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Introducing Direct Costing and Activity Based Costing in a Farm Management System: a conceptual model

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Abstract

We present the model of a new information system for agribusiness management that supports Direct Costing and Activity Based Costing methodologies. We conducted interviews with key-informants to evaluate their needs and identify the information requirements for the introduction of structured cost management approaches in a Farm Management Information System. The paper presents a viable design of the system supported by a working prototype and a set of reports for farm decision makers. This system offers precise information about crop costs, with general costs allocation procedures based on the consumption of activities, and enables sensitivity analyses.

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Keywords: farm management information systems; direct costing; activity based costing; conceptual model; data flow diagram; entity-relationship diagram

1. Introduction

Farm Management Information Systems (FMIS) are the subject of growing attention in research since they can benefit from recent technological developments in terms of new Web-based services and Precision Agriculture (PA) technologies [1]. Nevertheless, large part of the interest is on the interfaces between FMIS and machines, operators, and PA devices, and there is a consistent lack of attention on how the large amount of data is processed to support farm management [2]. In particular, cost analyses appear not particularly developed in actual FMIS. Costs are central elements in managerial decisions and especially in complex organizations that typically manage several

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products in the same production facility, such as farms: the appropriate allocation of general costs to products impacts the way in which products economic performance are interpreted and reported. Therefore, we propose a model of a FMIS that introduce modern approaches to manage costs in farm businesses: Direct Costing (DC) and Activity-based Costing (ABC) approaches.

The aim of this paper is to identify the information requirements for the development of a DC and ABC in a FMIS.

In the next sections, we review relevant literature about FMIS, DC, and ABC approaches. Then, we depict the methodology applied in defining the model with the involvement of key-informants from agribusiness. Finally, we propose the results explaining the design of the model of the system with diagrams to highlight data structure and data flows.

This study is part of the on-going EU ICT-AGRI ERA-NET research project "RoboFarm", funded by the Italian Ministry of Agriculture, Food and Forestry Policies, which aims at combining ICT, sensors, and Robotic technologies to develop an evolved FMIS for farm management.

2. Theoretical background

Research about Farm Management Information Systems has raised a growing interest in recent years, for agricultural activities have become more and more complex and decision-making activities need to be supported by a larger amount of information. Despite many farmers are still used to carry on analytical activities by using pen and pencil, the information processing workload has become higher and higher [2], thus creating a strong pressure on farm managers to adopt IT solutions. The advent of Precision Agriculture (PA) further increased the need to analyze sparse and different types of information. Moreover, the management of information and decision making are now core issues in developing successful PA applications [3]. Research about FMIS has developed rich framework to address the data management issues of modern agriculture and PA applications. We review the core findings of this literature in Section 2.1. Then, in Section 2.2, we focus on the specific applications of DC and ABC in agriculture, depicting the open questions in research and the subject of this study.

2.1. FMIS development

Many research efforts have been spent in systematizing the framework of FMIS, because that class of systems addresses the specific attributes of farms: presence of biological processes, fixed supply of land, small company size, weather forecast and perfect competition [3,4]. In this context, substantial improvements have been made in terms of machinery performance monitoring, collection of site specific data [5], but there is a relevant gap "between the acquiring of such data and the efficient use of in agricultural management decision making" [2]. Special attention has been devoted in defining the information flows with detailed data-flow-diagrams [5], data streams related to different processes [6], architectural designs for the information systems [1,7], conceptual models and functional requirements for future FMISs [2,3,8].

In this rich context, we focus on the data processing systems oriented at decision making support with specific cost analysis approaches. Many information flows can become the input sources for specific cost analyses and support a more conscious decision making process. The development of an FMIS model focused on managerial decisions is a particularly relevant area of investigation, because there is a growing interest in increasing the level of cost control on farm activities. However, currently, the managerial approaches oriented towards this goal developed in other industries have not really gained ground in the agricultural context, yet.

2.2. Direct Costing and Activity Based Costing in farm management

Economic analyses can be significantly improved by the availability of detailed and specific data provided by the new tools and systems adopted in PA. This richness of data needs to be directed through a structured process of elaboration that enables the transformation of raw data into a structured and synthetic form, that conveys the information required in decision making. Crop choices, machinery renewal, the use of external services are some examples of decisions that require the adoption of specific management and accounting tools to set cost comparisons and support decision making. Furthermore, in many cases general costs (e.g.: depreciation of machinery) are not correctly allocated to crops: they are usually allocated considering only the extension of the plots. Although this approach may be useful to evaluate costs where land is the main cost driver and production constraint, nevertheless this approach may lead to significant evaluation errors in managerial choice, for instance favoring complex products realized in small quantities, and disfavoring simpler products realized in large quantities.

