

FACEPA

*Farm Accountancy Cost Estimation and
Policy Analysis of European Agriculture*



Cost of production. Definition and Concept

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Executive Summary

The aim of this deliverable is to provide a theoretical framework for the analysis of cost of production concepts, in particular describing the cost structure of FADN accountancy system. The analysis would serve as a background to the development of a general cost of production model, that will use FADN as the main source of information.

Depending on the final objective of the analysis there are different kinds of costs and, consequently, different methodologies for the cost accounting and calculation. Every approach gives specific information on variability, behaviour, monetary expression and so on. The data availability is a discriminant in the choice of the appropriate approach.

In spite of the importance of accounting, the agricultural sector has a low level of bookkeeping and accounting practice. Moreover, the presence of multiple activities and enterprises makes difficult the allocation of some cost category, as indirect or common costs. Further difficulties arise in case of mixed farms where some costs are connected to one product (directly attributable) while others must be allocated using appropriate allocation keys. The common and indirect costs are a big portion of total costs, also in FADN accounting system.

The choice of the allocation approach is the main problem of every methodologies and many studies have been made to solve it. The literature gives us different examples of cost accounting and, as concern FADN, sometimes the allocation rules are implemented using information coming from other sources.

Moreover, FADN system does not take into account the evaluation of the implicit costs, that is own resources (labour, capital and land) but, in a long-term perspective cost analysis, their estimation appears very important.

Finally, an introduction of the differences between econometrical and mathematical programming models try to introduce more relevant aspects of the cost estimation. Programming mathematic approach appears to be a more useful tool to explore deeper the situation at a farm level.

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Abbreviations and Acronyms

AAEA	American Agricultural Economics Association
ABC	Activity Based Costing
AICPA	American Institute of Certified Public Accountants
ARMS	Agricultural Resource Management Survey
AWU	Agricultural Work Unit
CAR	Costs and Returns
CC	Cost Centre
CICA	Canadian Institute of Chartered Accountants
DEFRA	Department for Environment Food and Rural Affairs
EAA	Economic Accounts for Agriculture
EISfOM	European Information System for Organic Markets
EU	European Union
FACEPA	Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture
FADN	Farm Accountancy Data Network
FFI	Family Farm Income
FLDP	Farm Level Data Project
FNVA	Farm Net Value Added
IAS	International Accounting Standards
IASB	International Accounting Standards Board
IASC	International Accounting Standard Committee
IFRS	International Financial Reporting Standards
LP	Linear Programming
LUGW	Livestock Unit Grazing Week
OLS	Ordinary Least Squares
PLS	Partial Least Squares
PMP	Positive Mathematical Programming
SGM	Standard Gross Margin
UAA	Utilized Agricultural Area
WFDB	Whole Farm Database

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Introduction

The last three decades have witnessed a large increase in research investigating product costing practice and production costs estimations. Starting from the industrial sector, the different methodologies have also been applied in other sectors, including agriculture. Today's agricultural inputs and outputs are more complex than in the past, so economic theory has become more sophisticated and precise.

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, engineering process changes and engineering product changes. Full costs and variable costs are also used to evaluate the profitability of a product, determine the optimal production process and 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, there are different costs for different purposes. The importance of using farm costs calculation and estimation for policy purposes is increasing. Over time, policymakers have used the cost of production as a basis for farm policy (either directly or indirectly), especially for taking decisions about price support levels.

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 example, the United States Department of Agriculture has estimated annual production costs and returns for major field crops and enterprises since 1975. It used data coming from the Agricultural Resource Management Survey (ARMS), which is a national survey done each year on US agriculture. 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 micro-economic 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 one hand it is a basis for agricultural sector analysis and on the other it is an instrument for agricultural policy analysis. The current practised standards in FADN have recently been analysed considering their conformity with the International Financial Reporting Standards (IFRS), which are standards and interpretations adopted by the International Accounting Standards Board (IASB). Many of the IFRS standards are known by the old name of International Accounting Standards (IAS), the accounting principles issued between 1973 and 2001 by the International Accounting Standard Committee (IASC), replaced in 2001 by the IASB. For this reason, the standards are now also named IAS/IFRS.

The IAS/IFRS have become relevant in Europe. Since EU Reg. 2002/1606 they have been obligatory for the consolidated financial statements of capital market enterprises (listed in the European Exchange) but, in the long run, they will also be implemented for individual companies and for different sectors.

In February 2001 the IAS 41 *Agriculture* was issued, specifically for the agricultural sector. It prescribes the accounting methods, financial statement presentation and the disclosures related to agricultural activity. As a consequence, many studies and analyses have been done concerning the adoption of international accounting standards in FADN. The comparison between FADN and IFRS accounting principles has been made in the previous chapter. Here, further details will be stressed in order to pay more attention to the costs and revenues accounts. Understanding the nature and destination of costs in the FADN system is one of the main aims of this work. The determination of production cost at a farm level, in fact, requires a precise specification of all the types of farm inputs. Some are specific costs, directly attributable to the single enterprises, while others are common costs that require an allocation procedure. There are also implicit costs that must be calculated at their opportunity value (labour, capital and land).

There are consequently different methodologies to calculate production costs at a farm level, depending on the costs, farm type, accounting approach, etc. Each methodology follows a specific theoretical framework and has a justification within a specific modelling context. The way in which costs are analysed depends on the final objective and on the use of the analysis.

A short description of the FADN contents is given in the *first chapter*, where the variables taken into account, types of farming and income indicators resulting from the accounting system are briefly illustrated. Attention is paid to the difference between FADN and the international rules of IAS 41, especially as regards the costs and returns accounting principles.

The *second chapter* explains the classification of costs in the FADN accounting system in detail. The costs are divided into two categories: intermediate consumption (specific costs and overheads) and total external factors (remuneration for the resource not property of the holder).

The principles of cost calculation are illustrated in the *third chapter*. There are different kinds of costs and, consequently, different methodologies for the cost accounting and calculation. Moreover, in the agricultural sector there are further difficulties due to the nature of the agricultural process. More specifically, there are multiple activities and enterprises in agriculture and, consequently, a high presence of common costs. The main problem of every approach is to share the indirect or common costs in every enterprise of the farm. This is a typical problem of the agricultural sector: although agricultural products are increasingly being produced on specialized farms, most farms have joint production (like cow's milk and beef or cereals and straw). Some of the costs on these mixed farms are connected to one product and directly attributable, whilst others must be allocated using different rules. As a consequence, indirect accounting cost techniques must be taken into account.

A practical application of different allocation methodologies is illustrated in the *fourth chapter*. It is divided into two parts. The first part focuses on joint production costs (direct and indirect) and on the main allocation problems. The second part refers to different cost calculation approaches in the dairy sector, organic farming and the pig sector. In particular, the approach of Directorate General of Agriculture will be illustrated, which has used FADN data to analyze the dairy and crop sectors. Another interesting methodology is the analysis of Arfini, which is an application of Integrated Direct Costing, made using the Cost Centre concept. Finally, contract and non-contract farming models are taken into account to highlight the different cost structure and the need to make a distinction between them if the differences are statistically significant.

The evaluation of own resources (labour, capital and land) is dealt with in the *fifth chapter*. The FADN system does not take these costs into account but, in a long-term perspective cost analysis, the need to estimate the cost of own resources appears very important. Although these costs are not taken into account in the FADN system, the scientific literature is in agreement about the need to calculate them. Different methods are illustrated in the chapter suggested by the Task Force on Commodity Costs and Returns of the American Agriculture Economics Association.

Finally, the *sixth chapter* summarises the literature on cost estimation models in agricultural production. More specifically, after the introduction of the cost function concept (according to the microeconomic approach), the analysis highlights the difference between the econometrical

and mathematical programming estimations used to assess the production cost function. The two methods will be compared in order to describe their more relevant aspects. Further details about the cost estimation will be developed by other project partners.

1. Some general concerns about the FADN accounting system

1.1 Introduction

The Farm Accountancy Data Network (FADN) of the European Union was established with Council Regulation 79/65/EEC with the aim of collecting data from agricultural holdings. Today, FADN plays an important role in agricultural accounting, making business and income analysis possible at a microeconomic level in a sector with a low level of book-keeping and accounting practice. Moreover, the information in FADN can be helpful in the decision-making procedure, either directly or indirectly.

In 2001, the International Accounting Standards Boards (IASB) implemented an International Accounting Standard for Agriculture (IAS 41) that prescribes the accounting treatment and the financial statement related to agricultural activity.

In this chapter, after a brief description of the FADN system, there will be a discussion on some contents of IAS 41, together with a comparison between FADN and IAS 41.

1.2 A brief description of Farm Accountancy Data Network (FADN) contents and results

The Farm Accountancy Data Network (FADN) of the European Union was established with the Council Regulation 79/65/EEC of 15 June 1965. 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 agricultural activities of different farm types, size 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 (ESU¹) is 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 overhead costs 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.

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.

The Farm Return includes the following sections:

¹ 1 ESU = 1.000 €

Table 1: Contents of the table 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 farm 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.

The calculation of income indicators in FADN is illustrated in the following table:

Table 2: Calculation of income indicators in the FADN accounting system

FADN accounting method
Total output
- Total intermediate consumption
+ Balance current Subsidies and Taxes
= Gross Farm Income (GFI)
- Depreciation
= Farm Net Value Added (FNVA)
+ Balance subsidies and taxes on investments
- Total external factors
= Family Farm Income (FFI)

1.3 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 base for policymakers in the decision-making procedure. While in many countries, accounting for farming activities has traditionally received little attention, in others different pronouncements on 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)² 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.

² IASB is a Board of International Accounting Standards Committee (IASC), it is a private institution that set out and diffuse the international accounting principles. The aim of IASC is to co-ordinate the drafting procedures and improve the communication of firm's economic information.

1.3.1 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 asset³.

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:

1. capability to change: living animals and plants are capable of biological transformation;
2. 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;
3. measurement of change: the change in quality or quantity is measured and monitored.

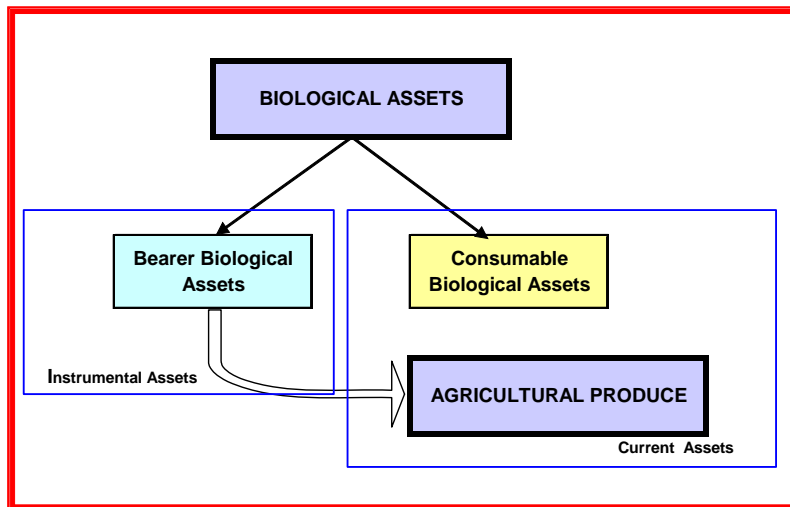
Following the IAS 41 definitions, biological assets can be:

- *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.

