Introducing Activity-Based Costing in Farm Management:
The Design of the FarmBO System

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ABSTRACT

Recent research indicates that farm managers do not rely on adequate informative support in their decision making processes. This paper proposes a model of a Farm Management Information System which integrates the Activity-Based Costing approach. In describing the design and development of the "FarmBO" system, it provides a detailed functional requirement definition and the description of a working system prototype. The solution is designed to show the impact of general costs on the different crops, allocating them on the basis of the production cycle complexity. It includes a report section directly linked to the database which provides crop balance sheets and simulations in terms of what-if analyses. The system allows farm managers to 1) analyze deviations between budgeted and actual costs; 2) compare crop balance sheets across different years; 3) perform sensitivity analyses. This work accounts for prototype validation in two farms and discuss results and possible developments.

Keywords: Activity-Based Costing, Decision Support System, Farm Management Information Systems, FarmBO System, Management

1. INTRODUCTION

In the last few years, new technologies applied on machines and equipment, new Web-based services, and new solutions from Precision Agriculture have proven able to generate large amounts of data that could improve farm management activities (Nikkilä, Seilonen, & Koskinen, 2010). Research on Farm Management Information Systems (FMIS) has proposed many models of information systems oriented towards the integration of multiple data sources, benefiting from the support of new methodologies (Sørensen, Pesonen, et al., 2010) and languages (Papajorgji, Pinet, Miralles, Jallas, & Pardalos, 2010). One of the efforts of this pervasive data collection activity is to enable cost analysis, which is a core part of the managerial decision-making activity. Nowadays, farmers are required to select not only the most profitable crops, but also the right level of investment in machines and the proper use of external services. All these decisions relate with cost analysis. Although agricultural

practice may look simple, farms are complex organizations which produce several products and a large part of the costs are indirect with respect to products. A long-standing problem is connected to the use of different procedures for the allocation of indirect costs to products and their impact on how the economic performance of products is reported and interpreted.

Surprisingly, current commercial FMIS present highly customized approaches towards product costing, and the existing literature has dedicated less attention to the design of cost analysis procedures. Furthermore, the great availability of data is not complemented by new developments in the elaboration phase (Sørensen, Fountas, et al., 2010): FMIS research remains focused on connecting new devices and stakeholders rather than on transforming heterogeneous data into useful information for farmers. In particular, cost analyses appear not particularly developed in FMIS. The current approaches tend to rely on parametric estimations of costs or on very specific approaches not validated in common managerial research and practice. Since indirect costs (e.g.: machine depreciation) are becoming the most important part of total costs in agricultural practice, their allocation plays a pivotal role. This is a classic problem in industrial accounting, and Activity-Based Costing is a well-known approach for allocating indirect costs to final cost objects, be they products, services or clients. Activity-Based Costing allows a part of the indirect costs proportional to their real use of the resources which originated those costs to be allocated to the final cost objects. Nevertheless, in agricultural research less attention has been focussed on this topic, and the few existing studies cover a limited range of applications and are related to a punctual use of Activity-Based Costing approach rather than to a broad definition of a systematic approach supported by an FMIS.

Hence, the possibility of integrating Activity-Based Costing procedures in an FMIS model is still questioned. The aim of this paper is to propose a model of FMIS which integrates Activity-Based Costing procedures. In this study, we present the development of the Farm-BO system (the name comes from a contraction of Farm and University of Bologna), starting from the collection of functional requirements; we then describe the design aspects; finally, we show the reports produced by the system. FarmBO was tested in two validation cases, where it provided detailed support in understanding the cost of final products, comparing crops and performing crop choices in a farm.

This paper is structured as follows: first, the relevant literature about FMIS and Activity-Based Costing applied in farm management is reviewed. Second, the methodology applied in designing the FarmBO system, the functional requirements and the database model are presented. Then, the potentialities of the report section are shown. Finally, the advantages of introducing Activity-Based Costing procedure in FMIS are discussed.

2. THEORETICAL BACKGROUND

In recent years, the development of new technologies on machines and equipment has led to the generation of a large amount of data from the field. The information processing workload is increasing (Sørensen, Fountas, et al., 2010), and this stimulates the adoption of IT solutions in farms. Moreover, the introduction of Precision Agriculture technologies poses new challenges, requiring FMIS to process large amounts of raw data from multiple and dispersed sources (McBratney, Whelan, Ancev, & Bouma, 2005; Zhang, Wang, & Wang, 2002). The panorama remains very articulated: a vast group of farmers do not rely on IT technologies either for their day-by-day activities or for their decisional processes, but another smaller group is more oriented towards new technologies, not only related to machinery or equipment, but also devoted to information processing and decision support. While many software houses are incorporating cost analysis functionalities in their products, in many cases their solutions do not propose validated accounting approaches. Research about FMIS has developed a rich framework to address the data management issues of modern agriculture and PA applications. In this section,

we review the core findings of this literature and we then focus on the specific applications of Activity-Based Costing in agriculture.