To address these issues, two main approaches have been proposed in accounting that support a structured decision making process: DC and ABC. DC is an accounting practice that is oriented at charging variable costs directly to products [9]. ABC is a methodology developed to face the increasing level of fixed costs in the modern companies [10,11]. Allocation of fixed costs to products is complex and ABC "*measures costs and performances of activities, resources and cost objects, assigns resources to activities and activities to cost objects based on their use, and recognizes causal relationships of cost drivers to activities*" [12].

An ABC system is based on the idea that products make use of certain general activities developed inside the company and these activities require some resources to be done. It means that, first, the cost of the resources are allocated to the activities and, then, the costs of activities are allocated to the products (costs objects) using specific activity drivers for each activity. In this way, it is possible to assign overheads to products in a more accurate and precise way. This logic enables managers to have a deeper control on how products or services, brands, customers, channels of distribution, or facilities consume resources and generate costs. Furthermore, this logic fosters the understanding of patterns of resource consumption at the micro level. Managers can have access to a deeper level of information that enables corrective actions directed to the enhancement of revenues, profitability and cost reduction. ABC prevents some distortions related to product cost information that arise from traditional accounting systems where the overheads (indirect costs) are arbitrarily attributed, usually in proportion to an activity's direct cost. Traditional systems create higher distortions when there are sophisticated production structures, with a wide range of products or services that require the assignment of large amount of general costs.

The combination of DC and ABC enables to analyze cost supporting detailed managerial analysis based on a precise view of the cost of the single crop, considering its relative use of machinery and human resources. In agricultural and food literature there is only sparse evidence on cases of application of DC and ABC to farm management. ABC has been applied in case studies regarding different situations: fish processing in Finland [13], fish markets in Taiwan, combined with a linear programming technique [14], sawmilling in Finland [15], winemaking in Spain [16], ornamental plant cultivation in Spain [17]. Only Chrenková [18] proposes a complete framework not depended to a specific business. Nevertheless, her analysis is oriented at defining an analytic framework on Microsoft Excel.

Here, our purpose is to consider the specific information flows required by the use of a combination of DC and ABC in a FMIS. Modern ICT and PA technologies offer the possibility to collect a large amount of data that can be used to set a precise monitoring of costs with a reduced intervention by farmers, since automatic processes could collect large part of the data and perform information processing activities.

In the next sections we detail the model presenting data flows, then we propose a possible architecture of the system, and, finally, we show the reporting functionalities of this application.

3. Analysis and design methodology

To define the requisites of the FMIS module dedicated to DC and ABC we started from the typical procedure suggested in literature: (1) interviews and definition of the activities; (2) measurement of the cost of the activities; (3) definition of the cost drivers; (4) definition of the activity rates; (5) allocation of costs to products and cost analysis [19,20]. We devoted particular attention to adopting a user-centric approach to foster future adoption by decision makers. In the next sub-paragraphs, we describe the phases of our study. According to the first point of the procedure, we conducted interviews to collect opinions from key-users about the managerial decisions they take in their activity and how they can be supported by a structured economic analysis tool. Therefore, we traced DFD diagrams and modeled a system prototype according to point two, three and four. Finally, we defined reports and evaluated the results with key-informants referring to point five. In interviews, we focused on general questions and also on a specific case study. In the next sections we detail these phases.

3.1. Collection of the requisites

To adopt a user-centric approach, we investigated what specific outputs users are going to expect from the system and what data they can provide or can be automatically collected. This is coherent with the need to develop applications that are focused on users' needs and grant more chances of adoption [3]. We conducted a round of five interviews to define the context in which the system is expected to operate, the final cost objects, and a list of activities related to a specific crop: the local production of potatoes with Protected Geographical Indication in the surroundings of Bologna, Italy. We defined with informants a list of activities to give a parsimonious representation of what the main components of variable and fixed costs are. The output of this step is a list of activities, selected according with the 5% rule: if an activity accounts for less of the 5% of the time, it is not relevant and can be aggregated to another one.