The following table summarises 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 in the market.

³ 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)

Figure 1: 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.

The table below shows the method used by IAS 41 to define this value.

Table 3: Definition of the value for biological assets and agricultural produce according to IAS 41

Market price (net price) <ul style="list-style-type: none"> - transport costs - other costs to get assets to a market = Fair Value <ul style="list-style-type: none"> - Point-of-sale costs <i>commissions to brokers and dealers</i> <i>levies by regulatory agencies and commodity exchanges</i> <i>transfer taxes and duties</i> = Valuation for biological assets and agricultural produce
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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 market⁴ 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 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 in 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 a forest with long-term production cycle.

1.3.2 Comparison between FADN and IAS 41 accounting system

Different studies have considered and analysed 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, 2003; Elad 2004; IBH 2005; Herbohn 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

⁴ 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.

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 recognise 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.

1.4 Summary

This chapter illustrates some general concerns about FADN accountancy. Today FADN fulfils an important role and represents a relevant source of statistics in the European Union. FADN collects data concerning assets, liabilities, revenues and expenses of farm systems and permits economic analysis of agricultural holdings.

As described in the chapter, the actual structure of FADN is based on a sectorial approach, offering many details about the use of the land for the production of agricultural commodities but paying little attention to land-use other than primary production. In other words, FADN does not take into account the income from other sources such as non-agricultural activities on farms (diversification). The inclusion of other income sources permits not only the agricultural production to be analysed, but also ecological, social and economic functions, i.e. the multifunctionality of agriculture.

The off-farm activities (pluriactivity) are also not taken into account in FADN, so a comparison between the total income of farms and other household incomes is very difficult. This is a limitation of the FADN system: increased attention is paid to a more comprehensive concept of farm household income that encompasses all income sources available to family members as well as their accumulated wealth.

Policymakers could have need of information about the structure of the total income of farm households because this can be a good indicator of the status of the sector. Moreover, it can be used to measure the effectiveness of social, fiscal and agricultural policies in meeting the objectives.

Notwithstanding this limitation, FADN system is a very important accounting system for agriculture. In the last year, different economists began an analysis of its accounting rules, especially making comparison with the new IAS 41, the International Accounting Standard for agriculture, issued by the International Accounting Board.

In IAS 41 all types of biological assets and agricultural produce are measured at the fair value. The evaluation of the agricultural activity at the current moment (at the point of harvest) also permits the transformation process to be represented in an immediate way, in order to provide the possibility of estimating future economic benefits. So, fair value is a helpful approach for biological assets, with the characteristic of biological transformation. But fair value is easy to understand when markets for the biological assets are active and fluid. Otherwise, there are practical difficulties with the evaluation when there are not active markets: in this case, ascertaining fair value may be costly, in particular in developing countries (Elad 2004).

In addition, there are practical difficulties in valuing biological assets separately from other assets on which they are located, such as land. For example: in the case of forest or grapevines the market value is often assessable only considering the corresponding land. In this case it is allowed to assess the present cash-value of the assets as a residuum by calculating the difference of present cash-value of cropped and uncropped agricultural land.

2. Classification of costs in the FADN accounting system

2.1 Introduction

This chapter illustrates the classification of FADN costs ensuing from the documents of the Community Committee for FADN and the main European Regulation on FADN.

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)

Following the general instructions of the EU document RI/CC 1256 (2006), farm costs are listed in table F as the value of all non-capital inputs (except unpaid labour) used in producing non-capital products during the accounting year. In other words, the farm costs are related to the consumption of production resources during the accounting year corresponding to the annual production⁵. Consumption also includes farm use (i.e. the value of crop products produced and used on the holding to obtain the final agricultural products) and inputs received as payments in kind.

Grants and subsidies on farm costs are not deducted but considered under a specific heading.

Specific costs and farming overheads represent the *Total intermediate consumption*, an accounting flow which consists of the total monetary value of goods and services directly consumed or used as input in the production process⁶.

The external factors are the costs of the inputs not in the property of the holder (wages, rent, interest paid). They are valued on a cash basis.

Table G lists all the inputs used to increase, repair or replace the holding's fixed assets (which are considered as investments) and their depreciation. Depreciation is a fixed cost that concerns the capital assets (plantations of permanent crops, farm buildings, fixed equipment, land improvements, etc.) and in FADN it is calculated on the basis of the replacement value of the assets.

⁵ If the consumption does not correspond to the production in the accounting year, changes in stocks of inputs (including costs accruing to growing crops) should be indicated in FADN under circulating capital.

⁶ The evaluation of intermediate consumption is made considering the purchaser's market price at the time when the good or services enter the production process (accrual basis), not when they are acquired by the producer. The two times will coincide for services but not for goods because they could be bought and stored as inventories before being used in the production.

2.2 Specific costs

In the FADN system, specific costs are related to crops and livestock.

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

1. seeds and seedlings, purchased and produced on the farm (bulbs, corms, tubers and seed preparation costs)
2. fertilisers, soil improvers (lime, compost, peat, manure) and crop protection products
3. 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 the specific forestry costs here (fertilisers and crop protection products).

The specific costs for livestock include feedstuffs and other specific livestock costs.

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 farm⁷: oilcake, compound feed, cereals, dried grass, dried and fresh sugar beet 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 concern veterinary fees, artificial insemination, milk tests, products for cleaning livestock equipment, storage costs, etc.

The following table summarises the contents of the different headings.

Table 4: Inputs – Specific costs

SPECIFIC COSTS	
Specific crop	Seed and seedlings purchased, produced and used on the farm; fertilisers 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
Specific livestock Feedstuffs produced on the farm	Feedstuffs for grazing stock, pigs, poultry and other small animals
Other specific livestock costs	

⁷ The feedstuffs produced on the farm include marketable farm products such as forage crops used as feedstuff.

2.3 Overhead costs

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

The overhead costs for labour and machinery include, for example, 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 is also possible to indicate the amount of insurance for farm buildings but this information is optional.

Table 5: Inputs – Farming overheads

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)	

2.4 Total external factors

This 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 6: Inputs – Total external factors

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

Wages and social security: this heading includes the wages and social security charges (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): this heading includes the net value of cash and payments in kind for renting of land, buildings, quotas and other rights for the farm business.

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

2.5 Depreciation

The 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.

2.6 Summary

This chapter has described the list of costs used by the Commission in the FADN accountancy framework. This description can be useful for understanding some concepts and definitions used in the next sections. As will be stressed, FADN costs have different characteristics and, as a consequence, they cannot be treated in the same way. In general, specific costs and overheads present characteristics of variable costs: they increase or decrease with the production activity. With regard to overheads, these are not linked to specific production lines and so are not directly measurable. They consequently need a specific rule for allocation among the farm enterprises. This problem will be treated in the following chapters.

3. Cost of production: classification, definition and calculation

3.1 Introduction

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. In the previous chapters, a description has been given of the concepts used for the accountancy framework and the classification of costs in FADN.

Here, an overview of different methodologies used to classify, define and calculate the production costs will be presented. Compared to the past, today's farm inputs and outputs are more complex. Over time, the agricultural economics discipline has been developed using more sophisticated tools and the measurement of cost of production has become more precise and accurate.

Although farms usually have been excluded from cost accounting research and since the procedures of record keeping and accounting appeared not to be necessary, empirical evidence about the usefulness of accounting when reaching for a high performance level in farm management have been found (Argilés and Slof, 2003).

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 cost of production estimates has been extended and today it regards not only farm management specialists, but also the policymakers who use the estimates to set prices, subsidies, agricultural policies, etc. As a consequence, there are different methodologies for cost accounting depending on the final objectives and uses.

In this chapter a first classification of costs will be made. There are numerous ways to make a cost classification, depending on the characteristics taken into account. Consequently, there are different ways to calculate costs of production. Moreover, in the agricultural sector there are multiple activities and enterprises and it is sometimes difficult to allocate the common costs that are a considerable component of total cost.

3.2 Classification of costs

The cost is defined as the value of the production factors consumed or used to reach a final goal.

There are numerous ways to classify costs. Although every farm has its own cost structure (depending on the main activity or enterprises), it is possible to identify some typical cost classes. The following table summarises the usual cost classification.

Table 7: Classification of costs.

Classification Principle	Type	Notes
Relation and reference to the final object	traceable cost common cost direct cost indirect cost	Direct costs are traceable while indirect costs can be either traceable or common. Common costs are indirect
Behaviour	variable cost fixed cost quasi-fixed cost	Variable costs are traceable and direct. Fixed cost can be traceable and common. The fixed costs are “fixed” in the short-term.
Monetary transaction	explicit cost implicit cost	Implicit cost is an opportunity cost
Effective manifestation	actual cost standard cost	New targets: value-added standards
Time period	Short-term cost Medium-term cost Long-term cost	Long-term cost takes into account opportunity costs

Considering the relation between the cost and the final objective (enterprise, product, etc.), a first general distinction is made between *traceable costs* and *common costs*. The traceable costs can be directly assigned to the final objective on the basis of a cause-and-effect (causal) relationship. So, the relationship is immediate and made on the basis of objective parameters. Common costs cannot be assigned directly to an objective because farms meet them as a whole. They can be allocated after an estimation procedure, in a subjective way.

In general, an increase in the dimension of the final objective determines an increase in the traceable costs.

With regard to the possibility of assigning the cost to the final objective, a distinction is made between *direct costs* and *indirect costs*.

The direct cost is an expense that can be directly identified with a specific activity or product because it is possible to measure the quantity used in the productive process (for example direct labour, raw materials, etc.). Direct costs vary with the rate of output but are uniform for each unit of production. In general, a direct cost is traceable.

The indirect cost is an expense incurred in joint usage (overheads such as advertising, computing, maintenance, security, etc.) and therefore it is difficult to determine the exact

consumption or to identify with a specific cost object. Indirect costs are usually constant for a wide range of outputs and are grouped under fixed factors. Indirect costs can be either traceable or common.

Taking into account the different expression (monetary or not) of the costs, it is possible to make the difference between *explicit costs* and *implicit costs* (or imputed cost). The former refer to real transactions on an active market and generate a monetary transaction: the costs of inputs can be determined using market purchase prices and quantities. On the contrary, implicit costs do not generate monetary transactions, so the cost of using the inputs must be computed considering the opportunity costs, i.e. the value of the input in its next best alternative use. For example: not paying rent on the self-owned property generates an implicit rent considered as an implicit cost because while rent is a deductible expense, implicit rent is not. The same thing happens with the implicit cost of liquid assets or shareholder's capital that is the maximum interest that would be earned on them as a fixed deposit or as an investment in alternative ways. In the agricultural sector, a typical implicit cost is referred to family work: in this case the cost could be calculated multiplying the annual units of family work by a reference income (usually equal to the earnings of non-agricultural workers).

The difference between explicit and implicit costs underlines an important difference between the economic and accounting points of view. In the first case, a farmer's decisions are made taking into account the total cost (explicit and implicit components) while in accounting terms, only the monetary transactions are taken into account, so only the explicit costs.

With respect to the responsiveness to production levels (or behaviour⁸), the costs are classified as *fixed (constant) costs* and *variable (flexible) costs*.

Fixed costs are irrespective of different production levels (within certain limits), while variable costs grow with higher levels of production (proportionally or not). If there is no production, there are no variable costs.

