

Literature Review on Cost of Production Methodologies

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Introduction

The structure and level of cost of production (CoP) have major implications for competitiveness of agriculture and income level of farmers. Production costs not only shape the development of farming systems but also affect their sustainability and determine overall food production potential.

The availability of good quality data on CoP is a key requirement for conducting comparative analysis useful for policy decision, scientific output and/or for decisions of agricultural market agents. In view of this, this report aims to provide a review of methodologies on CoP approaches as applied in major world producing/trading countries/regions (Argentina, Australia, Brazil, Canada, EU, New Zealand, Ukraine, USA) and by Global Networks (agri-benchmark, IFCN). The report will be updated to include also review of methodologies in other developing countries. In particular, the report aims to summarize the methodologies and approaches for data collection and processing and their appropriateness as well as it provides recommendations.

The report is organized in **xx** methodological topics that are relevant to be considered when developing and conducting CoP calculations. In particular the report considers the following methodological issues:

1. Typology of production costs
2. National data collection systems versus global networks
3. Representative farm versus sample of farms
4. Frequency of data update
5. Unit of observation
6. Accounting costs versus economic costs
7. Valuation of farm owned factor of production
8. Allocation techniques

Typology of production costs

CoP is an economic indicator assessing the economic performance of production. Cost is defined as the value of a factor of production (input) employed in the production of final outputs. The classification of production costs can be made along several dimensions. Table 1 summarises seven possible ways of categorising production costs (AAEA 2000; Cesaro *et al.* 2008).

For the purpose of the present study a possible classification of CoP that might be relevant from methodological point of view is based on whether costs are traceable to specific farm activity (i.e. direct versus indirect costs). A direct cost is a cost that can easily and conveniently be traced to the particular farm activity (e.g. commodity). For example, in most cases the use of fertilizer is a direct cost of a particular crop as far as the flow of utility it produces benefits to that crop.

Vice versa an indirect cost is a cost that cannot be easily and conveniently traced to the particular farm activity. For example, if a farm produces several crop commodities, the cost item such as machinery maintenance is an indirect cost of all crops for which the machinery was utilised.

Here, the reason is that machinery maintenance costs are not caused by any specific crop but are common to all. Indirect costs are incurred to support multiple activities (e.g. multiple crop commodities) and cannot be traced to each individually.¹ Indirect costs are usually constant for a wide range of outputs and are grouped under fixed factors.

It is possible to classify almost any kind of cost as either direct or indirect. Labour costs, for example, can be indirect, as in the case of maintenance personnel and managerial labour; or can be direct, as in the case of hired labour for specialised work carried out on a particular commodity. Similarly, other costs such as machinery and equipment maintenance costs, such as for tractor depreciation, are typically classified as indirect costs, while machinery and equipment used for a specific commodity (e.g. corn sowing machine), are included in direct costs.

Considering monetary flows, a second possible distinction is made between cash costs and noncash costs. For cash costs, monetary payments and the consumption of input are realised in the same period (e.g. cash payments for fuel, fertilizer, seed, repairs, and similar items). For non-cash costs, either the payment is not realised (opportunity cost of own inputs) or there is a time lag between the time when payment was made and when the input was used (e.g. capital depreciation). Depreciation costs account for the declining value of farm assets such as machinery and buildings. Opportunity costs (also referred to as implicit cost and/or imputed cost) represent the cost of own inputs (e.g. own land, labour and capital). Because own inputs are used at farm level, they forgo income which could be earned if they were employed in alternative activities. The opportunity cost represents the value of own inputs in the next best alternative use (e.g. the opportunity cost of family labour is off-farm wage; the opportunity costs of own land is market rental price). The consideration of opportunity costs is one of the key differences between the concepts of economic cost and accounting cost. The latter usually does not consider the opportunity costs because the actual payment transactions are not realised. Economic costs consider all explicit and implicit costs incurred by farms including opportunity costs.

Table 1: Typology of production costs

Classification description	Type of costs	Description	Examples
In relation to farm activity	-Direct cost -Indirect cost	Direct cost can be assigned directly to a farm activity (e.g. commodity). Indirect costs are spent per group of products or per farm as whole.	-Direct cost: fertilizers, seeds -Indirect cost: overheads, machinery maintenance, depreciation
In relation to cash flow	-Cash cost -Noncash cost	Costs based on whether monetary payment follow input flow in a given period.	-Cash cost: fertilizers, seeds, hired labour, rental costs -Noncash cost: depreciation, opportunity cost of own inputs
In relation to whether actual expenses were incurred	-Explicit cost -Implicit cost	Explicit costs are actual incurred expenses. Implicit cost (or imputed cost, implied cost) are not associated with actual expenditure payments.	- Explicit cost: expenditures on fertilizers, seeds, hired labour, rental costs - Implicit cost: opportunity cost of own inputs

¹ Other terminology often used is *joint costs* (or shared costs). Joint costs are costs incurred in a production process involving more than one product which production cannot be separated from each other (e.g. wool and sheep meat production are joint products hence all sheep costs are joint costs; inputs purchased for the farm as a whole such as overheads). Joint costs can occur either as direct costs or as indirect costs. Some inputs such as fertilizer or lime, which are normally viewed as direct costs and can be assigned to a particular commodity, may have an inter-temporal or residual carry-over effect that may impact the production of other commodities (AAEA 2000).