2.1. FMIS Development

Due to the increasing need to process large amounts of data, FMIS literature has shown a considerable growth in the number of researchers dealing with this issue. Research efforts have addressed conceptual models and functional requirements for future FMISs (Sørensen, Pesonen, Bochtis, Vougioukas, & Suomi, 2011; Sørensen, Fountas, et al., 2010; Sørensen, Pesonen, et al., 2010), architectural designs for the information systems (Nikkilä et al., 2010; Voulodimos, Patrikakis, Sideridis, Ntafis, & Xylouri, 2010), information flows (Fountas, Wulfsohn, Blackmore, Jacobsen, & Pedersen, 2006), data flows related to different processes (Nash, Dreger, Schwarz, Bill, & Werner, 2009).

FMIS represent a particular class of information systems which combine the specific needs of farms with database architectures and information management technologies. The presence of biological processes, a fixed supply of land, small company size, weather forecast and perfect competition are some of the specific features that differentiate farms from other companies (Kay, Edwards, & Duffy, 2011; Sørensen, Pesonen, et al., 2010). Considerable efforts have been made to evolve the FMIS, leading to new approaches to machinery performance monitoring, and collection of site specific data (Fountas et al., 2006). Furthermore, the specific needs of Precision Agriculture pose new challenges to FMIS. For instance, Geographic Information Systems (GIS) require appropriate designs (Nikkilä et al., 2010) and some new developments converging with this direction, as shown in the case of the vineyard zone definition proposed by Acevedo-Opazo et al. (2008). Nevertheless, as reported by Sørensen, Fountas, et al. (2010), many scholars point out that "automatically collected data or data by manual registration is not used due to data logistic problems, leaving a gap between the acquiring of such data and the efficient use of this in agricultural management decisions".

Our contribution is aimed at addressing that gap, proposing an FMIS prototype which supports Activity-Based Costing procedures in order to improve farmers' decision-making processes.

2.2. Activity-Based Costing in Farm Management

The introduction of the Activity-Based Costing approach can lead to improvements of managerial activities and decisions in farms. Allocation of fixed costs to products is complex and, as mentioned before, may be tricky, leading to major errors in product cost assessment, profitability analysis and in other areas of management decision making. Activity-Based Costing is a sophisticated methodology for allocating fixed costs to final cost objects, for instance products. The introduction of Activity-Based Costing was due to the increasing level of fixed costs in modern companies (Cooper & Kaplan, 1988; Johnson & Kaplan, 1987). Activity-Based Costing "*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*" (Dierks & Cokins, 2000). The Activity-Based Costing approach is based on the idea that the development of final products requires the use of resources (e.g.: machines, human resources, materials). Usually, resources generate fixed costs, which need to be charged to products. Activity-Based Costing requires costs to be allocated first to the activities that generated them; second, to the products that required those activities. According to Ferreira (2004), an Activity-Based Costing system is composed of two critical processes. The first is the Resource-Activity Assignment Process, which measures the resource consumption generated by the different activities performed in the company, with a high level of granularity. The second is the Activity-Cost-Object Tracing Process, which measures which activities are required by products (or final cost objects) and allocates the corresponding portion of costs.

In conventional approaches, fixed costs are allocated to final products using an allocation base such as crop extension, or the value of final products, which can lead to significant misrepresentations of final product costs. While traditional approaches may be useful to evaluate costs where land is the main cost driver, they may lead to significant evaluation errors when there are strong differences in the complexity of the products: simple products realized in large quantities receive a large portion of costs in comparison with complex products realized in small quantities. Therefore, simple products could appear less convenient than complex products.

The adoption of Activity-Based Costing systems is still particularly limited due to the high quantity of data needed for their application. Anthony, Hawkins, & Merchant (2010) propose some data about Activity-Based Costing adoption in the world: 6% of companies in the United Kingdom have adopted Activity-Based Costing systems; 36% of USA companies; and 12% in Italy. Abusalama (2008) classifies implementation issues or difficulties into three main types: "technical", "behavioral" and "systems" barriers. Examples of "technical" barriers are: difficulties in identifying activity centers, identifying cost drivers, and assigning costs to activities. Examples of "behavioral" barriers are individual issues, such as lack of senior management support, lack of suitable accounting staff, and internal resistance. Examples of "systems" barriers are inadequate hardware and software, and data collection difficulties. Finally, Cinquini et al. (2008) point out some critical aspects related to Activity-Based Costing implementation: the introduction of an Activity-Based Costing system requires (1) the change of the cost structure in which the overheads allocation requires sophisticated processes, (2) the design of a more accurate cost measurement system, (3) the design of more analytic product costing tools. In other words, the size of the company and its organizational structure can affect the feasibility of the introduction of an Activity-Based Costing system, because it requires a considerable set up effort.

