that includes the processing costs (SPE_TRASF). This variable is the sum of the processing cost for livestock (SPE_TRASF (al) in the table ALL) and crops (SPE_TRASF (co) in the table COL). A processing cost item is also imputed in the table AZI (SPE_TRASF (az)) but it does not coincide with the sum of the two cost items recorded for livestock and crops. In other words:

$$\text{SPE\_TRASF (az)} \neq \text{SPE\_TRASF (al)} + \text{SPE\_TRASF (co)}$$

The reason for this difference has been identified through a careful analysis of the registration system. It seems to be due to the fact that the processing cost of crops (SPES_TRASF(co)) includes the value of the processed product, as well as the cost of processing, storage and marketing. On the contrary, in the variable

SPE_TRASF (az) and SPE_TRASF (al) this value is not included[10].

In the analysis the sum of SPE_TRASF (al) and SPE_TRASF (co) is considered, therefore also the production value of processed vegetables.

Table 2.4 - Cost variables definition

Variable description	Variable name	Variable source	Source file
Purchased Feed	FEEDPC	SPE_MANGI	ALL
		SPE_LETTI	ALL
Home-grown Feed	FEEDHC	RE_MANGI	ALL
		RE_LETTI	ALL
Vet costs	VETCOS	SPE_ALTRE	ALL
Seed	SEED	SPE_SEME (perm. crop excl.)	COL
		RE_SEME	COL
Fertilizer	FERTIL	SPE_FERT	COL
		RE_LETA	COL
Crop protection	CRPROT	SPE_ANTIP	COL
Contract work	CONWOR	SPE_NOLI	COL
Mechanization	MACHUK	SPESE_MECC	AZI
Other costs: *water, specific costs for farm tourism, other costs, new plants for permanent crops*	OTHSIC	SPE_ACQUA	COL
		AGRTU_SPES	ENT
		SPESE_GENF	AZI
		SPE_ALTRE	COL
		SPE_SEME (for perm.crops)	COL
Land rent	LANDCO	AFF_PASS	AZI
Interest rate	INTERE	PASS_CAPFO	AZI
		PASS_CAPAG	AZI
Wages	WAGES	SALARI+ON_SOC+ACCANT_TFR	FAM
Depreciation	DEPREC	AMMORT_TOT	AZI
Processing cost	TRASFO	SPE_TRASF	ALL e COL
Contribution margin	**MC**	**DIFFERENCE OUTPUT - INPUT**	

10 This fact creates a different cost and production accounting for vegetable and animal products. In the first case, the processing production value is considered as a crop output (as will be seen later in the description of the variables related to production) and as an input for the processed products. For instance the value of grapes is an output in the case of grape production, but it becomes an input for wine production. In the case of livestock products the value of the processed products is not counted either as input or as output of livestock processed products.

The output value of crops, livestock and processed products are taken from the tables COL, ALL and PRO, considering the variable PRO_LOR.[11] All of these products are listed on the left-hand side of Table 2.2. The most important products have been defined individually while similar productions have been aggregated. For instance: citrus fruits are the sum of the production value of lemons, oranges, clementines, etc. In the same way, meat production is the sum of meat production per type of livestock. The variables considered separately (PR_LOR_CAR from the table ALL) are encoded as cattle, sheep, pigs and poultry. Everything else has been put in a residual item (other livestock).

The processed products value for vegetables and livestock (items include in the variables CMILK, OMILK, QWINE, TWINE and OLIST), have been calculated from the table PRO as follows:

Value of sales + premium + own consumption and gifts + salaries in kind + assets + closing valuation –opening valuation

The milk production in quantities is stored in the variable PRODUZ of the table PRO. In the case of animal products, such as milk, the value of the processed product is neither considered as an output in the production value nor recognized as cost of raw milk in cheese production.

Additional information considered by the model is the UAA per crop (taken from the table COL). It is important to take into account that the area is given by the sum of the UAA, associated crops and repeated crops areas.

2.5.1 Sample size after the outliers analysis.

The outliers analysis has been performed in two steps. Initially, farms with missing values for some specific costs have been eliminated. For instance: cropping farms with costs accounted in the table AZI but without details of the costs of seeds, fertilizers, etc., in the table COL; farms with permanent crops with costs in the table AZI but without details of fertilizers and crop protection in the table COL.

The second part of the outliers elimination was performed using a specific program developed in the FACEPA project (see section 2.2.1). The variables considered for outliers detection are 29 outputs ("other milk", "eggs", "contract rearing", "other activities" and "other livestock" are excluded) and 14 inputs (contri-

11 The variable gross production (PRO_LOR) is present in the table COL and is calculated as: (value of sales + premium and grants + own consumption and gifts + salaries in kind + assets + reuses for breeding + farm use of seed + closing valuation + production -opening valuation)

bution margin is not included). The outliers analysis was performed separately on the datasets for each year (Table 2.5). Only the farms present in all the three years have then been selected, in order to use a balanced panel to make the estimations. The sample was not weighted because some variables are not objective variables in the Italian sampling plan (so their variability is not taken into account in the sampling). Therefore the not weighted balanced panel has been preferred to the weighted total sample.

Table 2.5 - Number of farms in the starting dataset, after outliers elimination and in the balanced panel 2005-2007.

Year	Number of farms		
	Starting dataset	After outliers elimination	Balanced panel
2005	15,002	13,636	7,717
2006	15,183	13,756	7,717
2007	15,346	13,893	7,717

Source: our processing on Italian FADN.

2.6 The results for Italy

The econometric model described in the previous sections has been applied to the balanced panel obtained from the 2005-2007 Italian FADN, after the outlier elimination. For every production process, the number of farms and the average production per year are calculated starting from the information in the dataset. They are not estimated by the model.

The estimation results are, in fact, the technical coefficients β_{ik}, that express the expenditure on input i required to produce one unit of output value k. Multiplying the estimated technical coefficient by the production value per hectare or per ton (calculated starting from the dataset information), it is possible to obtain an estimate of the unit cost of production of input i. The estimated coefficients for the different cost items are sometimes not statistically different from zero. In this case it is not possible to evaluate the coefficient and the corresponding production cost value per hectare (or per ton). These values are reported in the tables, highlighted in grey. It is also interesting to consider the variability of the results, analyzed by means of the calculation of confidence intervals for β_{ik} coefficients: the maximum and minimum with a confidence level of 95% should contain the actual value. The minimum and maximum values of the coefficients have been multiplied by the average value of production per hectare (or per ton) in order to obtain a range in monetary terms.

The results of the estimation are compared with the cost allocation done by the surveyors at the end of the accounting year. So, for every crop, a histogram can compare the estimated cost with the allocated ones.

Analyses have been made for the main products at national level and, where the sample size allowed for a sufficient reliability of the results, at district level.

2.6.1 Common wheat

One of the first results from the common wheat sector analysis is the increase in production value per hectare during the considered period. Following the national statistics, this positive trend seems to be due to an increase in the UAA and in prices, whereas the yields have decreased (INEA, 2008; INEA, 2007). As concerns the number of farms producing common wheat in the sample, after a slight decline in 2006, the number increased to 1,100 units in 2007 (Table 2.6).

The most important component of the estimated cost per hectare seems to be depreciation, mechanization costs and land rents. Due to the high cost estimate the contribution margin is always negative for all three years considered, although the difference is reduced significantly in 2007.

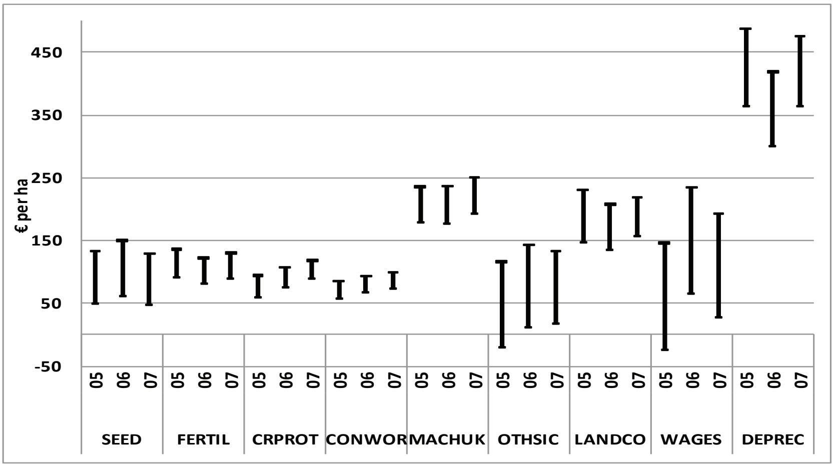
Wages, other costs and depreciation show higher variability in the estimates (Figure 2.1). Instead, the mechanization cost, one of the most relevant, has a relatively limited variability. The estimated interval for contract work is stable and very low in all years: in 2007, for instance, the minimum value per hectare is 74 € and the maximum 100 €. Note that the estimate intervals are confidence intervals at 95% levels so the minimum values can be negatives. Greater levels of variance yield larger confidence intervals and hence less precise estimates of the parameters. So, it could be useful to visualize also the minimum and maximum estimated values for the main costs in every production process in order to have an idea about their variability.

Table 2.6. - Number of farms, production, production cost estimated for common wheat in Italy (€ per ha)

	2005	2006	2007
Number of farms	1,044	1,002	1,100
Production	851	928	1,237
SEED	92	106	89
FERTIL	114	101	110
CRPROT	77	92	104
CONWOR	72	80	87
MACHUK	208	207	222
OTHSIC	48	77	76
LANDCO	189	172	188
INTERE	-7	-9	-8
WAGES	61	150	111
DEPREC	426	360	420
MC	-429	-408	-161
	Associated coefficients are not statistically significant at 95% level		

Source: our processing on Italian FADN.

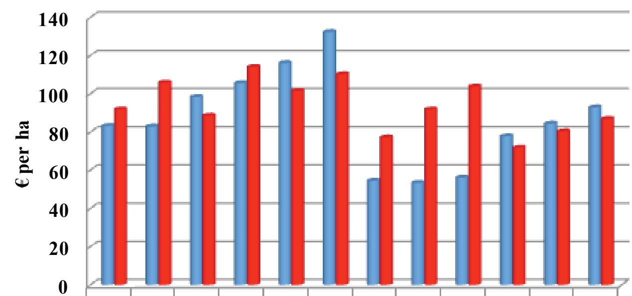
Figure 2.1 - Minimum and maximum estimated values for the main cost items for common wheat in Italy (2005-2007)



Source: our processing on Italian FADN.

As previously mentioned, the Italian FADN surveyors allocate specific and common costs to the different production processes, on the basis of information received from farmers or their experience. These attributed values are compared with those estimated by the model (Figure 2.2). The average values assigned by the surveyors, calculated for the same farms analyzed by the econometric model, have a more regular pattern than those estimated by the model. This could be due to the fact that the surveyors tend to allocate them in the same way over the years. Costs, with the exception of crop protection, have increased over time but this trend does not always seem to be caught by the model. The main differences between estimated and allocated costs for common wheat are observed for crop protection costs. According to the assignment in the Italian FADN database, in fact, the cost of pesticides per hectare is lower than the value estimated by the model: 56 € per hectare for the former against 104 € per hectare for the latter in 2007. On the contrary, contract work presents very similar values and the same trend with both considered methods.

Figure 2.2 - Estimated and attributed values of seed, fertilizer, crop protection and contract work for common wheat (2005-2007)



	SEED			FERTIL			CRPROT			CONWOR		
	05	06	07	05	06	07	05	06	07	05	06	07
Attributed	83	83	98	106	116	132	54	53	56	78	84	93
Estimated	92	106	89	114	101	110	77	92	104	72	80	87

Source: our processing on Italian FADN.

Common wheat production is concentrated in northern Italy, both in terms of number of farms and UAA (Farm Structures Survey 2007 – ISTAT 2009). This different distribution of farms is reflected in the considered sample where 73% of the farms located in the North of Italy produce common wheat. This implies that the results obtained for the national sample are very similar to those obtained implementing the model at a district level, only for the North of Italy[12].

12 The results are available on request from the authors.

2.6.2 Durum wheat

Similarly to common wheat, for durum wheat the total production per hectare has increased. Since yields per hectare in the FADN sample have been the same in 2006 and 2007, the increase could be due to prices. This also results from the national statistics (ISTAT 2008a), which highlight an increase in the total production value (+25%) but a decrease in yields (-9%). The number of farms in the sample that produce durum wheat also increased in the last year (from 577 in 2005 to 1,621 in 2007).

Important components of total cost are depreciation, mechanization costs and wages (Table 2.7). Land rent and interest do not play a relevant role and the associated coefficients are not statistically different from zero. This result for land rent can be explained by the low incidence of rented farmland in central and southern Italy (ISTAT 2009), where durum wheat is particularly widespread. The estimated contribution margin improved in the three years, becoming positive in 2007.

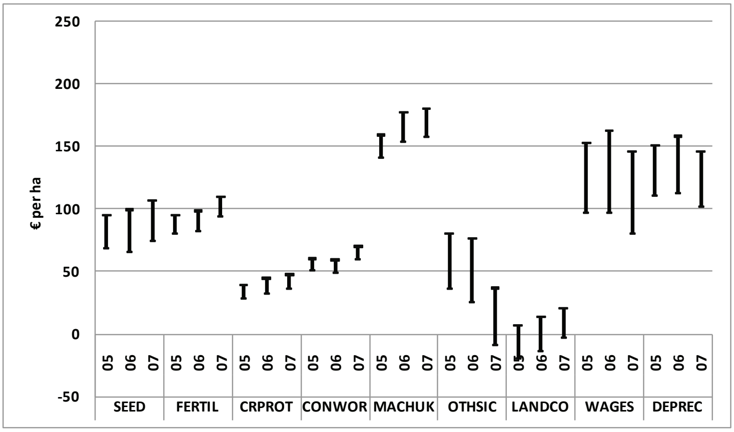
Table 2.7 - Number of farms, production, production cost estimated for durum wheat in Italy (€ per ha)

	2005	2006	2007
Number of farms	1,735	1,536	1,621
Production	577	680	1,206
SEED	82	82	91
FERTIL	88	91	102
CRPROT	34	39	42
CONWOR	56	54	65
MACHUK	150	166	169
OTHSIC	58	51	14
LANDCO	-6	0	9
INTERE	1	1	4
WAGES	125	130	113
DEPREC	131	135	124
MC	-141	-67	474
(shaded)	Associated coefficients are not statistically significant at 95% level		

Source: our processing on Italian FADN.

Depreciation, wages and other costs have the highest range between estimated minimum and maximum value (Figure 2.3). However, none of the estimated ranges of cost for durum wheat are too wide, especially for contract work, crop protection and fertilizer. This is probably due to the large number of farms producing durum wheat (the variability of the estimation usually decreases when the number of observations increases).

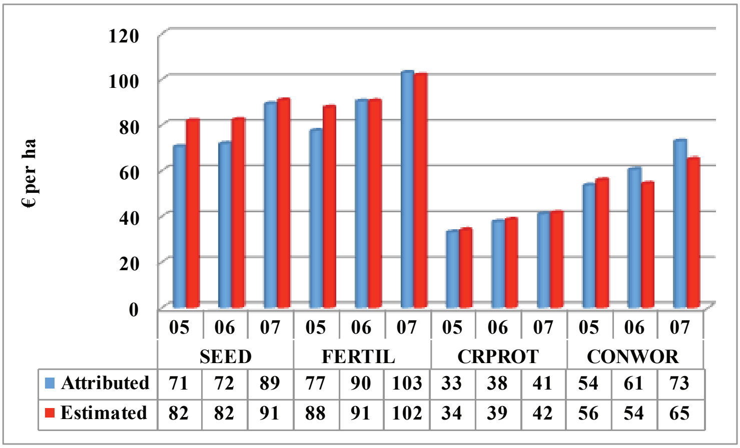
Figure 2.3 - Minimum and maximum estimated values for the main cost items for durum wheat in Italy (2005-2007)



Source: our processing on Italian FADN.

The comparison between attributed and estimated costs for the durum wheat production process gives very similar results in terms of both value and trend (Figure 2.4).

Figure 2.4 - Estimated and attributed values of seed, fertilizer, crop protection and contract work for durum wheat (2005-2007)



	SEED			FERTIL			CRPROT			CONWOR		
	05	06	07	05	06	07	05	06	07	05	06	07
Attributed	71	72	89	77	90	103	33	38	41	54	61	73
Estimated	82	82	91	88	91	102	34	39	42	56	54	65

Source: our processing on Italian FADN.

Durum wheat production is concentrated in the Centre and South of Italy: in 2007, 26% of the Italian production came from the Centre and 66% from the South (ISTAT 2008a). The Italian FADN dataset shows the same distribution: the number of farms involved in this production is very high for the South (1,187 in 2007), quite high in the Centre (367 in 2007) and very low in the North. Indeed, the district estimation was performed only for the Centre and South of Italy.

The production per hectare and estimated costs differ in the two districts (Table 2.8). Every year, the production per hectare is higher in the Centre of Italy than in the South and the difference increased from 2005 to 2007. In the last year, despite the increase in all estimated costs, the highest production value made the contribution margins positive from 2006 to 2007.

Table 2.8 - Number of farms, production, production cost estimated for durum wheat in Centre and South Italy (€ per ha)

	Centre Italy			South Italy		
	2005	**2006**	**2007**	**2005**	**2006**	**2007**
Number of farms	404	349	367	1,296	1,142	1,187
Production	620	777	1,486	557	641	1,106
SEED	109	111	107	69	77	88
FERTIL	126	115	114	67	83	97
CRPROT	55	65	52	32	39	40
CONWOR	56	31	47	48	52	66
MACHUK	209	283	196	129	140	158
OTHSIC	64	102	15	58	48	27
LANDCO	44	26	49	14	23	20
INTERE	11	8	16	2	1	1
WAGES	167	80	27	86	130	108
DEPREC	172	274	246	128	124	109
MC	-393	-316	617	-75	-75	391
(shaded)	Associated coefficients are not statistically significant at 95% level					

Source: our processing on Italian FADN.

2.6.3 Maize

The number of farms in the sample producing maize is high (over 1,500 in 2005) and rather steady in the analyzed period. The increase in the value of maize production per hectare from 2005 to 2007 seems to be due to a substantial price rise[13], whereas the yield did not increase in the period. The national statistics confirm this trend (ISTAT 2008a). Fertilizer, mechanization costs and depreciation are the highest cost items for maize (Table 2.9). The value per hectare of these costs increased in absolute terms between 2005 and 2007, but their relevance on total production decreased. This reduction results in the increase of the contribution margin that became positive in 2007. Only a few coefficients are not statistically different from zero: two of them are the contribution margin for 2005 and 2006, while the estimated contribution margin was significant in 2007.

Table 2.9 - Number of farms, production, production cost estimated for maize in Italy (€ per ha)

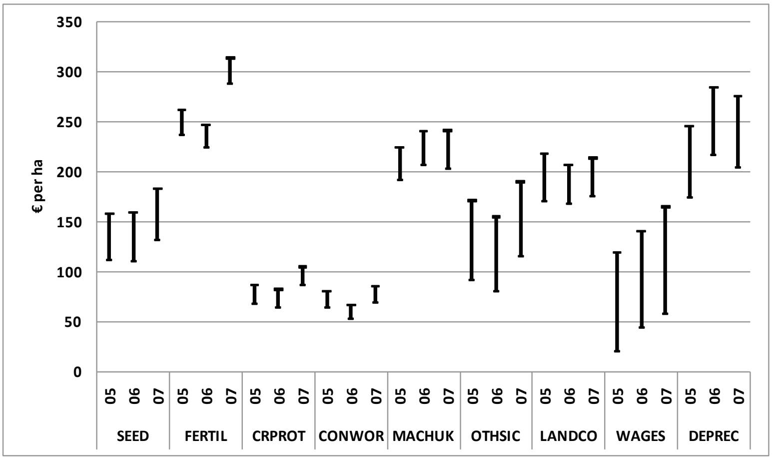
	2005	2006	2007
Number of farms	1,514	1,489	1,454
Production	1,259	1,413	1,990
SEED	135	135	157
FERTIL	250	236	302
CRPROT	78	74	96
CONWOR	72	60	77
MACHUK	208	224	223
OTHSIC	132	118	153
LANDCO	195	188	195
INTERE	5	11	15
WAGES	70	93	111
DEPREC	211	251	240
MC	-96	24	421
(shaded)	Associated coefficients are not statistically significant at 95% level		

Source: our processing on Italian FADN.

Other costs, wages and depreciation show the highest variability between minimum and maximum (Figure 2.5). Their trend, however, is quite regular. As seen for common and durum wheat, the variability of crop protection and contract work is low.

13 The maize price in € per ton increased 53% between 2005 and 2007 according to the DATIMA-ISMEA dataset.

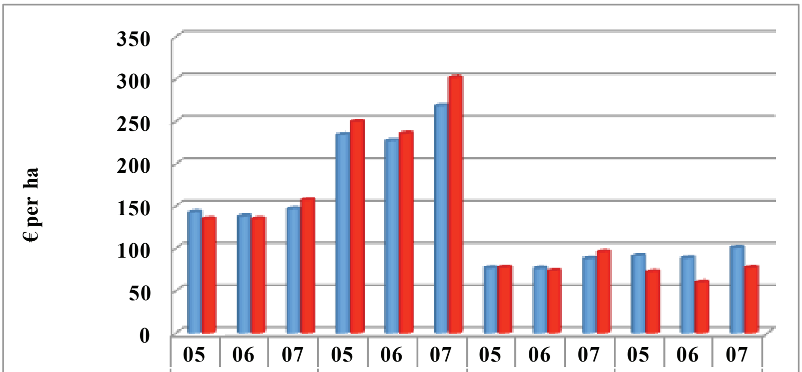
Figure 2.5 - Minimum and maximum estimated values for the main cost items for maize in Italy (2005-2007)



Source: our processing on Italian FADN.

Estimated results from the GECOM model are rather similar to values attributed by surveyors (Figure 2.6). Excluding the results of 2007 for fertilizer cost, the main difference concerns contract work.

Figure 2.6 - Estimated and attributed values of seed, fertilizer, crop protection contract work for maize (2005-2007)



	SEED			FERTIL			CRPROT			CONWOR		
	05	06	07	05	06	07	05	06	07	05	06	07
Attributed	143	138	147	234	227	268	77	76	88	91	89	101
Estimated	135	135	157	250	236	302	78	74	96	72	60	77

Source: our processing on Italian FADN.

Maize is cultivated in all Italian regions, but in particular in the North. According to ISTAT (ISTAT 2008a), in 2007 almost 92% of maize production was concentrated in the North. Considering that the FADN dataset gives the same percentage, the estimation performed for the northern district provides results very similar to the whole Italian sample. This could be explained by the large number of farms located in the North (80% of the total sample), which affects the estimation at national level.

2.6.4 Apples

According to ISTAT, in 2007 the Italian apple sector was one of the most important fruit crops in terms of area (ISTAT, 2009; ISTAT 2008a), with more than 56,000 hectares, only less than peaches and table grapes. Between 2006 and 2007 there was an increase of the total production (in quantity) and a positive trend in producer prices (+16.4%, ISMEA 2011a). This could justify the increase in the production value per hectare (Table 2.10) from 2005 to 2007 (+41%), not caused by an increase in yield.

Apple production does not have seed costs because, as mentioned in section 2.5, the costs of new plants for permanent crops are considered as other costs (OTHSIC) that, together with depreciation and wages, are the most relevant production costs. As concern wages, it is important to point out that apple harvesting needs a large amount of casual labour, for which social security contributions are paid by the farmer. Estimated contribution margin rose every year, in particular in 2007, whereas wages decreased.

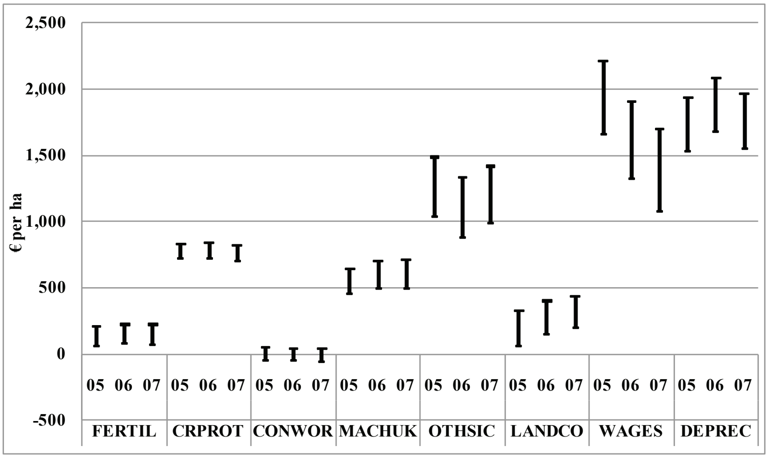
Table 2.10 - Number of farms, production, production cost estimated for apples in Italy (€ per ha)

	2005	2006	2007
Number of farms	386	384	380
Production	10,155	11,378	14,361
FERTIL	138	151	148
CRPROT	776	781	762
CONWOR	2	-6	-11
MACHUK	552	598	602
OTHSIC	1,264	1,105	1,201
LANDCO	193	275	316
INTERE	40	79	94
WAGES	1,931	1,614	1,387
DEPREC	1,736	1,879	1,757
MC	3,524	4,901	8,105
	Associated coefficients are not statistically significant at 95% level		

Source: our processing on Italian FADN.

Depreciation, wages and other costs are also highly variable: there is a big difference between estimated minimum and maximum every year (Figure 2.7).