In relation to unit of production	-Variable cost -Fixed cost	Variable costs change with production level; fixed costs are independent of production level.	-Variable cost: seed, fuel, machine repairs, fertilizer -Fixed cost: depreciation on buildings and machinery
In relation to unit of comparison	-Total cost -Average cost -Marginal cost	The distinguishing criterion is unit of measurement with respect to which cost change, such as per farm, per hectare, per unit of production.	
In relation to usage	-Expendable -Capital -Capital services	Expendable are inputs consumed in a given period. Capital is a stock concept. Capital services are services obtained from the capital stock in a given period.	-Expendable: seed, fuel, feed -Capital: machinery, buildings, equipment, land, human capital -Capital services: services provided by equipment, labour, etc.
In relation to farm operations	-Operating costs -Overhead costs	To what extent they related to operation of farm processes.	-Operating: seed, fuel, feed -Overhead costs: the purchase of land, buildings, machinery

Other standard classification of costs used extensively in economic theory is according to its variation with respect to the unit of production. Variable costs change with production level, whereas fixed costs are independent of production level. In other words, variable costs are affected by the farm's actions in the period under consideration, whereas fixed farm costs incur independently of the actions undertaken by the farm in the period under consideration. Note that some fixed costs may be quasi-fixed implying that they are flat within a certain range of production but change if the range is overshoot (e.g. machinery).

With respect to the unit of comparison, the costs can be classified as total costs, average costs and marginal costs. The total costs represent the value of all inputs (cash and non-cash) a farm uses in a given period and they are the sum of variable and fixed costs. Average costs are total cost split per unit of measurement such as per hectare or per unit of production (e.g. per tonne). Further, average costs can be distinguished by type of costs such as average fixed or average variable costs. The marginal cost is the change in total cost that arises due to the change in one additional unit of output or input.² The marginal cost with respect to output is total cost change when production changes by one unit. Equivalently, the marginal cost with respect to input is total costs change when input use changes by one unit (e.g. marginal cost of labour, marginal costs of land).

Other distinction of costs is in terms of inputs usage during the production process. Expendable are inputs that are completely used up or consumed during a single production period. Capital is a stock that is not used up during a single production period but provides services over time. Capital services are the flow of productive services that can be obtained from a given capital stock during a production period.

Finally, the cost can be distinguished in the link they have with respect to farm operations. Operating costs are related directly to the operation of farm activities. They can also refer to the costs of operating a specific farm activity (e.g. wheat production). Operating costs can be either

² Expressed mathematically, the marginal cost is the first derivative of the total production costs.

variable or fixed costs.³ In contrast overhead costs are costs incurred on the purchase of factors such as land, buildings, machinery and equipment to be used in the production process. Unlike operating costs, overhead costs are one-time expenses and ensure that a given farm production process is in an operational status. Overhead costs are fixed and are therefore independent of the level of production.

Recommendations

Key challenges in calculating accurately production costs is to assign each cost item to a specific unit of interest (e.g. per tonne of a production) which strongly depends on the cost type. In particular problematic are shared costs that are not directly linked to a specific product but are incurred on multiple products (e.g. indirect costs, fixed costs, overhead costs) as well as cost for which payments are not realised and need to be imputed (e.g. opportunity cost of own factors). These cost categories require special attention and application of an appropriate technique to obtain accurate cost values. For the shared costs, an allocation technique is necessary to be applied to split the costs incurred on multiple farm activities into specific units of interest. Same holds for cost for which payments are not realised; usually associated with farm owned factors of production (e.g. labour, capital, land). To identify appropriate cost values, there is need to apply an appropriate imputation technique to identify their opportunity cost. These cost types are subject to potential significant error of final cost calculation if suitable imputation and/or allocation techniques are not established. For this reason an expert advice is recommendable as the application of different techniques require specialised knowledge of economic theory and quantitative methods.

The cost types that are directly linked to production of a specific farm activity (e.g. direct costs) can be more easily identified per unit of interest. In this case the identification and calculation of cost of production does not pose a significant methodological challenge in terms of the need to use sophisticated techniques and thus it less dependent on specialised expert knowledge.

National data collection systems versus global networks

Most countries covered by this report conduct their own collection of data on production costs as part of national agricultural data gathering exercise (Isermeyer 2012). Very different concepts for the collection of farm-based CoP analysis have been developed and implemented over the last number of decades, categorized by different criteria, including (but not exclusively): regional coverage (world-wide; EU-wide; national; regional), representativeness (stratified sample; farmer groups with voluntary participation), unit of analysis (single farm data; farm averages; typical farms), depth of the data (whole farm data; farm enterprise data), and data collection method (delivery of bookkeeping data; interviews; panel discussions).

For example, the EU collects CoP data across all its 27 Member States (MS) through the Farm Accountancy Data Network (FADN). The FADN was launched in 1965 for the purpose of evaluating the income of agricultural holdings, and development of agricultural holdings and the impacts of the Common Agricultural Policy (FADN 2010).

In the United States the CoP data are gathered as part of the annual Agricultural Resource Management Survey (ARMS) since 1996. Data in prior years were collected as part of the annual Farm Costs and Returns Survey (FCRS) (USDA-ERS 2012a, 2012b).

³ For example, AAEA (2000) recommended that all expendable costs to be classified as operating costs and all other costs to be grouped as overheads in the commodity cost calculation method applied in the US.