Variable costs can be divided into three categories with respect to their behaviour:

- proportional costs: the variation is proportional to the production level variation
- progressive costs: they grow in a more proportional way with the increase in production (i.e. the labour costs in case of overtime work)
- regressive costs: they grow in a lower proportional way to the increase in production

Between them there are the *quasi-fixed (and quasi-variable) costs* that are flat within a certain range of production and jump to higher levels if certain thresholds are overcome (i.e. the costs for water services that have a fixed basic rate and variable prices with higher consumptions).

⁸ The relationship between costs and activity is known as cost behaviour.

In practice, costs can be divided into *actual costs* and *standard costs*. The actual cost is the actual amount paid or incurred. It derives from the farm accountancy at the end of the production process and includes direct labour, materials and other direct charges. The standard cost is the estimated or predetermined cost of performing an operation or producing a good or service under normal conditions (where special or extraordinary factors that may affect performance are absent). Standard costs are used as target costs (a basis for comparison with the actual costs) and almost always vary from actual costs because every situation has its share of unpredictable factors.

Depending on the time period analysed the costs can be broken down into three categories:

- *short-term cost* leads to a cash outflow in the same period (typically one year) and when receipts are below these costs the farm could have a cash outflow and, so, liquidity problems;
- *medium-term cost* is equal to the short-term costs plus depreciation. When receipts are equal to the medium-term cost, there is enough money for the investments needed to replace the current assets. No income is retained for the farmer and his family;
- *long-term cost* is equal to the medium-term cost plus the cost for the own capital and labour, evaluated at their opportunity cost. A shortfall in the receipts compared to the long-term costs can result in an income that is insufficient for the expenditures of the farmer and his family. This kind of cost is taken into account in the comparison of competitiveness that needs a long-term perspective.

Given the accounting purposes, the kind of analysis and requirements of the analysts, it is possible to aggregate the costs to obtain different cost configurations. The *partial configuration* takes into account only the direct costs and, consequently, its determination is objective. When also indirect costs are allocated among the different objects (enterprises, products, activities, etc.), the result is a *full configuration*. In this case there are subjective components resulting from the allocation process. The *technical-economic configuration* also includes the implicit costs and it is the most complete configuration.

3.3 Approaches to calculating and estimating cost of production

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

1. *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 plants. 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.
2. *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 estimates can be made using cost functions from time-series data, average regressions from cross-section data, frontier function and so on. The most important limitation of this approach is connected with the data because, also in the presence of uniform accounting systems, it is impossible to eliminate every degree of distortion. Moreover, the time series of long duration may reflect variations in the plant 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 of allocating common costs among enterprises.
3. *Economic-engineering approach*, which “synthesizes” 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 does the typical analysis of accounting data. It is necessary to know the production system, the nature and sequence of the 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 machine operation. This approach encompasses studies ranging from simple descriptive comparisons of labour time requirements to detailed estimates of short-run and long-run 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 underlined for statistical studies. Moreover it can be applied in cases where

accounting record data are not available. Usually it is the only approach possible when the objective is to compare methods or develop improved methods of operation. 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 lack is the use of constant input coefficients that makes it impossible to measure or account for coordination problems such as plant scale increases.

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 practises, the descriptive and statistical analysis of accounting data could be sufficient. If the objective is to measure short-run cost function to provide managerial tools for decision-making, then the statistical and economic-engineering approaches can be combined.

3.4 Concerns about the calculation of cost of production in agriculture

As previously stated, cost is the value of the production factors consumed to attain a goal. The measurement of this consumption is characterized by uncertainty because it is not easy to refer all the costs to the final goal. This can be a single operation of the farm sector (process costing) or the final result of a production activity (product costing).

The methodology that tracks, studies and analyses all the costs accrued in the production and sale of a product is named *product costing*. The measurement of cost of production is done using appropriate cost accounting methods and requires an allocation process that can be subjective. As a consequence, cost estimation could be more or less accurate.

The last three decades have seen a large increase in research investigating product costing practice (Brierley, Cowton, Drury, 2001). This interest can be attributed to different reasons:

- prior to the 1990s there was little information available on product costing practices;
- there has been interest in examining how costing practices are changing with changes in the business environment;

- there has been a lot of criticism of product costing practice, deriving mainly from informal contacts between academics and practitioners or from observations of a small number of companies.

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 for assessing their management strategies and reach 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.

The application of product costing methodologies in the agricultural sector presents some difficulties. Today, despite a higher specialization level, farm activities are more than one and it is 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 summarised 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 during the year depending on climate variation: a consequence is a change in the indirect costs and, so, a variation of the stock values;
- in 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, work, etc.);
- on farms there is usually not a developed use of book-keeping practices.

3.5 Principles and methodologies for cost accounting

Cost accounting⁹ is the methodology by which all elements of cost incurred in an activity are collected, classified and recorded. These elements are summarised and analysed to determine a

⁹ 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. At the start, 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

selling price or to determine 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 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 analysed 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.

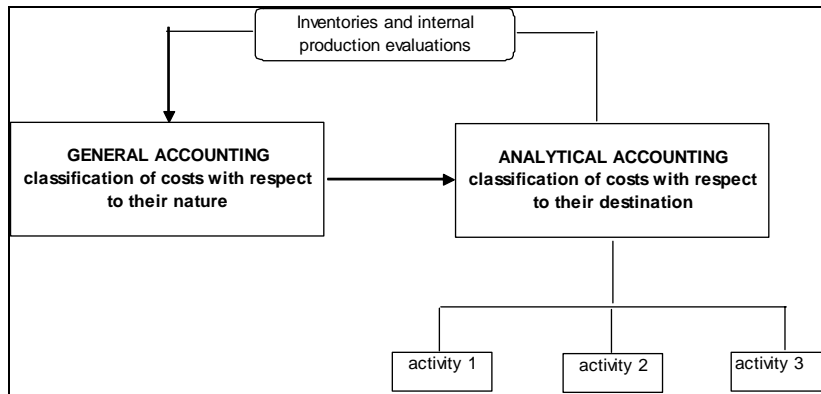
Considering this definition, the aim of analytical accounting is to determine the costs of every farm activity or enterprise, to define the right evaluation rules for the different elements of the balance and to verify the correspondence between the estimated and realised values.

The following scheme summarises 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.

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.

As a consequence of this evolution and progress, there are now different approaches used to estimate the commodity costs and the choice among them depends on the ability of farmers to report commodity specific costs for that item. For example: it is easy to report the cost of seed purchased for a commodity, but not for the fuel cost because fuel is used to produce several commodities on the same farm and so, it needs an estimation procedure. The main problem is generally the allocation of overheads and indirect costs among the different activities.

Figure 2: Links between general and analytical accounting systems



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

Direct Costing (DC) 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 fertiliser 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 custom services, it is necessary to define how much of the total farm expenditures for each input were 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 not problems for direct and traceable costs because quantity and prices are well 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 overheads 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 fails to report the cost of activities and processes. In particular, the methodology to allocate the indirect costs (overheads) using 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 a different

need of 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 system, that seemed 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) which 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 the control of business and to increase efficiency. It provides the basis for the concept of accounting control. Different studies have been done with regard to 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 achieved on similar jobs 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 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 has been used largely 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 practice.

Historical Costing (HC) is a method that uses historical costs for direct material and direct labour while overhead costs 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.

3.6 Summary

This chapter deals with the classification, definition and calculation of production costs. There are different ways to classify the costs and every approach gives specific information on variability, behaviour, monetary expression and so on. Depending on the final objective of the analysis and the kind of data available, there are three ways to calculate and estimate the cost of production. Descriptive and statistical analysis start from accounting data, while the engineering approach sets technical coefficients for a farm and multiplies them by prices. This last approach appears to offer more in terms of analytical power but requires a higher cost. An amalgamation of all three approaches may therefore be appropriate in some cases.

Final aim and kind of data are also important in the choice of accounting system. It can be based only on variable costs (direct costing) or provide for a more elaborated calculation (indirect costing, ABC costing, standard costing). These appear to be better adapted and useful in the production cost analysis of the agricultural sector because it has a considerable number of common and general costs to allocate among the enterprises.

Generally speaking, many cost analyses made using FADN data are based on a descriptive and statistical approach and do not consider a technical coefficient. But, in many cases, the methodologies can be combined, as will be illustrated in the next chapter, where the most common allocation procedures used for common and indirect costs will also be described.

4. The allocation of joint costs and overheads

4.1 Introduction

As stated in a previous chapter, one of the main problems in cost accounting is to allocate the cost among different enterprises. Why is it important to have information on enterprise level of costs? First of all because they are useful in the business management, for example to evaluate the performance of the individual enterprises, to decide if to expand an enterprise or not, or to judge the advantage of establishing a new enterprise. Moreover, this kind of information can be helpful in preparing activity budgets, planning operations, etc. Secondly, information on the enterprise level of cost is important within an agricultural policy perspective. In fact, decision makers can improve their capacity to assess the consequences of agricultural policies and technology scenarios on the economic performance of different kinds of farms.

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.

This is the case for FADN accounts, which are not based on analytical accounting. So, there is no separate recording of costs for the various activities or enterprises on the holding. The specific costs of crop products and animals are recorded separately (not by product but by group of products) and all the other costs are recorded with respect to the whole farm. For these costs it is necessary to define precise rules to allocate them in every enterprise.

This chapter focuses on the different methodologies to allocate direct and indirect joint production costs among the enterprises. The former can be allocated directly, on an objective basis while the latter require an arbitrary procedure. FADN includes both kinds of costs, but the allocation process sometimes needs to be integrated with further information.

In general, the literature refers to studies and analyses conducted in the dairy sector, where there is the problem of the co-existence of the milk and beef sectors, with different degrees of specialization. Different procedures will be presented.

The chapter also deals with the pig sector, illustrating an interesting calculation based on the time period cost classification.

Finally, organic farming and contract farming models are taken into account. Their cost structure can be different from conventional farming and non-contract farming. It is sometimes

difficult to highlight these differences, especially in the case of organic farming and some analysis of variance could be useful.

4.2 Joint production costs and the allocation among enterprises

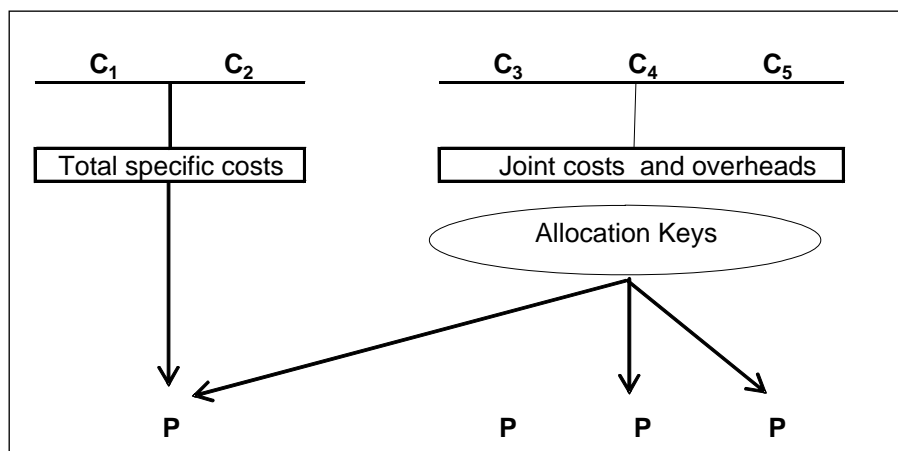
Joint production costs are those costs that are incurred on groups of products rather than on individual and separate ones (AAEA CAR Estimation Handbook, 2000). Joint production costs arise in three different situations:

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

These three cases may give rise to joint costs that occur either as direct costs or as 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 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 3: 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.