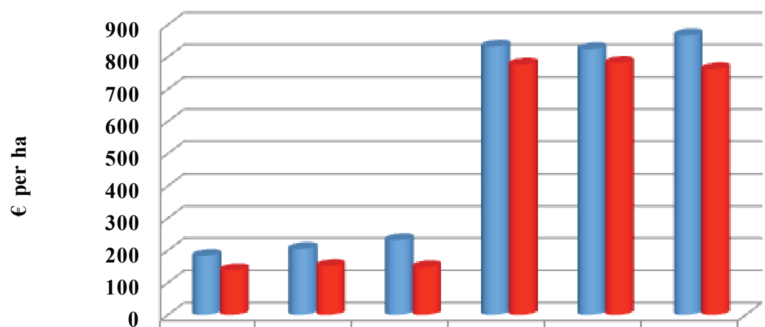
Figure 2.7 - Minimum and maximum estimated values for the main cost items for apples in Italy (2005-2007)



Source: our processing on Italian FADN.

Since estimate coefficients for contract work are not statistically different from zero, they have been excluded from the comparison with the allocation made by the surveyors (Figure 2.8). For fertilizer and crop protection costs the results are quite similar but the estimated costs appear systematically lower than those attributed.

Figure 2.8 - Estimated and attributed values of fertilizers and crop protection for apples (2005-2007)



	FERTIL			CRPROT		
	05	06	07	05	06	07
Attributed	183	204	232	833	824	867
Estimated	138	151	148	776	781	762

Source: our processing on Italian FADN.

Apple production is concentrated in Northern Italy. According to national statistics (ISTAT 2008a), 84% of the surface area and 92% of apple production (in quantities) was located there in 2007. In the analyzed sample 88% of the farms that produce apples are located in the North and they produce 96% of the production value. For this reason, also in this case, the estimation performed for the farms in the North, gives results very similar to the estimation made for the whole Italian sample.

2.6.5 Quality Grapes

Grapes are a typical Italian product, widespread throughout the country: in 2007 vineyards represented more than 33% of permanent crops UAA (ISTAT, 2009). The Italian FADN dataset made the distinction between table grapes (produced in Southern Italy) and grapes for wine (produced all over the country). Grapes for wine can be further divided into grapes for table wine and quality wine.

In Italy, the UAA growing quality grapes was more than 295,000 hectares in 2007, 39% of the grapes UAA (ISTAT, 2009), +3% with respect to 2005. The production value has also increased from 2005 to 2007 (Table 2.11), probably because of an increase in the price, whereas the yield per hectare has gone down in the analyzed period, a trend confirmed in the national statistics (ISTAT 2008a). This can be justified by the large number of wines with registered designation of origin (DOC and DOCG), for which the protocol imposes a limit on the annual yield because excesses of production can negatively affect the wine quality.

In this analysis, all the estimated coefficients are different from zero. The main cost items are wages and depreciation. Quality grapes production, as previously seen for apples, in some cases needs manual harvesting, often done by casual labour. Wages are also rather variable, and they show an increase in 2007.

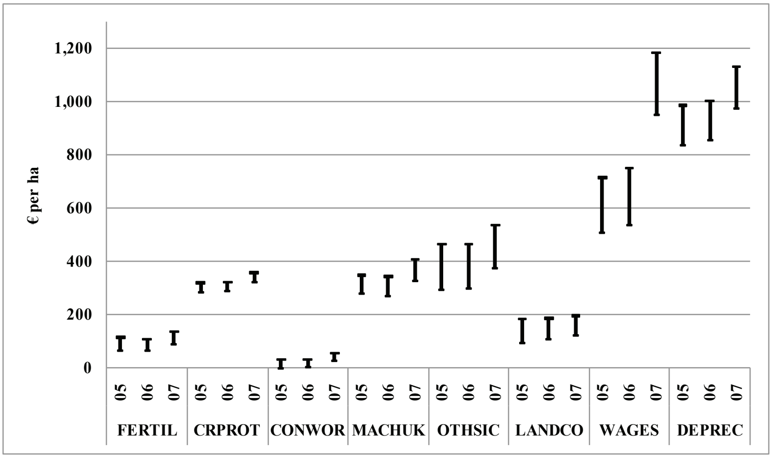
Table 2.11 - Number of farms, production, production cost estimated for quality grapes in Italy (€ per ha)

	2005	2006	2007
Number of farms	939	962	974
Production	5,534	5,407	5,872
FERTIL	91	86	114
CRPROT	302	305	341
CONWOR	16	19	41
MACHUK	314	307	368
OTHSIC	381	383	455
LANDCO	139	148	161
INTERE	35	21	25
WAGES	611	645	1,066
DEPREC	911	930	1,053
MC	2,734	2,563	2,248
	Associated coefficients are not statistically significant at 95% level		

Source: our processing on Italian FADN.

The costs with a lower variability are fertilizers, crop protection, machinery costs and contract work (Figure 2.9).

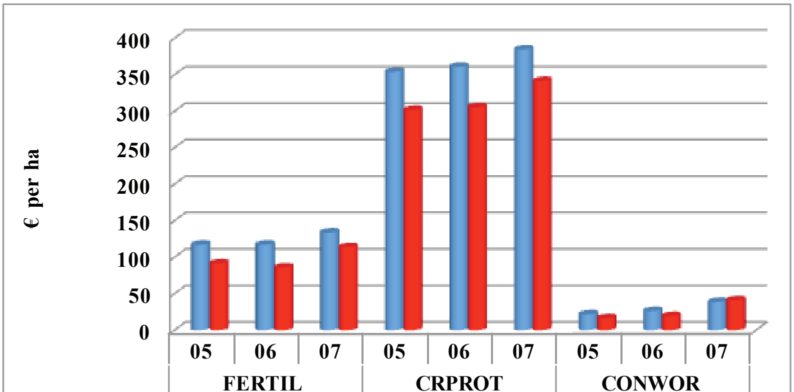
Figure 2.9 - Minimum and maximum estimated values for the main cost items for quality grapes in Italy (2005-2007)



Source: our processing on Italian FADN.

The comparison between attributed and estimated costs (Figure 2.10) shows that the former are systematically higher but in general, the differences are not very big and they have the same increasing trend between 2005 and 2007.

Figure 2.10 - Estimated and attributed values of fertilizers, crop protection and contract work for quality grapes (2005-2007)



	FERTIL			CRPROT			CONWOR		
	05	06	07	05	06	07	05	06	07
Attributed	117	117	134	354	361	385	22	26	39
Estimated	91	86	114	302	305	341	16	19	41

Source: our processing on Italian FADN.

Quality grapes for the production of wine with a registered designation of origin (DOCG and DOC) are concentrated in the North of Italy. In 2007, 59% of this production was located there, 24% in the Centre and the rest in the South (ISTAT 2009). The results of the FADN sample reflect this distribution (Table 2.12). In the whole period, the production value per hectare of northern farms has been higher than in the other districts. In the same way, some estimated cost items are different in the districts. Fertilizer cost is very low in North, whereas other costs are lowest in South. Land cost in the North is significant and rather steady. In Central and Southern Italy, on the contrary, land cost is variable or not significant. This can be explained by the different incidence of rented land, which is widespread in the North but not in the Centre and South. Contribution margin is higher in the North of Italy than in the other districts. Some trends are the same for all districts: wages has a big increase in 2007 (this result is very strange especially for the South of Italy) and contribution margin goes down from 2005 to 2007.

Table 2.12 - Number of farms, production, production cost estimated for quality grapes in North, Centre and South Italy (€ per ha)

	North Italy			Centre Italy			South Italy		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Number of farms	622	639	653	166	171	168	151	152	153
Production	6,235	6,001	6,533	4,727	4,857	5,109	3,952	3,737	4,140
FERTIL	61	81	80	104	79	121	201	150	306
CRPROT	311	325	354	278	298	294	324	270	409
CONWOR	15	22	32	27	21	61	-19	14	20
MACHUK	306	319	356	305	242	367	357	330	468
OTHSIC	373	459	540	100	312	322	287	166	265
LANDCO	192	192	197	74	93	142	-26	1	-8
INTERE	34	7	19	23	45	25	29	28	22
WAGES	553	580	951	790	914	1,348	494	640	1,412
DEPREC	986	953	1,048	754	964	1,157	809	729	728
MC	3,405	3,061	2,954	2,271	1,888	1,274	1,496	1,410	519
(shaded)	Associated coefficients are not statistically significant at 95% level								

Source: our processing on Italian FADN.

2.6.6 Quality Wine

Italy is one of the most important wine producers in the world. In 2007, Italian wine production was more than 42 million hectolitres, less than in 2006 (-13%). About 36% of total wine production is table wine (following the Italian classification system, table wine is a basic wine, made in Italy but without reference to the production area), while 64% is classified as either IGT (29%) or DOC-DOCG (35%). These appellations permit a better specification of the production areas and, in general, are intended as a mark of quality. The production reduction was due especially to a downturn of table wine (-26%), whereas the drop has been less marked for IGT and DOC-DOCG wines (-4.5% and -3.7%). Notwithstanding the decrease in production, analysis of the Italian FADN sample shows an increase in the production value per quintal (Table 2.13), especially in 2007. Other official statistics (ISMEA, 2001b) show an increase in the index price for DOC-DOCG wine from 90 in 2006 to 103 in 2007 (basis 2000).

Table 2.13 - Number of farms, production, production cost estimated for quality wine in Italy (€ per q)

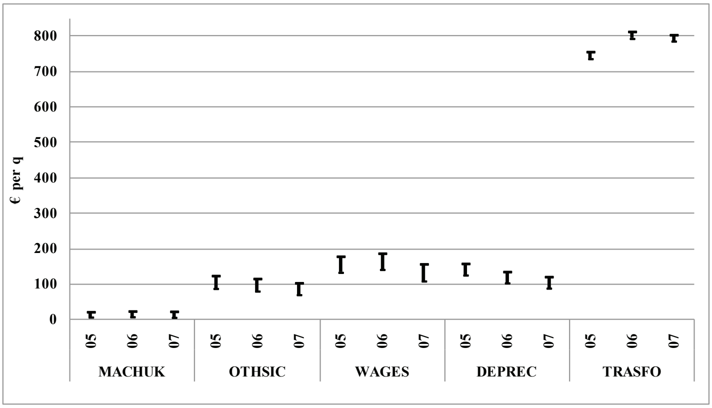
	2005	2006	2007
Number of farms	261	257	231
Production	1,792	1,826	2,010
MACHUK	15	17	15
OTHSIC	106	99	87
INTERE	5	6	7
WAGES	156	165	133
DEPREC	142	120	105
TRASFO	746	803	795
MC	619	617	866
	Associated coefficients are not statistically significant at 95% level		

Source: our processing on Italian FADN.

Differences between minimum and maximum estimated costs are low, in particular for machinery and transformation (Figure 2.11). The highest variability is in wages and depreciation.

In this analysis DOC-DOCG and IGT productions are considered as quality wine. In the estimation of production, fertilizers, crop protection, contract work and land costs are excluded because they are chargeable to grape production. With respect to crop and permanent crop production, in this case there is an additional item cost that is the processing cost. This is the more relevant cost on total production for quality wine (Table 2.13). Others relevant cost items are wages and depreciation, but their relevance on total production is very low compared to processing cost. Estimated contribution margins are always positive and increase in 2007. All the estimated coefficients are statistically significant.

Figure 2.11 - Minimum and maximum estimated values for the main cost items for quality wine in Italy (2005-2007)



Source: our processing on Italian FADN.

According to the national statistics (ISTAT 2008b), 60% of DOC-DOCG wine production and 62% of IGT came from Northern Italy in 2007. Also in the FADN sample most of the farms that produce quality wine are located in the North. Here, the production value per quintal is different from the whole Italian sample: 1,602 € per quintal in 2007 against 2,010 € for the whole sample (Table 2.14). Another difference concerns the wages estimation: their relevance on total production in the northern district is lower than in the total Italian sample. Processing costs seem to be higher in the whole sample, but their relative importance on total production is the same.

Table 2.14 - Number of farms, production, production cost estimated for quality wine in North Italy (€ per q)

	2005	2006	2007
Number of farms	172	164	145
Production	1,536	1,428	1,602
MACHUK	19	19	19
OTHSIC	58	99	82
INTERE	7	12	13
WAGES	77	73	77
DEPREC	100	95	95
TRASFO	640	648	659
MC	636	481	656
	Associated coefficients are not statistically significant at 95% levelC		

Source: our processing on Italian FADN.

2.6.7 Cows' Milk

As concern cows' milk production, the large number of farms included in the dataset reflects the importance of the dairy sector in the country.

In 2007, in Italy the total production of cows' milk was 11.1 million tons (-0.3% from 2006 , INEA, 2008) with a market value equal to 5.2 billion € (+3% from 2006, thanks to the increase of farm gate prices of unpasteurized milk).

In this analysis we considered total production of cows' milk and its products, like cheese, butter, etc. However, the majority of farms in the dataset do not convert milk into products: only 5% of total production can be set to cows' milk products. This can also explain the non-significance of the processing cost coefficient (Table 2.15). The production value per ton increases in 2007, as expected by the price rise. Purchased feed and home-grown feed are the main cost items, and their relative relevance increased in the period. This result is compatible with the trend of index prices of inputs bought by farmers. Feed increased in both 2006 and 2007 compared to 2005 (ISTAT 2007, ISTAT 2008a), but particularly in 2007 when the index was 114.7 (bases 2005).

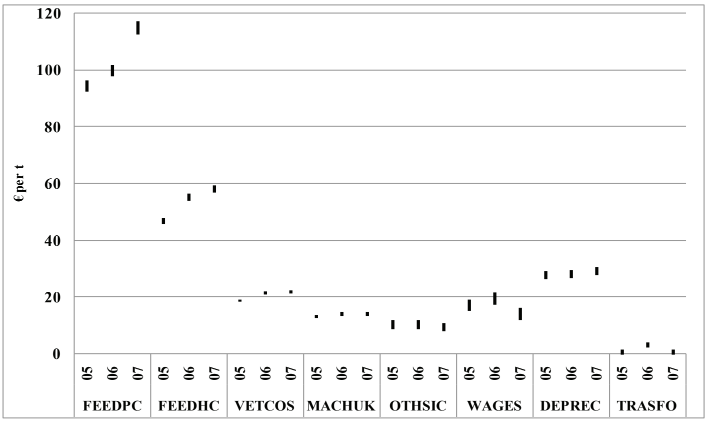
Table 2.15 - Number of farms, production, production cost estimated for cows' milk in Italy (€ per ton)

	2005	2006	2007
Number of farms	1,314	1,276	1,268
Production	374	375	401
FEEDPC	94	100	115
FEEDHC	47	55	58
VETCOS	19	21	22
MACHUK	13	14	14
OTHSIC	10	10	9
INTERE	2	3	2
WAGES	17	19	14
DEPREC	28	28	29
TRASFO	0	3	1
MC	144	122	137
(shaded)	Associated coefficients are not statistically significant at 95% level		

Source: our processing on Italian FADN.

Estimated variability is not very high, probably because of the large number of farms involved. The more variable cost items are wages and purchased feed (Figure 2.12).

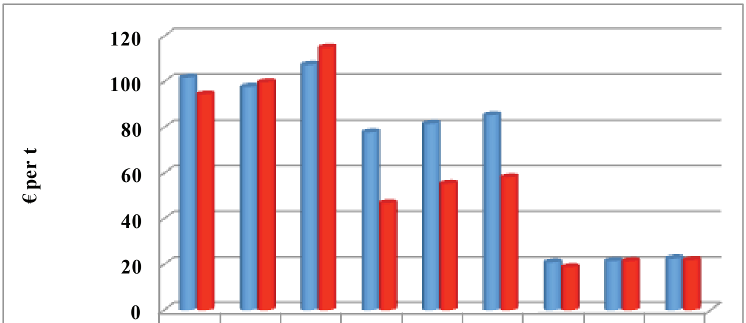
Figure 2.12 - Minimum and maximum estimated values for the main cost items for cows' milk in Italy (2005-2007)



Source: our processing on Italian FADN.

Attributed costs are lower than estimated costs for purchased feed and other specific livestock costs (Figure 2.13), but the trends are the same. The home-grown feed cost attributed by the surveyors is higher than the estimated cost.

Figure 2.13 - Estimated and attributed values of purchased feed, home-grown feed and other livestock specific costs for cows' milk (2005-2007)



	05	06	07	05	06	07	05	06	07
	FEEDPC			FEEDHC			VETCOS		
Attributed	102	98	107	78	82	85	21	21	23
Estimated	94	100	115	47	55	58	19	21	22

Source: our processing on Italian FADN.

A different type of analysis[14] on the costs of cows' milk was done on the Italian FADN dataset (Pretolani and Cavicchioli, 2008). The results are not all comparable with the GECOM estimation because of the different aggregation and assumptions. Besides, the analysis took into account only farms specialized in cows' milk production whereas the GECOM model considered all the farms producing cows' milk, more or less specialized. However, taking these limitations into account, a comparison between some cost items is feasible. Purchased and home-grown feed are higher in the GECOM estimation than in Pretolani and Cavicchioli's analysis, whereas it is the opposite for depreciation (Table 2.16). This means that a further investigation on the home-grown feed cost allocation procedure made by the surveyors is required. Total explicit costs are similar to the sum of estimated cost in the GECOM model (sum from purchased feed to processing cost). Indeed, in 2005, explicit costs are 259 € per ton and the sum of GECOM estimated costs is 264 € per ton.

14 For a description of this methodology see Pretolani and Cavicchioli (2008)

Table 2.16 - Cows' milk cost of production (Pretolani and Cavicchioli, 2008)

	2005	2006	2007
Purchased feed	85	84	94
Home-grown feed	39	41	43
Other livestock specific costs	19	20	20
Depreciation	42	42	42
Total costs (*)	375	384	394
- explicit	242	249	259
- calculated (*)	133	135	135

Source: DEPAAA on RICA-INEA dataset.

(*) not comparable with GECOM estimation results

Although the dairy sector is widespread in Italy, there are important differences in structure and production between the North and South of the country. The majority of milk production is concentrated in the North, more specifically on the Pianura Padana that represents the most important area. 83% of milk collected by the food industries comes from the North of Italy (ISTAT 2008b), 10% from the South and the rest from the Centre. The production structure is also different: the number of milk cows per farm is 33 in the North, 31 in the Centre and only 17 in the South (ISTAT 2009).

The cost estimation was performed on the three districts, but the results for the Centre are not shown because of the small number of farms. Cows' milk production value per ton is quite similar in the North and South, with a different trend. It has increased in Southern Italy and remained steady in the North (Table 2.17). A difference between these two districts concerns the cost of purchased feed and veterinary costs that are higher in Northern Italy.

Table 2.17 - Number of farms, production, production cost estimated for cows' milk in North and South Italy (€ per ton)

	North Italy			South Italy		
	2005	2006	2007	2005	2006	2007
Number of farms	793	767	767	438	429	422
Production	386	360	385	338	437	465
FEEDPC	99	101	116	64	76	83
FEEDHC	49	53	57	41	64	58
VETCOS	21	22	23	10	13	14
MACHUK	14	13	14	9	8	9
OTHSIC	10	8	9	7	5	7
INTERE	2	3	2	1	1	1
WAGES	15	15	12	15	21	18
DEPREC	29	27	30	22	26	24
TRASFO	1	4	0	-1	0	1
MC	146	114	123	171	224	251
	Associated coefficients are not statistically significant at 95% level					

Source: our processing on Italian FADN

2.7 Remarks

This chapter discussed the result obtained by applying the GECOM model to the Italian FADN database, that has required an adaptation of the model scheme to the specific characteristics of the Italian FADN. Seven process have been analyzed and for everyone the estimated costs have been compared with some costs allocated by the surveyors at the end of the accounting year. This is a characteristic of Italian FADN so the application of GECOM method can be considered an improvement of our accounting scheme or an objective validation method.

Generally speaking, the adaptation of GECOM model to the Italian FADN gives reasonable results for the main products in the considered years (2005, 2006 and 2007) and also the comparison between estimated cost and attributed cost shows interesting results in most cases. In all the considered cases, the lowest estimated variability has been found for seeds, fertilizers, crop protection costs and contract work.

For common wheat, cultivated mostly in the North of Italy, coefficients are, in general, statistical significant at 95% level (excluding wages and depreciation in 2005 and interests in the three years). The increase of the production value per hectare of common wheat seems to be due to an increase in cultivated areas and in the prices, whereas the yields are decreased. The estimation results shows also a general increase in the cost per hectare of seeds, fertilizers and contract work (which estimated variability is very low), confirmed by the similarity with the attributed values (excepting for crop protection costs) which show also the same trend.

Durum wheat estimation results permit to highlights the regional differentiation of estimates between the Centre and the South of Italy. In general, there are few coefficients not statistically significant at 95% level and a very high similarity between estimated and attributed costs. But the regional differentiation shows two different cultivation conditions of durum wheat: the Centre of Italy is characterized by higher production value per hectare but also by higher production costs. However, it seems that since 2007 the contribution margin became positive from both areas.

Apples are cultivated mainly in the North of Italy. The production value per hectare is increased in the three years (+41%) as a consequence of a positive trend in the producer prices. All the coefficients are statistical significant at 95% level (excluding contract work) and the most important cost item is represented by wages and depreciation (which have also the highest estimated variability).The estimated costs for fertilizer and crop protection are similar to the attributed ones.

Quality grapes and wines production costs have been estimated separately, with a regional differentiation for quality grapes. In general, crop protection costs and wages are the main variable cost items in the grapes cultivation. From 2005 to 2007, all the estimated costs show an increase (especially wages) and, as a consequence, the contribution margin per hectare has dropped (-18%). The same increase is highlighted by the process of Italian FADN attributed costs which in general, are higher than the estimated ones. The regional differentiation put on evidence the highest production value and the lowest costs per hectare in the North of Italy (+59%) with respect to the South. Coefficients related to land cost are not statistically significant in the South, probably because the rent land practice, widespread mostly in the North (more observations). As concern wine, the costs are related mainly to the the transformation process, increased from 2005 to 2007 (+7%). But the general drop in the other costs accompanied by a rise in the production price (+12%) has had as a consequence an increase in the contribution margin per quintal of production (+40%). All the coefficient are statistically significant at 95% level and positives and there is a very small estimated variability in the main cost items.

As concern cows' milk production, the high number of farms included in the dataset reflects the importance of dairy sector in the country. Notwithstanding the inclusion of cows' milk products in the analysis, the 95% of the total production can be set to cows' milk and this explains the non significance of the transformation cost coefficient. Moreover, the estimated variability is very low. The production value per ton is increased (+7% from 2005 to 2007) mainly because of the price increase. As expected, the most important expenses are represented by feed cost (purchased and home grown) both increased (+23%) in the period. This trend is confirmed by the comparison with the attributed costs resulting in the Italian FADN which highlights an overestimation of home grown feed costs: 82 €/t against the estimated 53 €/t (similar to the result of other analysis). This is not explained by the model but requires a further investigation on the cost allocation procedure carried out by the surveyors. The regional differentiation between the North and the South of Italy shows a cost structure quite similar: only the purchased feed and the veterinary costs are higher in the northern Italy while the other items are almost the same. The average contribution margin per ton, it is higher in the South (+68%).

The model could be adapted to perform other specific analyses. In every case, it requires knowledge of the context to be analyzed, in order to choose the right combination of inputs and outputs that meets the agricultural characteristics of the study area. In the estimation analysis, it is important also to consider the limits related to basic assumption. In particular, the model cannot be used to analyze the effect of scale or the effects of adopting a particular technology. Moreover, it is necessary to detect the outliers because the model seems to be very sensitive: the results have improved significantly after the application of Mahalanobis distance procedure.

Chapter 3

POSITIVE MATHEMATICAL PROGRAMMING TO ESTIMATE SPECIFIC COSTS OF PRODUCTION

3.1 Introduction to the PMP approach

Positive Mathematical Programming (PMP) is widely used for evaluating the effects of the CAP instruments on the dynamics of agricultural processes and farm economic variables, both for ex-post and ex-ante analysis. The main contribution of this methodology to agricultural economics is due to its capacity to maximize the information contents in the agricultural datasets available at European level, such as FADN, REGIO, IACS (Arfini et al., 2003; Paris and Howitt, 1998). With the recovery of farm decision variables, by estimating the total variable cost function, PMP can reproduce the exact observed farm allocation plan and the decision variables (total specific variable costs) that led farmers to decide on such a production plan.

Many papers have adopted the PMP methodology for developing models to assess the impact of proposed or already implemented CAP reforms. Also in European research projects, this approach is used with micro-based information, like FADN[15]. In most cases, PMP is proposed in its "classical" form, where the procedure is split in three phases: differential costs recovery, estimation of the non-linear cost function and lastly, calibration using a non-constrained production model with a non-linear objective function (Howitt, 1995). Applications of this basic version are the most common, e.g. for evaluating CAP reform impacts (Arfini et al., 2005).

An attempt to introduce innovations in the basic approach was made by Heckelei and Wolff (2003), who proposed a methodology that avoids the first phase for

15 Several European research projects have developed and applied models based on the Positive Mathematical Programming methodology, such as CAPRI (Heckelei, 1997; Heckhelei and Britz, 2000) and EUROTOOLS (Paris and Arfini, 2000) in the V FP, GENEDEC (contract no. SSPE-CT-2004-502184 and CARERA (contract no. SSPE-CT-2005-022653) in the VI FP.

calibrating the observed situation by directly imposing first order conditions in the cost function estimation phase. This approach was also used with cross-section data in order to enhance the consistency of the cost estimation (Heckelei and Britz, 2000). More advanced extensions of PMP are due to Paris (2001), who generalized the method adopting an equilibrium model in a static framework and in a dynamic price expectation approach.