Research studies on Activity-Based Costing applications in the farming and food processing contexts are limited: fish processing in Finland (Setala & Gunasekaran, 1996), fish markets in Taiwan (Lee & Kao, 2001), sawmilling in Finland (Korpunen, Mochan, & Uusitalo, 2010), winemaking in Spain (González-Gómez & Morini, 2006), ornamental plant cultivation in Spain (González-Gómez & Morini, 2009). Finally, Chrenková (2011) proposes a complete framework, without reference to a specific business, but her analysis based on a Microsoft Excel sheet is not supported by an FMIS.

Despite the paucity of research and applications, Activity-Based Costing offers the considerable advantage of improving decision making processes, providing a reliable method to process the wealth of data collected from the field, also with the aid of Precision Agriculture technologies. Farmers face many complex decisions, ranging from crop choices to machinery renewal and the use of external services. In many cases, indirect costs play a pivotal role in a decision, as more and more activities are completed using expensive equipments. If cost allocation procedures return a misleading representation, the company is more exposed to risks.

Applying Activity-Based Costing, farm managers can achieve greater control on the consumption of resources and improve their decision-making processes. Furthermore, the accounting process itself can be positively influenced. The scope of the Activity-Based Costing system allows fine and accurate adjustments to be made to the company cost structure, reducing overhead costs (Cooper & Kaplan, 1988).

The possibility of improving farm management activity providing a solution which integrates Activity-Based Costing triggered the development of the FarmBO system, as detailed in the next sections.

3. DESIGN AND DEVELOPMENT OF THE FARMBO SYSTEM

The development of the FarmBO system started with a detailed functional requirements definition phase. We then proceeded to develop a

working prototype of the system. Finally, we validated it in two farms. The next subsections present this development process.

3.1. Functional Requirements Analysis

In this stage, the typical procedure suggested in accounting literature for the introduction of Activity-Based Costing systems (Anthony, Hawkins, & Merchant, 2010; Rafiq & Garg, 2002) was combined with the usual steps of IT systems development and adapted to the case of farming activity. We conducted interviews with different key users and stakeholders to collect their opinions about the managerial decisions farmers need to take in their activity and how they can be supported by a structured economic analysis tool. Since the likelihood of adoption is influenced by the coherence of the tool with the users' needs (Sørensen, Pesonen, et al., 2010), we conducted two rounds of interviews with a group of four farmers, who operate in Northern Italy, and we designed the initial data flows referring to the production of potatoes. We then traced the core functions of the system and its main elements. Therefore, we expanded our analysis by collecting the opinions of twelve farmers and technicians from three countries (Italy, Greece and Turkey). We focused on the specific outputs users are going to expect from the system. Furthermore, we compared the data provided manually by users with the data that could have been automatically collected. Finally, we developed four use case groups to describe the development phase of the system prototype according to common guidelines about use case modelling in UML language (Cockburn, 2001; Phillips, Kemp, & Kek, 2001; Rosenberg, & Stephens, 2007). The first use case group, reported in Figure 1, presents the planning activities which farmers usually conduct to decide which crops they are going to cultivate in their fields. These activities span from a simple crop selection and assignment (use case 1.1) to more advanced decisions, which can be anticipated at this stage: definition of crop cycles (use case 1.2), assignment of resources to activities (use case 1.3), and definition of budget costs related to the activities which are going to be conducted on each crop (use case 1.4). More complex activities always include simpler activities from use case 1.4 to 1.1. In these preparatory activities, the farmer can be supported by an agronomist who helps in selecting the best crops, setting up the production cycles, and defining the budget costs. The cases are represented in grey background colour because they require human interaction and decision-making.

Figure 2 shows the use cases regarding the day-by-day activities conducted by the farmer, who is required to record the use of resources. The general case 2.1 can be specialized showing how its "children" are differentiated. Four different types of resources have been identified: human resources, machines and equipment, materials, and external services. The main task of the farmer is to record the consumption that activities make of resources. In general, it is a time-based consumption (in use cases 2.1a, 2.1c, 2.1d), which is quite easily measurable (Kaplan & Anderson, 2007). Use of materials is based on quantity variations as in use case 2.1b, e.g.: level of tanks or other containers. Moreover, machine use generates fuel costs, which is a case linked with an Include relationship because it can be performed when a machine is linked with a specific activity (use case 2.2). An automatic system could be particularly useful to measure fuel consumption. Moreover, all the use cases are in blue background colour to show that they could be supported by automatic systems for recording time or material consumption.