3.2. Design of the system

In designing the system, we combined the specifications proposed by users with the information requirements of a DC and an ABC system. We defined DFD diagrams to trace data collection, transformation of data in information, and decision making, according to a structure similar to the one developed in Fountas et al. [5]. A DFD diagram is composed by different elements (processes, external entities, data stores, and data flows) and is part of the Structured Systems Analysis and Design Methodology for designing information systems [21,22]. We also modeled the database using Entity-Relationship diagrams according to Davis and Yen [23] and created a working prototype in Microsoft Access, finally we defined specific reports according to key-informants requests. We validated the design in a meeting with key-users and also with a panel of four experts in agricultural technology.

3.3. Validation of the model and definition the reports

We developed a prototype of the system in a Microsoft environment and we evaluated it in the case study, paying attention to the enhancement of reports, detailing the single analysis that our informants required. We set the parameters of what-if analyses and discussed the impact of the results proposed by the system on their decision making activity.

4. Results

The results of this study include a rich framework related to the system design, with the support of the key-informants we selected. In the next sections, we present the DFD and Entity-Relationship (E-R) diagrams, the data sources for the application of DC and ABC approaches, and we describe the interfaces and the report section.

4.1. Conceptual model

We designed an outline of the system after having collected the users' requirements during interviews. Interviewees stressed the need of a simple structure with clear procedures to insert data, process information, and analyze results on reports. Therefore, referring to Fountas et al. (2006), we developed a DFD diagram, reported in Figure 1, to show the main structure of the system. The diagram is divided in three parts: data collection, information processing and decision.

The data collection section is designed to support the transfer and recording from machines and equipment, human resources, service providers and warehouses. The effort is to record the majority of costs as direct costs on specific activities on a single crop. Therefore, for machines, human resources and service providers, costs are measured in terms of time spent in a specific activity. Material usage is measured in terms of used quantity.

These data are collected in specific tables of the database: Figure 2 reports the core elements of the system design showing a limited portion of the complete E-R model, which counts about 50 tables.

Once data are collected, the system allocates direct costs to the crops as shown in the Information part of the diagram in Figure 1. General costs need to be allocated according to an ABC procedure. Therefore, the system collects data about resource usage. The E-R diagram in Figure 2 shows the specific tables devoted to monitor resource usage collecting data from the field. These raw data are combined with activity drivers defined in the setup of the system to generate activity rates and allocate general costs to single crops.

4.2. ABC development

In order to allocate general costs to crops and final products, after the identification of the activities, an activity driver needs to be identified for each activity. The choice of the activity driver needs to be consistent with the use of the underlying resource. In other words, each time the activity is performed, it should generate the same consumption of the underlying resource and the same amount of costs [10,19].

For each activity, it is necessary to calculate the activity rate, which is the unitary cost of an activity. The activity rate is calculated by dividing the overall cost of an activity by the overall volume of the activity. It is a common practice not to use at the denominator the overall volume of an activity, but the overall capacity of the resource. The denominator presents the maximum volume that would be possible to do with the resources assigned to the activity.

Table 1 shows the specific activity drivers we defined for the different types of resources. According to the request for simplification, we measured resource usage mostly in terms of duration according also with the recent formulation of Time-Driven ABC [24]. We report also some viable alternatives that can be considered in the setup of the system.

The final step of the procedure is the allocation of the cost to the products. The allocation for each product unit is calculated by multiplying the activity rate by the quantity of activity required by the unit of product. This is done for every activity. The overall cost of the product is the sum of the allocated costs plus the direct costs.

4.3. Interfaces and reports

Large part of the data required to run the system can be acquired using automated technologies or very structured approaches. We present some examples in the last column of Table 1. The system is designed to be hosted in a cloud-based system, that makes it accessible from different locations and also on the field. The design of interfaces to devices and tools goes beyond the objectives of this study, but the design of the system using SQL language in a Microsoft database allows a vast range of compatibility. In our prototype, we developed forms to insert data, manage information, and generate reports.

In the definition of reports, we devoted particular attention to the requirements set during interviews. They asked for a cost control interface for the different crops of their farms: they were interested in understanding the impact of general costs on the different crops, allocating them not on the basis of the land surface area only, but on the basis of the complexity of the production cycle. They also asked to perform simple simulations in terms of what-if analyses related to variation in selling prices, cultivated extensions, production per Ha. Combining these requirements, we designed a reporting system on Microsoft Excel linked to the database to reduce complexity and compatibility issues and leave the possibility of personal customization on reports. We combined a balance sheet designed to offer decomposed data per single crop, with a set of different what-if analyses.