The demand for an assessment of agricultural policy measures has risen dramatically during this last decade and contributed to the development of a set of economic tools that would respond to such needs using all the available information. PMP plays an important role in this field. The methodology can provide useful results to policymakers even in the presence of a limited set of information, as generally happens when European agricultural databases are used. PMP can respond in a flexible and consistent way to a large spectrum of policy issues, typically concerning land use changes, production dynamics, variations in gross margin and other main economic variables (costs, subsidies, gross saleable production, etc.). However, all these PMP applications are developed exploring the supply side of the agricultural sector while the demand side seems to be delegated to well-posed problems solved by econometric techniques.

In this chapter, the mathematical structure of the PMP model will be explained in order to clarify the application that will follow in the last two chapters.

3.2 Mathematical structure of the PMP model

Paris and Howitt (1998) and Paris and Arfini (2000) described the mathematical programming process to analyze farmer behaviour. This process recovers the latent information driving the farmer's decision process and uses it to assess the likely responses to market and policy scenarios. PMP consists of three steps.

The first is defined by N linear programming (LP) models, one for each farm and by an additional LP model for the entire sub-region or district. The n-th individual farm model $(n=1,\ldots,N)$ 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, λ. The n-th farm LP model has the following structure:

$$\max_{x_v^n} GM = \sum_{v=1}^{V} [x_v^n (pr_v^n - c_v^n)] + \sum_{v=1}^{V} xh_v^n \, sh_v^n \quad (1)$$

where x_v^n is the production level for each process, $v=(1,...,V)$, of each farm in the sample, n=(1,...,N), while pr_n^v are c_n^v the price and cost associated with each product level, respectively. The objective function takes into consideration the amount of farm subsidies — defined as the product of the growing area, xh_n^v, and the per hectare subsidy level, sh_n^v — as part of the farm gross margin (GM).The objective function specified in (1) is subject to a series of constraints that can be expressed as:

$$\sum_{v=1}^{V} (a_v^n x_v^n) \leq b^n \quad (2)$$

$$x_v^n \leq \overline{x}_v^n + \varepsilon \quad (3)$$

$$x_v^n \geq 0 \qquad \text{pr} \quad (4)$$

where a_v^n is the element of the technical matrix of the different activities implemented on each of the n farms in the sample (the n -th matrix A of technical coefficients is defined as $A_n=[a_{nij}]$, where $a_{nij}=h_{Rni} / x_{RnJn}$), b is the vector of availability of limiting allocable inputs. (4) presents the non-negativity constraint placed on the primal variables of the problem.

Constraints (2) are called structural constraints, while constraints (3) are called calibration constraints. The constraint in Equation (2) indicates the overall availability of scarce factors to be allocated among the various production processes V. In this model, the only limiting factor is the land to be used for the various production processes. Constraint (3), on the other hand, concerns the production capacity of each activity on the farm, defined according to the levels of production observed. Constraint (3) reproduces the initial situation observed in terms of production levels for each farm activity. The term ε, a low positive number selected at will, serves to separate structural constraint (2) from calibrating constraint (3). In fact, if this term is omitted, the linear dependence between the two constraints would lead to dual positive values for all the calibration constraints while the shadow price for the structure constraint in (2) would remain at zero, making interpretation difficult and hardly reflecting reality (Paris and Arfini, 1995).

The problem of linear programming (1)-(4) uses calibration constraints to reconstruct the observed situation, restoring the dual values associated with the production capacity constraints in (3), λ_v''.

This initial phase therefore serves to derive the dual variables specific to the production processes used on the farm. This information incorporates the technical and economic elements the farmer considers in defining the farm production plan.

However, the lack of specific cost information at farm level means that it is not possible to derive the cost function parameters for the marginal product, since its marginal cost value is null. So it is necessary to implement an alternative first phase, different from the traditional PMP model formulation, where the shadow prices associated with the binding and calibrating constraints are derived, by the resolution of a problem in which the constraints are represented by the equilibrium conditions of the problem (1)-(4). This is solved by means of traditional econometric tools (Heckelei and Wolff, 2003) and by the innovative methodology proposed below.

3.3 Deriving the cost function

The objective of the second phase of the PMP procedure is to estimate the farm cost function. Starting from the vector of the shadow prices associated with the calibration constraints, it is possible to determine a new cost function that meets the criteria defined by both economic theory of production costs and farm reality. To meet the non-linearity condition for the objective function of the third phase, a quadratic functional shape is used (Howitt, 1995). Starting from the information on the problem of linear programming it is therefore possible to build a new quadratic cost function defined as follows:

$$(\lambda + c)\overline{x} = \frac{1}{2}\overline{x}'Q\overline{x} \qquad (5)$$

where λ and $\boldsymbol{c}$ are, respectively, the vector of the dual values that determine the first phase and the vector of the accounting costs, $\overline{\boldsymbol{x}}$ is the vector of the known production levels and $\boldsymbol{Q}$ the matrix of the non-linear function of total costs. In (5) the elements for matrix $\boldsymbol{Q}$ are still unknown and must be derived through suitable estimation methods. In the literature (Paris and Arfini, 2000), estimation through application of the principle of maximum entropy is preferred. With this principle, the uncertainty regarding the realization of that event must be maximized in order to derive the probability of distribution for a given event. To clarify the concept, the general formula of the entropy for s possible occurrences of the same phenomenon is introduced as follows:

$$H(p_1, p_2, ..., p_s) = \sum_{i=1}^{s} p_i \log \frac{1}{p_i} = -\sum_{i=1}^{s} p_i \log p_i \qquad (6)$$

where p_i is the i-th probability of a probability $p_i = \frac{1}{s}$ distribution made up of s elements. From (6) one can see that if the probability — that is the case of uniform distribution, where the degree of uncertainty is highest — the function is maximized and is an increasing, monotone function of s. The case of uniform distribution corresponds to the case where some elements are available for a given phenomenon. However, when some distribution moments are known, following the above reasoning, the entropy of the probability distribution can be maximized by placing constraints on the moments used to derive it. In other words, the probability distribution closest to the uniform distribution is taken into account (Jaynes, 1957).

Given that entropy measures the degree of uncertainty regarding realization of a phenomenon, this approach can be applied to estimating a parameter, the value of which can be defined within an as-yet unknown probability distribution. On the basis of these concepts and considering the adaptations given by Paris and Howitt (1998), the parameters of matrix Q can be recovered by maximizing the probability distribution associated with an interval of suitably specified support values. The non-linear programming problem of maximum entropy is applied to the estimation of the matrix Q decomposed according to the Cholesky factorization, where $Q = LDL' = TT'$, where L is a triangular matrix, D a diagonal matrix and $T = LD^{1/2}$. The problem can then be solved by maximizing a probability distribution for which we know the expected value, which corresponds to the marginal cost $\lambda + c$ determined in the first phase. The objective function of the problem of maximum entropy is thus presented as follows:

$$\begin{aligned} \max_{p^l_{(\cdot)}, p^d_{(\cdot)}, p^u} \quad & - \sum_{v=1}^{V} \sum_{v'=1}^{V} \sum_{w=1}^{W} \left(p^l_{vv'w} \log p^l_{vv'w} \right) \\ & - \sum_{v=1}^{V} \sum_{v'=1}^{V} \sum_{w=1}^{W} \left(p^d_{vv'w} \log p^d_{vv'w} \right) \\ & - \sum_{w=1}^{W} \left(p^u_w \log p^u_w \right) \end{aligned} \qquad (7)$$

where $p^{l}_{(\cdot)}$ and $p^{d}_{(\cdot)}$ are the probability of the distribution associated with elements of the triangular matrix $\boldsymbol{L}$ and diagonal matrix $\boldsymbol{D}$, while $p^{u}_{(\cdot)}$ are elements of the probability of errors, or differences, vs. the farm costs-sum. In fact, the cost matrix is estimated on the basis of the following equation:

$$\bar{\lambda}_v + \bar{c}_v = \sum_{v'=1}^{V} \left\{ \sum_{v''=1}^{V} \left(T_{vv''} T_{v''v'} \right) \right\} \bar{x}_{v''} \; ! \tag{8}$$

where $\bar{\lambda}_{(\cdot)} + \bar{c}_{(\cdot)}$ is the average marginal cost of the production processes for the g roup of N farms considered in the model. $T_{(\cdot)}$ is an element of the matrix $\boldsymbol{T}$ obtained through Cholesky's * decomposition. In fact:

$$T_{vv''} = \sum_{v'=1}^{V} \left\{ \sum_{w=1}^{W} \left(p^{l}_{vv'w} z^{l}_{vv'w} \right) \sum_{w=1}^{W} \left(p^{d}_{vv'w} z^{d}_{vv'w} \right)^{1/2} \right\} \tag{9}$$

The relationships inserted into (9) clarify the role of the support values in the process of estimating the cost matrix. The components $z^{l}_{(\cdot)}$ and $z^{d}_{(\cdot)}$ are the appropriately selected support values (Paris and Howitt, 1998). Associated with the distribution of probability, and , they define the elements of the triangular matrix $\boldsymbol{L}$ and diagonal matrix $\boldsymbol{D}$. It must be pointed out that matrix $\boldsymbol{Q}$ is unique and is derived from the marginal costs of the farm-sum. In this context, the cost function specified according to the $\boldsymbol{Q}$ matrix is also called the frontier cost function, indicating that the farm-sum cost function is the most efficient activity cost structure (Paris and Arfini, 2000).

To define the quadratic marginal cost associated with each farm in the sample, the difference (or error) vs. the average marginal cost must be determined. Thus, for the processes implemented — that is for those which are strictly positive — the individual marginal cost function is:

$$\lambda^{n}_{v} + c^{n}_{v} = \sum_{w=1}^{W} \left(p^{un}_{vw} z^{un}_{vw} \right) + \sum_{v'=1}^{V} \left\{ \sum_{v''=1}^{V} \left(T_{vv''} T_{v'v''} \right) \right\} \bar{x}^{n}_{v''} \tag{10}$$

where $(\lambda^{n}_{(\cdot)} + c^{n}_{(\cdot)}$ is the individual marginal cost of the $\boldsymbol{n}$-th farm. The average errors are given by the product obtained, multiplying the specially identified support values $z^{un}_{(\cdot)}$ and the relative probabilities $p^{un}_{(\cdot)}$. Moreover, given that the cost function contains all production processes implemented by the sample of farms considered, we must also consider those farms that have not implemented the entire range of processes identified for the sample as a whole. For this reason, the model calls for the following relation for N farms:

$$\overline{\lambda}_v^n + \overline{c}_v^n \leq \sum_{w=1}^{W} \left(p_{vw}^{un} z_{vw}^{un} \right) + \sum_{v'=1}^{V} \left\{ \sum_{v''=1}^{V} \left(T_{vv''} T_{v'v''} \right) \right\} \overline{x}_{v''}^n \qquad (11)$$

All the above probability distributions must meet the following condition:

$$\begin{cases} \sum_{w=1}^{W} p_{(\cdot)}^{l} = 1 \\ \sum_{w=1}^{W} p_{(\cdot)}^{d} = 1 \\ \sum_{w=1}^{W} p_{(\cdot)}^{un} = 1 \end{cases} \qquad (12)$$

Problem (7)-(12) provides the probability distribution values for the elements of the triangular matrix L, the diagonal matrix D and for the vector of the residual marginal variable costs for each farm in the sample. The reconstruction of the elements that make up matrix Q is obtained from the following:

$$q_{vv'} = \sum_{v''=1}^{V} \left\{ T_{vv''} T_{v'v''} \right\} \qquad (13)$$

where $q_{(\cdot)}$ is one of the parameters that make up the cost matrix Q. The cost function specified by the above method preserves the technical information regarding the calibration constraints.

If the cost function is inserted in a problem similar to the one identified in the first phase, it is possible to reproduce the situation observed, but without the calibration constraints. This last model exactly reproduces the base period allocation and output decision of the single n-th farm and of the entire region. That is, the primal and dual solutions of this quadratic programming model are exactly equal to the primal and dual solution of the initial LP model which, in turn, reproduces the 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. It can be used to analyze various scenarios of agricultural policy with changes in output prices, and limiting resource availability.

3.4 PMP dual approach

One of the main limits of the PMP standard approach is related to the existence of the specific costs per process otherwise the estimation of the Q matrix parameters can produce zero value for at least one activity. This case is avoided considering farm datasets where the specific costs of production are present, like the Italian FADN, which contains information about the accounting costs. In Italy, in fact, an attribution of the accounting costs to each process activated on the farm is made by the surveyors at the end of the survey. Instead, the possibility of applying the PMP standard approach in the European context is reduced because of the lack of information about specific costs of production.

As suggested by Arfini and Donati (2009), it is possible to overcome this problem by developing a more general PMP approach that does not implement the first phase. As already mentioned, the first phase of PMP is devoted to identifying the implicit marginal costs associated to the farm activities by the way of a set of calibrating constraints that force the model to reproduce the observed situation. Calibrating constraints are imposed so that at least one shadow value associated to them is equal to zero, otherwise it is very likely to obtain a shadow price for the structural constraint (land) equal to zero (Paris and Howitt, 1998). So, the constraint $x \leq \overline{x} + \varepsilon$ avoids the possible degeneration of the problem and makes it possible to obtain a positive shadow price for the structural constraints. In the second phase of PMP, a shadow price associated to a given calibrating constraint equal to zero impedes a correct estimation of the cost function. To avoid this situation that can lead to a misspecification of the non-linear cost function, the PMP standard approach requires the presence of the explicit costs associated to the different activities. As equation (8) suggests, the marginal cost for each process is the summation of the shadow price associated to the calibrating constraints, λ, and the explicit cost, c. If for a certain process, λ is equal to zero, the component c permits a positive value to be maintained for the cost associated to an activated process. In other words, to guarantee that the standard approach works properly, the explicit cost should be present in the model.

Arfini and Donati (2009) proposed merging the first phase with the second phase through the dual properties of the PMP approach. In this respect, Paris (2011) justified this approach discussing the KKT conditions derived from the Arfini-Donati setup.

Let us assume a sample of farms composed of N farms and that information about production plan, prices and technical coefficients is known (the quantity of factors used to obtain one unit of each farm product) at farm level. We assume also to consider only one limiting factor, the land available at farm level, $\boldsymbol{b}_n$. The use of factor per unit of output is represented by the technology matrix $\boldsymbol{A}_n$. The known production levels for each farm are indicated by the vector $\bar{\boldsymbol{x}}_n$, while output market prices are represented by the vector $\boldsymbol{p}_n$ and exogenous marginal cost related to each activity is represented by the vector $\boldsymbol{c}_n$. This latter can be viewed as the cost originated by the farm accountancy.

The objective of a PMP model is to recover some of the information that cannot be directly collected at a farm level but that is part of the farmers' decision-making process, in a more or less conscious way. This information that is obviously lacking in the official farm databases, can be derived through the PMP properties. The implicit information that we want to reveal is the vector λ_n, that contains for each farm the additioal marginal cost considered by farmers in defining a certain production plan with the explicit cost $\boldsymbol{c}_n$. Adopting the approach of Arfini-Donati and discussed by Paris (2011) we introduce the following formula:

$$\min_{\mathbf{u}_n, y_n, \boldsymbol{\lambda}_n, \mathbf{Q}} \left\{ \sum_{n=1}^{N} \frac{1}{2} \mathbf{u}_n' \mathbf{u}_n + \sum_{n=1}^{N} \left(b_n y_n + \boldsymbol{\lambda}_n' \bar{\mathbf{x}}_n + \mathbf{c}_n' \bar{\mathbf{x}}_n - \mathbf{p}_n' \bar{\mathbf{x}}_n \right) \right\} \tag{14}$$

subject to

$$A_n' y_n + \boldsymbol{\lambda}_n + \mathbf{c}_n \geq \mathbf{p}_n \qquad (\mathbf{w}_n) \tag{15}$$

$$\mathbf{c}_n + \boldsymbol{\lambda}_n = \mathbf{Q} \bar{\mathbf{x}}_n + \mathbf{u}_n \qquad (\mathbf{z}_n) \tag{16}$$

where $\boldsymbol{y}_n \geq 0, \boldsymbol{\lambda}_n \geq 0,$ and $\boldsymbol{Q}$ is a matrix symmetric positive semidefinite as stated by Paris and Howitt (1998) and Paris (2011). $\boldsymbol{w}_n$ and $\boldsymbol{z}_n$ are the shadow prices associated to equations (15) and (16) respectively. $\boldsymbol{u}_n$ is the vector of marginal cost deviations per farm, that is the distance between the marginal cost $\boldsymbol{c}_n + \boldsymbol{\lambda}_n$ and the marginal cost $\boldsymbol{Q}\bar{\boldsymbol{x}}_n$ of a non-linear cost function to estimate, so that $\boldsymbol{c}_n + \boldsymbol{\lambda}_n - \boldsymbol{Q}\bar{\boldsymbol{x}}_n = \boldsymbol{u}_n$. The parameters of $\boldsymbol{Q}$ to estimate are part of a quadratic cost function aiming to give flexibility to model responses to farm simulations. The model is optimized by a combined objective function, (14), which considers a least-squares technique and the minimization of the difference between the total revenue, $\boldsymbol{p}'_n \bar{\boldsymbol{x}}_n$, and the total cost, $\boldsymbol{b}_n \boldsymbol{y}_n + \boldsymbol{\lambda}'_n \bar{\boldsymbol{x}}_n \boldsymbol{xn} + \boldsymbol{c}'_n \bar{\boldsymbol{x}}_n$. The minimization of this difference identifies the optimal condition for the PMP standard approach, or in general terms that, at the optimum, the primal objective function should be equal to the dual one.

The above model integrates the first and second phase of the standard PMP approach by using the PMP dual properties. In this model, there is no explicit trace of the calibrating constraints nor the epsilon terms that help to break the linear dependency between structural and calibrating constraints. The constraints of the model (15)-(16) concern the equilibrium conditions with marginal cost greater than or equal to marginal revenue and the relation for shifting from a linear to a quadratic cost function. The model does not repeat the tautological procedure of the standard approach deriving the information about the output levels, already known before developing the model, but reveals the hidden information about the differential marginal costs inside the production levels and makes it available for the simulation phase.

To understand better the significance of this problem and the corresponding properties, we can transform the model into its alternative Lagrangean representation, as follows:

$$L = \sum_{n=1}^{N} \frac{1}{2}\mathbf{u}'_n\mathbf{u}_n + \sum_{n=1}^{N}\left(b_n y_n + \boldsymbol{\lambda}'_n\overline{\mathbf{x}}_n + \mathbf{c}'_n\overline{\mathbf{x}}_n - \mathbf{p}'_n\overline{\mathbf{x}}_n\right) + \sum_{n=1}^{N}\mathbf{w}'_n(\mathbf{p}_n - A'_n y_n - \boldsymbol{\lambda}_n - \mathbf{c}_n) + \sum_{n=1}^{N}\mathbf{z}'_n(\boldsymbol{\lambda}_n + \mathbf{c}_n - \mathbf{Q}\overline{\mathbf{x}}_n - \mathbf{u}_n) \quad (17)$$

From the Lagrangean function we can obtain the following relevant KKT conditions:

$$\frac{\partial L}{\partial \mathbf{u}_n} = \mathbf{u}_n - \mathbf{z}_n = \mathbf{0} \quad (18)$$

$$\frac{\partial L}{\partial \boldsymbol{\lambda}_n} = \overline{\mathbf{x}}_n - \mathbf{w}_n + \mathbf{z}_n \geq \mathbf{0} \quad (19)$$

$$\frac{\partial L}{\partial y_n} = b_n - A_n\mathbf{w}_n \geq 0 \quad (20)$$

The partial derivatives (18) indicate that the deviation terms, $\boldsymbol{u}_n$, are equal to the dual values, $\boldsymbol{z}_n$, linked to equation (16). Since the problem tries to minimize the squares of the farm cost deviations u_n and z_n should assume very small values close to zero. The KKT condition (19) can be rewritten as $w_n - z_n \leq \bar{x}_n$, showing that difference between the two shadow prices associated to equations (15) and (16) should be less than or equal to the realized outputs. In this respect, if we consider that the shadow price of the equation representing the equilibrium condition can be interpreted as the shadow output quantities, we can state that $w_n \approx \bar{x}_n$. Furthermore, as we have affirmed for the KKT condition (x), z_n can be viewed as a small term close to zero, we can state that $z_n \approx \varepsilon$. Rearranging the information, the KKT condition (19) becomes: $w_n \leq \bar{x}_n + z_n$, corresponding to the equation (x) of the standard approach. This implies that the model (14)-(16) correctly represents the PMP standard specification even without the explicit calibrating constraints. Taking the previous considerations into account, the KKT condition (20) can be interpreted as the structural constraint related to the land use. Moving b_n to the right hand side of equation (20) and changing the sign, we can obtain $A_n w_n \leq b_n$ that corresponds to equation (2).

In turn, the Arfini-Donati approach permits the tautological procedure of the PMP standard approach to be overcome, obtaining all the necessary information about the total marginal cost useful for the simulation phase.

3.5 PMP dual approach without exogenous costs

As stated in the previous sections, PMP in its standard approach, presented in the paper by Paris and Howitt (1998), is a method consisting of three phases, each of which is geared at obtaining additional information on the behaviour of the farmer so as to be able to simulate his behaviour in conditions of maximization of the gross margin (Paris and Howitt, 1998; Paris and Arfini, 2000). The PMP method has been widely used in the simulation of alternative policy and market scenarios, utilizing micro technical-economic data relative both to individual farms and to average farms that are representative of a region or a sector (Arfini et al., 2005). The success of the method can be largely attributed to the relatively low requirement for information on the business and, first and foremost, to the possibility of using databases, including the FADN database (Arfini et al., 2005) .

Notwithstanding the numerous studies that adopt the PMP approach using FADN data, the methodology comes up against a limitation consisting of the lack of data on specific production costs per process. As previously mentioned, this poses a problem during the calibration phase of the model, when the estimation of the cost function requires a non-negative marginal cost for all production processes activated by a single holding (Paris and Arfini, 2000).

This problem is dealt with in this analysis by resorting to an approach that utilizes dual optimality conditions directly in the estimation phase of the non-linear function. The approach qualifies itself as an extension of the Heckelei proposal (2002), according to which the first phase of the classical PMP method can be avoided by imposing first order conditions directly in the second cost function estimation phase. Moreover, as a guide to the correct estimation of the explicit activity costs, the model considers the information relative to the total farm variable costs available in the European FADN archive. This "innovation" becomes particularly important as it enables us to perform analyses utilizing the European database without having to resort to parameters that are exogenous to the model.

According to this new approach, the PMP model falls into two phases: a) the aim of the first is to estimate specific crop costs through the reconstruction of a non-linear function of the total variable cost that considers the exogenous information on the total variable costs observed for the individual farm; b) the aim of the second is the calibration of the observed production situation through the solving of a farm gross margin maximization problem, in the objective function of which the cost function estimated in the previous phase is entered.

The first phase is defined by an estimation model of a quadratic cost function in which the squares of errors are minimized:

$$\min_u LS = \frac{1}{2}\mathbf{u}'\mathbf{u} \tag{21}$$

subject to

$$\mathbf{c} + \boldsymbol{\lambda} = \mathbf{R}'\mathbf{R}\overline{\mathbf{x}} + \mathbf{u} \qquad \text{if } \overline{x} > 0 \tag{22}$$

$$\mathbf{c} + \boldsymbol{\lambda} \le \mathbf{R}'\mathbf{R}\overline{\mathbf{x}} + \mathbf{u} \qquad \text{if } \overline{x} = 0 \tag{23}$$

$$\mathbf{c}'\overline{\mathbf{x}} \le TC \tag{24}$$

$$\mathbf{u}'\overline{\mathbf{x}} + \frac{1}{2}\overline{\mathbf{x}}'\left(\mathbf{R}'\mathbf{R}\right)\overline{\mathbf{x}} \ge TC \tag{25}$$

$$\mathbf{c} + \boldsymbol{\lambda} + \mathbf{A}'\mathbf{y} \ge \mathbf{p} + \mathbf{A}'\mathbf{s} \tag{26}$$

$$\mathbf{b}'\mathbf{y} + \boldsymbol{\lambda}'\overline{\mathbf{x}} = \mathbf{p}'\overline{\mathbf{x}} + \mathbf{s}'\overline{\mathbf{h}} - \mathbf{c}\overline{\mathbf{x}} \tag{27}$$

$$\mathbf{R} = \mathbf{LD}^{1/2} \tag{28}$$

$$\sum_{n=1}^{N} u_{n,j} = 0 \tag{29}$$

By means of the model (21)-(29) a non-linear cost function can be estimated using the explicit information on total farm variable costs (TC) available in the FADN database. The restrictions (22) and (23) define the relationship between marginal costs derived from a linear function and marginal costs derived from a quadratic cost function. $\boldsymbol{c+\lambda}$ defines the sum of the explicit process costs and the differential marginal costs, i.e. the costs that are implicit in the decision-making process of the farmer and not accounted for in the bookkeeping. Both components are endogenous to the minimization problem. To guarantee consistency between the estimate of total specific costs and those effectively recorded by the farm accounting system, restriction (24) imposes that the total estimated explicit cost should not be greater than the total variable cost observed in the FADN database. Restriction (25) defines a further limit on the costs estimated by the model, where the non-linear cost function must at least equal the value of the total cost (TC) measured. In order to guarantee consistency between the estimation process and the optimal conditions, restriction (26) introduces the traditional condition of economic equilibrium, where total marginal costs must be greater or equal to marginal revenues. The total marginal costs also consider the use cost of the production factors defined by the product of the technical coefficients matrix $\boldsymbol{A'}$ and the shadow price of the restricting factors $\boldsymbol{y}$; while the marginal revenues are defined by the sum of the products' selling prices, $\boldsymbol{p}$, and any existing public subsidies. The additional restriction (27) defines the optimal condition, where the value of the primary function must correspond exactly to the value of the objective function of the dual problem. In order to ensure that the matrix of the quadratic cost function is symmetric, positive semidefinite, the model adopts Cholesky's decomposition method, according to which a matrix that respects the conditions stated is the result of the product of a triangular matrix, a diagonal matrix and the transpose of the first triangular matrix (28). Last but not least, restriction (29) establishes that the sum of the errors, $\boldsymbol{u}$, must be equivalent to zero.