The next two sections give some information about the methods for allocating direct and indirect joint costs.

4.2.1 The allocation of direct production joint costs

The AAEA Costs and Returns Estimation Handbook gives some indication about the methods for allocating direct production joint costs.

Regarding land cost, FADN includes different items: rent paid, taxes and other charges on land and buildings, interest and financial charges (loans for purchase of land). It excludes the opportunity cost. Usually, global land cost may be divided among the various enterprises on the basis of how much land each enterprise uses. This method simplifies the cost allocation but, in some instances, land cost may take different values depending on the quality of the land and its uses: land in permanent pastures has a different value from land for arable crops.

Another group of direct joint costs are machinery costs¹⁰. These costs can be allocated using technical keys like the hours of use in the different operations associated to each enterprise. One common machinery cost difficult to allocate is car expenses, i.e. the costs of the share of private cars for business use. Allocation can be made using economic keys (based on revenue proportions).

The allocation of labour cost depends on how the labour is used. Any labour associated with operating or maintaining machinery should be allocated using the same basis used to allocate machinery costs. When there are not specific enterprise indications, the cost of labour is treated as a general overhead.

4.2.2 The allocation of indirect production joint costs (overheads)

Generally speaking, the various 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

¹⁰ For instance, FADN includes machinery hire, machinery and equipment maintenance, engine fuel and lubricants.

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 last method can lead to a relatively low profitability of products with relatively high (variable) costs already allocated (for instance, in 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 can be different from the cost of the same product on the mixed farms because of economies of scale and the results will consequently only 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 in farms specialized in milk production). This scheme is similar to the theory of Proni (1940), used in different Italian analyses. Generally speaking, the model is very easy to use if the farm has book-keeping because it does not require any key to allocate the indirect and common costs.

Following this approach, the production cost of the prevailing 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 the 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 production 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 have been carried out 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:

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

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.

4.3 Calculation of the cost of production on dairy farms

An example of cost allocation among different enterprises can be illustrated using FADN data. This analysis focuses on dairy farms, where beef and milk production co-exist so, as result, some difficulties can arise in the estimation of milk production cost.

The literature refers to different analyses made to calculate the milk cost on dairy farms. Here the approach will be described first used by the DG Agriculture of the European Commission, which uses only FADN data to set a group of allocation keys for every kind of cost taken into account.

Another interesting method is the application of Integrated Direct Costing in the dairy sector. Arfini (1997) developed this analysis starting with the definition of a general Cost Centre as a unit in which costs can be allocated. This approach is developed using FADN data (survey approach) but also technical coefficients (engineering approach), so it can be implemented using FADN data together with additional information.

Following that, an overview of the general literature will illustrate different approaches that might also be interesting for the FADN system.

4.3.1 The approach of the Directorate General of Agriculture (European Commission)¹¹

A study concerning analysis of the costs allocation system comes from the Directorate General of Agriculture of the European Commission (EC RI/CC 1342, 2001; EC RI/CC 1331, 2001; EC G3/EL, 2007). 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. In particular, the methodology defines the allocation key for farming overheads, depreciation and other non-specific inputs of specialised dairy farms at EU level (TF 41). The aim is to estimate the cost of production for milk, on farms with different levels of specialisation 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 costs)
- all other costs (farming overheads, depreciation, external factors)

¹¹ As concerns arable crops, a program named ARACOST for estimating the costs of production has been developed by the European Commission. 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 example, seed and seedlings purchased, fertilisers, crop protection, motor fuel, lubricants, farming overheads, depreciation are allocated considering

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

While motor fuel, lubricants, farming overheads and depreciation

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

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, fertilisers and soil improvers, crop protection products) are shared according to the percentage of fodder crops, forage crops and temporary grass in the total 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 northern part), 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 reared the young calf and those who fatten the animals on the farm. European typology does not allow to precisely identify a beef production system, so the analysis uses a study of INRA that built a Typology of Grazing Livestock System in the European Union.

The following table displays the allocation keys used for every kind of cost used in the analysis:

Table 8: Allocation keys used for the milk and beef sector (European Commission)

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

In the past, the allocation of indirect costs was made 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 this one, which also considers subsidies (RI/CC 1331, 2001).

4.3.2 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 specialised 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 (see figure 4).

Three kinds of CC have been distinguished for the specialised 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

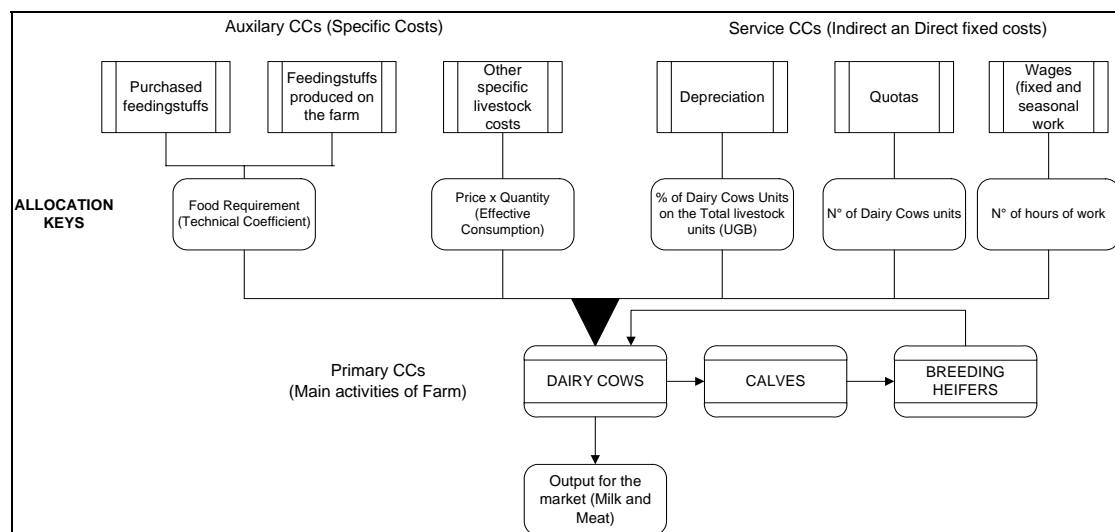
to the fixed assets cost (depreciation), the allocation among the three primary CCs is in proportion to the use of the production factor by the animals. To do this, a technical parameter (UGB)¹² has been used to obtain a homogeneous measure of the entire livestock. Labour costs are allocated taking into 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.

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 applied is 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.

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.

Figure 4: Arfini’s scheme for dairy farms



¹² UGB (Unitè Gros Bovin). This is a livestock unit system used to compare or aggregate animals of different species or categories. Equivalences are based on the food requirements of animals. UGB = 1 dairy cow; calves < 6 months = 0.25 UGB; calves 1-2 years = 0.60-0.70 UGB; breeding heifers > 2 years = 0.70-0.90 UGB. The ranges depend on the sex of animals and the function (for fattening or calving).

4.3.3 Other approaches: a literature review

De Roest, Menghi and Corradini (2004) refer to the calculation of milk cost production. 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 types can be implicit or explicit.

In this study, the overheads allocation is made using these coefficients:

$$\frac{\textit{Fodder Crop Surface}}{\textit{Utilised Agricultural Area}} \qquad \frac{\textit{Revenues from milk}}{\textit{Total Revenues}} \qquad \frac{\textit{Revenues from meat}}{\textit{Total Revenues}}$$

These coefficients can 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 specialised 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) used 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 methods¹³.

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.

¹³ Salghetti and Ferri used the rents of land with similar characteristics for the own land and the rate of investments with an analogous risk degree for own capital. For family labour, they multiplied the hours by the wages of fixed and temporary workers.

Specific studies of the economics of milk production have been done by *Colman, Farrar and Zhuang* (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. overhead costs). This last category has been calculated from 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. In particular, this study applied a procedure to record and allocate the forage variable costs, taking into account grassland and fodder crops.

For grassland, the “non-harvest” variable costs are recorded for all the grassland on the farm. The costs include seeds, fertilisers, “non-harvest” contracts and casual labour costs. 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). Allocation of the “non-harvest” variable costs is made on the basis of the percentage of the total LUGWs used by the dairy enterprise. This calculation takes into account both the period that the cows were at grass and the proportion of conserved grass that was consumed by the dairy herd during the year. In addition, the harvest variable costs are recorded for each type of conserved grass (contract harvesting, casual labour and miscellaneous costs). The harvest costs are allocated proportionally to the total quantities of each of the types of conserved grass fed to the cows.

For fodder crops, the non-harvest and harvest variable costs are recorded separately for each fodder crop. These costs are then allocated proportionally to the dairy enterprise according to the proportion of each crop fed to the dairy cows.

The area of grassland and fodder crops used by the dairy herd is calculated on the same basis as the allocation of the forage variable costs, i.e. by a combination of LUGWs and quantities of conserved grass and fodder crops fed. Stocking rate is the total area of grassland and fodder crops allocated to the dairy herd divided by the annual average number of cows in the herd.

4.4 Calculation of the cost of production in the pig sector

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 fattening pigs to obtain the amount sold in terms of kilograms:

$$\text{amount sold (kg)} = \frac{\text{total sales (€)}}{\text{price (€ / kg)}}$$

They only consider those farms with no sales other than fattening pigs and with no purchases of piglets¹⁴. 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:

1. assuming the equal profitability of all products: receipts/total costs is the same for every product
2. 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 the following table:

Table 9: Production costs scheme for the pig sector (Boone and Wisman)

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				

¹⁴ On the selected farms the ratio between the average number of pigs for fattening and the average number of breeding sows is included within 4 and 9.

4.5 Calculation of the cost of production 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 environmental-friendly agricultural practices, food quality and food safety. As a result, organic farming acquired increasing importance and an identification code in FSS and FADN was implemented. 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 project 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, organic farming practises have some practical consequences on crop and livestock production (Acs, Berentsen, Huirne, 2005). As a consequence, 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 (fertilisation), 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 structure with respect to conventional farming. 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 fertilisation 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.

There is a little information concerning the calculation of production cost in the organic farm sector. Anderson (1994) states that organic farms, compared with conventional farms, tend to have less land, smaller gross farm incomes, a higher proportion of owned land, higher labour requirements, more enterprise diversity. This last characteristic is also underlined in Firth's analysis (Firth, 2002) that deals with the effectiveness of gross and net margin analysis and full cost accounting in organic farm systems.

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

An EU research project named EU-CEEOPF (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, a similar endowment with production factors and similar farm types.

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

1. DG Environment in 2002 commissioned a study to analyse the effect of the CAP on environmentally-friendly farming systems using organic farming as example (analysis on direct payments based on data 2000)
2. European Environmental Agency commissioned a study on the IRENA¹⁵ indicator *Organic price and incomes* (analysis on income indicators based on data 2001)

The result of the first study shows that organic farms in the EU received 20% more CAP payments per hectare than conventional farms. Organic farms on average received more than 70% higher payments from the agri-environmental and Less Favoured Area payments and 18% fewer payments per hectare from the Common Market Organizations than conventional farms. 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.