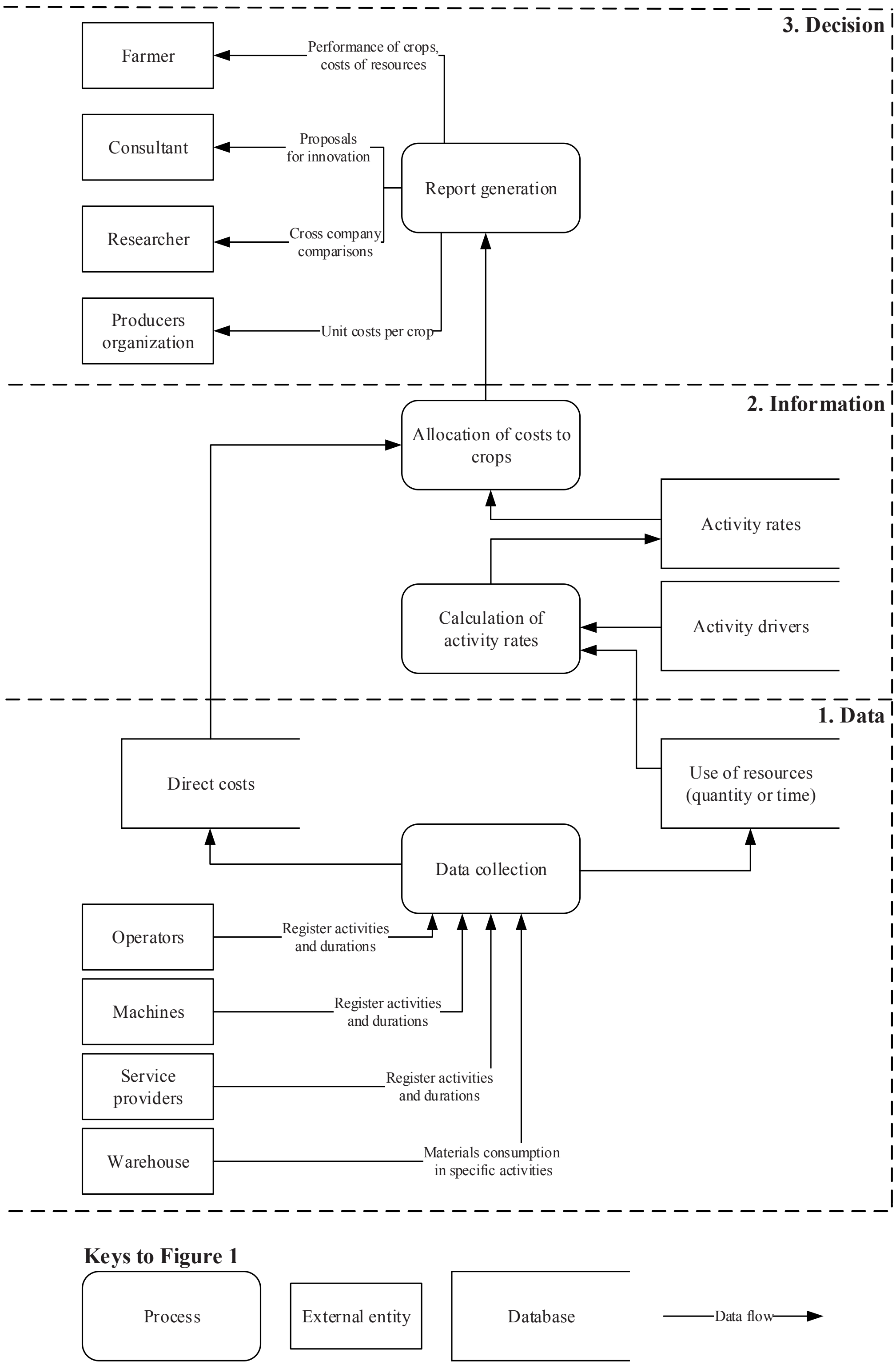

Figure 1. DFD of the system.