The use of the least squares approach overcomes the problem associated with the arbitrary support values decided by the analyst, which is one of the main criticisms addressed to PMP.

The cost function estimated with the model (21)-(29) may be used in a model of maximization of the farm gross margin, ignoring the calibration restrictions imposed during the first phase of the classical PMP approach. In this case, the dual relations entered in the preceding cost estimation model guarantee the reproduction of the situation observed. The model, therefore, appears as follows:

$$\max_{x \geq 0} ML = \mathbf{p'x} + \mathbf{s'h} - \left\{ \frac{1}{2} \mathbf{x'\hat{Q}x} + \mathbf{\hat{u}'x} \right\} \tag{30}$$

subject to

$$\mathbf{Ax} \leq \mathbf{b} \tag{31}$$

$$A_j x_j - h_j = 0 \qquad \forall j = 1, ..., J \tag{32}$$

The model (30)-(32) calibrates the farming system observed, thanks to the function of non-linear cost entered in the objective function that preserves the (economic) information on the levels of production effectively attained. The estimated matrix $\boldsymbol{Q}$ is reconstructed using Cholesky's decomposition: $\mathbf{\hat{Q}} = \mathbf{\hat{R}'\hat{R}} = \mathbf{\hat{L}\hat{D}\hat{L}}$. Restriction (31) represents the restriction on the structural capacity of the farm, while the relation (32) enables us to obtain information on the hectares of land (or number of animals) associated with each process $\boldsymbol{j}$. Once the initial situation has been calibrated through the maximization of the farm gross margin, it is possible to introduce variations in the public subsidies and/or in the market price levels in order to evaluate the reaction to the changed environmental conditions. The reaction of the farm will take into account the information used during the estimation phase of the cost function, in which it is possible to identify a real, true matrix of the farm choices, i.e. $\boldsymbol{Q}$. In this framework, the PMP methodology described in this section will be implemented for the recovery of the specific production costs related to the process whose data are collected in the FADN.

Chapter 4

APPLICATION OF THE PMP MODEL TO ESTIMATE SPECIFIC COST IN ITALY

4.1 Objectives

The specific cost estimation using FADN information and the PMP model described in chapter 3 has been developed in the FACEPA project with respect to the European and national FADN databases selected from among the WP6 partners. This application is described in Deliverable 6.2 (see Annex 1). The aim of the work was to test the PMP-based methodology to capture information about variable costs per activity, validating them with observed information obtained from the same database when available. The application of this validation method is not easy to do in all EU Member States so for this reason the PMP model has been applied only for Italy, Belgium and Hungary.

This chapter describes the analysis carried out in Italy. The Italian FADN, in fact, collects the specific variable costs for each crop concerning seeds, fertilizers, pesticides and services provided by third parties. This information is the result of an allocation process made by the surveyors (starting from farmers information or personal experience) and it is not transferred to the European database. As underlined in chapter 2 dealing with the application of the GECOM model, the result of this allocation process can lead to an imperfect evaluation of farm specific costs, even if it is the closest possible to the real information. As done with the GECOM model, it also represents a benchmark for the PMP application, in respect of which it is possible to validate the estimating methodology for the Italian specific costs.

In order to improve the estimation, a quality check of the data is important to avoid the negative influence of the outliers. As mentioned in chapter 2, FADN is affected by "out of range" values that have to be adequately treated. This is why the estimation procedure is anticipated by an outliers check, so that the estimation can be applied reducing the influence of anomalous values.

The estimation results refer to three aggregation levels. One refers to the whole area (the three regions together), one to the single region and the last to a "homogeneous farm" obtained after a cluster analysis. Like the econometric method, the PMP model has a high flexibility that permits the analysis to be differentiated in order to capture the territorial specificities. The different territorial aggregation levels show how the criteria used in the definition of the datasets become crucial in order to obtain a good estimation of the observed variable costs.

4.2 Data entry description and quality control procedure

The Italian regions selected for the analysis are in Northern Italy, where there is a high level of farm specialization and an intensive use of agricultural resources. The most relevant activities are livestock (dairy and beef specialization) and arable crops. According to 2009 Eurostat information, the Veneto-Lombardy-Piedmont area contains 50% of the total livestock in Italy. The average farm size is 5 ha, whereas the national average is 2 ha (Eurostat, 2009). The analysis refers to 2007 accounting year.

The farm sample considered in this analysis is composed of 738 farms belonging to Farm Type 1 (arable crops). The average farm size is 50 ha. Piedmont's RICA farms are the biggest in terms of hectares. On average, the incidence of cereals on the total UAA in the sample is 43%. The average Gross Saleable Production (GSP) per hectare is 1,774 €, while the total variable cost per hectare is 600 € (Table 4.1).

Table 4.1 - Statistical description of Italian FADN sample – Farm type 1 - 2007

Area	N. of farms	Av. UAA (ha)	Cereals / tot (%)	GSP/ha (€)	Total Variable Costs /ha (€)
Veneto	220	44	62	1,956	656
Lombardy	165	46	40	1,763	370
Piedmont	353	56	36	1,689	661
Total	738	50	43	1,774	600

Considering the entire sample, rice covers 39% of the total acreage, followed by maize with 25% and common wheat with 15%. Maize is the most important crop in Veneto, while in it is rice in Lombardy and Piedmont. Another important crop is soya, that in Veneto is grown on 17% of the entire acreage. Indeed, Veneto is specialized in producing maize and soya because of the presence of dairy and beef farms and important food industries. Figure 4.1 summarizes the crop distribution in the three regions.

Figure 4.1 - Crop distribution in FT1 Sample for the Italian case study

Fig. 4.1.a - Crop distribution in Veneto Farm type 1 sample

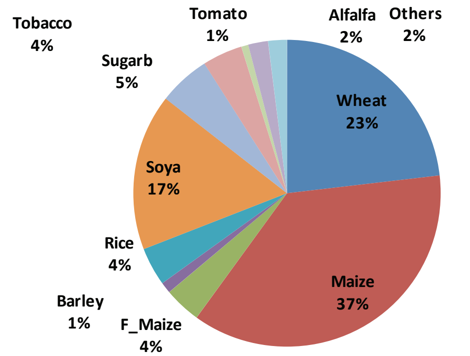


Fig. 4.1.b - Crop distribution in Lombardy Farm type 1 sample

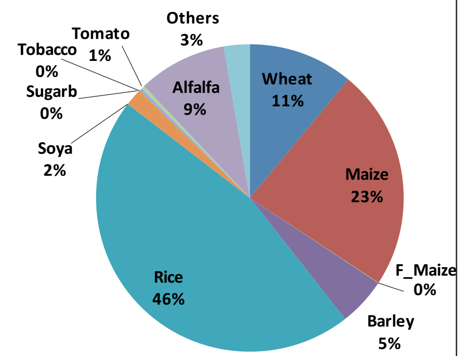


Fig. 4.1.c - Crop distribution in Piedmont Farm type 1 sample

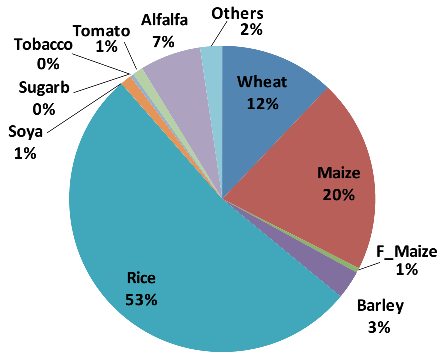
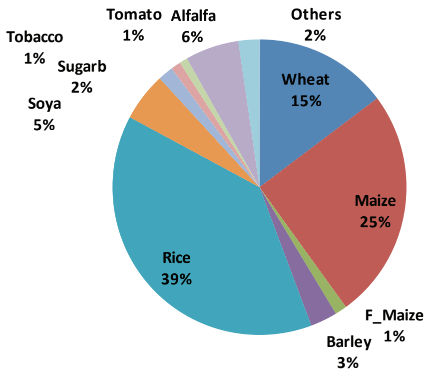


Fig. 4.1.d - Crop distribution in the entire Farm type 1 sample area



All the crops depicted above are considered in the PMP model analysis and specific variable costs are estimated for each activity. As described in the previous section, the estimation is made using the information on acreage, yields, prices for each crop at farm level and total variable cost at farm level.

In order to achieve a good fitness of the estimation to reality, it is important to avoid the presence of outliers by selecting a homogeneous sample of farms in terms of the main variables influencing the production function and the dynamics of production cost (for instance, yields and output prices). Figure 4.2 and Table 4.2 present some descriptive information on prices and yields of the four main crops included in the FADN sample. As can be seen at first glance, the observations are less dispersed for some crops, like common wheat and rice, while the dispersion is very high for maize and soya. The main factor that influences this dispersion is the variation in yields. The degree of dispersion is measured by the standard deviation. It is very high for maize, at 31, which means a variation with respect to the mean of 3.1 tons per hectare while, for rice, the dispersion in yields is more restrained and equal to 0.9 tons per hectare.

Figure 4.2 - Price and yield distribution in FT1 sample for the Italian case study

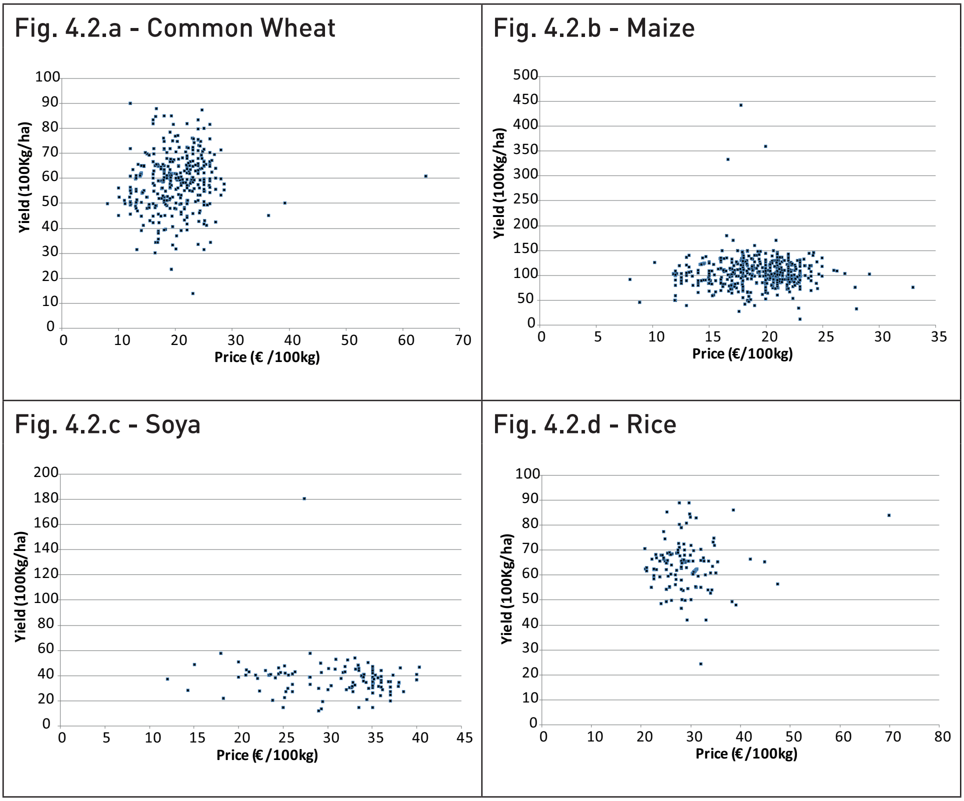


Table 4.2 - Crops selected from the FADN sample (Lombardy, Piedmont and Veneto): price in €/100 Kg; Yields in 100 kg/ha

Crop	Variable	N. of Obs.	MIN	MAX	Mean		Std. Deviation
					Statistic	Std. Error	
Common Wheat	Prices	335.00	8.00	64.00	20.01	0.27	5.09
	Yields	335.00	13.99	90.00	58.54	0.59	11.41
Maize	Prices	546.00	7.98	33.01	19.14	0.15	3.39
	Yields	548.00	12.00	442.48	106.02	1.32	30.83
Soya	Prices	127.00	12.00	40.26	30.85	0.53	5.98
	Yields	125.00	12.19	180.77	37.74	1.42	15.88
Rice	Prices	145.00	20.72	69.83	29.01	0.46	5.55
	Yields	144.00	24.36	89.05	63.80	0.77	9.23

The high degree of dispersion also conceals the presence of outliers that for some crops can strongly influence the capacity of the model to correctly estimate the production costs. For instance, maize has several observations that are out of range: figure 19.b shows a cluster of points surrounded by several out of range observations. These points represent outliers that should be eliminated from the estimation process.

The distorting information represented by the outliers can also be analyzed at a farm level. Fig. 4.3 shows the farms on a scatter plot considering the Gross Saleable Production (GSP) per hectare and Total Variable Costs (TVC) per hectare on the axes. It is evident that some points are very distant from the average observations and they can be considered as outliers. Looking at a detail of the same sample on a reduced scale, there is clearly a need to adopt statistical techniques aiming to select a homogeneous set of observations, by means of the detection and removal of the outliers.

In conclusion, the main aim of the outliers analysis is to remove all the farms that, because of crops or activities, are not homogeneous with respect to the characteristics of the sample. This homogeneity is evaluated by means of Principal Component Analysis (PCA) and Cluster Analysis (CA). The latter is implemented using the K-mean methodology. Only the clusters with the highest number of homogeneous farms are used for the process of PMP cost estimation in order to guarantee a sufficient number of observations for crops to submit to estimation.

Fig. 4.3 - Farm distribution between GSP/ha and TVC/ha (Veneto-Lombardy-Piedmont) - standard scale

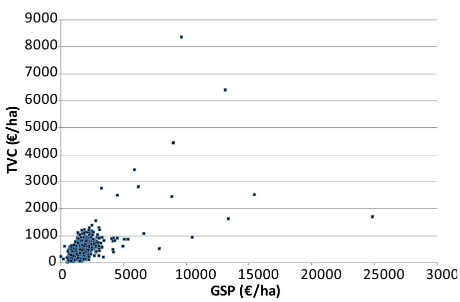
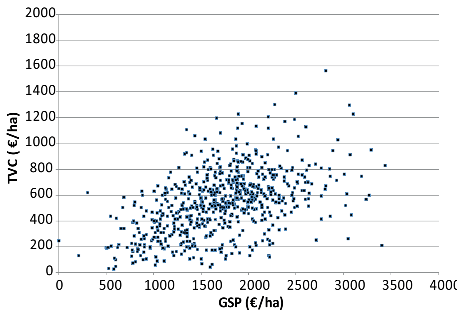


Fig. 4.4 - Farm distribution between GSP/ha and TVC/ha (Veneto-Lombardy-Piedmont) - reduced scale



4.3 The specific accounting cost estimation for Italy

The estimation of variable cost per activity in the selected Italian regions (Veneto, Lombardy and Piedmont) is described taking into account three aggregation levels:

- the macro-area North of Italy (the three regions together);
- each region separately (one dataset per region);
- the "homogeneous farm" detected by cluster analysis.

The different territorial aggregation level shows how the criteria used in the definition of the datasets become crucial in order to obtain a good estimation of the observed variable costs.

Before commencing an analysis of the results it is useful to recall that PMP allows two types of specific variable costs to be estimated for each activity: the accounting cost (c) and marginal implicit (adding) cost (λ).These costs are estimated under economic constraints because of the use of the dual property of a profit maximization problem, implicit in the model (see equations (1)-(9), chapter 3) where the shadow prices associated to production activities are exactly equal to the sum of the *estimated accounting cost* and the *estimated differential marginal costs*. The estimated accounting cost may be interpreted as the part of production shadow price that can be explained by the farm accounting values, while the estimated differential marginal cost might be considered as the opportunity cost associated to each activity. The sum of the estimated accounting cost and the estimated differential marginal cost provides the exact measure of the total marginal cost associated to each activity.

The estimated differential marginal costs are defined in this work as "*hidden costs*", to indicate the part of estimated total marginal cost not recorded in the farm accounting sheets but considered by farmers in defining the production plans. The hidden costs refer to the specific and individual opportunity costs that each farmer considers when deciding whether to introduce a given crop in the production plan. This cost can be considered as "pure economic cost" due to the fact that it is a function of the profit maximization logic (expressed by the observed price) and of the characteristic of the production function (expressed by the observed yields).

The estimated specific variable costs are compared with the observed variable accounting costs as they appear in the FADN dataset. As concerns these latter costs, it is important to remember that they can present distortion due to the surveyors' allocation process that can lead to misspecification in respect to a given cost related to a given production technique. One example is provided by irrigation costs, for which the accounting procedure is difficult because they are often not explicit. For these reasons the comparison between estimated variable cost and observed marginal accounting cost can fail when some types of cost are not explicit even for farmers.

In order to validate the estimation procedure, the "estimated specific variable costs" are compared with the "observed specific variable costs" through the t-test. The test allows it to be verified that the two means derive from a population with the same mean ($H_0 : \mu_1 = \mu_2$). When the probability is very low the hypothesis $\mu_1 = \mu_2$ is rejected. This procedure is possible only with respect to the Italian FADN that includes the information about the specific costs by activity.

4.3.1 The estimation for the macro-area North of Italy (Veneto, Lombardy and Piedmont as homogenous area)

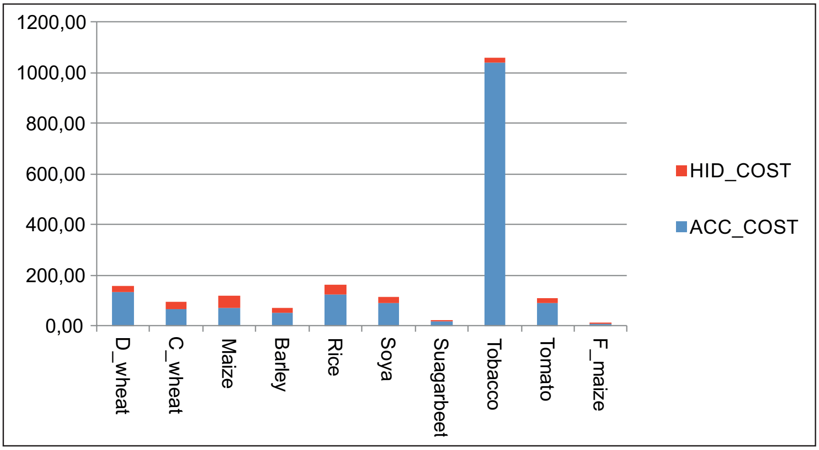
Table 4.3 shows the results obtained using the information about the entire sample for Farm Type 1 (arable crops) where the observed accounting costs are compared with the estimated ones. The comparison is performed only between these pairs of costs because the hidden cost, as opportunity cost, is not recorded by the Italian FADN.

Table 4.3 - Comparison between observed accounting cost and specific variable cost estimated by the PMP model – Veneto, Lombardy and Piedmont – Farm type 1, Year 2007 (€ per ton/1000)

Crop	Observed cost	Std. Error	Estimated Accounting Cost	Std. Error	Hidden cost	Std. Error	Total Marginal Cost	Std. Error
D_wheat	0.07575	0.00598	0.13428	0.01738	0.02680	0.00205	0.16108	0.00244
C_wheat	0.07016	0.00170	0.06602	0.00332	0.03275	0.00289	0.09878	0.00309
Maize	0.06232	0.00161	0.07439	0.00172	0.04685	0.00243	0.12124	0.00206
Barley	0.06052	0.00329	0.05130	0.00543	0.02099	0.00167	0.07229	0.00206
Rice	0.11425	0.00313	0.12368	0.00470	0.03833	0.00363	0.16201	0.00575
Sorghum	0.06466	0.01705	0.04719	0.01233	0.01949	0.00200	0.06669	0.00200
Prot_crops	0.08839	0.00904	0.08747	0.01744	0.01959	0.00323	0.10706	0.00352
Soya	0.11664	0.00590	0.09133	0.00676	0.02504	0.00333	0.11636	0.00427
Sugarbeet	0.01405	0.00050	0.01721	0.00124	0.00096	0.00015	0.01817	0.00031
Potato	0.05974	0.01268	0.12623	0.02343	0.03735	0.00908	0.16358	0.01381
Rape	0.18170	0.04158	0.11232	0.02731	0.02266	0.00238	0.13497	0.00283
Sunflower	0.11240	0.02158	0.11070	0.03307	0.02117	0.00150	0.13188	0.00197
Tobacco	0.97254	0.10625	1.03875	0.08186	0.02164	0.01118	1.06039	0.02012
Melon	0.11124	0.02712	0.12270	0.03737	0.01627	0.00230	0.13897	0.00280
Tomato	0.05094	0.01876	0.09376	0.04093	0.01844	0.00624	0.11219	0.01364
F_maize	0.02065	0.00557	0.00924	0.00240	0.00136	0.00064	0.01060	0.00084
T_grass	0.02434	0.00287	0.03165	0.00779	0.00224	0.00022	0.03389	0.00038
Alfalfa	0.01352	0.00130	0.02766	0.00316	0.00616	0.00073	0.03382	0.00088
Meadow	0.01403	0.00086	0.02986	0.00336	0.00789	0.00058	0.03775	0.00086

In Figure 4.5, the estimated total variable cost is split between the accounting costs (ACC_COST) and hidden costs (HID_COST) for some relevant activities, Tobacco is the crop with the highest accounting cost, justified by the high cost of production.

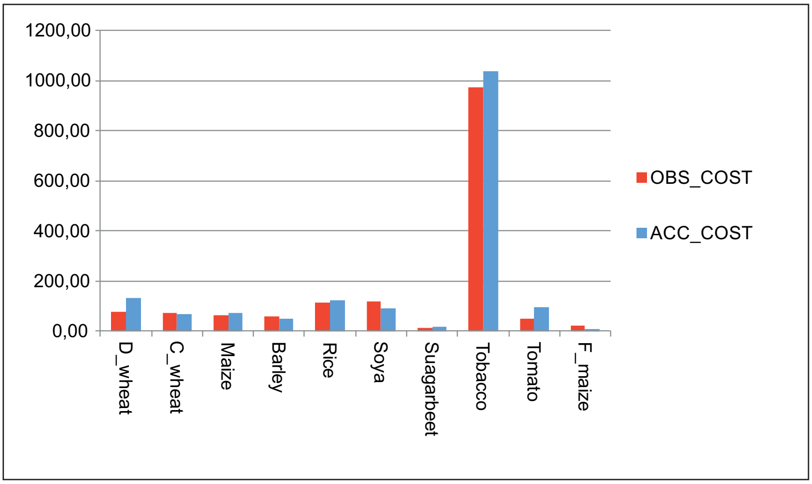
Figure 4.5 - Total marginal cost distribution - Veneto, Lombardy and Piedmont – Farm type 1, Year 2007 (€/t)



Source: our processing on Italian FADN.

Figure 4.6 compares the observed accounting costs with the estimated one. For the most numerous crops, like common wheat, maize, barley, rice and soya, the differences in absolute value remain within a range between 6% (common wheat) and 20% (soya).

Figure 4.6 - Comparison between observed variable costs and estimated accounting costs - Veneto, Lombardy and Piedmont – Farm type 1, Year 2007 (€/t)



Source: our processing on Italian FADN.

Nevertheless, the pure investigation of the differences does not say anything about the statistical significance of the estimation from an inferential point of view. For this reason the t-test has been performed in order to verify the good fitness of the estimation by comparison of the estimated accounting cost with the mean of the observed accounting costs.

The results obtained applying Student's t-test are presented in Table 4.4, where the most significant values are written in bold. For the entire Italian sample, the test of paired groups indicates a high significance for common wheat, protein crops and sunflower, while for barley, rape and fodder maize the significance level is only good (less than 50%). For the other estimates, the null hypothesis should be rejected for most of the crops, since the probability is lower than 1%.

Table 4.4 - Student's t-test for estimated and observed accounting costs - Veneto, Lombardy and Piedmont – Farm type 1, Year 2007.

	Paired Differences					t	Sig. (2-tailed)
				95% Confidence Interval of the Difference			
Crop	Mean	Std. Deviation	Std. Error Mean	Lower	Upper		
D_wheat	0.0607708	0.0941463	0.0192175	0.0210163	0.1005253	3.162	0.004
C_wheat	-0.0013917	0.0557586	0.0035843	-0.0084523	0.0056688	-0.388	0.698
Maize	0.0139243	0.0340009	0.0016046	0.0107708	0.0170778	8.678	0.000
Barley	-0.0063194	0.0508202	0.0064542	-0.0192253	0.0065866	-0.979	0.331
Rice	0.0086862	0.0408357	0.0034762	0.0018123	0.0155601	2.499	0.014
Sorghum	-0.0273333	0.0231198	0.0133482	-0.0847660	0.0300993	-2.048	0.177
Prot. crops	-0.0096231	0.1022543	0.0283603	-0.0714148	0.0521686	-0.339	0.740
Soya	-0.0215915	0.0812341	0.0089708	-0.0394406	-0.0037424	-2.407	0.018
Sugarbeet	0.0024846	0.0074877	0.0011990	0.0000574	0.0049118	2.072	0.045
Potato	0.0659294	0.0646643	0.0156834	0.0326821	0.0991767	4.204	0.001
Rape	-0.0577750	0.1799401	0.0636184	-0.2082087	0.0926587	-0.908	0.394
Sunflower	-0.0011200	0.1504740	0.0475840	-0.1087626	0.1065226	-0.024	0.982
Tobacco	0.0662250	0.0761189	0.0380594	-0.0548971	0.1873471	1.740	0.180
Melon	0.0160250	0.1126294	0.0563147	-0.1631935	0.1952435	0.285	0.794
Tomato	0.0356211	0.2019461	0.0463296	-0.0617138	0.1329560	0.769	0.452
F_maize	-0.0105500	0.0256396	0.0090650	-0.0319852	0.0108852	-1.164	0.283
T_grass	0.0122818	0.0342730	0.0103337	-0.0107431	0.0353067	1.189	0.262
Alfalfa	0.0149816	0.0209442	0.0033976	0.0080974	0.0218658	4.409	0.000
Meadows	0.0175032	0.0275066	0.0034933	0.0105178	0.0244886	5.010	0.000

For instance, maize, which showed a difference between the estimated mean and the observed mean of 19%, does not pass the t-test at a level of probability equal to zero. In other words, it is not true that the estimated mean can explain the mean of the observed costs. According to the brief statistical description of maize observations given previously, this result may be attributable to the strong dispersion in prices and yields and to the lack of gathering a specific cost related to irrigation (that strongly influences the yields).