4.6 Contract and non-contract farming models: differences in cost structure

Contracting is a form of joint production where the farmer supplies tools, land, labour and management, while the processor supplies technical assistance, animals, some inputs such as seeds, pesticides or feeds and undertakes to buy the farmer's output at a predetermined price. From the point of view of the processor, this arrangement ensures raw material supplies (of the desired quality). From the point of view of the farmer such an arrangement provides an assured market and hence reliable income (and a lower risk level).

A very common kind of contracting concerns livestock farming under contract, for example the agistment contract. This is a case of vertical integration between processing firms and breeding farms.

Usually, the processing firm supplies animals, feedstuffs and technical assistance, while the farmer (agistor) puts at disposal his structure (buildings, land, machinery, labour). As a consequence, the farmer only provides a service because all the strategic decisions are taken by the firm. This relationship can be more or less close, depending on the kind of animal and aim of the contract. For example, contract rearing is very common in the poultry sector and the link

¹⁵ Indicators reporting on the integration of environmental concerns in agricultural policy. There are 35 indicators and two of these (no.5 and no.7) address organic farming specifically.

between the two parties is very strong. As concerns cattle and pigs, the phenomenon is increasing but it is still difficult to obtain data about this tendency.

In FADN this kind of farming is highlighted in the item *Contract rearing* (cattle, sheep, goats, pigs, poultry and other animals under contract) in which the holder does not assume the economic risk in rearing or fattening animals. Under this item the receipts from contract rearing must be recorded. In FADN the number of animals raised or fattened under contract are also recorded and the animals taken or given into agistment for the period of the year during which they are present on the holding.

The differences between contract and non-contract farms are underlined in different analyses, conducted in specific livestock sectors. Most of them emphasize the different cost structure between the farming models, while some literature refers to a statistical methodology to see whether these differences are statistically significant or not.

A comparison between contract and non-contract farming models is included in an interesting survey on the economics of pig production presented by Sheppard (2004). The survey was part of a Special Economic Study of the economics of the pig sector in England, commissioned and supported by the Department of Environment, Food and Rural Affairs (DEFRA) with the contribution of six English Universities. The farm costing phase of the study involved 300 pig farms recruited from a stratified sample and preceded by a survey of the structure of pig production in England. The survey sample included herds of rearing and finishing pigs kept under contract (i.e. not belonging to the farmer but to a third party) as well as breeding, breeding-finishing and finishing herds owned by the farmer.

The comparison between different farming models shows that in this case non-contract production seems to be more profitable than contract production. This is due to a different cost structure between the two models because contract producers do not pay for feed, veterinary services, medicines and other drugs. As a consequence, labour, building charges and other fixed costs assume a much higher proportion of total costs than they do for non-contract producers.

This table shows the composition of costs in the different farming models.

Table 10: Cost composition for different farming models (% , Sheppard, 2004)

	non contract breeding	contract rearing	non contract finishing	contract finishing	non contract breeding-finishing
Feed	44.6	-	53.6	-	51.5
Other variable costs	8.7	13.1	8.7	8.5	8.7
Labour	22.3	38.8	14.2	46.6	16.8
Other fixed costs	15.2	48.1	16.9	44.9	14
Other cost items	9.2	0.0	6.6	0.0	9.0

With regard to revenues, the farms under contract have no revenues from sales, but mainly from the payments for contract pig keeping, while on the farms without a contract revenues come from sales.

Although this is only an example of cost structure analysis, the result shows clearly that there is a difference between contract and non-contract farming models. The question that arises is how big this difference is. It could be enough to oblige analysts to take it into account when making their models or it could be not sufficiently significant to justify different modeling. It could be that there are no great differences between economic results, but significant differences between the various groups of costs. With regard to this, a comparative analysis of contract and non-contract farming model has been done by Tatlidil and Akturk (2004) for tomato production in Turkey. The aim of this work was to compare these two kinds of models by calculating unit production costs and to describe the positive and negative aspects of both models. A statistical method was used to see if there is a difference for the main variables such as number of seedlings, fertilisers and chemical values, hours of labour, hours of machinery, irrigation fees, amount of production and so on. More specifically, the ANOVA F test was used for the analysis of variance between two or more of these groups. The null hypothesis is that there was no difference between contract and non-contract farming models.

The data were collected through interviews during 2001-2002 production period. The sample was composed of 104 farms, 57 under contract and 47 without contract. The whole production process was examined in great detail on every farm, considering the single production activity (soil preparation, planting, irrigation, fertilisation, harvesting, etc.) and its labour and machinery cost per hectare, including materials (fertiliser, seedlings, and so on).

The ANOVA F test was applied considering the weighted averages of physical and financial values for contract and non-contract farming models. As a consequence, the variable costs for the two models taken into account in this work have been obtained as the sum of labour, machinery and material costs for every production activity per hectare.

$$\text{Total Variable Costs} = \sum_{i=1}^n [(hour_l \cdot value_l)_i + (hour_m \cdot value_m)_i + (quantity_s \cdot values_i + other\ variable\ costs)$$

l = labour

m = machinery

s = material used (fertiliser and chemical costs)

i = production activity

The total production cost is equal to the sum of total variable costs, interests and fixed costs (management costs, rent of land, depreciation, etc.).

In this specific case of tomato production there are no differences between contract and non-contract farming in the machinery and equipment used in production. Differently from the previous study, the cost composition here is as follows:

Table 11: Cost composition for contract and non-contract farming in the tomato sector (%)

	Contract farming	Non-contract farming
Total variable costs	81.2	82.2
<i>Labour cost</i>	26.2	29.1
<i>Machinery cost</i>	11.7	13.1
<i>Material cost</i>	23.0	19.6
<i>Other variable cost</i>	2.8	2.6
Interest of revolving fund	17.5	17.7
Total fixed costs	18.8	17.8
<i>Management cost</i>	2.4	2.5
<i>Rent of land</i>	12.6	10.5
<i>Depreciation</i>	2.9	3.6
<i>Interest on irrigation equip.</i>	0.9	1.3

Also in this case the component of labour is higher in non-contract farming than in contract farming, while material cost is lower.

The result of this work is that there was a statistically significant difference between the two types of farming in terms of number of seedlings, fertiliser costs, labour wages and amount of production. The difference was insignificant with respect to machinery hours and amounts paid for irrigation and chemicals.

It is also possible to apply this methodology in FADN to see if, within a specific type of farming group, there are differences between contract and non-contract farming models. In the case of significant difference, the cost structure could not be the same and this would require a specification in the model or different modelling.

4.6.1 Contract work on the farm

An implication of the economic specialisation process in the agricultural sector is the increase of contract work costs: farms cease to perform certain functions which are taken up by agricultural contractors. These functions can be directly or indirectly linked to the agricultural production, depending on the production stage taken into account.

Contract work costs usually concern activities such as manuring, liming, ploughing, sowing, weeding, pest control, plant protection, etc. These activities are generally part of the production process and are linked to the production of agricultural and forestry products. Moreover, in many cases, they need expensive machines and equipment.

Contract work may be performed by specialist contractors, for whom these contracts are the principal activities, or by agricultural holdings. In this latter case, contract work usually takes the following forms:

- occasional aid given to neighbours on a fee basis: the farmer has a supplementary income deriving from additional activities, such as accommodation for livestock (especially fattening)
- use of a machinery pool placed at the disposal of other holdings complete with the necessary personnel. Sometimes, the high cost of machinery and its low rate of utilisation by an individual holding leads to machine sharing among the other holdings.

Increasingly, farmers are deriving their main agricultural income from contract work for persons for whom farming is no more than a secondary activity and who are, in some cases, merely the owners of the land.

In FADN there is the possibility to individuate contract work costs and revenues. The costs include *Contract work and machinery hire*, which shows the total cost of services provided by agricultural contractors (including the leasing of machines). In revenues there is the corresponding *Contract work for others* that includes hiring out of equipment and agricultural contract work.

A farm can be more or less specialised in this kind of contract and, depending on the specialisation level, it can have a different cost structure. Depending on the proportion of these costs/revenues on the total farm costs and revenues it could be possible to measure the weight of this component. The modelling phase should take into account the presence of a farm with a high percentage of contract work, because it is possible that the cost structure and activities differ from a farm with a low percentage of this kind of contract.

4.7 Summary

Joint production costs have been defined as costs that are incurred on groups or products rather than on individual and separate one. Overheads includes items for which is difficult to determine the impact of the input on either output or cost for a specific enterprise.

As a consequence, in the calculation of cost for each enterprise at a farm level, problems can arise in the allocation procedures. Direct costs can normally be associated with a specific enterprise while indirect costs may apply to several enterprises or production cycles. In the latter case, the allocation may be not objective. The Task Force of AAEE normally recommend excluding estimates of general overhead expenses from the calculation of costs and returns if those costs cannot be allocated on an objective basis. Where allocation is necessary, different methods can be used. Some of these are described in this chapter. The analyses done by the

Directorate General of the European Commission have been done using FADN data, so their application is immediate and the keys chosen to allocate costs are relatively simple.

Some other studies are more complicated, for example Arfini's analysis, who uses the integrated indirect costing to make the allocation. This analysis is very interesting and mixes an engineering approach (technical coefficient) with a survey approach, so needs an integration of FADN information with further farm surveys.

A similar approach was used to compare contract and non-contract farming models and to underline the difference in cost structure. It seems that the most important differences can be observed on livestock farms rather than crop farms. The use of the economic results to differentiate contract and non-contract farming models is not sufficient and other tools may be used to underline the different cost structure (and, so, the different modelling). One of these is the ANOVA F test.

In general, although the allocation rules are theoretically well explained, their application could be difficult because of the lack of information in farm accounting. In the FADN analysis, the allocation rules are sometimes implemented using information coming from other sources. Perhaps the whole FADN accounting system and rules may be modified to include additional information helpful for a more complex accounting analysis. An integration with other sources is otherwise necessary, either to apply a survey approach or to conduct analyses and studies based on engineering approaches.

5. The calculation of own resources: labour, capital and land

5.1 Introduction

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 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.

This chapter discusses the approaches recommended by the AAEA Cost and Return Estimation Handbook to calculate the opportunity cost of labour, land and capital. The scientific literature recommends the estimation of these opportunity costs also in order to have further information about the efficient use of farm resources.

5.2 Own labour

Labour is one of the most important inputs in agricultural production. There are two categories of farm labour: hired labour and unpaid labour. The cost of the first category includes wages, salaries, benefits and other associated costs, while family labour is included in the second one.

Despite the importance of this cost in the EU agricultural context (characterised by the presence of 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 of 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 work¹⁶.

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 fact 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. Also the experience and the incentives differ between family members and hired workers: usually a family worker is assumed to be more productive than a hired worker and his work it is better done because of the expectation to share the net farm income. If these differences are important, it is necessary to adjust the calculation.

The third approach use the off-farm wage rates of farm 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 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 value personal and location characteristics.

¹⁶ 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 wages. 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 on-farm jobs into account).

5.3 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.