During the on field activities, the planned activities may, for some reason, have to be changed or cancelled, or some new activity may be needed. Therefore, the system should support these unexpected procedures in which a technician or an agronomist is likely to advise the farmer (use case 3.1, 3.2, 3.3). In the three conditions shown in Figure 3 (insert, modify, and delete an activity), the (re)definition of resources associated with the activity (use case 3.4) is required, along with a budget reformulation (use case 3.5). Moreover, use cases 3.4

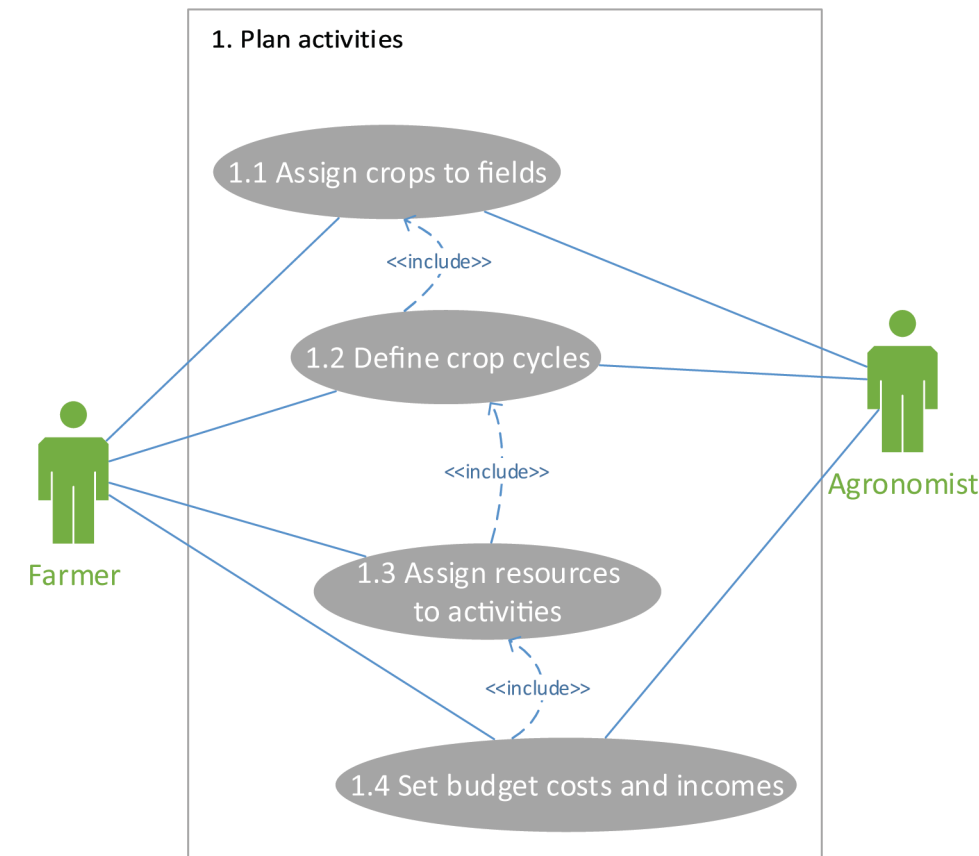*Figure 1. Use cases about initial set up of the system*