4.3.2 The estimation of accounting costs for each region as homogenous area

In order to assess the capacity of the model to capture the territorial specificities and, thus, improve the estimates, the entire Italian sample has been stratified in three groups of farms corresponding to the three regions considered for Italy. Also in this case, the PMP model performs the estimation using all the available information included in the sample, which consists of the activity observations for each individual farm.

4.3.2.1 The case of Veneto region

Table 4.5 shows the estimation outputs for Veneto region. Observing and comparing the estimated accounting costs with the observed costs a strong improvement of the estimation goodness, with respect to the previous analysis, is evident. For most crops, like common wheat, barley, soya and sugarbeet, the difference between the estimated and the observed accounting costs is lower than 10%. On the contrary, for some crops the divergence from the observed values remains more or less the same: the durum wheat estimate is completely different with respect to the observed data, maize also presents a divergence of 30% from the observed value.

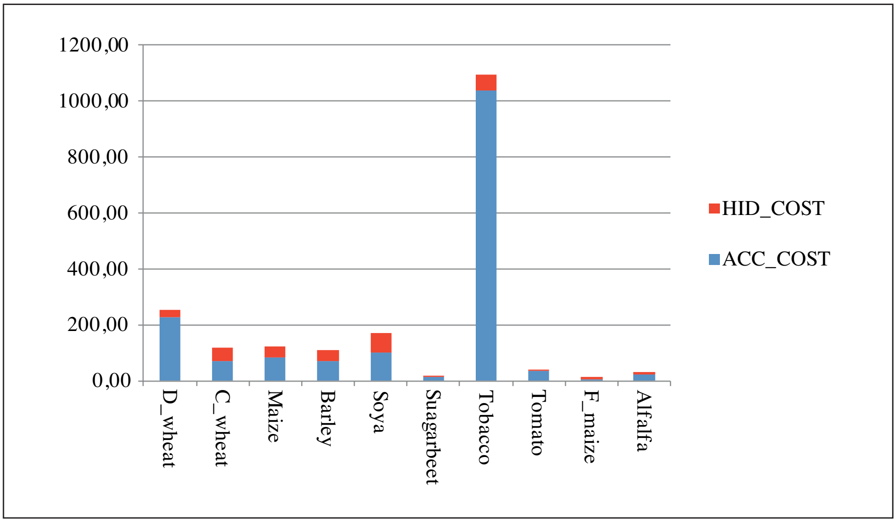
Table 4.5 - Specific cost estimates obtained from PMP model - Veneto sample (€ per ton/1000)

Crop	N_OBS	Observed cost	Std. Error	Estimated Accounting Cost	Std. Error	Hidden cost	Std. Error	Total Marginal Cost	Std. Error
D_wheat	11	0.06730	0.00433	0.22931	0.02464	0.02513	0.00861	0.25444	0.02451
C_wheat	110	0.07020	0.00203	0.06853	0.00549	0.04956	0.00790	0.11809	0.00599
Maize	184	0.06557	0.00118	0.08523	0.00255	0.03895	0.00377	0.12418	0.00300
Barley	17	0.07180	0.00645	0.06843	0.02050	0.04060	0.01198	0.10903	0.01527
Rice	6	0.12074	0.00483	0.14119	0.04230	0.18740	0.04930	0.32859	0.06858
Sorghum	1	0.07874	0.00000	0.00000	0.00000	0.04885	0.02128	0.04885	0.02128
Prot_crops	4	0.08886	0.00755	0.15265	0.01891	0.03100	0.01266	0.18365	0.03276
Soya	82	0.11336	0.00437	0.10317	0.00927	0.06615	0.01234	0.16933	0.00913
Sugarbeet	42	0.01426	0.00045	0.01538	0.00145	0.00330	0.00050	0.01868	0.00069
Sunflower	2	0.17323	0.02564	0.23890	0.11892	0.03637	0.01555	0.27527	0.03879
Tobacco	4	0.97254	0.10625	1.03875	0.08186	0.05621	0.01332	1.09496	0.02355
Tomato	7	0.03133	0.00720	0.03477	0.00841	0.00740	0.00342	0.04217	0.00459
F_maize	8	0.01120	0.00043	0.00601	0.00234	0.00940	0.00359	0.01541	0.00367
Alfalfa	13	0.00937	0.00156	0.02387	0.00849	0.00827	0.00220	0.03213	0.00221
Meadows	7	0.01966	0.00506	0.00872	0.00000	0.00231	0.00038	0.01103	0.00038

If for durum wheat there is a problem of numerousness of observations that may have influenced the estimation, for maize the problem is different. Even if the number of observations for this crop is very high (184), a strong dispersion in the prices and yields plays an important role in distorting the estimation results.

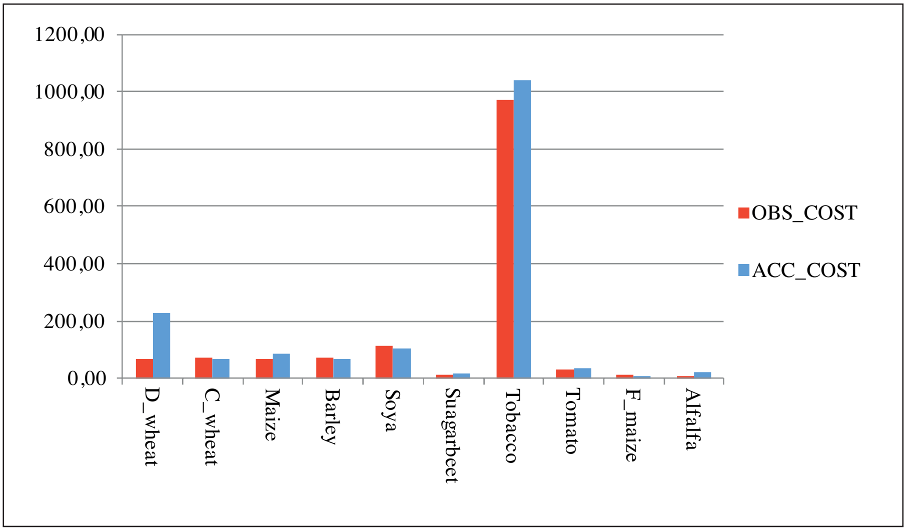
The analysis of the estimated accounting and hidden marginal costs (Figure 4.7) does not change the considerations developed for the entire sample, in the sense that the hidden cost remains a residual cost component with respect to the accounting cost. As stated previously, although most of the estimates are in line with the observed values, a few amplify the divergence with respect to the previous estimation (Figure 4.8).

Figure 4.7 - Total marginal cost distribution - Veneto sample (€/t)



Source: our processing on Italian FADN.

Figure 4.8 - Comparison between observed costs and estimated accounting costs - Veneto sample (€/t)



Source: our processing on Italian FADN.

The *t*-test shows a relevant improvement in the estimation significance for most crops (Table 4.6). For common wheat and barley the *t*-test indicates a higher than 90%probability that the estimated mean is equal to the observed mean, while for sunflower and tomato the significance is over 80%. Also sugarbeet, fodder maize and alfalfa present a very good significance of the estimated mean. The worst results correspond to durum wheat and maize, for which the degree of probability that the two means are equal is null. Maize outcomes confirm those obtained for the entire sample.

Table 4.6 - t-test for estimated and observed accounting costs - Veneto sample

Crops	Paired Differences					t	Sig. (2-tailed)
				95% Confidence Interval of the Difference			
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper		
D_wheat	0.1623200	0.0839499	0.0265473	0.1022659	0.2223741	6.114	0.000
C_wheat	-0.0004943	0.0554849	0.0059486	-0.0123197	0.0113312	-0.083	0.934
Maize	0.0194960	0.0304049	0.0022854	0.0149858	0.0240063	8.531	0.000
Barley	0.0009273	0.0647307	0.0195170	-0.0425594	0.0444139	0.048	0.963
Rice	0.0204333	0.1101644	0.0449744	-0.0951772	0.1360438	0.454	0.669
Protein crops	0.0637500	0.0545134	0.0272567	-0.0229930	0.1504930	2.339	0.101
Soya	-0.0132200	0.0873351	0.0104385	-0.0340443	0.0076043	-1.266	0.210
Sugarbeet	0.0011690	0.0086062	0.0015981	-0.0021047	0.0044426	0.731	0.471
Sunflower	0.0656500	0.2891360	0.2044500	-2.5321336	2.6634336	0.321	0.802
Tobacco	0.0662250	0.0761189	0.0380594	-0.0548971	0.1873471	1.740	0.180
Tomato	0.0019500	0.0239079	0.0097604	-0.0231398	0.0270398	0.200	0.850
F_maize	-0.0044667	0.0058586	0.0033825	-0.0190203	0.0100869	-1.321	0.318
Alfalfa	0.0152000	0.0142836	0.0101000	-0.1131327	0.1435327	1.505	0.373

4.3.2.2 The case of Lombardy region

The estimation obtained for this region, presented in Table 4.7, provides a marked increase in the estimation fitness for durum wheat, barley and soya. For durum wheat the estimated accounting cost is 30% higher than the observed cost (barley +4% and soya +17%). For this subset, the estimated accounting cost for common wheat worsens with respect to the Veneto and entire sample outcomes, with a difference of +14.5% from the observed data.

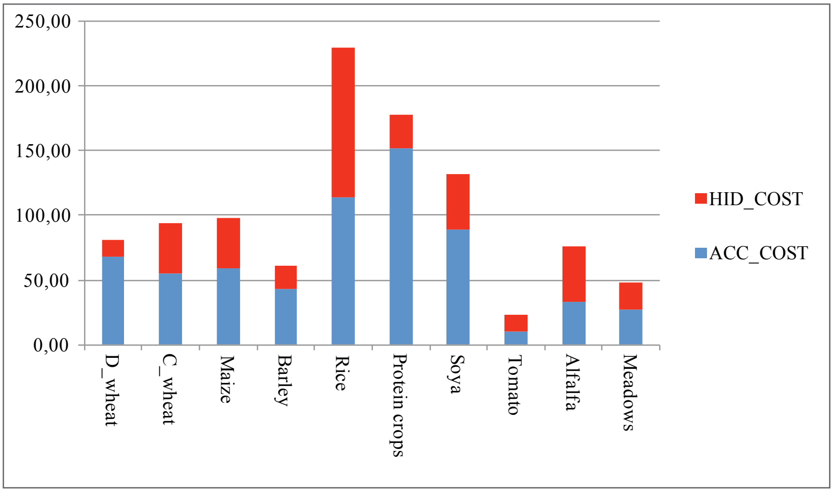
Table 4.7 - Specific cost estimates obtained from PMP model - Lombardy sample (€ per ton/1000)

Crop	N_OBS	Observed cost	Std. Error	Estimated Accounting Cost	Std. Error	Hidden cost	Std. Error	Total Marginal Cost	Std. Error
D_wheat	8	0.05180	0.01531	0.06763	0.01945	0.01367	0.00207	0.08130	0.00298
C_wheat	46	0.04845	0.00310	0.05546	0.00777	0.03845	0.01148	0.09391	0.01065
Maize	74	0.04618	0.00300	0.05910	0.00322	0.03877	0.00402	0.09786	0.00365
Barley	23	0.04124	0.00753	0.04281	0.00837	0.01783	0.00482	0.06064	0.00639
Rice	38	0.09353	0.00635	0.11371	0.01094	0.11537	0.01487	0.22908	0.01493
Sorghum	1	0.03505	0.00000	0.00000	0.00000	0.03228	0.00425	0.03228	0.00425
Protein crops	5	0.07190	0.01186	0.15215	0.03987	0.02559	0.01088	0.17775	0.01184
Soya	13	0.07573	0.01001	0.08916	0.01914	0.04276	0.01182	0.13192	0.01460
Rape	1	0.03828	0.00000	0.00000	0.00000	0.02744	0.00356	0.02744	0.00356
Melon	1	0.01947	0.00000	0.08245	0.02556	0.26945	0.12405	0.35190	0.14415
Tomato	2	0.00853	0.00053	0.01041	0.00000	0.01232	0.00159	0.02273	0.00160
Alfalfa	27	0.01515	0.00248	0.03266	0.00457	0.04306	0.00757	0.07572	0.00670
Meadows	24	0.01526	0.00158	0.02669	0.00612	0.02157	0.00575	0.04826	0.00680

Observing Fig. 4.9, for Lombardy the hidden cost represents an important component of the farmer's decision process. In particular, this added marginal cost is important for cereals and alfalfa. Considering that the estimation deviations are all quite positive, that means that the outcomes overestimate the "real" accounting cost, the production plan at regional level is strongly influenced by implicit costs that are not captured by the agricultural accounting systems.

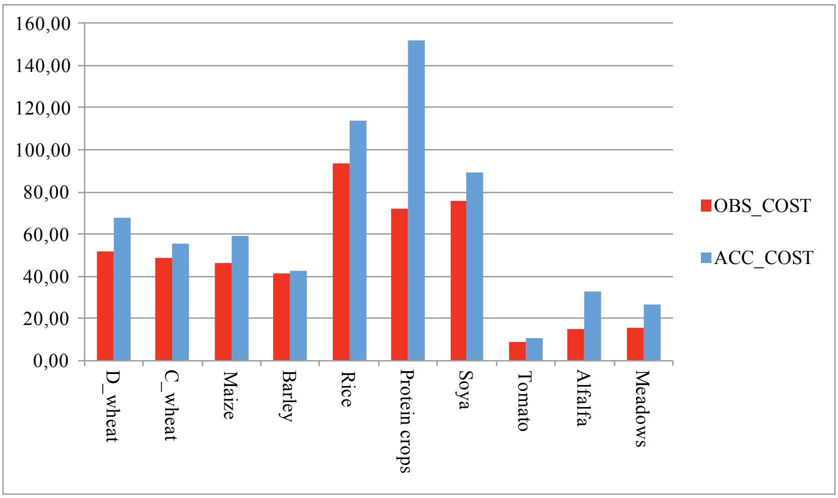
Analysis of Fig. 4.10 verifies that the estimations for cereals, soya and tomato are roughly near the target value of the observed accounting costs, while for protein crops and alfalfa the estimations are far from the target value.

Fig. 4.9 - Total marginal cost distribution - Lombardy sample (€/t)



Source: our processing on Italian FADN

Fig. 4.10 - Comparison between observed costs and estimated accounting costs - Lombardy sample (€/t)



Source: our processing on Italian FADN

In order to verify if the means obtained from the individual estimated accounting costs is representative of the mean originated from the observed values, the t-test has been implemented. Table 4.8 presents the level of probability associated to each crop. The level of significance is high for durum wheat and common wheat, indicating that it is not possible to reject the hypothesis that the two means are different with a probability of 66% and 63% respectively. Barley also shows a high level of significance.

Table 4.8 - *t*-test for estimated and observed accounting costs - Lombardy sample

Crops	Paired Differences					t	Sig. (2-tailed)
				95% Confidence Interval of the Difference			
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper		
D_wheat	0.0086167	0.0448852	0.0183243	-0.0384875	0.0557208	0.470	0.658
C_wheat	0.0044280	0.0449068	0.0089814	-0.0141086	0.0229646	0.493	0.626
Maize	0.0038746	0.0259270	0.0031675	-0.0024495	0.0101987	1.223	0.226
Barley	-0.0068000	0.0339325	0.0102310	-0.0295961	0.0159961	-0.665	0.521
Rice	0.0164342	0.0495990	0.0080460	0.0001314	0.0327370	2.043	0.048
Protein crops	0.0823333	0.1128924	0.0651785	-0.1981069	0.3627736	1.263	0.334
Soya	0.0240000	0.0785200	0.0277610	-0.0416444	0.0896444	0.865	0.416
Alfalfa	0.0161696	0.0276196	0.0057591	0.0042260	0.0281132	2.808	0.010
Meadows	0.0095091	0.0273577	0.0082487	-0.0088701	0.0278882	1.153	0.276

Despite the *t*-test carried out for the previous samples, in this case the probability level for maize reveals a value different from zero, equal to 22.6%. The significance is evidently low, but we have no reason to refute the hypothesis of equality between the two means for this crop. It is worth noting that the level of significance for maize is better where the cropping technique is almost homogenous in all the area.

4.3.2.3 The case of Piedmont region

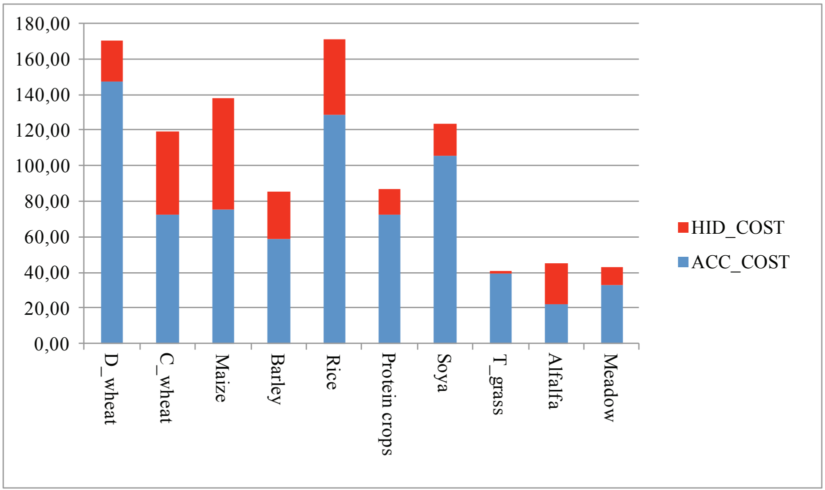
The estimation results obtained for Piedmont are very similar to those described for the other two regions and for the entire sample taken as a whole (Table 4.9).

Table 4.9 - Specific cost estimates obtained from PMP model - Piedmont sample (€ per ton/1000)

Crop	N_OBS	Observed cost	Std. Error	Estimated Accounting Cost	Std. Error	Hidden cost	Std. Error	Total Marginal Cost	Std. Error
D_wheat	16	0.09354	0.00794	0.14723	0.02763	0.02327	0.00328	0.17050	0.00404
C_wheat	178	0.07594	0.00268	0.07230	0.00508	0.04728	0.00404	0.11959	0.00441
Maize	243	0.06484	0.00301	0.07498	0.00286	0.06277	0.00416	0.13775	0.00328
Barley	75	0.06388	0.00398	0.05893	0.00791	0.02663	0.00262	0.08556	0.00311
Rice	98	0.12188	0.00347	0.12831	0.00501	0.04299	0.00458	0.17130	0.00805
Protein crops	14	0.09415	0.01373	0.07256	0.01998	0.01450	0.00171	0.08706	0.00216
Soya	23	0.15148	0.02335	0.10574	0.01940	0.01785	0.00311	0.12359	0.00517
Sugarbeet	2	0.00951	0.00456	0.00435	0.00187	0.00080	0.00015	0.00515	0.00016
Potato	18	0.06075	0.01406	0.12942	0.02649	0.06079	0.01541	0.19022	0.02385
Rape	6	0.24419	0.05470	0.11220	0.03693	0.01281	0.00359	0.12501	0.00438
Sunflower	7	0.08773	0.01833	0.07497	0.02138	0.02376	0.00212	0.09873	0.00248
Tomato	14	0.06681	0.02979	0.13748	0.05727	0.01212	0.00567	0.14961	0.01539
F_maize	3	0.04865	0.01212	0.01190	0.00739	0.00422	0.00031	0.01612	0.00031
T_grass	23	0.02434	0.00287	0.03912	0.00809	0.00161	0.00026	0.04072	0.00101
Alfalfa	24	0.01392	0.00175	0.02195	0.00501	0.02338	0.00189	0.04533	0.00187
Pasture	1	0.00571	0.00000	0.00000	0.00000	0.00275	0.00049	0.00275	0.00049
Meadow	92	0.01329	0.00098	0.03257	0.00379	0.01006	0.00104	0.04263	0.00160

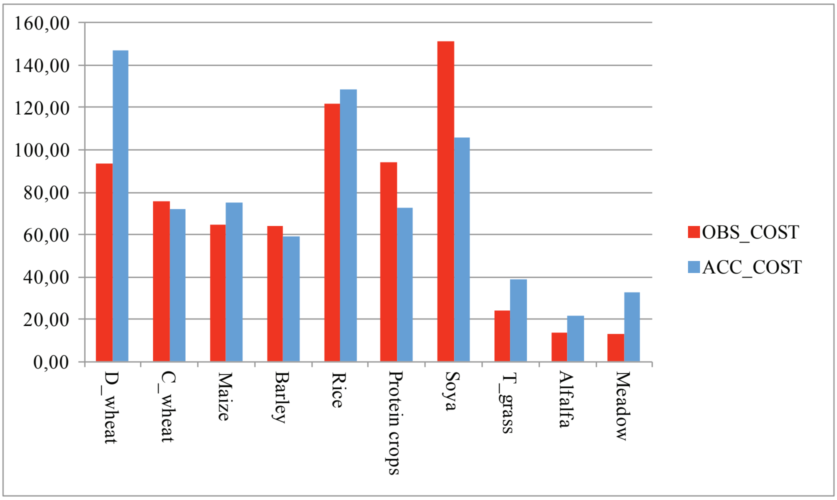
The crop with a high degree of fitness to the observed data is common wheat (-5% with respect to the observed accounting cost), which confirms the good estimates previously obtained. The estimates also confirm the model stability for barley, providing an estimated accounting cost 7% lower than the observed data. The estimation for maize, which is also in this case the crop with the highest number of observations, is +15% compared with the corresponding observed accounting cost. Among the main crops in the region, the most relevant divergence of the estimations concerns soya (+30%), durum wheat (+57%), grassland (+60%) and tomato (+110%).

Figure 4.11 - Total marginal cost distribution - Piedmont sample (€/t)



Source: our processing on Italian FADN

Figure 4.12 - Comparison between observed costs and estimated accounting costs - Piedmont sample (€/t)



Source: our processing on Italian FADN

Considering the *t*-test, the results for Piedmont seems to be better than the estimation obtained for the entire sample, confirming that a greater degree of territorial homogeneity improves the fitness of the estimates. Common wheat, barley, protein crops, soya, sugarbeet and sunflower present a level of significance between 55% and 82%, which means a very high probability that the estimated mean is equal to the mean generated by the observed data. The mean derived from the estimated individual accounting cost for maize is associated to a very high probability that it is different from the observed mean.

Table 4.10: *t*-test for estimated and observed accounting costs - Piedmont sample

	Paired Differences						
				95% Confidence Interval of the Difference			
Crops	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	Sig. (2-tailed)
D_wheat	0.0537818	0.0907642	0.0273664	-0.0071944	0.1147580	1.965	0.078
C_wheat	0.0022885	0.0605872	0.0053139	-0.0082251	0.0128020	0.431	0.667
Maize	0.0139077	0.0389144	0.0026918	0.0086010	0.0192143	5.167	0.000
Barley	-0.0061674	0.0704716	0.0103905	-0.0270949	0.0147601	-0.594	0.556
Rice	0.0062854	0.0404977	0.0041333	-0.0019202	0.0144910	1.521	0.132
Protein crops	-0.0194625	0.0911720	0.0322342	-0.0956842	0.0567592	-0.604	0.565
Soya	-0.0171571	0.1360563	0.0363626	-0.0957137	0.0613994	-0.472	0.645
Sugarbeet	-0.0052000	0.0128693	0.0091000	-0.1208265	0.1104265	-0.571	0.670
Potato	0.0678133	0.0687080	0.0177403	0.0297641	0.1058626	3.823	0.002
Rape	-0.1044000	0.2020111	0.0903421	-0.3552299	0.1464299	-1.156	0.312
Sunflower	-0.0076667	0.0787790	0.0321614	-0.0903402	0.0750069	-0.238	0.821
Tomato	0.0670846	0.2364237	0.0655721	-0.0757848	0.2099540	1.023	0.326
F_maize	-0.0358500	0.0511238	0.0361500	-0.4951793	0.4234793	-0.992	0.503
T_grass	0.0197455	0.0337036	0.0101620	-0.0028969	0.0423878	1.943	0.081
Alfalfa	0.0079077	0.0222103	0.0061600	-0.0055139	0.0213293	1.284	0.223
Meadows	0.0191077	0.0275874	0.0038257	0.0114273	0.0267881	4.995	0.000

The significance level for durum wheat, potato, temporary grass and meadows rejects the null hypothesis according to which the estimated and observed means are equal.