5.4 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 Used Agricultural Area (UAA) of the farm:

1. UAA in owner occupation: the holder is owner.
2. Rented UAA: the holder is not the owner but a fixed rent is paid (in cash or kind).
3. Share-cropped UAA: land is farmed jointly by the grantor and the sharecropper on the bases of a sharecropping agreement.

The AAEE Handbook C&R refers to different alternatives for calculating the land costs in these three cases.

In the first, when farmland 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 value¹⁷. 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 share-cropping 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.

For example: assume that the landlord receives 40% of the receipts and pays 40% of the costs. If the total receipts amount to 231 € and the total costs are 30 €, the calculated cash-equivalent land rental value would be $[(0.4 \cdot 231) - (0.4 \cdot 30)] = 80.4$ €, that is a reduction in cash receipts of 92.4 € and a reduction in cash cost of 12 €.

5.5 Summary

One of the most complicated tasks of cost accounting is the calculation of implicit costs that do not generate monetary transactions. As a consequence, they must be computed considering the opportunity cost that is the value of the input in its best alternative use. FADN does not consider opportunity cost of own resources, despite their importance for determining the efficient use of farm resources. The inclusion of opportunity costs permits a complete cost configuration to be obtained.

It is not easy to define opportunity cost univocally, especially for own labour. The best alternative use of labour work, in fact, depends on skills, productivity and opportunities in off-farm work. Moreover, it is necessary to have precise information on the labour market and location characteristics. The same thing happens with the land: the agricultural value of the land is different, depending on the use, characteristics and so on.

It is very specific. As a consequence, the estimation of own resources could be made by every Member State.

¹⁷ 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.

6. The cost function and costs estimation methodology

6.1 Introduction

In this section some concepts of cost are discussed from a mathematical point of view. Starting from the analysis of the cost function, the maximization and minimization processes concerned with it will be considered. After introducing the concept of cost function, the marginal and average cost and the relation between these two will be defined.

From the economics literature we can see how the cost function plays an important role in firms, we identify the function of total cost of production and for this reason start from an equation that underlines the total costs at a given level of the prices of the inputs as treated by Silberberg (1990) and Varian (1992).

$$C = C * (y, w_1, w_2, \dots, w_n)$$

Where y is the output level while w_1, w_2, \dots, w_n are the prices of the factors x_1, x_2, \dots, x_n .

The cost of production comes from the objectives of the firms, the action programme of the firm's actors and a mix of factors of the function production, such as the rules of contracting and the factor prices in some cases.

A further development of the research affirms that cost functions are based on the *wealth-maximizing* of the firm's behaviour, so the π represents the flow quantity profits in the assertion Maximize

$$\pi = pf(x_1, x_2, \dots, x_n) - \sum_{i=1}^n w_i x_i$$

Now y is not described as a parameter in the cost function, rather it defines the supply curve of such a firm with $y = y^*(w_1, w_2, \dots, w_n, p)$, because it is the output resulting from a combination between input as a function of factor and output prices, where $x_i = x_i^*(w_1, w_2, \dots, w_n, p)$ represents factor-demand curves for the profit-maximizing firm.

But in order to identify the cost functions we need y to be a parameter in models. So the theories have developed on the concept of minimum possible cost, where only if the total cost of producing that output level is as low as possible, the difference between total revenue and total costs can be a maximum.

Minimize

$$C = \sum_{i=1}^n w_i x_i$$

Subject to

$$f(x_1, x_2, \dots, x_n) = y^0$$

where y^0 is a parametric value of some arbitrary level of output. The solution of the first-order Lagrangian equations, if the first- and second-order conditions are valid for a determined minimum.

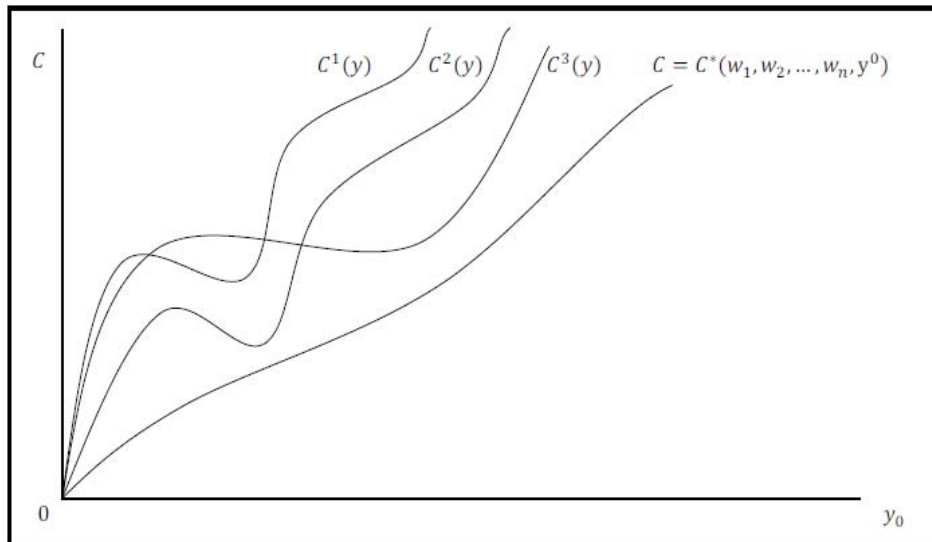
$$x_i = x_i^*(w_1, w_2, \dots, w_n, y^0) \quad i = 1, \dots, n$$

These equations are important because they define the *indirect cost function* as

$$C = \sum_{i=1}^n w_i x_i^*(w_1, w_2, \dots, w_n, y^0) = C^*(w_1, w_2, \dots, w_n, y^0)$$

where C^* is the minimum cost and refers to the parametric values $w_1, w_2, \dots, w_n, y^0$.

Figure 5: The cost function



The marginal cost (MC) function is expressed as the derivative of the total cost (C) function with respect to the level of output. It is defined as

$$MC = \frac{\partial C}{\partial y} = \frac{\partial(\sum w_i x_i)}{\partial y}$$

Note that the marginal cost may change with volume, and so at each production level, the marginal cost is the cost of the next unit produced, so it is right to underline that MC is the minimum increase in cost associated with an increase in output level.

Referring to the equations

$$C = \sum_{i=1}^n w_i x_i^*(w_1, w_2, \dots, w_n, y^0) = C^*(w_1, w_2, \dots, w_n, y^0)$$

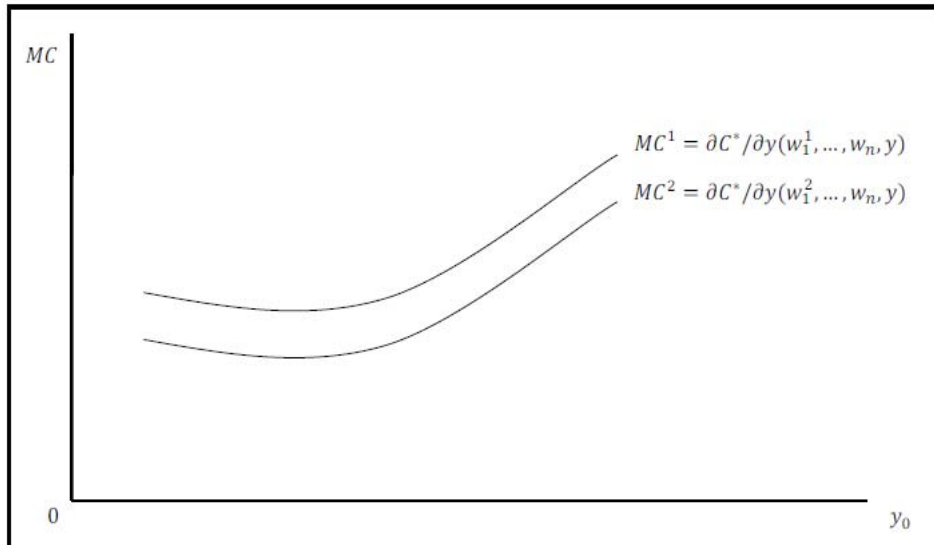
it is possible to rewrite the marginal cost in terms of C^* as

$$MC = \frac{\partial C^*(w_1, w_2, \dots, w_n, y)}{\partial y}$$

Note that any hypothetical change in factor price determines a shift in MC curve, like the figure below.

$$MC^1 = \partial C^* / \partial y(w_1^1, \dots, w_n, y)$$

Figure 6: The marginal cost function

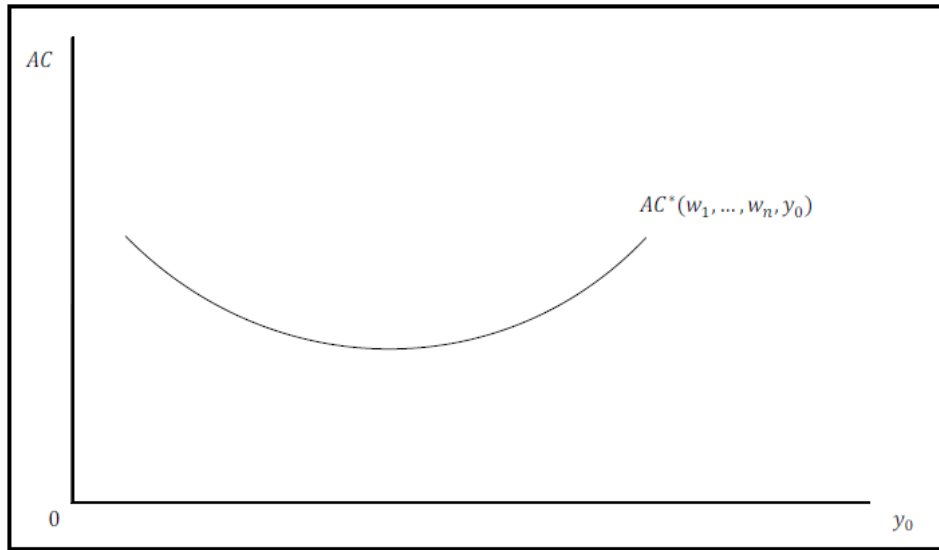


The average cost function (AC) is defined as the cost of a single production unit:

$$AC = \frac{C^*(w_1, w_2, \dots, w_n, y)}{y} = AC^*(w_1, w_2, \dots, w_n, y)$$

In another way the average cost can be regarded as the minimum cost achievable at any output and factor price level. So the average cost can be represented as a U-shaped curve. Note how this particular trend stems from two factors: the fixed average costs for the initial decrease of the curve, with the variable average costs in the final increase.

Figure 7: The average cost function



To describe the relationship between average and marginal costs, we have to start with the definition of average cost,

$$AC = \frac{C^*(w_1, w_2, \dots, w_n, y)}{y}$$

Indeed, differentiating both sides compared to y yields

$$\frac{\partial AC^*}{\partial y} = \frac{[y(\partial C^*/\partial y) - C^*]}{y^2}$$

In this equation we can see that

$$\frac{\partial C^*}{\partial y} = MC^*$$

so it can be rewritten as

$$MC^* = AC^* + \frac{\partial AC^*}{\partial y} y$$

and it identifies the general relationship between marginal and average quantities. In the last equation the marginal costs equal average cost plus an adjustment factor, called damage.

Marginal quantities are often considered more than average quantities, because average quantities, unlike marginal quantities, do not consider the link between the most important variables, like the factor inputs, while these variables are included in the marginal quantities.