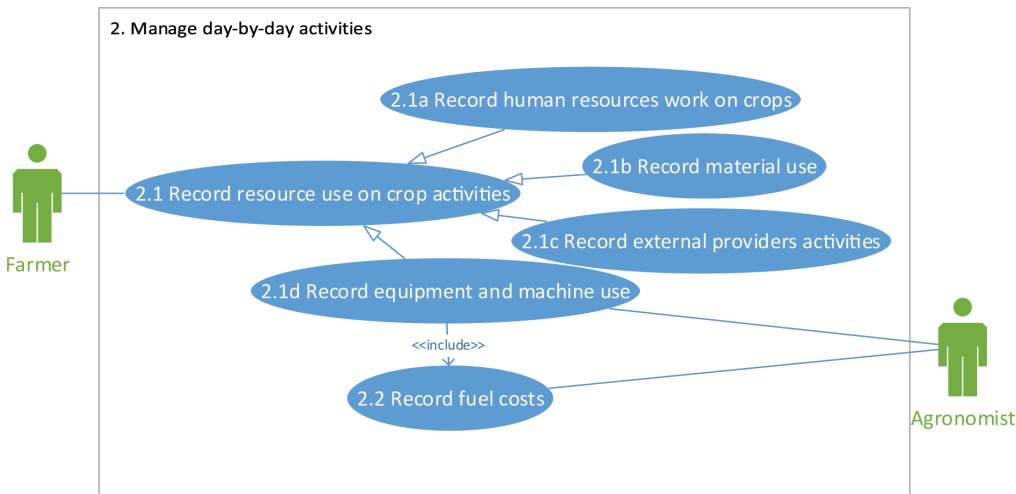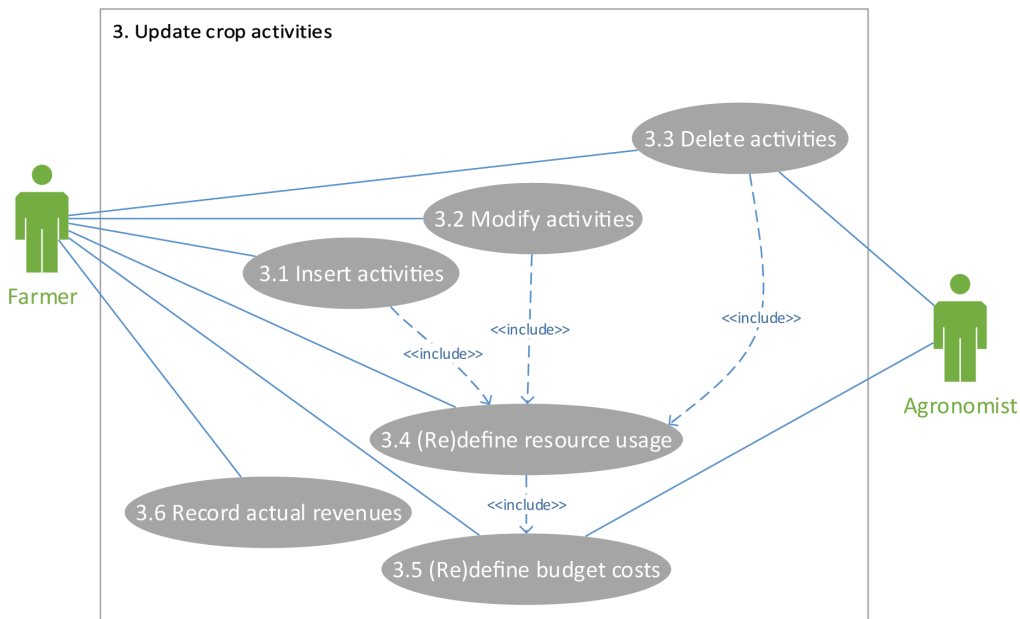*Figure 2. Use cases regarding day-by-day activities management*

Figure 3. Use cases regarding activity updating

and 3.5 can happen independently from the previous conditions, for different reasons (e.g.: the decision to switch from internal machines and human resources to an external provider of services, or vice versa). Use case 3.6 is about actual cost recording.

Figure 4 proposes the use case regarding the decisional phase, which is the most complex functional area supported by the FarmBO system. With the support of an agronomist, the farmer allocates indirect costs (use case 4.1) to activities and crops, according to an Activity-Based Costing procedure, described in the next pages. The allocation encompasses different types of costs: depreciation (use case 4.2), maintenance (use case 4.3), and all the other general costs of the farm (use case 4.4), for instance insurance costs. The farmer evaluates the results of the work carried out during the year and compares the actual outcomes with the budget forecasts (use case 4.5). Costs and revenues variances make it possible to focus attention on the performance in resources management. Comparisons between crops of different years facilitate the choice of future

productions (use case 4.6). The farmer can assess crop balance sheets and crop sensitivity analyses, which are presented in the subsection dedicated to reports. While the generation of these reports is an automated process (use cases 4.7 and 4.8, with blue background), an agronomist is required to validate the output to check their consistency (e.g.: check that depreciation procedures have been set up carefully by the farmer) before making it available to farmers. Decision-making may then become based on structured data from sensitivity analyses (use case 4.9).

3.1.1. Design of the System

In designing the system, the requirements of Activity-Based Costing systems were integrated in internal data management procedures. The relational database was defined adopting a flexible structure. First, all main entities were identified: crops, fields, activities resources (human, machines and equipment, materials, external services). Second, the system was modelled around these main entities, develop-