4.3.3 Homogeneous group of farms identified through cluster analysis

The previous analysis has demonstrated that there is a positive correlation between the degree of homogeneity of the investigated groups of farms and the estimation fitness on observed data. In order to improve the analysis and minimize the risk of keeping outliers in the estimation, it is necessary to increase the level of homogeneity of the groups to be managed with the PMP model. The purpose of this further testing step is to evaluate the response of the model with respect to a more homogenous group of farms. With this objective, cluster analysis has been applied on the entire set of information for the three Italian regions. The cluster analysis has been developed using the K-mean method, the best-known and applied partitioning method (for a review, see Atkinson et al., 2004). This procedure classifies the *n*-units into *k* distinct clusters, with *k* chosen *a priori* by the analyst, according to an iterative method that step-by-step reaches the optimal distribution of observations in *n* groups.

The cluster analysis is preceded by a principal component analysis for identifying the explanatory variables of the sample under investigation. Once the optimal number of clusters and the group of farms have been identified, the most numerous group will be submitted to the estimation process. In this way it is possible to select some homogeneous groups that can be used in the model. As already shown, farms belonging the same Farm Type in the same region can present a strong variability in terms of price and yields. This variability can strongly influence the quality of the accounting cost estimation.

The number of clusters that responds better to the criterion of homogeneity with respect to prices and yields for Veneto-Lombardy-Piedmont is 10, where it is possible to observe a strong concentration of farms within the sixth cluster (384 farms), while the others are dispersed among the remaining groups. These last may contain values distorting the estimation of accounting costs when considered in a unique group for the PMP estimation.

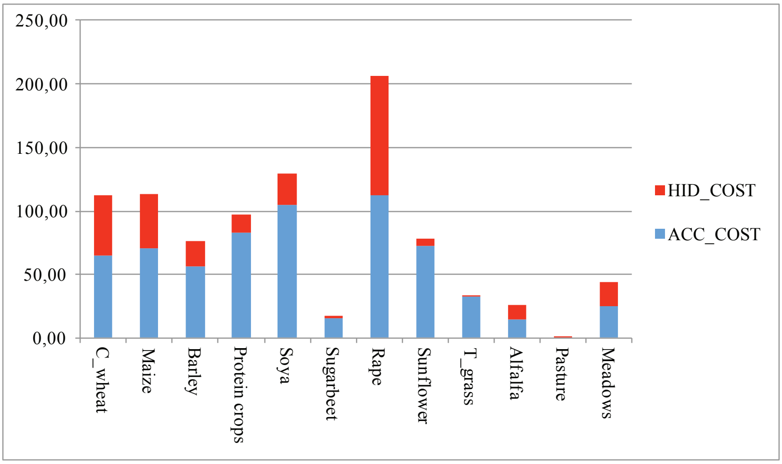
An analysis of Table 4.11 highlights that some crops present in the previous evaluations are missing, like durum wheat and rice. These two crops, for instance, are present on farms that are not considered in the sixth cluster. The degree of homogeneity is thus reliant on the level of farm specialization, so that the farms specialized in rice production with a technology quite different from the other farms are not captured by the most numerous group. The same happens with tomato production that is also missing in the sixth cluster.

Table 4.11 - Specific cost estimates obtained from PMP model, Veneto-Lombardy-Piedmont, 10 groups, cluster 6 (€ per ton/1000)

Crop	N_OBS	Observed cost	Std. Error	Estimated Accounting Cost	Std. Error	Hidden cost	Std. Error	Total Marginal Cost	Std. Error
C_wheat	197	0.07113	0.00231	0.06501	0.00383	0.04752	0.00718	0.11254	0.00511
Maize	311	0.06106	0.00133	0.07100	0.00175	0.04258	0.00267	0.11357	0.00230
Barley	62	0.06208	0.00504	0.05673	0.00699	0.01929	0.00367	0.07602	0.00612
Protein crops	11	0.09320	0.01502	0.08331	0.00980	0.01383	0.00897	0.09714	0.00948
Soya	74	0.11812	0.00659	0.10452	0.00804	0.02489	0.00608	0.12941	0.00784
Sugarbeet	17	0.01452	0.00079	0.01569	0.00207	0.00179	0.00043	0.01747	0.00065
Rape	6	0.11845	0.02814	0.11202	0.03581	0.09389	0.03235	0.20591	0.03229
Sunflower	8	0.12248	0.02720	0.07227	0.03161	0.00601	0.00245	0.07828	0.02434
T_grass	5	0.03504	0.00623	0.03290	0.01416	0.00040	0.00025	0.03331	0.00323
Alfalfa	6	0.01432	0.00296	0.01423	0.00168	0.01149	0.00760	0.02572	0.00750
Pasture	1	0.00571	0.00000	0.00000	0.00000	0.00104	0.00022	0.00104	0.00022
Meadows	77	0.01404	0.00113	0.02553	0.00407	0.01834	0.00230	0.04387	0.00331

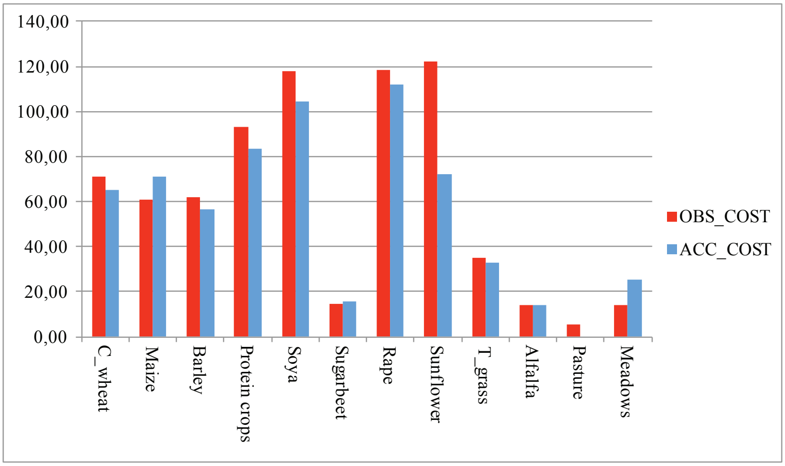
Comparing the observed with the estimated accounting cost, the percentage deviation is more smoothed than the results achieved with the other samples. Common wheat and barley confirm the excellent estimation goodness with a deviation of 8.6% with respect to the observed accounting costs. This is also a sign of the high uniformity in the technology for this two crops. All the estimates obtained for common wheat and barley have given results close to the observed reality. For maize, the deviation is quite restrained (+16% on the observed information). For soya the variation is about 11%, while for sugarbeet and alfalfa the results are more satisfying, with a deviation of 8% and 0.6% respectively. Only sunflower highlights a strong difference from the observed value, of -41% (see Fig. 4.14).

Fig. 4.13 - Total marginal cost distribution, Veneto-Lombardy-Piedmont - 10 groups, cluster 6 (€/t)



Source: our processing on Italian FADN

Fig. 4.14 - Comparison between observed costs and estimated accounting costs, Veneto-Lombardy-Piedmont - 10 groups, cluster 6 (€/t)



Source: our processing on Italian FADN

The *t*-test for the estimates provides significance values that are higher on average than the results obtained for the previous samples. Estimated costs for some crops (like sugarbeet) that presented poor *t*-test significance in the other samples, improve their fitness in this one, while for other crops, like common wheat, the worse estimates remain within an acceptable range of significance. The case of common wheat is a good example of this kind of result: compared to the estimates obtained with the other sample stratification, the estimates carried out on clusters are worse indicating a significance of 30%, which is much lower than the significance of about 60% obtained in the other estimation processes.

Table 4.12 - *t*-test for estimated and observed accounting costs, Veneto-Lombardy-Piedmont, 10 groups, cluster 6

Crops	Paired Differences					t	Sig. (2-tailed)
				95% Confidence Interval of the Difference			
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper		
C_wheat	-0.0044612	0.0517577	0.0042689	-0.0128980	0.0039756	-1.045	0.298
Maize	0.0099957	0.0233423	0.0013499	0.0073391	0.0126522	7.405	0.000
Barley	-0.0058595	0.0642430	0.0099129	-0.0258790	0.0141600	-0.591	0.558
Protein crops	-0.0185571	0.0733837	0.0277364	-0.0864257	0.0493115	-0.669	0.528
Soya	-0.0104111	0.0820993	0.0103435	-0.0310876	0.0102653	-1.007	0.318
Sugarbeet	0.0012933	0.0082950	0.0021417	-0.0033003	0.0058869	0.604	0.556
Rape	-0.0375500	0.0942819	0.0471409	-0.1875735	0.1124735	-0.797	0.484
Sunflower	-0.0508286	0.1304534	0.0493068	-0.1714779	0.0698207	-1.031	0.342
T_grass	-0.0061500	0.0577706	0.0408500	-0.5251985	0.5128985	-0.151	0.905
Alfalfa	-0.0048000	0.0008485	0.0006000	-0.0124237	0.0028237	-8.000	0.079
Meadows	0.0111474	0.0277703	0.0045049	0.0020195	0.0202752	2.474	0.018

The cluster construction improves the average significance of the estimates, extending the number of crops with good fitness to observed data. Nevertheless, even if this is true for most specific cost estimations, the accounting cost for maize continues to remain insignificant for the *t*-test. This is probably due to the large variability of observed accounting costs with respect to the value of yields and prices for this particular crop.

4.4 Remarks

The discussion of the results obtained in the previous sections has highlighted the capacity of the PMP model to recover with a good degree of approximation the observed accounting costs for cereals and some other crops that present information about price and yield with a low level of variability, i.e. sugarbeet. The number of available observations is important but not crucial for obtaining significant accounting cost estimates; an example of this is maize, for which there is a high number of observations but which has provided bad statistical test results for all the investigated samples submitted to the validation procedure. In this specific case, an important role has been played by the yield variability mainly caused by the difficulties in identifying the irrigation costs within the observed specific accounting costs used as reference term in the validation phase. The lack of this information in the observed accounting costs has strongly contributed to rejecting the null hypothesis on the significance of the equality of estimated and observed means. Further attempts to obtain a higher homogeneity of the farm information through the territorial stratification and cluster analysis have not improved the estimation for this crop. This example illustrates how the estimation validation may be influenced by lacks in the observed information that can produce distortions in statistical tests.

The results obtained also demonstrate a strong influence of two other factors in the estimation process:

- the presence of outliers: the out-of-range values have without doubt an important effect on the estimation and a preventive check is fundamental for reducing the interference of this kind of component as much as possible in the estimation process.
- the degree of internal sample homogeneity: the obtained estimates are much more significant as the sample homogeneity increases. This is evident for the three Italian regions, where the territorial stratification and clustering have produced a marked improvement in the estimate significance.

An attempt has been made to mitigate the problems encountered during the estimation process and to improve the significance of results through cluster analysis, which has produced homogenous groups of farms using their production (yields) and economic (prices) characteristics as variables. The presentation of case study results has been limited to the specific marginal costs at sample level, without considering a deeper level of information. As described in the previous chapter, the developed PMP model is a micro-based model that uses farm information at individual level so that the results are also obtained at individual level. The results can thus be aggregated in different ways according to the research objectives. The model can provide the specific marginal cost estimates for each crop from farm level to a more aggregated level, like specific territorial area (e.g. altitude), economic size, physical size, and so on. Table 4.13 shows the results on specific accounting costs for common wheat achieved for the three Italian regions aggregated according to farm size class.

Table 4.13 - Estimated and observed specific accounting costs for common wheat per size class - €/t.

Region	Size class (ha)	Specific Accounting Cost			N. of obs.
		Estimated	Observed	Var. %	
Veneto	<10	71.44	72.63	-1.6	23
	10-20	62.53	77.13	-18.9	14
	20-50	67.81	71.55	-5.2	36
	50-100	82.01	67.48	21.5	20
	100-200	68.04	63.85	6.6	13
	>200	48.67	53.95	-9.8	4
	Total	68.53	70.20	-2.4	110
Lombardy	<10	28.94	31.17	-7.2	6
	10-20	45.55	61.71	-26.2	10
	20-50	79.03	48.34	63.5	15
	50-100	35.58	45.89	-22.5	8
	100-200	48.35	42.30	14.3	4
	>200	157.30	54.30	189.7	3
	Total	55.46	48.45	14.5	46
Piedmont	<10	68.04	63.07	7.9	50
	10-20	67.85	80.31	-15.5	39
	20-50	69.62	80.08	-13.1	50
	50-100	74.81	78.25	-4.4	22
	100-200	81.11	81.38	-0.3	11
	>200	207.00	101.72	103.5	6
	Total	72.30	75.94	-4.8	178
Veneto-Lombardy-Piedmont	<10	65.55	62.81	4.4	80
	10-20	58.30	76.84	-24.1	65
	20-50	63.18	71.72	-11.9	99
	50-100	64.26	69.50	-7.5	49
	100-200	74.45	68.07	9.4	29
	>200	146.76	77.20	90.1	13
	Total	66.02	70.16	-5.9	335

Moving from an aggregated result to a less aggregated one, the estimation variability increases. In particular, observing the results for the three regions considered as a whole, it is evident how the stratification leads to an amplification of the estimation errors for some size classes; for instance, the biggest class presents a very high divergence of the estimated specific accounting cost with respect to the observed one, while most of the other classes show differences with respect to the observed data higher than the average value calculated for the entire sample. This estimation behaviour is repeated for the three regions considered separately; the worst results generally correspond to the size classes where the number of observations is low, indicating that the estimation process tends to centre the specific cost estimation on the average information.

In conclusion, the PMP methodology allows the recovery, with the accounting costs, of the information hidden inside the production level that each farmer has taken into account in the land allocation process. This kind of cost is important not only for the total marginal cost reconstruction but also for the calibration. The cost estimates obtained can be used for reproducing the basic production situation of each farm and the PMP methodology guarantees this result. This new information can be used in a model for evaluating the reaction of each farm included in the sample faced with alternative policy and market scenarios. The farm response can be evaluated in terms of land allocation, variation in GSP, total variable costs and gross margin. This last information will be provided at individual and aggregated levels.

Chapter 5

APPLICATION OF THE PMP MODEL WITH LATENT INFORMATION

5.1 Introduction: latent technologies and latent activities

The hypothesis supporting the idea that latent information exists related to latent technologies and latent activities arises from the assumption that farmers consider all the available information in the definition of their production plan. Some comes from their past experience and some from the experience of their neighbours or from advice given by experts (agronomists) who suggest introducing new crops.

Neighbouring farms can play the role, for instance, of benchmark or leader in a certain production organization or technology. In this sense, a farmer can use the other's experience as a reference, or indicator, for measuring the efficiency and identifying a path for development of his activity. In this process, farmers are guided by their specific attitude to change the status quo on their farms, in a dynamic context approach.

The specific attitude generally depends on different variables, like risk aversion, level of technical knowledge, availability of capital, family structure, age of the farmer, presence of extension services in the territory, etc. All these variables affect the farmer's decision process, driving him to select a certain combination of crops to produce in a given year. The result of this decision leads to identifying the rational use of the available inputs taking into account all the production possibilities, including the potential crops not grown in the past. Why does a given farmer produce common wheat and alfalfa and not, for instance, tomato and sugarbeet, which are grown on other farms in the area? And, are tomato and sugarbeet considered in the decision process as potential crops to include in the production plan?

The result of this process is that a given farmer could potentially insert them in his production plan, but in reality he will choose them only when the economic scenario makes those technologies or those crops profitable. Until then the information is "latent" in the sense that it is known by the farmers but not used.

Economic "latent information" related to farm crops already exists in the FADN dataset or can easily be introduced. More precisely it is possible to differentiate between i) "latent technology" when the information related to the production technology for a given crop already exists in another farmer's production plans but not on the given farm; ii) "latent crop" when the information is related to a given crop that does not exist in the farm production plan for any farms belonging to the FADN sample.

To thoroughly understand the concept of latent information it is necessary to know the components of the farmer's decision process. When he decides about the combination of activities, he is not alone but acts within an "environment" characterized by several different production decisions that indicate the different possibilities he could adopt. Among all these possibilities he selects only one combination that he assumes to be the best solution. The driving force that leads farmers to select a certain production plan and not others is the cost function associated to each activity. The total cost function is the economic translation of the available technology and all the other factors leading to the decision. The total cost includes all the variable costs involved, more or less explicitly, within the production plan decision process. This total cost function is the total economic cost that considers both the accountancy cost and the implicit cost of the decision. This latter is the part of the cost not revealed by the accountancy books but considered by the farmer in the decision process. There are two types of these costs:

- the hidden costs associated to the selected activity: these indicate the relationships between the activities and relevance of each crop within the production plan (see chapter 4)
- the costs associated to the activities that could be chosen by the farmers but that were not adopted: these are opportunity costs, i.e. the sacrifice made by the farmer for having preferred to allocate his resources to other activities.

These latter costs mean that farmers make decisions taking into account not just the activities in the production plan, but also all those activities present in the territory where they produce, considered in the decision process and defined as "latent activities". In other words, the latent information is related to activities (technologies or crops) not adopted by a given farmer since their associated cost was too high with respect to the selected production plan processes, considered more profitable. This is the concept of "latent activities" that could potentially be adopted if the environmental conditions change.

The "latent technology" is a different way to produce the existing crops in the production plan. The farmer knows that for producing a given crop he could use a different combination of inputs in order to obtain a different yield performance. If, for instance, the farmer produces maize with a certain technology, defined by his personal experience, machinery, etc., he knows that it could be possible to use another technology to obtain a different level of output or to have the same output with a different level of cost. Using all the available information about the different technologies, the farmer decides to adopt only one.

The "latent crop" is related to information about a new crop that does not exist in the sample at the time of the observation but which is artificially introduced in the farm dataset. It could be implemented when market conditions make this crop profitable.

For both decisions, crops and technologies, farmers are aware of the costs that each choice can entail. In order to identify the economic behaviour of the farmers, the information about the latent information should be considered with the observed activities in the evaluation process. This can verify under which conditions farmers keep the same activities and in which other conditions they move to other ones. Within this perspective, the farmer's behaviour is analyzed with respect to a production plan where the observed activities are accompanied by latent technologies and latent crops.

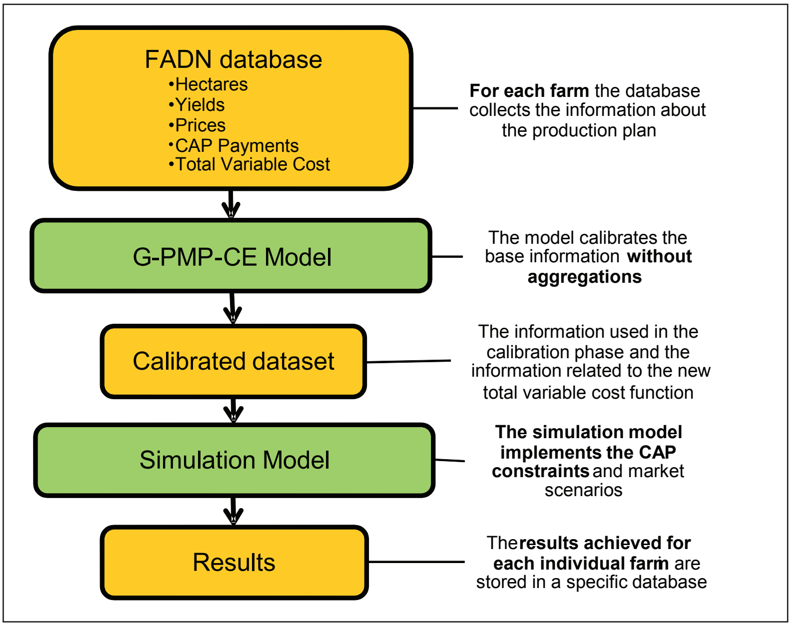
5.2 Hypothesis adopted, assumptions and structure of the model

The described concept of latent information has been included in the PMP model within a framework in which some environmental variables, like market prices and agricultural policy, might change. The model presented in the third chapter is a PMP based model that implements the latent information approach with the estimation of the specific costs missing from the FADN database. The model tries to estimate the specific costs for the observed and realized activities and for latent technology and latent crops; latent information is used in the simulation phase of the PMP procedure in order to capture the farmer's behaviour with respect to the possibility of changing the technology or changing the set of products observed in the basic year.

The information used originates from the FADN database and focuses on the case study of Veneto region in Italy. In order to work with homogenous information, only the subset of annual arable crops (Farm Type 1) has been selected.

Permanent crops, like fruits, are not considered, since for this type of process the model should be formulated in order to consider the long-term evolution of these activities and the long-term competition with annual crops. Livestock production has also been excluded because of the difficulty in modelling some information and lacks in the FADN data (e.g. meat yield, prices). The data have been used in the model at individual level, so each farmer is subjected to behaviour estimation and simulation. Each farm is firstly depicted in the observed situation with its production plan and the potential latent activity that each farmer could consider in the production plan. For each activity, realized and latent, the information collected is related to the hectares cultivated (for the latent crops, the hectares assumed are a very small portion of the cultivated land), yield, market prices and every specific public subsidy. In order to estimate the specific cost of production of each crop, the only information considered in the analysis and obtained from the FADN archive is the total variable cost at farm level. The total variable cost is important in order to drive the model as well as possible to recover the most realistic specific cost per crop. The information about the single farm payments, amount and number of rights, is collected from the European database and used at farm level. Figure 5.1 shows the structure of the model and relevant information needed and produced in each phase.

Figure 5.1 - Structure of the PMP model



Summarizing the layout of the model structure, the first phase is dedicated to the identification of the relevant information to use in the model. This part of the data processing defines filters in order to use the information useful for the PMP evaluation and organizes the data in order to be used with GAMS, the algebraic package adopted for building the model. The model calibration, by means of the General PMP Cost Estimator (G-PMP-CE) model, provides important information about the specific costs of realized and latent productions. These costs are used to calibrate the model and simulate farmer behaviour with respect to modifications in the CAP and market scenarios. The simulation model uses the calibrated data-set (all the information coming from the calibration procedure at farm level) to assess how farmers react to new scenarios taking into account the CAP constraints. The results obtained with the simulation model are stored in a specific database in order to organize the analysis.

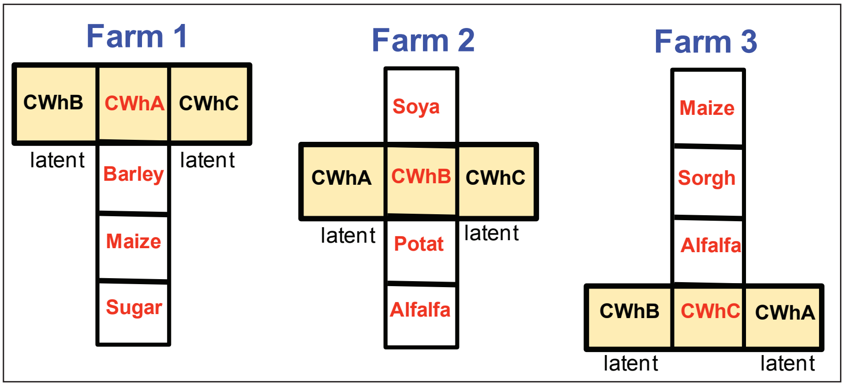
The simulation phase that has been carried out considering different agricultural policy scenarios and different market conditions will be explained in the next section.

5.3 Latent information in the simulation schemes

The model evaluation purpose is twofold: on the one hand, it aims to estimate the impact of policy and market scenarios on the possibility of adopting a new production technology in the production plan; on the other, the objective is to assess the role of CAP and the market in the introduction of a new crop in the production plan.

Figure 5.2 presents the scheme of a scenario where the objective is to evaluate the capacity of one technology not considered in the basic production plan to substitute another one already adopted on the farm. This simulation scheme aims to evaluate when and how the technologies not adopted by the farmer but considered in his decision process (as latent technologies) enter the production plan. For instance, let us suppose that for common wheat (CWh), a set of three different production technologies exists (A, B, C), characterized by different yields, costs and prices, and suppose that the sample is composed of three farms, each one adopting a different technology for common wheat.

Figure 5.2 - Decision scheme for latent technology scenarios



In this analysis, two crops grown in the basic year have been submitted to the latent technology evaluation. More specifically, the common wheat sector in Veneto region has been divided into three different technologies according to the yields, considered as the parameter for identifying the farm technology:

- ≤ 5 tons/ha (A)
- > 5 tons/ha and ≤ 7 tons/ha (B)
- > 7 tons/ha (C)

According to FADN information, each of these three technologies involve different prices and different costs, depending on their size, territorial location, farm structure, managerial variables, etc. Costs are estimated using the previously explained PMP approach, in order to highlight the implicit costs for these different technologies. In the simulation phase, all the information concerning the three technologies is used in order to evaluate the farmers' willingness to substitute the given technology of the basic situation with another one (adopted by other sample farms) in a new environmental framework.

According to the other simulation scheme, another set of scenarios concerns the possibility of introducing a new crop not present in the production plan but considered within the decision process. In this case, it would appear to be useful to investigate if the CAP policy can play a role in influencing the profitability of the new crop in place of the basic crops.

The new crop considered in the analysis is sorghum for energy production. We have assumed that this crop is not included in the basic production set at regional level. The crop enters the regional production plan as a new possibility with the related technological and economic information. In this sense, the aim is to test the hypothetical development of a biomass chain based on sorghum, estimating the price starting at which this new type of activity can be inserted among the other basic information. The results obtained will be used to define a threshold price for sorghum and to evaluate the relationships with the other crops.

5.4 Policy and market scenarios

The simulation model was developed in order to consider the effective situation in terms of policy and market in 2009. To do that, the model implements the CAP mechanisms in place in 2009 and the market prices of the same year. Starting from 2007, the year of data collection, the simulation for 2009 has updated the information on prices and CAP support, providing a new production plan at individual and regional level. This represents the reference scenario in our analysis, i.e. the scenario used for comparing the results obtained implementing the other simulations.