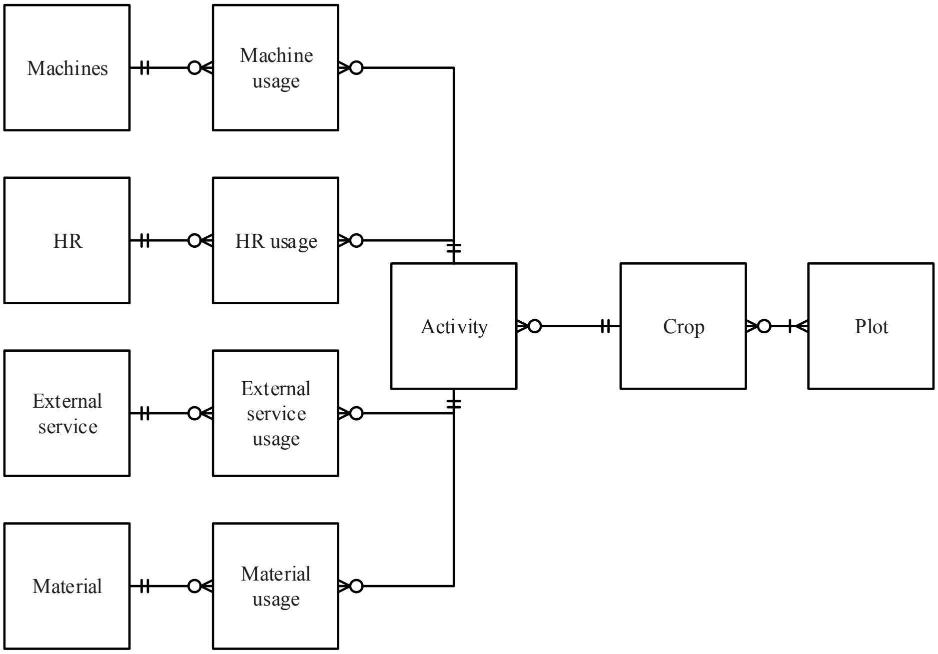

Figure 2. E-R diagram of the system adopting Crow's Foot notation [23]

Table 1. Data required by the ABC system.

Type of resource	Resource examples	Possible activity drivers	Measurement tool
Machinery	Tractor	Time	Data from the machine
		Fuel consumption	ISO BUS (starting time, ending time, rpm per minutes)
			Level control
		Maintenance	Cost per maintenance
Human Resources	Farmer Employee Seasonal worker	Time	Manual
			Badge
		Quantity or number of final products	Number of final products
		Path (meters) per field (crop)	GPS per person associated with a plant of the crops per period
			GPS per person (measures time and the entry/exit from a field)
Material	Not reusable material	Quantity	Machine ISO BUS (to be developed)
Service	Any service	Time	GPS Manual
		Upfront cost	Single cost of the service

5. Discussion

The results of this study open the possibility to introduce an application of the most recent systems for cost accounting (ABC and DC) in the growing literature about FMIS. We go in the direction of offering a significant support to the information processing phase in agricultural management. Moreover, we build on the existing conceptual models [2] proposing a model of the design of an FMIS economic module.

In our interviews, informants suggested to combine simplicity with a structured approach to provide farmers with a limited number of choices and the access to a platform that does not require sophisticated hardware and software investments.

A further contribution of this study is to offer a model that addresses cost management in FMIS. Many software houses are introducing cost analyses in their products, but in some cases they introduce custom approaches without referring to the solid guidelines of management theory. This framework can constitute a reference for developments compliant with the DC and ABC approaches.

6. Conclusions

As part of the literature about FMIS design and introduction, we focused on cost control, investigating the information needs related to the introduction of DC and ABC approaches in farm management with the support of a dedicated information system. We analyzed through interviews the requirements of farm managers and we combined them with the information needs of a DC and ABC application. The conceptual model is detailed with a DFD and a E-R diagram. We developed a prototype of the system along with a set of reports that introduce a detailed view of costs per crop, allocating general costs. Finally we designed what-if analyses to enable a satisfactory decision making process. The next steps are the introduction of the system in a cloud-based application linked to machines and operators. We identify two areas of further investigation. First, the interface with tools and machines can be designed to support an automatic process of data collection. We consider that a staging area that consolidates data before introducing them in the database is a solution that protects from erroneous recordings and incomplete transmissions, still reducing the data input workload. Second, in the reports section, we look towards the introduction of optimization methods, such as, for instance, linear programming, in the definition of the combination of crops per farm. Farms would benefit from the adoption of a sophisticated decision support system supported by operations research technologies that combines different decision variables.

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