After having defined the cost function and the marginal and average costs, the concept of cost estimation by econometric and mathematical programming approaches can be introduced.

6.2 Econometric models

This chapter explains how the cost is estimated by means of econometrics. We will analyze how the cost of production is estimated through the econometric approach. Two types of econometric analysis of agriculture will be distinguished and two examples presented to explain this difference of interpretation.

The main difference between mathematical economics and econometrics is that the former reduces theorems to the economic phenomena, and the latter tries to measure them (Emmer, 2000).

Through the specification of a model of farmer's behaviour within a competitive context, the model is estimated using different methodologies from the available data.

Econometric analysis of the agricultural sector is divided into two strands (Moro, Sckokai, 2006):

The first, the classic approach, also called "primal", translates into a direct definition of the farmer maximization problem, therefore it summarizes the technological characteristics in a production function;

The second one, which considers the dual problem, starts from functions of cost and/or revenue and/or profit and reaches behavioural equations for the producer indirectly.

The great advantage of the econometric models' approach is to produce various kinds of information that are very important for the analysis of agricultural policies and for simulation of operations, and able to provide elements of evaluation for policymakers.

There are many studies on the methodologies for estimating through an econometric approach and several econometric models have been developed for estimating agricultural production costs.

Two examples of estimations are given below. The models have been used on data from two different countries: France and Australia, the first to represent the classic approach, the second the dual one.

6.2.1 French example

The first example comes from a study on the cost of production estimation methodologies in agriculture (Desbois, 2006). It refers to the "primal" approach and analyzes the methodology for estimating production costs by comparing two econometric models: a standard specification based on a model for simultaneous equations and a nonparametric specification model based on the use of least-squares partial regression aspects.

The first model used to study RICA database is based on a linear cost function with constant coefficients. The regression equation is

$$Y_k = \sum_{j=1}^p \alpha_k^j X_j + \varepsilon_k \quad \text{with } \varepsilon_k \text{ i. i. d.}$$

where Y_k is the cost, X_j is the gross product, and α_k^j are the technical ratios. The estimation methodology applied is the least squares (OLS) because if some specific conditions are respected, it provides a correct estimator of the minimum variance of the technical production coefficients.

This econometric study was applied for the first time on French RICA data for the period 1970-1978, using about eight vegetable products and six animal products. In 1985, it was applied on European RICA between 1979-1984 with some changes: the estimation is always done charge by charge but the results are then adjusted to respect the coercion accounting equality; and also, irrelevant factors are forced a priori to zero; eventually negative factors are forced to a zero a posteriori if their absolute value is negligible or if they reflect a strong collinearity between explanatory variables.

The main results of this study are: classification of the EU states in order of production costs, purchasing power *ceteris paribus*; the identification of the states that are closest to the global cost index; but the negative aspect of this model is that the costs of land and family work are not satisfactory.

In order to solve this problem, the model must introduce some countable constraints a posteriori in the estimation of OLS. So the estimations are always obtained by means of OLS applied charge by charge and then the results are adjusted to respect the accounting rules.

The net margin is calculated as

$$M = \sum_{j=1}^p \beta^j X_j + \varepsilon_k \quad \text{with } \varepsilon_k \text{ i. i. d.}$$

But the definition of net margin as the difference between the valorisation and the cost of the product, imposes a constraint on linear coefficients for any property. The aim here is to respect the logic accountant

$$\sum_{k=1}^K \alpha_k^j + b^j = 1 \quad \forall j$$

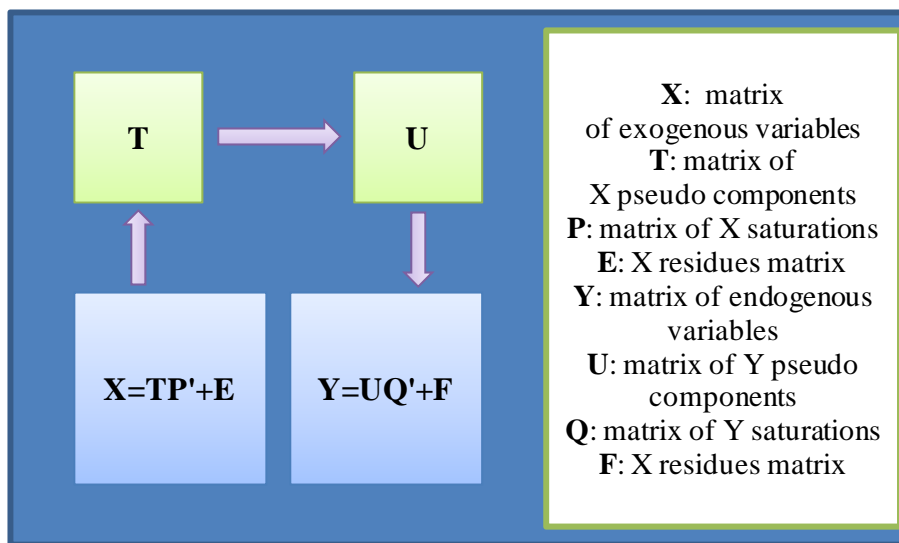
The second model used, named "soft modelling", proposed for the first time by Herman Wold in his study on a path model with latent variables, consists of extracting the factors called latent variables, by means of a linear combination of exogenous variables, selecting those that best model the endogenous variables behaviour.

The problem consists of explaining Y , the table endogenous variables, through X table exogenous variables in the presence of multicollinearity. The solution is to pass through the X orthogonal components for realising the projection of Y on X .

This methodology is in three stages:

1. calculation of the X orthogonal components;
2. regression on the X orthogonal components best correlated with Y ;
3. rewriting of the regression equation as a function of X .

Figure 8: The relation between variables and components



To improve the latent variables and explain the variability in the framework Y , it is necessary to adopt the solution of Partial Least Squares (PLS) regression through T orthogonal components in X and U in Y maximising their covariance by means of orthonormalisation.

6.2.2 Australian example

The second example is a study by Nguyen, McLaren and Zhao (2008) based on the estimating of a cost function using quasi-micro farm level data. It refers to the dual approach, or second strand of econometric analysis of the agricultural sector. These authors use two functional forms, transcendental logarithmic and normalised quadratic, which will be shown later.

The more interesting aspect of the research is to provide econometric estimates of key technological relationships and economic parameters for Australian broadacre agriculture. The original characteristic is the use of a unique dataset at a quasi-micro level drawn from the Australian Agricultural and Grazing Industries Survey conducted by the Bureau of Agricultural

and Resource Economics regarding the period 1990-2005 instead of average farms at a national level.

The restricted translog cost function is

$$\begin{aligned} \ln C(W, Y, Z, T) = & \alpha_0 + \sum_{i=1}^n \alpha_i \ln w_i + \sum_{l=1}^m \beta_l \ln y_l + \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n \alpha_{ij} \ln w_i \ln w_j \\ & + \frac{1}{2} \sum_{l=1}^m \sum_{k=1}^m \beta_{lk} \ln y_l \ln y_k + \sum_{i=1}^n \sum_{l=1}^m \delta_{il} \ln w_i \ln y_l + \sum_{i=1}^n \gamma_{ti} T \ln w_i + \sum_{l=1}^m \phi_{tl} T \ln y_l + \theta_t T \\ & + \frac{1}{2} \theta_{tt} T^2 + \sum_{i=1}^n \sum_{h=1}^v \rho_{ih} \ln w_i \ln z_h + \sum_{l=1}^m \sum_{h=1}^v \varphi_{lh} \ln y_l \ln z_h + \sum_{h=1}^v \psi_h \ln z_h \\ & + \frac{1}{2} \sum_{h=1}^v \sum_{g=1}^v \psi_{hg} \ln z_h \ln z_g \end{aligned}$$

where $Z = [z_1, z_2, \dots, z_v]$ is a vector of fixed inputs and other exogenous variables and T is a technological index.

The restricted normalised quadratic cost function is

$$\begin{aligned} C'(W, Y, Z, T) = & \alpha_0 + \sum_{i=1}^{n-1} \alpha_i w_i + \sum_{l=1}^m \beta_l y_l + \frac{1}{2} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \alpha_{ij} w'_i w'_j \\ & + \frac{1}{2} \sum_{l=1}^m \sum_{k=1}^m \beta_{lk} y_l y_k + \sum_{i=1}^{n-1} \sum_{l=1}^m \delta_{il} w'_i y_l + \sum_{i=1}^{n-1} \gamma_{ti} w'_i T + \sum_{l=1}^m \phi_{tl} y_l T + \theta_t T \\ & + \frac{1}{2} \theta_{tt} T^2 + \sum_{i=1}^{n-1} \sum_{h=1}^v \rho_{ih} w'_i z_h + \sum_{l=1}^m \sum_{h=1}^v \varphi_{lh} y_l z_h + \sum_{h=1}^v \psi_h z_h + \frac{1}{2} \sum_{h=1}^v \sum_{g=1}^v \psi_{hg} z_h z_g \end{aligned}$$

where $C'(W, Y, Z, T)$ and $W' = [w'_1, w'_2, \dots, w'_{n-1}]$ are defined as the total variable cost and input prices normalised by the price of input n th.

The production factors are grouped into five variable and two fixed inputs. The variable inputs are divided into:

- Contracts, services and materials for livestock;
- Contracts, services and materials for cropping;
- Other contracts, services and materials;
- Hired labour;
- Service cost of livestock capital.

The fixed inputs, embedded in the estimation model, are:

- Service cost of total land, buildings and other fixed improvements, and plant and machinery capital (capital);

- Total labour committed by the operator and his family (fixed labour).

Finally, the output variables are:

- Wheat and other grains;
- Cattle and other livestock;
- Sheep;
- Wool.

The widely-used translog functional form allows greater flexibility in measuring economic relationships compared to the traditional functional forms. It also has the ability to deliver formulas for price elasticities, elasticities of technical substitutions and scale economies in a more convenient way. While in restricted normalised quadratic functional form, less often used than translog form, the flexibility remains when the global concavity restriction is imposed.

The main results of the Australian examples show that most production inputs are substitutes for each other and are unresponsive to changes in own prices or other input prices. There is also some degree of independence between livestock and cropping production in the short run.

6.3 Mathematical Programming Models

The second estimation methodology to be described is the mathematical programming approach. The linear programming (LP) and positive mathematical programming (PMP) concepts are presented. We will also explain in detail the three phases into which positive mathematics programming is divided.

The objective of mathematical programming (or Optimisation) is to study problems which require determination of the minimum or maximum points of a real-value function, called *objective function* (or index of cost, or quality index, or merit function) in a prefixed set, the *admissible set*.

Until now, models based on the use of mathematical programming have mainly been used to help farmers to optimise their farm management.

The methodology is now being applied at the level of homogeneous groups of farmers, organized by industry or geographical area, with the aim of providing policymakers with information on the possible effects that can be generated by the application of specific agricultural policy measures in well-defined territories or areas.

Mathematical programming is widely used in agricultural economics in order to respond to two different objectives. The first one is related to the need for information about the right allocation of production inputs. In this case, mathematical programming is used for its normative

character. The second objective concerns predictions about a production system. Under this point of view, the methodology can be considered positive.

The mathematical programming applied to the production cost specification will be detailed with reference to the linear programming (LP) and the positive mathematical programming (PMP) approach. In this latter case, the estimation method of least squares and maximum entropy will be compared and the different results obtained discussed.