Figure 4. Use cases regarding decision-making phase
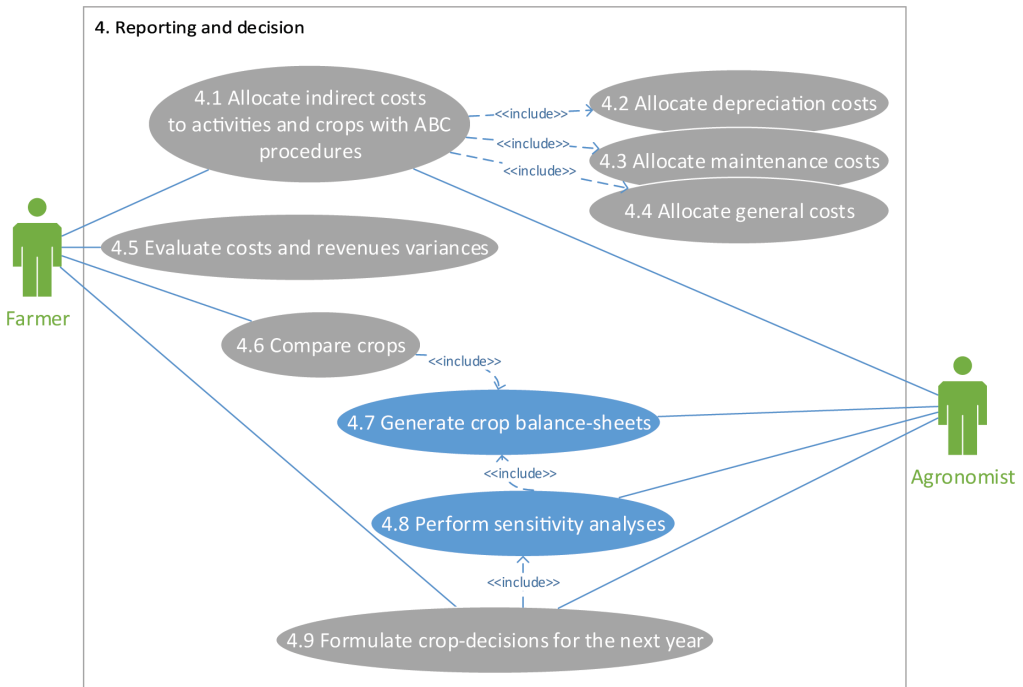
ing the most inclusive solution as possible, to allow extended compatibility with as many data structures as possible, including the automatic outputs from machines. Figure 5 presents the Entity-Relationship diagram with the key entities according to the guidelines and notation reported by Davis and Yen (1998).

Direct costs are recorded in the specific tables which match an activity with a resource per record. Adopting this solution, every cost is linked to both activity and resource. An activity generates the cost due to resource consumption which is then charged to the crop which required that activity. Indirect costs are only linked to resources (e.g.: depreciation), so they are allocated to activities and then to crops using an Activity-Based Costing procedure.

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 drivers has to be consistent with the use of the underlying resource. Every time the activity is performed, it should generate the

same consumption of the underlying resource and the same amount of costs (Anthony et al., 2010; Cooper & Kaplan, 1988).

While we refer to the accounting literature for the details of the Activity-Based Costing procedure, we present the information requirements of Activity-Based Costing implementation and how they are met in the design of the database of the FarmBO system. Figure 5 shows how indirect costs are allocated. Being indirect, they are recorded in tables linked only to the resources (in green in Figure 6).

Nevertheless, when a resource is associated with an activity, this latter uses the resource for a defined amount of time (Kaplan & Anderson, 2007) or according to a different driver. Therefore, in the allocation procedure depicted at the bottom of the picture, the costs linked only to resources are moved to activities and then summed for the four classes of resources which can be used in performing a single activity. This process makes it possible to create a crop balance sheet, which is the topic of the next subsection.

Figure 5. Entity-relationship diagram of the FarmBO system
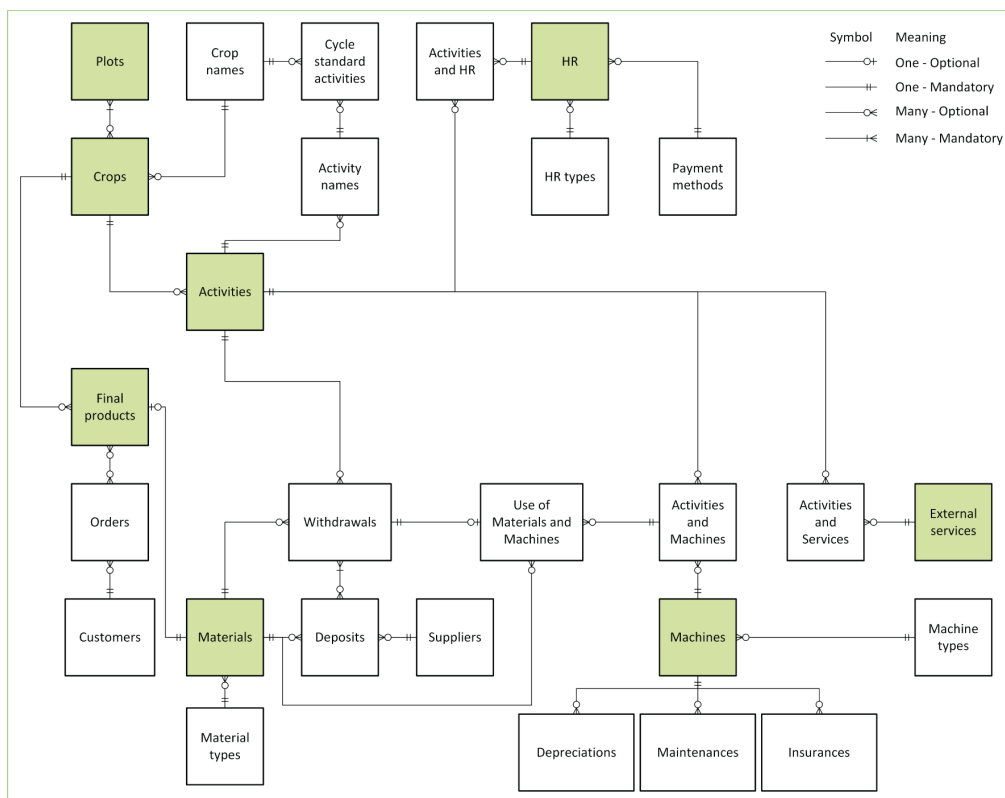
### 3.1.2. System Prototype: Interfaces and Reports