In National Food Supply Company (CONAB) in Brazil is compiling information on agricultural CoP with the purpose to identify differences in competitiveness between regions and technologies. The calculation method adopted by the CONAB aims to account for all costs items incurred by producer from the production initiation stage to product commercialization stage (Teixeira 2011;CONAB 2010).

In Canada most of the CoP information is collected by various agencies for their specific purposes conducted in at regional (province) level or national level.

In Australia the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) is collecting CoP production through farm surveys already for 33 years (Isermeyer 2012).

In New Zealand the Ministry of Agriculture and Forestry (MAF) is running a farm monitoring system. This system is relatively new. It is an alternative to an older system called “Economic Survey of sheep and beef”, which is also still being applied (Isermeyer 2012).

In the Ukraine, CoP data are collected under the so-called 50-sg report (State national wide survey). Additionally, CoP is created within AgriEfficiency project and the agri benchmark project (embedded in the worldwide agri benchmark consortium) operated by the Ukrainian Agribusiness Club (UCAB) (Isermeyer 2012, Slaston (2011).

An important advantage of the CoP data collected at national level is that they can be better tailored to address the national users' needs. However, because methodologies vary strongly across countries, it is problematic to use them for inter-country comparison. The application of national CoP data sources for international comparison would require further data processing and/or harmonization of methodologies but may not always lead to full cross-country comparable CoP values.

The agri benchmark and the IFCN based on representative farm approach are the main data sources available for international comparison of production costs. They apply a common methodology for costs identification and calculation across all covered countries. They can be applied without further methodological adjustments to compare production costs among available commodities and regions. These approaches are based on networks of experts, advisors, panel of farmers and statisticians located in different parts of the world who collect and process data locally and are coordinated by a central organization located in Germany (Isermeyer 2012).

Recommendations

Both systems of CoP data collections have their own advantages and disadvantages. However, a crucial issue necessary to be considered in this context is the relevance of comparability of CoP data across countries and the users' needs in this respect. The experience shows that the implementation of CoP data collection system at country level and un-coordinated across countries leads to the limited international comparability of the national level CoP data. To reduce this problem, international coordination is desirable to minimize the methodological differences between countries.

However, it must be recognised that a full harmonization may not be feasible from implementation point of view. Countries might be deterred from implementing a harmonised methodology as the existing national systems would need to be significantly adjusted or replaced by a new harmonised system. The exiting national systems are developed to address multiple policy objectives and are not solely design to deliver only the CoP data. Redesigning the national system for the purpose to improve the CoP data collection may thus conflict with the delivery of

data for addressing other policy objectives at national level hence making this option highly unrealistic (Langrell, Ciaian and Gomez y Paloma 2012).

The only CoP data collection systems fully harmonised between countries are those implemented by the global networks IFCN and agri benchmark. The application of common methodology across participating countries is ensured by a central organization which conducts development of methodology and coordinates its implementation, whereas partner institutions located in the participating countries conduct the actual collection of CoP data.

Representative farm versus sample of farms

The CoP data collection method as applied in the countries and global networks cover in this report is effectively based either on the large representative samples (e.g. FADN, ARMS) or the representative farm approach (e.g. agri benchmark, IFCN, CONAB).

The difference in objectives of national and global data collection systems, and differences in their use, largely determines the methodology in general, and sampling strategy, in particular. According to Garnier (2012) if the goal is to evaluate heterogeneity and average production cost per country, per region, or for different farming systems, representativeness of the studied sample is critical (e.g. Methods ARMS, 50-sg report, France Arvalis-Unigrains Observatory, FADN). However, if the goal is to evaluate the production costs of performing farms or to characterise the economic impact of innovative practices (e.g. minimum tillage, low input system, organic farming, etc.), then the sample representativeness is still important but is secondary compared to the needs of having detailed and specific economic and technical data on technology, farm practices, timing of activities through the season, etc.

The FADN (EU) is based on a representative sample, with regard to region, farm specialization and farm size. The sample covers more than 80.000 farms representing a population of about 6.4 million farms, which cover approximately 90% of the total utilized agricultural area (UAA) and account for about 90% of the total agricultural production of the EU. An individual weighting scheme is applied to each farm in the sample corresponding to the number of farms it represents in total population. The weighing scheme allows to aggregate CoP values to different regional level (e.g. country, EU level) or by farm specialization and farm size (FADN 2010).

The French data collection system for wheat and corn - Arvalis-Unigrains observatory - is based on a sample of 4000 farms from 14 departments. A weighting scheme is applied to each farm in the sample corresponding to its relative share in national production (Garnier 2012).

In US the ARMS survey is a stratified and probability-weighted sampling design. Each farm sampled in the ARMS represents a known number of farms with similar attributes so that weighting the data for each farm by the number of farms provides a basis for calculating estimates for the target population. Target populations for a commodity include all farms producing the given commodity (USDA-ERS 2012b).

The 50-sg report in Ukraine is representative sample of agricultural enterprises that exceed certain size limits (e.g. 200 ha; 50 cows, pigs, sheep (500 poultry); 20 workers) with the sample size containing around 9.000 farms. Other countries where representative sample approach is used include for example Australia, Canada, etc.

The farm monitoring system of New Zealand also collects data from relatively large number of farms. However, the survey is based on voluntary participation of farmers. Therefore, it is not possible to make this system statistically representative at regional/country level or across farm types. For example, in the dairy sector about 10% of all farmers are in the system (Shadbolt 2011; Isermeyer 2012).