6.3.1 Linear programming models (LP) and positive mathematical programming (PMP)

The first type of mathematical model used is LP. This means that the objective function and all the constraints of the model are presented as simple linear functions of decision variables.

The most important aspect of these models is the ease of resolution. By using a simplex algorithm, or a standard algorithm from the literature, the solution can easily be obtained. But there are limitations to which linear models should be subject. There are four main assumptions: proportionality, additivity, divisibility and certainty. It is also important to note that average costs are equal to marginal costs in LP, and that the costs are considered as exogenous.

To move from LP to PMP it is necessary to specify the normative and positive models. The first ones, where Z is the value of the objective function, want to

$$\max Z = c'x$$

subject to

$$Ax \leq b$$

Called the normative constraint. Here A is the fixed matrix of technical coefficients relating to limiting inputs and b is the carrier of the constraints on the availability of limiting inputs.

Instead the second models, the positive models, want to

$$\max Z = c'x$$

subject to

$$Ax \leq b$$

$$x \leq x_R$$

Where the model, having a normative constraint, also adds a positive one, which requires x to be less than or equal to the vector of agricultural policies carried out (x_R).

Based on a specific procedure of "exact" replication of reality observed, the PMP lessen the distinction between econometric models and quantitative analysis.

The great advantage of the PMP methodology is the use of a micro-type approach, which allows to simulate the farms behaviour, both single and aggregate. So it provides for the limits of linear programming and econometric models applied at farm micro level.

What occurs in the optimization processes of the objective function subject to technical and/or political constraints, is the obtaining of solutions in which the levels of activation of production processes differ materially from those empirically detected. The scarcity of information about the availability and use of resources compared to the number of activities observed determines a strong impediment to justified limitations on the behaviour of model and, consequently, a physiological tendency to obtain optimum results conditioned by overly-specialised production phenomena.

The principles on which the PMP methodology is based are the following:

All available information must be used, although not in explicit form. Moreover, even with a limited amount of information it is possible to obtain acceptable models.

The costs that the farmer must support have to be clear. Indeed, he must be aware of all types of cost he faces for the entire production.

Given that the farmer or his family takes decisions on the basis of the specific conditions of the farm, the production ordering that is used is the result of a decision process.

The farmer operates in a situation of optimum, so production levels reflect the level of business efficiency and technical ability (or willingness) of the farmer. In addition, the cost function that guides the choices of the farmer is that of total variable costs at farm level and not of individual production processes. In fact, the theory of production costs and the dual theory of mathematical programming are the only guides for the model calibration.

This kind of approach was developed on the basis of the following FADN observations: variety of production vector x_R , individual crop hectares vector Ha , total land area constraint b , prices of various activities vector p , unitary variable costs vector assigned to various activities c (only for Italian RICA) and total variable costs (TVC).

Positive mathematical programming is divided into three phases (Paris and Arfini, 2000):

1. Linear Programming phase (LP): to estimate the level of marginal costs of the various activities. At this stage they identify the specific information of production costs associated with the farmer's agricultural production plan, thanks to the marginal costs estimation of production processes implemented.

The primary problem is represented by

$$\max NR = p'x - c'x$$

Subject to

$$Ax \leq b \quad [y]$$

$$x \leq x_R \quad [\lambda]$$

where p is the price vector of the farm and c is the vector of the accounting cost for output unit.

As the land is only a limiting factor in this model, the A matrix is defined as

$$a_{ij} = \frac{ha_{ij}}{x_{Rij}}$$

and y refers to the first constraint, the structure constraint, which is the shadow price vector on constrictive inputs able to allocate, as the land, and λ is the vector of differential marginal cost corresponding to the production prices vector (output) made for each activity and refers to the second constraint, the calibration constraint.

While the dual is

$$\min CT = b'y + x_R\lambda$$

Subject to

$$A'y + \lambda \geq p - c$$

The objective of this phase is to obtain a consistent and accurate measure of marginal cost associated with the production level of each activity.

To respond to the problem of lack of information about the specific costs of farm activities, an alternative approach has been introduced widely based on the Heckelei solution (2002). It is important to note that in the Lagrange function the primary and dual problems are represented.

Lagrange function

$$L = p'x - c'x + y[b - Ax] + \lambda'[x_R - x]$$

Thus, in the case that the two constraints $b-Ax$ and x_R-x are equal to zero, the shadow price vector and translated vector of differential marginal cost become positive.

First order condition

$$\delta Lx = p - c - A'y - \lambda \leq 0$$

Interpretation of any dual constraint:

$$p \leq A'y + (\lambda + c)$$

2. Econometric estimation phase and choice of the function of total variable costs (matrix costs)

To rebuild the marginal cost function for a homogeneous farms group two conditions are necessary:

The existence of a self-selection process used by the farmer (his personal preferences that are reflected in the choice of certain crops over others).

The existence of a global cost function associated to the whole farm-type (FT), which includes all the processes taking place in the region.

So, the second phase of the PMP approach recovers the marginal cost function using linear specification parameters. Where the cost function

$$C(x) = \frac{x'Qx}{2}$$

presents a quadratic functional form compared to the quantity. In this function Q expresses the matrix of variable costs that is symmetrical, semi-defined and positive.

The FT marginal cost function can be defined as

$$VMC(x) = \lambda_{LP} + c = Qx_R$$

The cost for each farm function is expressed by the cost function for the sample and a non-negative deviation, the first component can be viewed as a frontier function for the technical-economic orientation.

The marginal cost function for the n th farm is

$$VMC(x_n) \equiv \lambda_{LPn} + c_n = Qx_R + u_n$$

Where u_n is a non negative carrier that assumes the role of indexing of the FT cost function with the characteristics of the n th farm.

Since not all crops in the sample are grown, a further specification is required: activities carried out and non-produced assets. So, it is possible to separate two constraints:

Crops grown

$$mc_{nk}|x_{Rk} > 0: \lambda_{nk} + c_{nk} = Q_k x_{Rn} + u_{nk}$$

If K activity is produced.

Crops not grown on the n th farm

$$mc_{nk}|x_{Rk} = 0: \lambda_k + c_k = Q_k x_{Rn} + u_{nk}$$

If K activity is not produced.

So thanks to the Cholesky's decomposition

$$Q = LDL'$$

Where L is the lower triangular unit of the matrix, D is the diagonal matrix with non-negative elements, and L' is the transpose of L , the Q matrix of cost function is symmetrical, semi-defined and positive.

At this point there are two approaches to reconstruct the function of marginal cost:

The Least Squares that considers the u_n vector, with $n = 1, \dots, N$, that indexes the n th farm, based on the minimisation of the difference between the n th farm and the cost function.

The Maximum Entropy which considers Cholesky parameters matrices L and D as the expected values of a probability function in relation to a discrete and known interval of S supported values.

3. Calibration phase of the PMP model for the analysis of agricultural policy.

The third phase consists of assembling a model that uses a non-linear function of the recovered cost variable able to reproduce primary and dual solutions of the PL models of the first phase.

Primary

$$\max NR = p'x - \frac{x'Qx}{2}$$

Subject to

$$Ax \leq b$$

Dual

$$\min CT = b'y + \frac{x'Qx}{2}$$

Subject to

$$A'y + Qx \geq p$$

6.4 Summary

After having explained the concept of cost function derivation, according to the microeconomic approach, the concepts of total cost of production, marginal and average costs, and the relation between them have been defined. The different methodologies have been distinguished according to the main estimation methods: the econometric and mathematical programming approaches. After a thorough critical review of the literature regarding cost estimation methodologies, the two estimation methodologies have been compared in order to underline some of their positive and negative aspects.

The most important difference between these two approaches is the amount of information necessary for developing the methodology: the econometric approach needs a greater quantity of data than the mathematical programming. The use of the econometric estimation also requires a greater commitment in the collection and management of the information requested. In fact the necessary data are not only numerous but could also require special attention on the time series.

Considering the use of both these approaches, the mathematical programming is easier above all as regards the normative context.

The results that can be obtained through the two methodologies are different: very detailed information cannot be obtained through the econometric estimation, as this would require too much data, while the mathematical programming, despite the fewer data needed, can explore deeper, reaching farm level.

The comparison between the two estimation methodologies shows that in both approaches an important role is played by the subjective component of the researcher: he is the one who decides which data to use and the models to choose.

These are the main considerations that have emerged from the literature on production costs estimating methodologies, with reference to the econometric and mathematical programming estimations. It should be noted that these elements must be well considered especially in the successive stage of the choice of the "general" cost production model of WP2.

Conclusions

In the European Union the FADN accounting system is the most relevant source of information available for analysis of incomes and costs of agricultural holdings at a microeconomic level.

Moreover, FADN has a structured body of rules and procedures to elaborate costs and returns and to calculate income indicators. Since its birth in 1965, FADN has been used both to make agricultural sector analysis and as an instrument for agricultural policy analysis.

The difficulties and the characteristics of agricultural accounting have led to the implementation of a specific International Accounting Standard for Agriculture (IAS 41). IAS 41 introduced the evaluation of the agricultural activities at the current moment and introduced also in this sector the concept of fair value. Fair value is a helpful approach for biological assets because it permits to represent immediately their biological transformations. Recognizing the change in values due to the transformation process in the income statement is very important for the decision-making process. This approach is easy to adopt in case of active and liquid markets, while in the opposite case, it may be costly. This is a limitation for the developing countries.

One important aim of this work has been the description and definition of costs, a preliminary work helpful to better understand the differences among the cost accounting methods and the difficulties of some cost allocations. In general specific costs and overheads of FADN present characteristics of variable costs because they increase or decrease with the production activity.

As concern overheads, they are not linked to specific lines of production or enterprises and, so, they are not measurable directly. As a consequence, to know the cost of each production or enterprise in FADN it is necessary to implement specific rules of allocation among the farm enterprises.

One difficulty in this analysis is connected to the fact that there are different ways to classify the costs and every approach gives a specific information for a specific purpose. Moreover, the calculation of some kinds of costs are not easy (for example the implicit costs).

These differences lead to various cost accounting systems which structure depends on the kind of costs taken into account and on the farm accounting. In the agricultural sector, the application of product costing methodologies presents some difficulties because usually there are more enterprises and a considerable number of common costs to allocate among the enterprises.

Moreover, in the farms there is not a developed use of book-keeping practices. The existence of the FADN accounting system in the European Union permits to collect accounting information from a sample of farms and, so, to calculate and estimate the cost of production on a survey approach base.

The literature gives us different examples of cost accounting. The main difficulties is the allocation of joint costs and overheads among the enterprises. Although the allocation rules are theoretically well explained, their application could be difficult because of the lack of information in agricultural accounting. For example, sometimes, there is not possible to know the distribution of work or machinery hours among each enterprise and consequently, other allocation rules must be used.

In case of FADN analysis, sometimes the allocation rules are implemented using information coming from other sources (Eurostat, National Accounting surveys, etc.). Maybe the whole FADN accounting system and rules may be modified to include additional information helpful for more complex accounting analysis.

Finally, the comparison between the econometric and programming mathematics approach put on evidence that we can not get very detailed information from econometric estimation, as this would require too much data, while the programming mathematics, despite the lower number of data needed, can explore deeper, reaching the firm level.

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