We developed a prototype of the system and we tested it in two validation cases. In this subsection, we present the main results focusing on interfaces and reports.

The prototype of the database was developed both in Microsoft Access 2013 and Microsoft SQL Server 2012. To responsively adapt the interfaces of the system to the user requirements, we designed them in the Access prototype. This choice allowed fast cycles of user-tests and changes of the interfaces. Finally, a mobile solution for data entry was explored adopting the Microsoft LightSwitch technology, which enables the creation of data entry interfaces for both mobile and desktop websites.

The system design also supports automatic acquisition of data or the use of very structured approaches. Modern tractors and machines are equipped with sensors and communication systems. During the activities, sensors record a large amount of data, which can be transferred to the FarmBO system after preprocessing. Human resource activities are still very pervasive in the Italian, Greek, and Turkish farms, as suggested by our informants, therefore we opted for a simple time tracking system which can be semi-automated through the use of badges.

The FarmBO system can be easily converted in a cloud-based solution with the support of modern LightSwitch interfaces. During our interviews, many respondents pointed out that having the possibility to record data in the system while performing the activity on the crop is a key element that can facilitate the system's adoption. LightSwitch language makes it possible to design web interfaces for mobile devices without compatibility issues related to different mobile operating systems,

Figure 6. Allocation of indirect costs in FarmBO system using an activity-based costing procedure
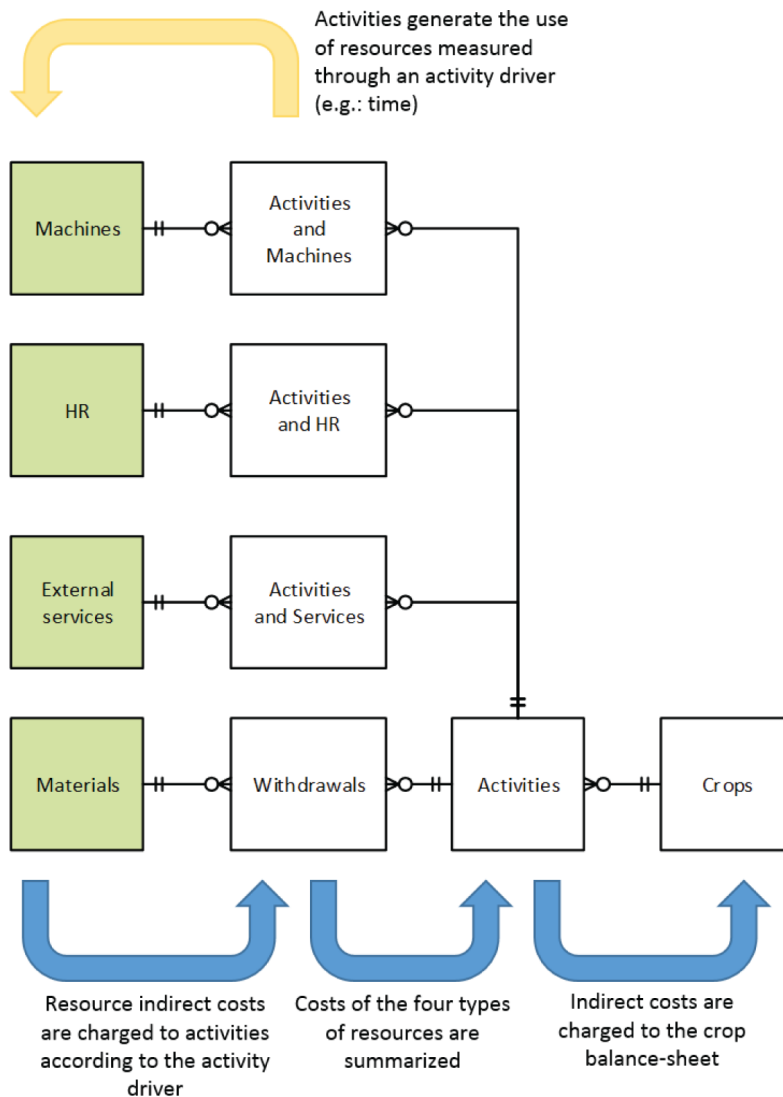
because the system is accessible via a browser. The final model of the cloud-based system is depicted in Figure 7: machines and operators upload data in the system; operators receive guidelines for managing their activities; farmers and agronomists have access to reports about crop performances and what-if analyses.