The CONAB (Brazil) applies the representative farm approach⁴ to calculate CoP for different commodities. The cost data collocation is executed through a panel meeting of around 10-15 experts composed of CONAB experts, farmers, trade unions, academics, representatives from financial institutions, input suppliers and other relevant institutions.

The agri benchmark and the IFCN global networks are also based on the representative farm approach and represent a good example of its application at international scale. The data collection is done via so-called 'panels'. The 'panels' consist of a networks of experts, advisors, panel of farmers, statisticians located in different parts of the world who collect and process data. The expert judgments of these panels decides all aspects related to CoP analysis, from representative farm selection to assigning CoP values to each cost category and activity.

The disadvantage of panel based approach is that the involvement of experts/advisors introduces certain subjectivity and personal perceptions in the whole data collection process. Additionally, an important weaknesses of the representative farm approach is low representativeness of collected data and inability to capture adequately variation of farming systems within regions. Finally, this approach is not well suited to capture farm structural changes (adjustment in technology, farm size, etc). Any structural change is accounted for through exogenous adjustment of representative farm in regular intervals. Although it is desirable to adjust the representative farm approach to reflect actual farm structure, it may pose a problem of comparability of CoP data over time due to the fact that characteristics of typical farms change over time (Langrell, Ciaian and Gomez y Paloma 2012).

However, the representative farm method as applied by the agri benchmark and the IFCN is a relatively inexpensive methodology from an implementation point of view, with a possibility of its application on a regular basis on a wider regional scale, particularly in less resourceful countries such as Asia, South America, Russia and Africa.⁵

Recommendations

Representative random sample represents a solid and recommendable method for collecting the CoP data. Compared to the representative farm approach, its main strength is in delivering CoP data that can be compared across different dimensions (e.g. regionally, temporally and across farm types) depending on the survey design and sample stratification. However, well designed and representative survey is demanding on financial resources. In contrast, representative farm approach is financially cheaper option, which makes it attractive for less resourceful countries. The representative farm approach is also more suited for collection of specific economic and technical data related to new technologies, farm practices, timing of activities through the season, etc.

Frequency of data update

The experience show that the frequency of CoP data update vary strongly across collection methods and countries. While some methods (FADN, 50-sg report and France Arvalis-Unigrains Observatory) allow an annual update of all data including farm structure, this is not the case for ARMS methods or methods of study based on the representative farm (agri benchmark, IFCN) (Garnier 2012).

⁴ Other terminology often used for 'representative farm' include for example 'typical farm', 'hypothetical farm', etc.

⁵ In most countries included in agri benchmark and the IFCN, the average number of representative farms is between 2 or 3 per commodity.

For the FADN (EU), a complete data collection is made every year, but due to the complexity of the collection process and data check and validation the data release is delayed by about two years; i.e. the most recent data available are two years old. For the Arvalis-Unigrains observatory, the release of data is delayed approximately one year (one harvest before). For the current year, Arvalis-Unigrains observatory provides estimations (Garnier 2012).

Concerning the ARMS method (US), estimates of production costs are based on farm surveys conducted every 4-8 years for each crop. For non-survey years, the CoP are estimated using structural data from surveys and annual data on prices, production and other indicators. This can cause discontinuities in data when new survey data replace non-survey estimates depending on how much technical and/or structural change occurred in the sector between the survey years, as well as changes in the sampling, questionnaire, and other data collection procedures. Data for major crop and livestock activities (corn, soybeans, wheat, cotton, dairy, and hogs) are gathered more often than that for other commodities (other feed grains, other small grains, sugar beets, rice, peanuts, tobacco, and poultry) (USDA-ERS 2012a).

In the agri benchmark and IFCN methods, input prices, selling prices and changes in yields are updated every year. A complete update of the representative farm (i.e. farm technology and size) is usually done every two to four years depending on the speed of structural change and innovation development. The release of CoP data in agri benchmark and IFCN methods is available timely for the current year (Garnier 2012; Isermeyer 2012). In CONAB (Brazil), the technological coefficients used for CoP allocation are updated every three years. However, the update of the coefficients may be done more frequently if significant structural changes took place (e.g. due to change in productivity, mechanization, irrigation method, etc.) (CONAB 2010). Similar as in the case of ARMS, updating the representative farm or technological coefficients every two-four may lead to discontinuities in the time-series analysis.

A regular update of CoP data is crucial for evolution of the farm competitiveness and farm structural change over time. Methods based on representative sampling are better suited to study the evolution of production costs and changing structure of farms over time if updated on regular bases. The methods based on the representative farm approach by construction are not able to fully capture the evaluation of farm structural change related to CoP because farm technology and size are predefined and have limited coverage of farm heterogeneity. Further, updating the representative farm in irregular intervals makes it problematic to track the evolution of farm competitiveness over time (Garnier 2012; Langrell, Ciaian and Gomez y Paloma 2012).

Recommendations

There is not observed a common practice in terms of frequency of collection and update of CoP data across surveyed countries and methods. The frequency of data collection for survey approach varies widely; between one year and up to eight years. It is recommended to adjust the frequency of data collection reflecting the importance of the commodity and development of sectorial and farm structural change. Sectors subject to faster structural change need more frequent data collection as opposed to less dynamic sectors. Also more important commodities in terms of production, area use and trade are recommended to be more frequently surveyed than other commodities. Further, it is recommended to provide estimates of CoP for non-survey years using annual data of relevant indicators (e.g. prices, production).