In terms of policy scenario, the model tries to reproduce the Health Check Reform (HC). On the basis of the HC document, the scenarios consider the actual situation in terms of subsidies provided for fruit and vegetables and the influence of the reform started in 2011. As the data adopted for this study refers to 2007, the model foresees a specific scenario that reproduces the transition period currently characterizing the fruit and vegetable sector. Then, in compliance with the decision of the Italian Minister, a scenario in which all the subsidies, fruit and vegetables included, are decoupled according to the historical approach, has been evaluated. The first scenario is the reference (base) scenario, while the second one is the situation forecast for 2011 onwards. It is important to mention that the decoupling scheme developed in the model for fruit and vegetables only concerns annual fruits and vegetables (mainly tomatoes) and not permanent crops, like peaches, plums, etc.

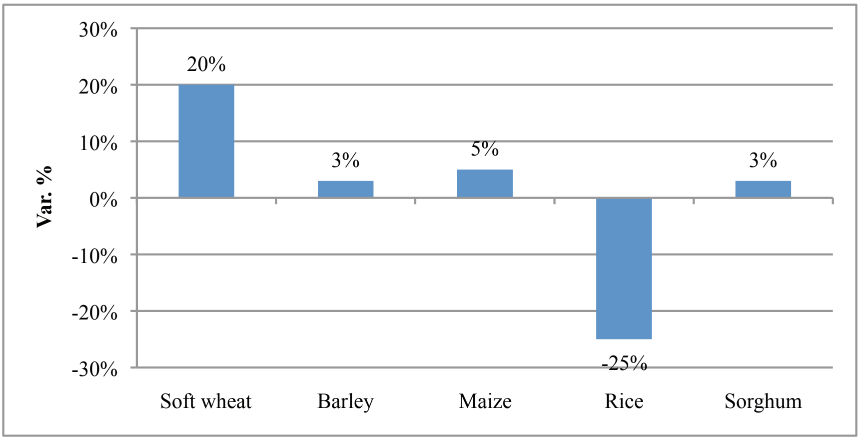
The modulation is also considered in the model. In the HC, modulation is the principal instrument addressing the financial strengthening of the second pillar, draining resources from the first pillar. In consideration of the new issues identified in the HC document as the new challenges to be tackled within rural development (climate change, renewable energies, water management and biodiversity protection), the Commission introduced a reinforcement of the compulsory modulation. The HC introduced a new mechanism based on a progressive increase of the modulation rate from 5% to 10% for the payments between 5,000 € and 300,000 € and

14% for part of the payments exceeding 300,000 €.

In summary, we can first identify three scenarios:

- Basic situation (2007): the scenario concerns the calibrated data, i.e. the production situation provided by the sample;
- Transitional fruit and vegetable reform period (reference scenario): the scenario reproduces, in terms of agricultural policy and market conditions, the situation existing in 2009 and is used as reference scenario for the simulation purposes;
- Total decoupling scenario: all the payments are decoupled according to the HC reform and new modulation rates are introduced. The market conditions are those predicted for 2013 (the last year of HC validity) by FAPRI16 for some relevant crops (Figure 5.3).

Figure 5.3 - Variation of market prices for some relevant crops (2013/2009)



The model does not consider livestock production, so the milk quota modifications are not taken into account.

Starting from these scenarios, the farm behavioural reaction towards the new activities is analyzed. The scenarios developed for responding to this issue should be divided in two groups: the first one related to the technology change and the second to the new crop introduction.

For assessing the adoption of new technologies, the scenarios consider a

16 FAPRI is the Food and Agricultural Policy Research Institute that produces predictions about the main world agricultural markets.

progressive increase in the observed price of 100 €/ton with a step-by-step increase of 1 €/ton. This means that for each product 100 cycles of simulation have been carried out in order to obtain a sensitivity response for the production plan and, in particular, for the technology substitution at individual level. For instance, if the observed price for a given crop is 200 €/ton, the sensitive analysis will consider a price variation from 200 €/ton to 300 €/ton. The aim of this simulation is to observe the dynamics of the three technologies at every change in the related price in order to capture the process of substitution within the three technologies and between the three technologies and the rest of the production plan.

As regards the new crop simulation, the objective is to evaluate under which economic conditions the new crop can be inserted in the production plan of the farms in Veneto. The new crop, represented by sorghum for biomass production, is submitted to a cycle of simulation that foresees the progressive increase in its price, starting from zero and reaching 150 €/ton. Also in this case, the simulations can be considered as a sensitivity analysis of sorghum with respect to the price evolution, but with further information to explore. Indeed, this approach applied to the potential new crop can provide useful information about the threshold at which the crop becomes profitable for the farm. If the objective is to assess if it is possible to develop a new food chain using a product that traditionally does not exist in a given territory, the simulation model can indicate the price level needed in order to obtain a production response in line with the food chain objective. For instance, in the case of sorghum for biomass, it is important to know the price that generates a sufficient raw material supply for the processing industry. This kind of simulation can also provide information about the change of the main economic variables and the production plan composition in relation to the price modification.

5.5 Results obtained for the latent technologies

As previously stated, the inclusion of latent information in the PMP model permits the impact of market price or CAP measure to be predicted on existing crops that adopt different technologies or on new crops that are introduced in a given territory.

The results show how the impact of price variation is sensitive to the farm size and level of specialization of the producers. In particular, an increase in price for common wheat determines the use of the most intensive technology for the crop and for the three farm yield types. This strategy will reduce the presence of common wheat with low yield and increase the technology with higher yield. With this strategy, farm income will increase, but there is a negative impact on the environment due to the increased area of the most intensive crops in Veneto region.

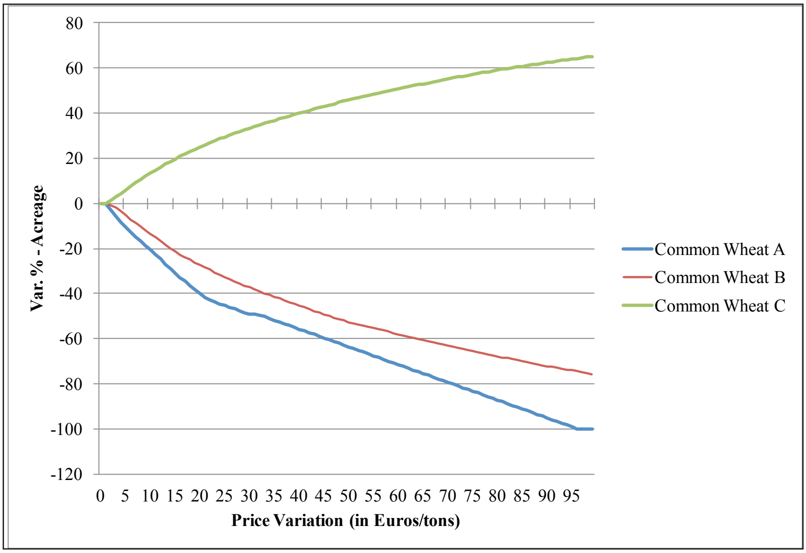
In the next section the graphs indicate the main impact on the land use of farms aggregated by their level of production intensity. For a better understanding of the model results, it is important to note that the option to activate a technology not present in the basic scenario is available at farm level when Health Check CAP modifications are introduced. For this reason all three technologies might be present in the first sensitive price scenario that follows the Health Check scenario.

5.5.1 Entire sample (Veneto region, Farm Type 1, arable crops)

Figure 5.4 shows how new market conditions for common wheat can affect farmers' decisions to adopt other types of technology to produce the same crop. The price increase indicates the prevalent technology very clearly: common wheat technology C is the dominant one, i.e. the technology with the highest productivity associated with the highest marginal profit. The increase in the market price causes a progressive positive trend in the incidence of common wheat C (the highest yields technology) and a decrease in technologies A and B. Technology B seems to be much more resistant to the competition with respect to technology A. In both cases, technology C substitutes the acreage of the less competitive technologies A and B. Indeed, even if the higher relative profitability of C largely benefits from the price increase, technology B maintains more than 20% of the acreage with a price increase of 100 €/ton.

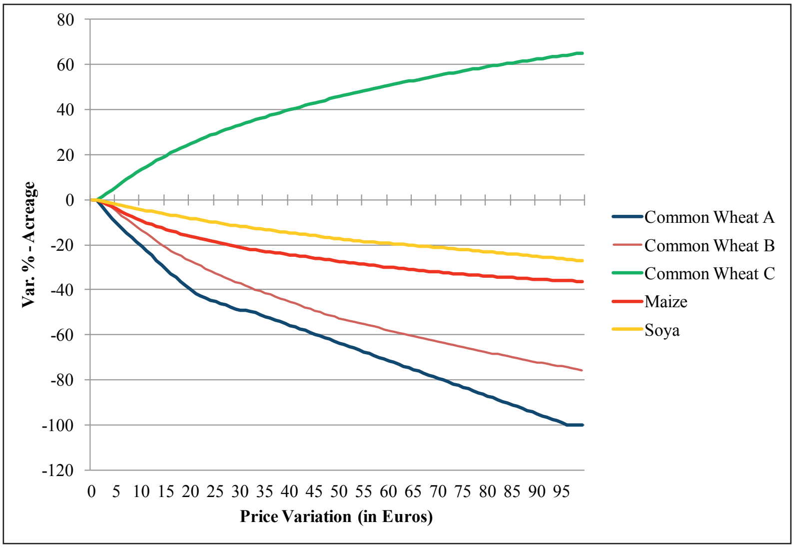
The positive variation of common wheat C indicates, as mentioned above, a process of substitution of the less intensive and profitable technologies in favour of the more intensive and profitable one. But, the substitution process does not involve only the three technologies of common wheat but also the other crops in the farm production plan. For this reason, a rise in the relative profitability of one crop, induced by a market price increase, can affect all the crops with a lower relative profitability. In Figure 5.5, the variation of the incidence of the three common wheat technologies are compared with two important regional crops, maize and soya. The surface area of common wheat C increases with respect to the acreage of the other two technologies, but also with respect to the acreage of maize and soya that in the market scenarios reduce by up to 35% and 25% respectively.

Figure 5.4 - Three technologies of common wheat evolution changing the prices (all farms)



Source: our processing on Italian FADN

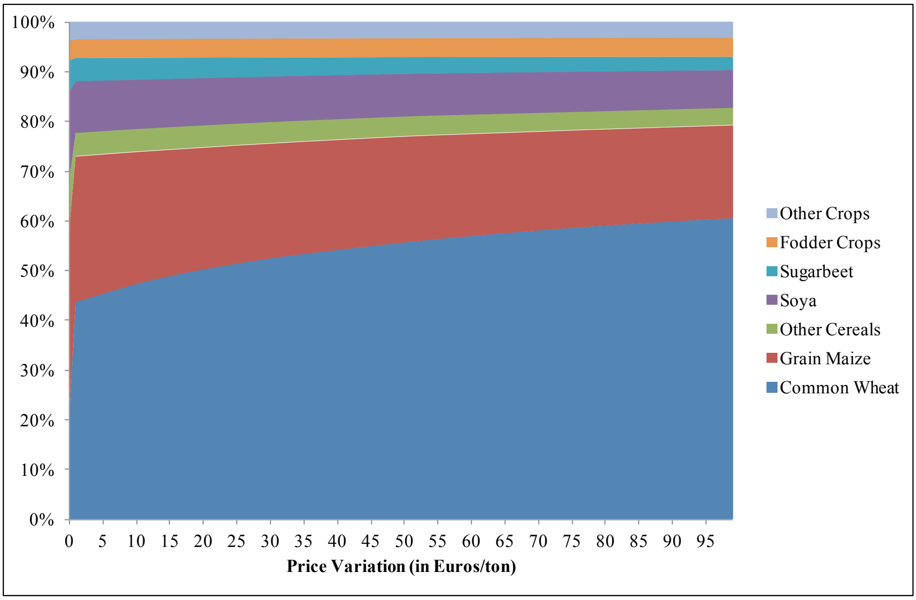
Figure 5.5 - Three technologies of common wheat evolution changing the prices wrt maize and soya (all farms)



Source: our processing on Italian FADN

Maize is the crop most affected in terms of percentage incidence (Figure 5.6), moving from 35% of the total area to 20%.

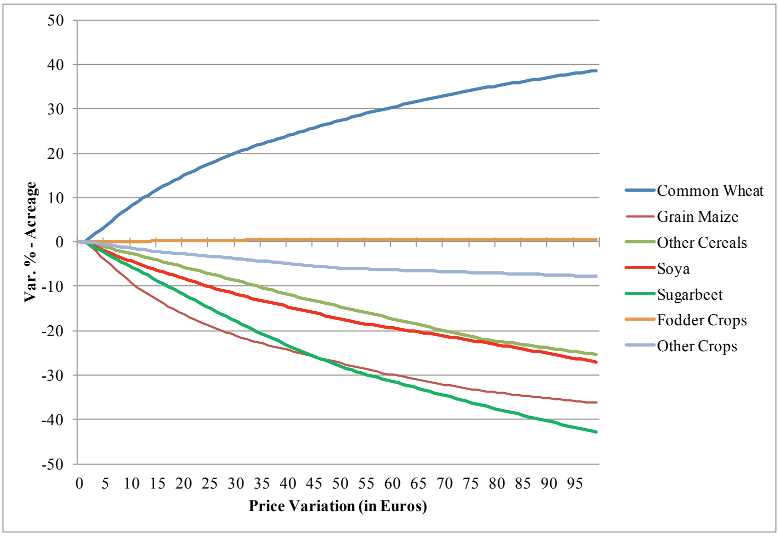
Figure 5.6 - Production plan dynamics according to common wheat price variation (all farms)



Source: our processing on Italian FADN

This kind of analysis permits the dynamics of common wheat technologies to be observed with respect to two important crops in the regional production set (soya and maize). But, as previously stated, the PMP model can provide information for the entire production plan, so that it is possible to analyze the behaviour of each crop according to common wheat price increase. Figure 5.7 shows the percentage variation of the acreage assigned to the main group of crops in the sample. As the figure shows, the curves that incorporate the sensitivity of the group of crops to the variation of common wheat prices indicate the importance and dominance of common wheat with respect to each other crop. The less competitive crops are maize and sugarbeet, which show the largest decrease in percentage terms. On the contrary, fodder crops seem not to be influenced by the market price modification, remaining stable at the basic situation. After a certain point, fodder crops show a slight tendency to increase in response to the major expansion of common wheat and the rotation criteria that the model requires. Indeed, the PMP model traces a relationship between the cereal crop and fodder crops in order to identify a sort of rotation criterion that must be considered to provide a more realistic framework during the simulation phase. In other words, the model states that the relationship between the two groups of crops calculated as the ratio between the two total acreages observed in the basic year, less a little tolerance, must remain the same.

Figure 5.7 - Percentage variation of the groups of crops changing the prices wrt the reference scenario (all farms)

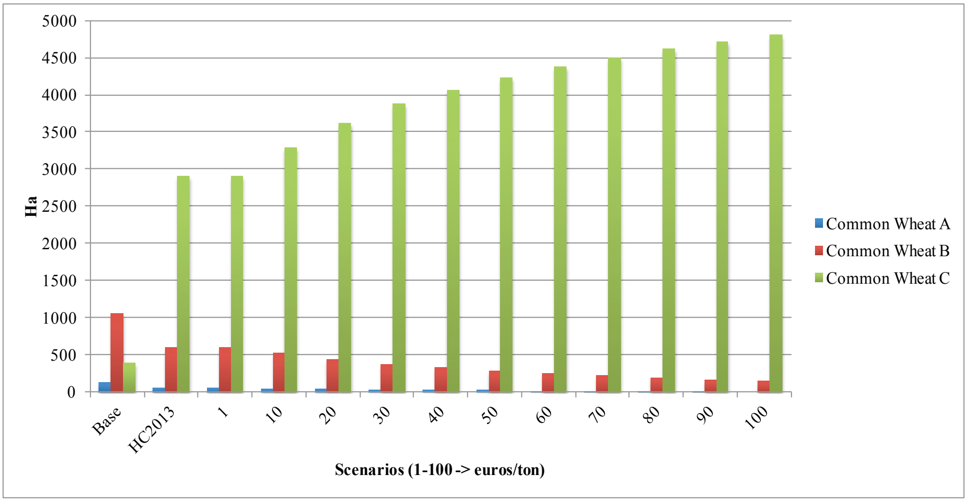


Source: our processing on Italian FADN

The analysis highlighted the evolution of the crop acreage, in particular common wheat, with respect to a variation in market prices. The analysis was addressed to this dynamic without considering the role of the CAP policy in defining this kind of behaviour. In the previous trends the price variations overlapped with the agricultural policy mechanisms and for this reason the policy component becomes a neutral element in the analysis. The CAP policy reform (the Health Check) is integrated in the first price scenario. In order to analyze how CAP influences the farmer's behaviour and, in particular, his decision about the adoption of one of the available technologies, the change in agricultural policy has been considered in the scenarios shown in Figure 5.8. More specifically, the first scenario (Base) identifies the reference scenario concerning the 2009 situation (in policy and market terms); the second scenario (HC2013) takes into account all the Health Check mechanisms, including the process of transition to the total decoupling and plain modulation (the two main CAP elements considered in our analysis).

In the base scenario, is possible to see the hectares covered by the three technologies of common wheat after the simulation with agricultural policy and price at 2009; while in scenario HC2013, the three common wheat technologies are simulated taking into account the total decoupling for fruits and vegetables and the reinforced modulation rate. The HC completion seems to influence the cross profitability of the crops so that the common wheat with the more advantageous technology considerably increases its weight with respect to the other technologies but also with respect to the other crops. The common wheat C moves from 400 hectares to 2,800 hectares, indicating that the change in agricultural policy could influence the modification of the farm technology. The progressive increase in common wheat price produces the increase in common wheat C and the reduction of the other two types of crops.

Figure 5.8: Acreage evolution of the three common wheat technologies changing the prices (all farms)



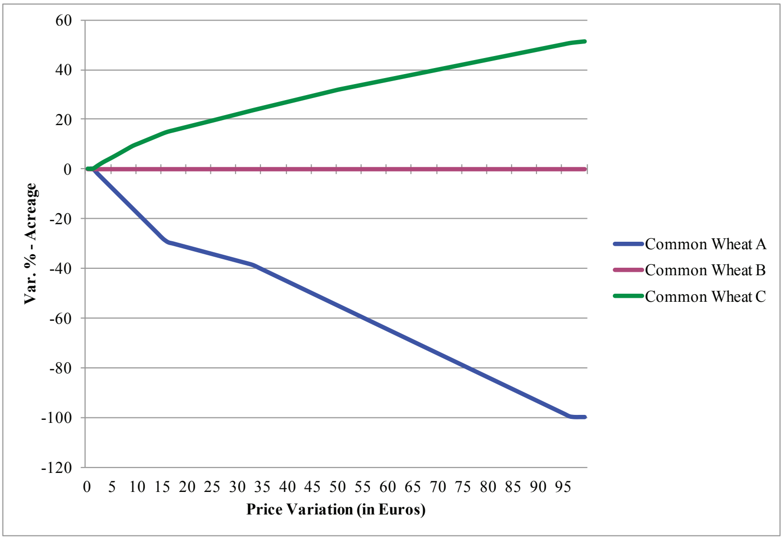
Source: our processing on FADN data

5.5.2 Results for original farm technologies

In the previous section, the main results obtained for the Veneto region have been proposed with the aim of providing some useful references in order to understand the meaning of the simulations carried out within the framework of this project task. In this section, we report the results obtained for the farms adopting one of the three different technologies for producing common wheat. In this context, the farms using technology A for producing common wheat are investigated for capturing the behaviour in response to the scenarios foreseen in our analysis.

Figure 5.9 shows the response of the three technologies of common wheat on those farms. It is clear that the rise in the common wheat price produces a decrease of the less profitable technology, in this case technology A, and an increase in the acreage cultivated with common wheat C, which is evaluated as the most profitable technology. Technology B is not activated, because on average it is less efficient and profitable than technology C. When the price approaches an increase of 100 €/ton, technology A disappears.

Figure 5.9 - Three technologies of common wheat evolution changing the prices (common wheat technology A - farms)

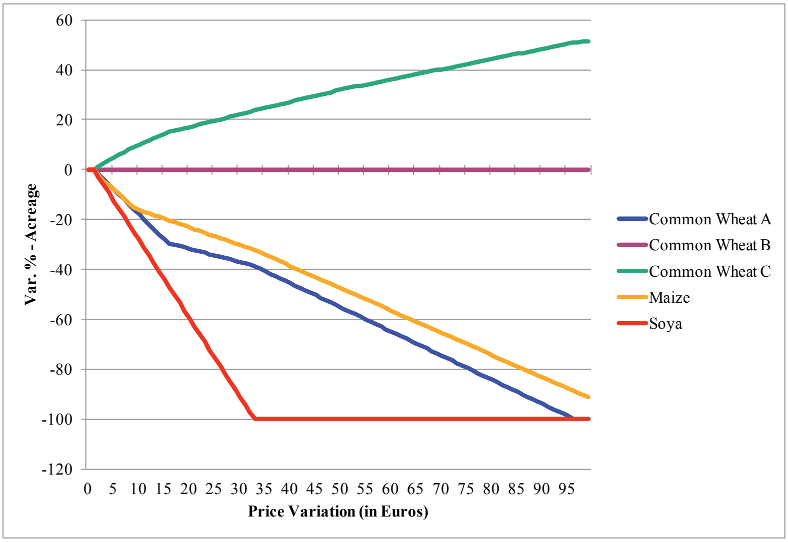


Source: our processing on Italian FADN

The relationship of common wheat with the rest of the production plan indicates that the positive variation of the common wheat price with the introduction of the new technology considerably reduces the profitability of the other crops. In particular, the surface area of maize and soya decreases in favour of common wheat.

The discussion about the role of the agricultural policy in the change of technology can be introduced considering Figure 5.10, where the reference scenario (BASE) and the situation proposed for 2013 (HC2013) are compared. The adoption of the total decoupling in all agricultural sectors added to a more intensive modulation pushes farmers to specialize in the crop where they can benefit better from the cost reduction and higher productivity. The behaviour is very similar to that observed for the sample: a reduction in common wheat A with a strong increase in common wheat C that from the scenario HC2013 reinforces its weight in the production plan.

Figure 5.10 - Three technologies of common wheat evolution changing the prices wrt maize and soya (common wheat technology A - farms)

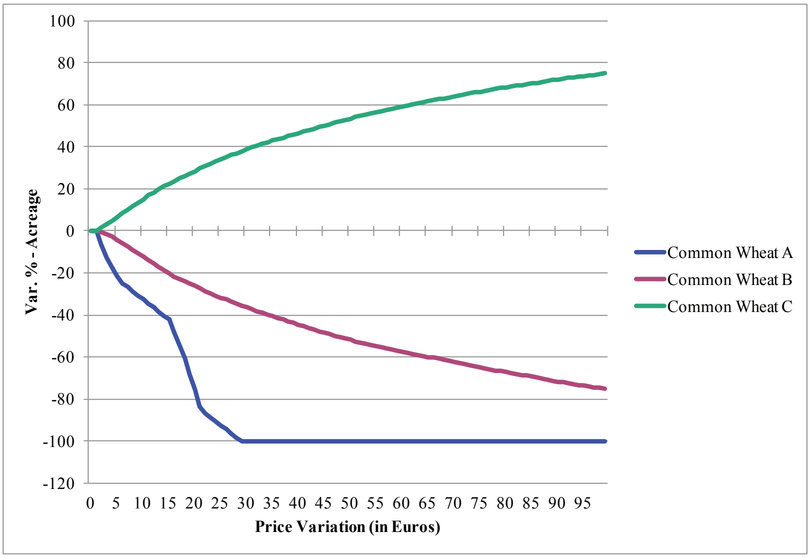


Source: our processing on Italian FADN

The farms with common wheat B have demonstrated a certain resistance to change the technology by moving to technology C. Figure 5.11 shows an important increase in the more productive common wheat (C) and a reduction in the acreage growing common wheat B, but without the disappearance of this production even at an increase of 100 €/ton.

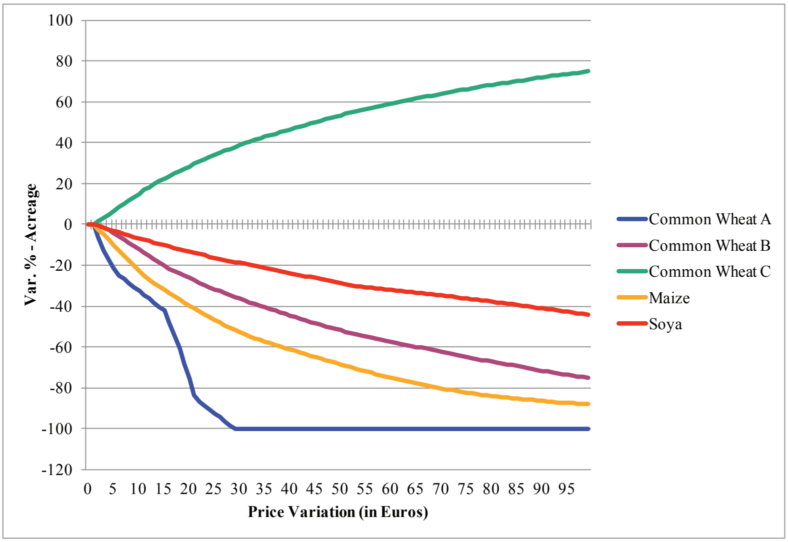
The competition with other crops is not different from the other results: grain maize, soya and sugarbeet are the crops that suffer most from the price increase of common wheat; the hectares dedicated to fodder crops do not change very much due to the rotation constraints that maintain the ratio with cereals around the value observed in the initial situation.