An accompanying issue is time lag in the release of CoP data. This is strongly linked to the data collection method and availability of financial resources and human and infrastructural capabilities in collecting, processing and checking the data. Delays (up to 2 years) can be observed for survey based approaches, whereas the methods based on representative farms are

usually able to deliver data with small or no delay. It is recommended a timely update of CoP data in order to increase their usefulness for policy decision, research and market agents.

Unit of observation

The unit of observation is different between surveyed countries, methods and cost types. Some countries which collect data through representative sample collect CoP data only for the whole farm (e.g. FADN) or by combining data collected by commodity or for the whole farm depending on the cost type (e.g. ARMS). Methods based on representative farm also collect data by commodity or for the whole farm depending on the cost type (IFCN, agri benchmark, CONAB).

One key factor that determines whether data are collected by commodity or the whole farm is the cost type. Data directly observed per commodity (e.g. direct costs) can be directly collected per commodity through farm surveys. The collection of costs at the commodity level is relatively easier for direct costs than for fixed costs and overheads such as machinery, buildings, management, and family labour. The majority of direct costs are traceable and can be assigned to a specific commodity, whereas the latter type of cost types are typically used to produce multiple farm commodities and thus it is not straightforward to allocate them to a specific commodity. For this reason, they are usually collected per farm as a whole or group of commodities and then an allocation technique is used to allocate them to specific commodities.

The FADN (EU) collects all CoP data per farm as a whole. Information on commodity specific CoP cannot be taken directly from the data set. Instead, it is necessary to estimate them. For example, the FADN data set collects monetary value of crop inputs, livestock inputs and other farm costs (e.g. overheads, depreciation, hired labour costs, interest costs) at farm level. They are not available per unit of commodity; e.g. per tone of wheat, corn or rapeseed.

The ARMS (US) collects commodity-specific costs (e.g. direct cost), input quantities and production practices by commodity (e.g. seeds, fertilizers, chemicals). Non-specific costs (e.g. overheads) are collected for the whole farm and are assigned to specific commodities based on an allocation formula.

The data collection process in ARMS is implemented in three phases. It starts during the fall when production practice and cost data are collected, and finishes in the spring when a follow-on interview collects data about whole-farm costs like overhead, interest, and taxes (USDA-ERS 2012b):

- Phase I: farmers selected for inclusion in the survey sample are screened to verify their operating status and to determine whether they are producing commodities targeted for data collection. This helps to improve survey efficiency in phases II and III.
- Phase II: data are collected at the individual field or production unit level. Phase II is a series of commodity surveys conducted to obtain physical and economic data on production inputs, management practices, and commodity cost of production.
- Phase III: data are collected on the whole farm level. Data are collected from a nationally representative sample of farmers in order to analyze the farm-level economic situation in the reference year. Farmers interviewed in Phase II are also included so that data from both surveys can be merged.

The unit of observation in methods based representative farm approach (IFCN, Agri benchmark, CONAB) is commodity level (e.g. per ha, per animal). The CoP can be split up into a quantity and a price component allowing detailed analysis across commodities and regions.

This method constructs the CoP data starting from the schedule of different commodity-specific activities up to the whole farm expenses. As described above main source of CoP of data are panel of experts combined with the data from the bookkeeping of real farms and from additional sources. This implies that direct costs (e.g. fertilizers, seeds) are identified per commodity whereas overhead are collected by the panel for a group of commodities or for the whole farm and then they are assigned to specific commodities based on an allocation formula (Garnier (2012; Isermeyer 2012). Important is to note that the cost disaggregation and split of different farm activities is usually much higher for approaches based on representative farm than in methods based on surveys.

Recommendations

Although the unit of observation varies across considered countries and methods it is recommended that the choice of data collection of a particular cost category should be mainly driven by the ability of farmers to report reliable data. For cost categories for which farms can report CoP per unit of observation (e.g. per commodity), these cost items should be collected at farm level per unit of observation. For cost categories used to produce several commodities, the collected data should be per group of commodities or at the whole farm level and then an allocation formula should be applied to split them to specific unit of observation. For example, costs items such as seeds and fertilizers can be relatively accurately collected per commodity from farmers directly, whereas overhead costs on buildings and machinery can be best collected at the whole farm level or group of commodities for which they are used.

Accounting costs versus economic costs

There are two conceptual approaches used in the general businesses management and economic literature with respect to CoP analysis and their practical application. These two concepts refer to economic costs developed within the economics science versus accounting costs applied in the business management field. The key difference between the two concepts is in cost categorization and in particular in terms of cost representation. Accounting costs include explicit costs of farms which are actually incurred by farms. They include actual outlays or expenses incurred on farm. The economic CoP usually exceed the accounting costs of production because they include both explicit accounting costs and implicit costs. For example, economic costs also include costs of family labour for which the actual expenses were not incurred, which is not the case of accounting principle.

To be able to conduct economic analyses with CoP data and to ensure comparability of CoP across and within farms/commodities/regions, important is to collect/calculate economic costs. Accounting approach will fail to provide a complete picture on CoP as the implicit costs are not covered when using this approach for data collection. The application of the accounting approach may thus lead to significant gaps in data which will vary by farms and/or regions depending weather farms use their own factors in production or purchase them on the market.

In practice, accounting costs are more easily available due the fact the accounting principle is most commonly applied method for recording farm activities. Even if farms do not keep records,⁶ explicit costs can be valued more accurately by farmers or experts because they are associated with actual market transactions. Collecting data on implicit costs is more challenging because they mostly concerns costs categories for which there are no market transactions. An inappropriate method needs to be applied to value implicit costs. The valuation of implicit costs is relevant for the following two type farm inputs:

⁶ Which is the case of many developing countries.

- *Valuation of farm owned factors of production (e.g. labour, land, capital):* When the farm is the owner (supplier) of factor used in production, there are no monetary transactions associated with these factors. The opportunity costs needs to be computed for them. The opportunity cost of a factor represents its value in its next best alternative use. For example, a good approximation of the opportunity cost of farm owned land is the market rental price of land.
- *Valuation in-kind farm expenses:* In rural economy transactions are often realised in-kind rather than in cash. For example, this may involve labour exchange between farms or payment of land rent to landowners in form output produced on land (e.g. share tenancy arrangements). The market prices of the in-kind transactions need to be collected to estimate their monetary value.

Valuation of farm owned factors of production

This concerns in particular the valuation of land, labour and capital owned by farm and used in the production process.

Opportunity cost labour

According to Mishra (2012) and following the human capital literature, the opportunity cost of time allocated to family labour is the maximum of the value of a unit time allocated to off-farm work or leisure. The total time is defined in as the sum of farm, off-farm, and leisure time. For off-farm to occur the opportunity costs must be equal to off-farm wage rate and the off-farm wage is an appropriate proxy for the price of unpaid family labour. Further Mishra (2012) notes that skills of family labour needs to be also taken into account when calculating its opportunity cost. In the agricultural productivity literature, unpaid labour is valued at the wage for “similar skilled” workers (controlling for gender, age, education, and occupation). On the other hand, Isermeyer (2011) arguments that a good proxy for opportunity cost of family labour could be the payment that the farmer has to incur for hiring a person who replaces the farmer when (s)he is on vacation.

The valuation of opportunity costs of labour is particularly relevant if CoP data are used for inter-farm competitiveness analysis in particular when comparing the performance of small-scale farms versus large-scale farms. Small farms use predominately family labour while large farms relay predominantly on hired labour. If opportunity cost for family labour is not accurately measured then the inter-farm comparative analysis may result in biased results (Isermeyer 2012).

The most common proxy used to measure opportunity costs of family labour in different countries and methods includes either off-wage of family labour or wage of hired agricultural labour (Table 2).

The ARMS (US) valued unpaid family labour at the hired labour wage rate for all agricultural employees before revision of its methodology in 1995. After switching to the AAEEA task force recommendations (AAEEA 2000), unpaid family labour is valued at an estimate of the off-farm wages paid to farm operators working off-farm. The CONAB (Brazil), Australia and agri benchmark also use off-farm wage as opportunity cost for family labour.

In the Arvalis-Unigrain Observatory (France), the number of hours assigned to an active full-time family labour is 1600 per year which is multiplied by hourly regional labour cost to obtain total family labour cost. Concerning the FADN (EU), the family labour force is remunerated at the level of the regional agricultural labour wage.

In the 50-sg report method (Ukraine), hired labour costs come directly from the accounting, the family labour cost is not valued.

Opportunity cost of land

Conceptually, the opportunity cost of holding land represents current agricultural value of the land multiplied by an appropriate interest rate. This value should be adjusted by other costs associated with land ownership (e.g. property tax and maintenance costs) to obtain total costs of holding land. In practice calculation of opportunity costs of owning land is complex because of variety of reasons in particular related to difficulty to find an appropriate interest rate or to estimate land value if markets are thin (AAEA 2000).

Most commonly applied proxy to calculate the opportunity cost of land is based on rental price information. However, due to the existence of wide diversity of rental contractual arrangements between tenants (farmers) and landowners (e.g. cash rent, share tenancy arrangements) across regions and countries, the approach based on rental price data may not be applicable and an alternative method needs to be used by taking into consideration specific local conditions prevalent in the land market.

Based on the methodology developed by AAEA (2000) for US, several alternative ways to estimate opportunity costs for farm owned land can be applied depending on the market conditions:

- In regions where cash rental markets are well developed, the cash rent paid for land use in agricultural production represents best proxy for opportunity cost of holding land.
- In regions where share tenure arrangements are prevalent, the opportunity costs should be calculated based on these arrangements. The share rental rates needs to be converted to a cash-equivalent value taking in consideration all cash and non-cash payments between tenant and landowner (e.g. the value of production share which landowner gains, landowner contribution to input costs).
- In regions where land is operated predominantly by farming landowners, rental rates are not suitable to be used for estimating land opportunity costs. Instead the opportunity cost should be calculated from market (sale) price of agricultural land by multiplying it with an appropriate real interest rate and adjusting it by other annual land costs (e.g. maintenance costs, property tax).
- In regions where rental and sale markets for agricultural land are not developed, the opportunity cost needs to be estimated based on the cost, yields and returns of land used in agricultural production.