Figure 5.11 - Three technologies of common wheat evolution changing the prices (common wheat technology B - farms)



Source: our processing on Italian FADN

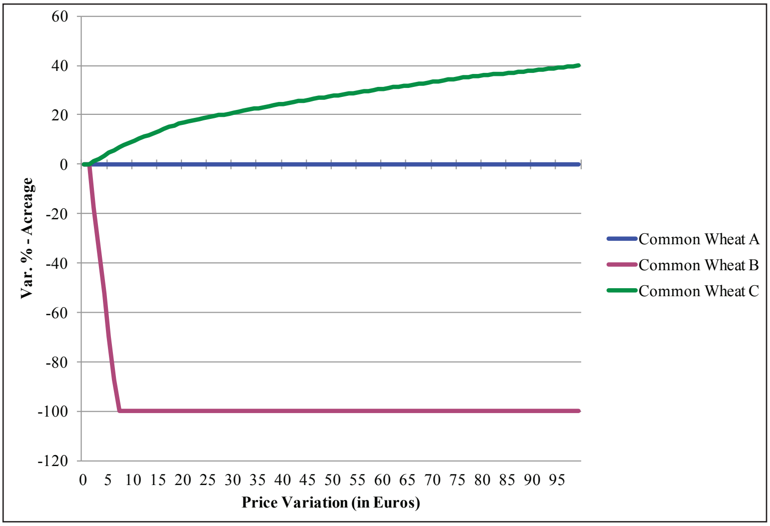
Figure 5.12 - Three technologies of common wheat evolution changing the prices wrt maize and soya (common wheat technology B - farms)



Source: our processing on Italian FADN

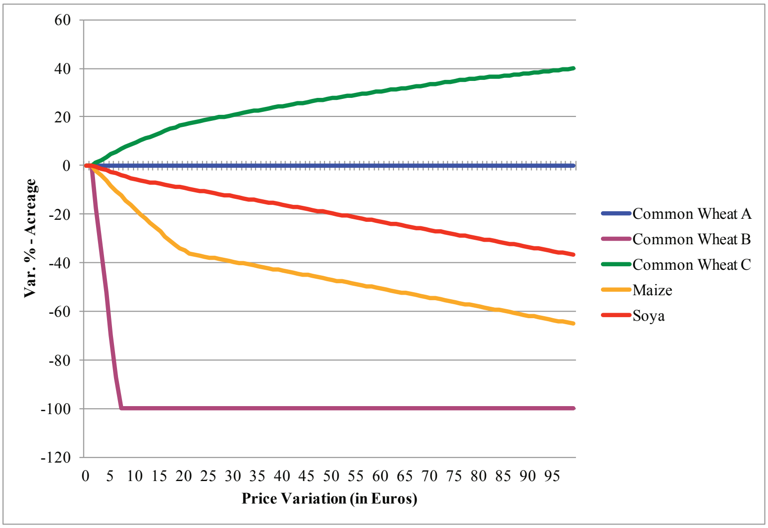
The positive variation in common wheat price has produced a strong incentive to invest in common wheat stimulating the more efficient technology in term of costs and yields. Technology C prevails over the other ones allowing a higher profitability to the farms. On the farms where technology C is present, the price rise produced an increase in this type of common wheat confirming the relative high profitability of this crop with respect to the other crops.

Figure 5.13: Three technologies of common wheat evolution changing the prices (common wheat technology C - farms)



Source: our processing on Italian FADN

Figure 5.14 - Three technologies of common wheat evolution changing the prices wrt maize and soya (common wheat technology C - farms)



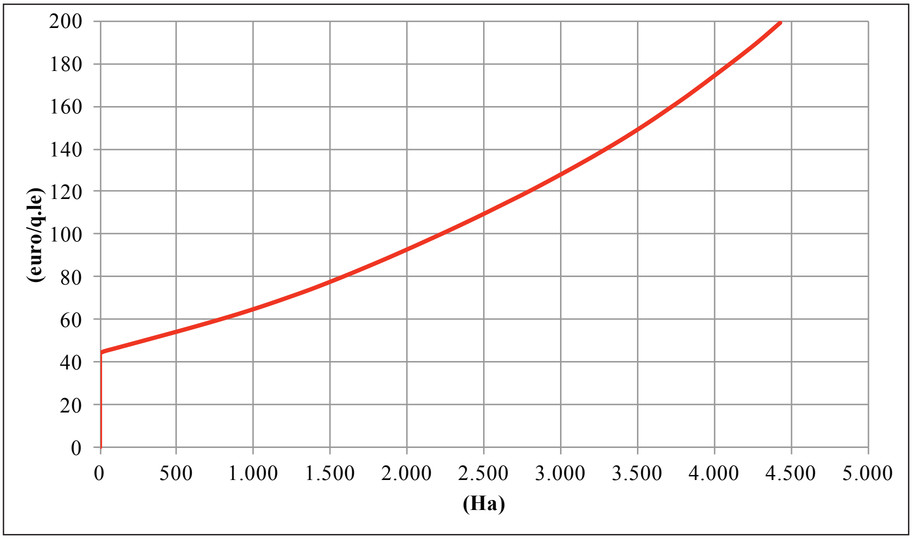
Source: our processing on Italian FADN

5.6 Results obtained for the latent crop

The simulations concerning the latent product have been developed with respect to a new crop that did not exist in the regional production plan. This latent crop is sorghum used for producing ethanol, a variety of sorghum with agro-energy aptitude. The information concerning average yields, price and specific production costs have been collected from a study promoted by the Emilia-Romagna region aiming to evaluate the possibility of building a regional supply chain for second generation bioethanol based on sorghum biomass.

The results obtained for the Veneto region permit the economic threshold (prices) to be identified starting from which sorghum for biomass production can be inserted in the production plan of the farms present in the sample. Figure 5.15 shows the response of the sorghum production decision with respect to its price variation. The graph presents a curve that starts to increase from a level of 4.5 €/tons, considered as the profitable threshold for this crop. The prices dynamics produce a decreasing increment in the acreage for sorghum. This means that the farm internal constraints do not allow a simple expansion of the crop. In particular, the rotation constraints and the complementary and substitution relationships within the cost matrix prevent the possibility of specializing the entire farm UAA in a single crop. The graphical representation of the simulation results is interesting because it shows the different production levels with respect to the different price levels. For a public institution or a private firm that intends to constitute a supply chain for the sorghum for biomass, this graph permits evaluation of the correct price to pay to producers in order to get a given quantity of raw material to process. So, for instance, if a group of farmers is interested in planting 2,000 hectares of sorghum, the price that should be paid to farms is more or less 90 €/ton.

Figure 5.15 - Evolution of the sorghum hectares varying the price

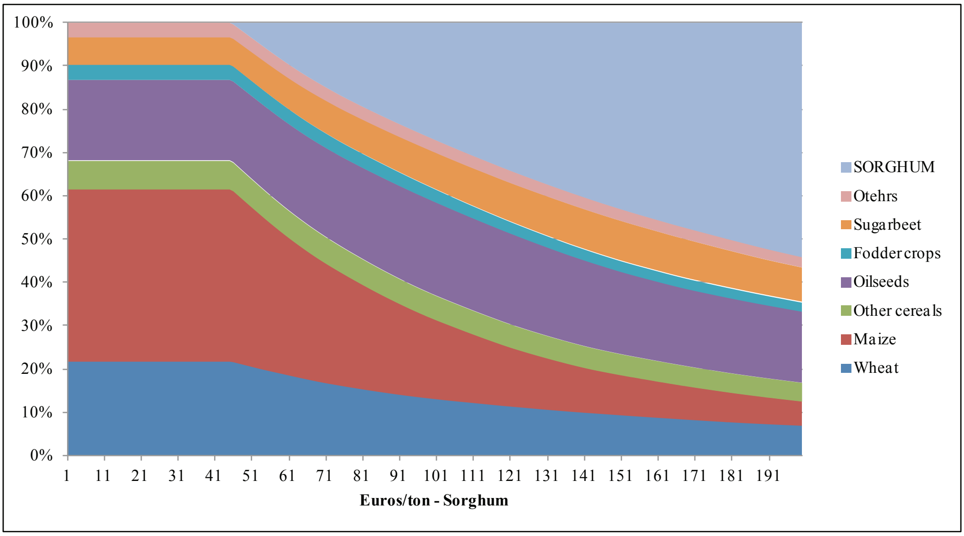


Source: our processing on Italian FADN

The simulation also permits the change in the relative incidence of sorghum with respect to the other crops in the regional production plan to be appreciated. Figure 5.16 highlights that the increase in the incidence of sorghum on the regional production plan is due to a strong reduction in the incidence of maize and wheat.

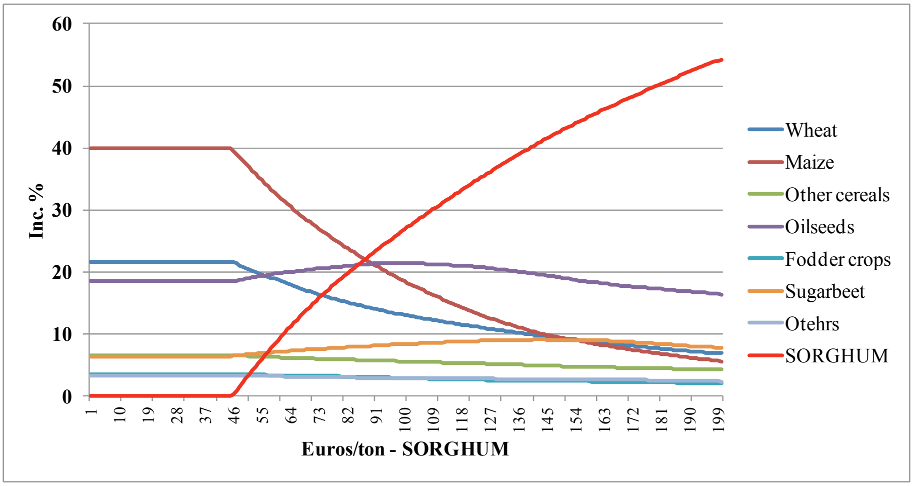
Figure 5.17 compares the dynamics of the incidence of each crop in relation to the variation in the sorghum price. In the figure, the increase in the incidence of sorghum is evident and corresponds to a reduction in maize and common wheat, while the other crops have kept roughly the same level as that observed in the basic scenario.

Figure 5.16 - Incidence of each crop on the regional production plan wrt a progressive increase in the sorghum price



Source: our processing on Italian FADN

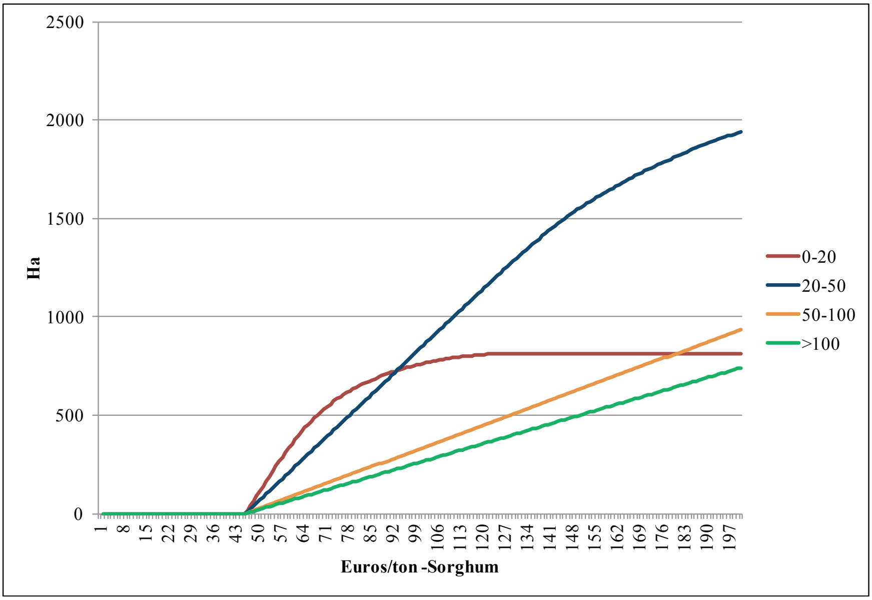
Figure 5.17 - Evolution of the specific incidence of each crop on the regional production plan



Source: our processing on Italian FADN

The simulation analysis is developed evaluating the individual behaviour farm by farm. The results obtained at the maximum level of detail correspond to the production plan dynamics for each single farm considered in the sample. For this reason it is possible to analyze the results in relation to different dimensions, like the size class of the group of farms considered. Figure 49 presents the evolution of the hectares planted with sorghum with respect to four size classes (0-20 ha, 20-50 ha, 50-100 ha, >100 ha). The most dynamic groups of farms are those with a size less than or equal to 50 ha, which present a strong response to the increase in price; while the farms bigger than 50 ha show a constant positive variation of the surface cultivated with sorghum. It can be said that the small farms can benefit from a new crop that can create the conditions for a notable improvement of the gross margin; in the case of the largest farms, the intensive techniques combined with a more complicated production plan reduce the profitability of introducing the new crop.

Figure 5.18: Dynamics of the sorghum hectares in relation to farm size class



Source: our processing on Italian FADN

CONCLUSIONS

The FADN accounting system is the most relevant source of information available in the European Union for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy. Since its birth in 1965, European farms and farming systems have seen important changes and FADN has been influenced by these developments. The inclusion of new Member States and the issue of an International Accounting Standard specific for agriculture (IAS 41) have required further efforts to guarantee the homogeneity and harmonization of the accounting rules. These concerns about farm accounting have led European researchers to develop appropriate tools to estimate the cost of production of agricultural commodities. The literature gives different examples of cost accounting. The main difficulty in the agricultural sector is the lack of an analytical bookkeeping accounting practice which does not permit an easy allocation of common costs among the different activities and the estimation of the implicit costs. FADN does not provide cost and returns per single enterprise or activity and so there is a need to generate this information in other ways. There are different methods to solve this problem, depending on the kind of costs taken into account and on the farm accounting details. The most sophisticated ones are based on statistical models that attempt to estimate functional relationships starting from the accounting data.

The calculation of production cost per enterprise serves as a basis for improving the agricultural and econometric modelling for measuring the impact assessment of the CAP. It can be useful to analyze the relationship between the cost structure and the farm performance or to quantify the relationship between the costs of producing commodities across the EU and the impact on landscape and natural environment.

In the FACEPA project the production cost estimation has been made applying two different models: a general econometric model (GECOM) and a mathematical programming model (PMP model) that has been used for predicting farm behaviour at micro and regional level in the case of change in market and policy conditions.

The GECOM model uses conventional econometric procedures to estimate the production cost of farming enterprises starting from FADN data. The model has been implemented in the FACEPA project using the European and national FADN datasets. Italy has applied the model to the national FADN (RICA) dataset of the period 2005-2007 for estimating the production cost of the most important Italian commodities (common and durum wheat, maize, apples, quality grapes, quality wine and cows' milk). The GECOM model estimates the unit cost of production of one given input to produce one unit of a given output. The results have been validated making a comparison with the costs allocated by the surveyors, a characteristic of the Italian FADN that is not transferred to the European system because of homogenization needs. Notwithstanding the general structure of the model, its specification requires an appropriate choice of the input and output aggregation according to the specific agricultural conditions and the structure of the dataset. In particular, a preliminary analysis to remove the outliers seems to be necessary because the estimates are sensitive to extreme values. Differently from other approaches, data defects may be of great importance because of the potential for biasing quantitative functional estimates.

The results obtained for Italy are, in general, good and statistically different from zero. They are realistic for the main products taken into account and the comparison between estimated and attributed costs gives similar results in most cases. In some comparisons, the differences need a deeper investigation in the Italian FADN cost structure. For instance: in the case of common wheat, the highest value of the crop protection estimated cost with respect to the observed cost is not explained by the model. The analysis of cows' milk shows that attributed costs of home-grown feed are systematically higher than estimated costs. This difference is probably due to the evaluation made by the surveyors that seems to be very high, also compared with other estimations found in the literature.

The flexibility of the GECOM model permits the application at different territorial level (for instance the analysis for quality grapes has been implemented for the north, centre and south of Italy). This has shown how, in the case of a low number of observations, it is necessary to pay attention when interpreting the results. A high number of observations, in fact, guarantees an improvement in the estimates and a lower variability between the maximum and minimum observed value. The application of GECOM model requires the knowledge of the agricultural context analyzed in order to chose the right combination of input and output that meets the agricultural characteristics of the selected area. The limits of the model are related to basic assumption, in particular the production technique that is considered the same in all the considered farms. So the scale effects are not take into account and it is not possible to investigate the consequences of the adoption of particular technologies in the cost production structure.

The GECOM model could be an important instrument to integrate in an objective way the information on production costs available in RICA and related to the single production process. Sometimes the lack in accounting information makes their allocation difficult and this kind of estimation should help the whole process.

As concerns the PMP model, its theoretical framework is useful for representing farm choice, including the cost related to the production function chosen by each farmer. Like the GECOM model, the PMP model reveals a good capacity to estimate the specific accounting costs when the information is numerous and homogeneous. One advantage is that the model permits to separate the accounting cost (identified in the farm accounting books) from the hidden cost, that is the implicit cost not observed but included in the farmer's decision process.

Application of the PMP model to a specific Farm Type and in a specific region is possible also in case of different agricultural specialization and territorial analysis level. In all the selected case, the validation of the results is obtained adopting the Student's *t*-test and comparing them with the observed accounting costs collected by FADN. In this regard, three Italian regions have been selected. The model represents a good estimator for the specific accounting costs for sugarbeet, barley and common wheat. The statistical tests for some crops remain unsatisfactory, due to a lack of information in some specific cost component, like irrigation.

Differently from the GECOM model, the PMP model has been applied considering different technology levels (referring to yields) and changes in the environment (market prices and agricultural policies). The analysis of these effects has been developed considering the adoption of a different technology for an activity already present in the farm production plan (latent technology) or related to a new activity (latent activity). The scenarios assumed for the evaluation concern a likely market price evolution for common wheat while the agricultural policy changes have been considered introducing in the model the total decoupling and modulation reinforcement foreseen by the CAP Health Check reform. The results obtained for the three different ranges of technology associated to common wheat highlight that in case of price increases, farmers tend to change the farm technology level and the main substitution process can be identified between the lowest and highest yield (representing technology). The farmers who move to the most productive technology completely abandon the previous one. The middle level of technology retains a significant part of the production even if the tendency is to substitute this with the most productive technology, that means an increase in the rate of production intensity within the group of farms. This result shows how farmers find it worth investing in new technologies when the level of market prices increases.

If the market price push the farmers towards changes in their farm technology, the agricultural policy mechanisms intervene in modifying the land allocation, according to a farm strategy based on the reduction of production costs. The adoption of the total decoupling in all agricultural sectors, combined with a more intensive modulation, push the farmer to specialize the production where he can obtain more benefits from the cost reduction and the increase in productivity. For this reason, total decoupling represents an incentive to reorganize farm production, minimizing the costs and giving priority to the process with high productivity: the new technologies are introduced into the production plan substituting the basic one in response to the new signal from the CAP.

The model applied considering the latent activity, i.e. an activity not present in the production plan in the observed sample of farms, provided a set of information about the profitability of introducing such an activity into the production plan. The model showed the economic threshold starting from which the new activity can be introduced alongside the other productions. This threshold changes, according to the type of farm, identifies different levels of profitability for introducing the new crop. This information allows to identify the types of farm that could be more available to introduce the new activity into their production plan. In case of territorial analysis, the introduction of a new activity could be considered as a supply of raw material for agrifood processing. The construction of a new supply chain based, as in our example, on biomass from sorghum, involves a feasibility analysis conducted to find the relationship between price levels and the related level of production. The PMP model and related simulation analysis allow to discover, for each type of farm and for each territorial area, the production level according to the different price levels of the crop.

In conclusion, the PMP model has captured the fundamental economic information about the specific production costs for each level of technology in order to evaluate the response of the FADN farms in terms of technology change, with respect to modifications in the reference environment. The model can be used for evaluating the capacity of a new technology to be adopted by the farms belonging to a specific type or a given territory, providing information about the economic thresholds associated to the new technology. In terms of policy interest, the model provides information about the productive recombination of the farm production plan and about the attitude of each farmer to adapt his production system to the new CAP framework.

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ANNEX 1: LIST OF FACEPA DELIVERABLES AVAILABLE IN THE WEBSITE

http://www2.ekon.slu.se/facepa/

Name	Title	Responsible Partner
Deliverable_D1-1-1_LEI	FADN Accountancy Framework and Cost Definitions	CUB
Deliverable_D1-1-2_LEI	Cost of production. Definition and concept	INEA
Deliverable_D1-2_SLU	A literature review on cost of production studies in agriculture	UCL, SLU, INRA
Deliverable_D1-3_vTI	The statistical usefulness of the EU FADN database for production cost estimations	vTI
Deliverable_D2-1_LEI	Evaluation and comparability of the EU and Member State FADN databases	INRA
Deliverable_D3-1_vTI	Implementation, validation and results of the production cost model using national FADN databases	vTI
Deliverable_D3-2_vTI	Implementation, validation and results of the production cost model using the EU FADN	vTI
Deliverable_D3-3_vTI	Comparison of cost estimates based on different cost calculation methods and/or different data bases	vTI
Deliverable_D4-1_INRA FACEPA Software	The FACEPA model software (estimating costs of production using the EU FADN database)	INRA, vTI
Deliverable_D4-2_INRA	User Guide. The FACEPA model software (estimating costs of production using the EU FADN database)	INRA, vTI
Deliverable_D5-1-1_CUB	Application and extensions of the Production Cost Model. Use and applicability of SFA	CUB
Deliverable_D5-1-2_CUB	Application and extensions of the Operational Competitiveness Ratings Analysis. Use and applicability of OCRA	CUB
Deliverable_D5-1-3_CUB	Methodology for analysing competitiveness, efficiency and economy of scale. Use and applications of DEA	INEA
Deliverable_D5-2 CUB	EU farms' technical efficiency, allocation efficiency, and productivity change in 1990-2006	CUB

Deliverable_D5-3_CUB	Assessment of the impact of EU accession on farm performances in the new Member States with special emphasis on the farm type	CUB, INRA
Deliverable_D6-1_INEA	Methodology to assess farm production costs using PMP farm models	INEA
Deliverable_D6-2_INEA	Methodology for the definition of case study farms and model structure for each case study	INEA
Deliverable_D6-3_INEA	The effects of the single farm payment on cost function and production function	INEA
Deliverable_D7-1_SLU	Methodology for including environmental outputs in cost and profit functions	SLU
Deliverable_D7-2_SLU	The influence of landscape services on farm costs: The case of Swedish milk farmers	UCL, LU, SLU
Deliverable_D7-3_vTI	Organic farming: implications for costs of production and provisioning of environmental services	vTI, ORC
Deliverable_D7-4_SLU	The disadvantage of farming in marginal agricultural regions and the potential loss of environmental values	SLU, LU
Deliverable_D9-1_UCL	Ex-post evaluations of agricultural and environmental policies in the EU with FADN data: methods and results	UCL, vTI
Deliverable_D9-3_vTI	Comparative ex-post analysis of past CAP reforms across selected Member States and regions with FADN data	vTI, UCL, INEA, UPM, INRA, LEI, IAE, EMU
Deliverable_D9-3 Annex_vTI	Comparative ex-post analysis of past CAP reforms across selected Member States and regions with FADN data	vTI, UCL, INEA, UPM, INRA, LEI, IAE, EMU
Deliverable_D9-4_vTI	Ex-Ante evaluations using Flexible Cost Functions with FADN data	vTI, MAF, IAE, UPM, INEA
Deliverable_D10-1_SLU	FACEPA public website	SLU

Finito di stampare nel mese di aprile 2013
dalla CSR Centro Stampa e Riproduzione s.r.l.
Via di Pietralata, 157 – 00158 Roma

In the European Union, the Farm Accountancy Data Network (FADN) collects data with the aim of determining costs and incomes and doing a business analysis of agricultural holdings. FADN is used to reach two objectives: on the one hand it is a basis for agricultural sector analysis and on the other it is a fundamental instrument for agricultural policy analysis. One of the problems of the FADN is the lack of an analytical book-keeping system: standard farm accounting information are limited to aggregate farm input expenditures, and production costs per unit of output are not collected at the level of production process. Their estimation is possible only applying specific allocation coefficients or using statistical methodologies. Unlike other EU Countries, in the Italian FADN (RICA) some costs are allocated to each production process by the surveyors at the end of the accounting year. This is, clearly, an arbitrary allocation procedure that can be subject to inaccuracies if the farmer does not record the costs separately or if there are aggregate costs or joint costs for which it is difficult to make an objective attribution.

This book presents some important results of the FACEPA project (Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture), a Small collaborative project (Grant agreement 212292) funded by the Seventh Framework Programme (KKBE-2007-1-4-14) which concerns the application of econometric (GECOM model) and mathematical programming methodologies (PMP) to estimate the cost of production in agriculture for the most important agricultural commodities. INEA was one of the involved partner and the leading partner of WP6 "Modelling farm technologies".

The book is structured in five chapters. Initially a theoretical framework of analysis of the production cost in agriculture is presented, together with a description of FADN dataset. The second chapter presents the structure of the econometric model (GECOM) and the application to the Italian FADN. The model has been adapted modifying some variables and taking into account the difference between areas and the characteristics of farm production at a local level. Three chapters are devoted to the PMP model application for arable crops in three northern regions (Lombardy, Piedmont and Veneto): unlike the econometric method, the PMP model produces information about the modification of farm technologies and farmer's behaviour in case of changes in agricultural policies and prices.

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ISBN 978-88-8145-294-1