In the ARMS (US), land is valued according to the average cash rental rate by commodity and region (USDA-ERS 2012a). In the FADN (EU), the opportunity cost of the owner-operated land is estimated on the basis of the rent that farm owners would need to pay for renting the land instead of owning it. More specifically, the FADN approximates the opportunity cost of land with the rental rate paid for land renting on the same farm, otherwise if there is no rented land on the farm, the average regional rental rate for the same farm specialization is applied (European Commission 2013). The Observatoire Arvalis-Unigrains, (France) estimates land opportunity costs in similar way as the FADN. The agri benchmark uses regional rental price as proxy for land opportunity costs. The 50 sg method (Ukraine) does not take cost of farm owned land into consideration. This issue is less relevant for the 50 sg methods because it considers

only medium and large agricultural holdings which rent around 99% of land they use (Garnier 2012).

Opportunity cost of capital

The opportunity cost of capital is the expected return forgone by investing in agricultural assets (e.g. machinery, equipment, farm buildings, breeding animals), instead of investing the same sum in alternative investments. In economic literature often it is approximated by the interest rate return that farmers could earn in financial markets.

The ARMS method (US), uses long-term interest on farm assets (e.g. machinery, equipment and buildings) and short-term interest on operating capital (e.g. fuel, repairs). A long-run rate of return to farm assets out of current income (10-year moving average) is used as the interest rate (1.23% for 2001-2010) to estimate the opportunity costs of farm assets. Opportunity costs for the operating inputs is based on the 6-month US Treasury Bill interest rate (i.e. next best "risk-free" alternative return) (AAEA 2000). The agri benchmark applies similar approach as ARMS.

In the FADN (EU), the cost of own capital is estimated based on the return for the equivalent value of capital if invested a bank. Own capital value is estimated as the average value of the assets (closing plus opening valuation divided by two) multiplied by the real interest rate. The operating capital is not valued in FADN (European Commission 2013). In the Arvalis-Unigrains Observatory (France), the cost of capital represents charges on operating capital, machinery and buildings. The 50 sg method (Ukraine) considers the accounting value of interest payments and equity costs.

Recommendations

Several recommendations can be drawn from the experience of CoP methodologies applied in different countries and global networks:

- Family labour: The recommended measure of the opportunity cost for unpaid family labour is off-farm wage for “similar skilled” workers.
- Farm owned land: The recommended valuation of farm owned land is cash rental rate of agricultural land. If cash rental markets are not developed well, then other methods should be applied depending on market conditions prevailing in the region: (i) the cash-equivalent values of the share rental agreements is recommended in regions where share cropping is predominant, (ii) the value based on land sale prices and real interest rate is recommended in regions where land is predominantly owner-operated, or (iii) the value based on estimated net land return is recommended in regions where rental and sale markets are not present.
- Farm owned capital: The recommended measure of the opportunity cost is an appropriate interest rate depending on the type of capital. If the costs are calculated and compared over time, the use of real interest rate is recommended to be applied instead of nominal interest rate.

Table 2: Approaches for valuating opportunity costs of farm owned factors.

	ARMS (US)	50 Sg report (Ukraine)	FADN (EU)	Observatory Arvalis-Unigrains	CONAB	Agri benchmark

Valuation of organic fertilizers	Valuation of the fertilizer units at the market prices	Not purchased organic fertilizers are considered as free	Not purchased organic fertilizers are considered as free	Not purchased organic fertilizers are considered as free		Free or an opportunity cost depending on the area
Family labour	Off-farm wage	Family labour cost not taken into account	Regional agricultural wage of paid agricultural labour	Regional hourly cost calculated for valuation of family labour. An active full-time family worker is equivalent to 1600 h / year.	Off-farm wage	Off-farm wage
Farm owned land	Average cash rental rate by commodity and region	Not taken into account (99% of land is rented)	Land rental price for land renting on the same farm. If no rented land on farm, the average rent for the region and production specialization	Land rental price for land renting on the same farm		Regional rental price
Farm owned capital	Long-term interest rate for farm assets; short term interest rate on operation capital	Accounting value of interest payments and equity costs	Real interest rate for farm assets	Charges on operation capital, machine and building	Long term interest rate	Long-term interest rate for machinery and buildings; short term interest rate on operation capital

Sources: Garnier (2012); Mishra (2012); USDA-ERS (2012a), European Commission (2013)

Allocation techniques

The CoP expenditure on multiple farm activities (e.g. commodities) is common in agriculture. Most farms operate several activities in a given period. Several inputs (e.g. capital, labour) may be shared among different farm activities resulting in joint costs. This concerns mostly indirect CoP which are not identified with a particular farm activity. Direct costs can be relatively straightforwardly associated with a specific activity.

According to AAEA (2000), joint costs may arise for three reasons: (1) expenses incurred for farm activities using a joint technology (e.g. allocation of pasture costs to a calf and cow), (2) expenses for inputs that affect more than one farm activity (with non-joint technology) (e.g. capital related expenses), and (3) expenses for production inputs that are either purchased for the farm as a whole or are used for all production activities undertaken by the farm (e.g. overheads). AAEA (2000) recommends that the allocation of joint inputs should be based on objective criteria reflecting information on input allocations and input levels. If appropriate criteria cannot be identified, the allocation of these costs to specific farm activities should be excluded.

In practice, different allocation techniques are used to allocate joint costs to specific farm activities. The allocation techniques vary by country and method. The two main determinants for

the choice of allocation technique are the type of costs to be allocated and the type of data collected. Some cost types may require simpler allocation formula than others depending on their interlinkage with different farm activities. The type of data collected strongly determines how particular costs can be allocated. For example, the collection of supporting data (e.g. machine hours allocated to different farm activities, input quantities per activity), may significantly improve the allocation of CoP. AAEA (2000) provides lists commonly used allocation techniques:

- Machinery costs (e.g. capital recovery of machinery investment, fuel, lubricants, and repairs): One commonly used method for allocating machinery costs per activity is based on the number of hectares and number of machinery practices used by a particular activity. Second approach often used is based on engineering formulas. However, when machinery are activity specific (e.g., potato harvester), there is no need to apply allocation formula but the associated machinery costs can be allocated to the respective farm activity.
- Buildings (e.g. costs of depreciation, interest, maintenance): Buildings used for specific activity, their associated costs should be allocated to the respective activity. Costs of buildings used to house or repair machinery should be allocated on the same basis as the costs of machinery which utilize these facilities.
- Labour: Allocation of labour costs depends on its use. For example, labour cost associated with operating or maintaining machinery should be allocated using the same basis as used in the allocating machinery costs. Labour costs incurred for specific activity, should be allocated to the respective activity.
- General farm overhead (e.g. accounting and legal fees, general farm liability insurance, otherwise non-allocated labour costs, utilities): Methods often used to allocate these costs is based on the gross value of farm production or on the basis of other allocated costs.

The methodology for cost allocation to estimate commodity costs in ARMS (US) is summarised in Table 3. In ARMS, direct costs (e.g. fertilizer and chemicals, feed) are collected per commodity directly from farmers and thus do not require an allocation technique to be applied (i.e. direct costing). Certain inputs for which monetary transactions are not available (e.g. homegrown seed and feed) are distributed based on similar approach as in the case of direct costs. However, to obtain their monetary value survey data on the physical quantities are combined with secondary data on input prices. The allocation of indirect costs is based on the combination of survey information on production practices, technical information on machine performance, and engineering formulas determined from machinery tests. These costs are computed for tractors, trucks, field machinery, the irrigation and drying equipment used in crop production, as well as the housing, feed storage, and manure handling equipment used in livestock production. The allocation of the whole-farm expenses to specific commodities is based on their share on the total farm operating margin (value of production less operating costs) (USDA-ERS 2012a).

The agri benchmark uses a top-down approach for cost allocation. First, total costs are split in commodity direct costs and the whole-farm costs or costs incurred for multiple commodities. The whole farm costs/ costs incurred for multiple commodities are split to commodities based technical coefficients (e.g. labour/machinery hours) or return shares. Fixed costs such as labour cost and machinery is allocated either by direct costing method (when data available by commodity), by using technical coefficients or by return shares. Overheads cost is allocated base

on return shares. The direct costs (e.g. fertilizers, feed) are allocated to commodity on which they have been spent (agri benchmark 2011).⁷

In the CONAB (Brazil) the cost values per commodity are obtained by multiplying the matrix of technical coefficients by the vector of factor prices. The technical coefficients are established by the panel of experts composed of CONAB experts, farmers, trade unions, academics, representatives from financial institutions and, input suppliers and other relevant agents. Secondary data sources are also be used (particularly for input prices) to complement the data collected through the panel meetings (CONAB 2010).

The ARMS, the agri benchmark and CONAB rely on a significant amount of costs and costs related data (e.g. technical coefficients) collected at commodity level. A different approach is followed by the FADN (EU). The CoP data collected under the FADN are aggregated at farm level and are not disaggregated per commodity (including direct costs). This requires application of an allocation technique for all cost types covered by FADN. The European Commission has developed several models to estimate CoP for the different commodities: arable crops, milk and beef, and permanent crops. These models allocate farm costs to a specific commodities based on the output shares for crop commodities and livestock units for animal products (European Commission 2013). On the other hand, the FACEPA (Farm Accountancy Cost Estimation and Policy Analysis of European Agriculture) has developed allocation technique based econometric tools and methods to calculate the FADN production costs to specific agricultural commodities (FACEPA 2011).

Table 3: Approaches used to estimate commodity costs in ARMS (US).

Direct costing	Valuing input quantities	Indirect costing	Allocating whole-farm expenses
<i>Crop commodities</i>			
Purchased seed	Homegrown seed	Fuel, lube, & electric	General farm overhead
Fertilizer	Manure	Repairs	Taxes and insurance
Chemicals	Unpaid labor	Capital recovery	
Custom operations	Land		
Hired labor	Operating interest		
Purchased water	Ginning		
<i>Livestock commodities</i>			
Purchased feed	Homegrown feed	Capital recovery	General farm overhead
Feeder animals	Grazed feed		Taxes and insurance
Vet & medicine	Unpaid labor		
Bedding and litter	Land		
Marketing	Operating interest		
Custom services			
Fuel, lube & electric			
Repairs			

Sources: USDA-ERS (2012a)

Recommendations

⁷ The IFCN uses similar approach.

A recommended best approach would be to collect as many cost positions as possible at the considered unit of observation (e.g. at commodity level). Joint costs should be allocated to the unit of observation based on objective criteria. The data collected through survey can be supplemented by various technical information (e.g. machinery performance) and additional supporting data (e.g. input prices) to be used for allocation of joint costs. However, if objective criteria are not available the joint costs should be excluded and should remain unallocated.

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