In the definition of reports, we devoted particular attention to the user-requirements that emerged during interviews. Informants asked for a cost control interface which shows the different crops of their farms. The key point was related to the impact of general costs on the different crops, allocating them not on the basis of the land surface area only, but also on the basis of the complexity of the production cycle. Our informants also requested the possibility to perform simple simulations in terms of what-if analyses related to variations in selling prices, cultivated extensions, and production per Ha.

Figure 7. Model of the cloud-based system
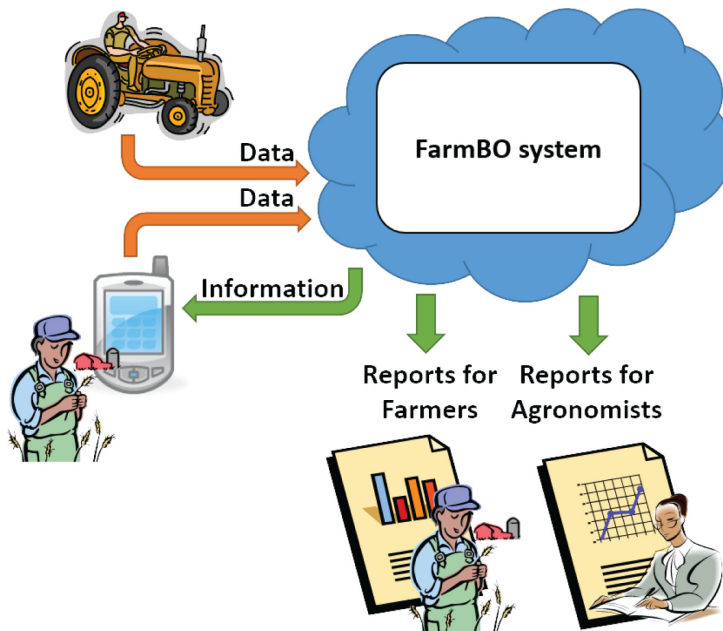
Combining these requirements, we designed a reporting system in Microsoft Excel linked to the database to reduce complexity and compatibility issues and leave the possibility of personal customization on reports. We combined a balance sheet designed to offer detailed information data per single crop, with a set of what-if analyses. The report section is designed in Microsoft Excel to enable farmers and agronomists to work on data. The system offers three main types of analysis. First, it makes it possible to analyze variances between budget and actual costs and identify if they are due to a change in the unit costs or to a change in volumes of activities (e.g.: number of hours, quantity of materials). Second, it traces the crop balance sheet for each crop, supporting comparisons between different crop varieties and different years. Third, it performs sensitivity analyses which are a specific class of what-if analyses which shows how a variable (e.g.: net profit) changes accordingly to the variation of two other variables (e.g.: unity price and produced quantity). This analysis was considered particularly important by our respondents because it

is able to convey straightforward information about the positions of profit and loss and the break-even point at different levels of two exogenous variables.

The FarmBO system was validated in two farms. The first produces four different varieties of potatoes in the countryside near Bologna (Italy), in a land extension of 35 Ha. The second cultivates grain sorghum and wheat in a land extension of 7 Ha. In both cases, the companies tested FarmBO in 2013, recording production cycles and costs on the platform. They evaluated the report section. Figure 8 reports the example of a sensitivity analysis for the production of a potato variety. It shows how the net profit per Ha changes according to variations in unit prices and in land use.

4. DISCUSSION AND CONCLUSION

From both the perspective of research and practice, there is a growing call for improving managerial decision making processes in farms.

Figure 8. Sensitivity analysis of net profits per ha related to production of potatoes

Sensitivity Analysis: Net Profits per Ha of Potato Primura (€/Ha)

Extension (Ha)	Unit Price (€/q)										
	350	375	400	425	450	475	500	525	550	575	600
15	-3653	-3365	-3076	-2787	-2498	-2210	-1921	-1632	-1343	-1055	-766
16	-3384	-3076	-2768	-2460	-2152	-1844	-1536	-1228	-920	-612	-304
17	-3114	-2787	-2460	-2133	-1805	-1478	-1151	-824	-496	-169	158
18	-2845	-2498	-2152	-1805	-1459	-1112	-766	-419	-73	274	620
19	-2575	-2210	-1844	-1478	-1112	-747	-381	-15	351	716	1082
20	-2306	-1921	-1536	-1151	-766	-381	4	389	774	1159	1544
21	-2036	-1632	-1228	-824	-419	-15	389	793	1198	1602	2006
22	-1767	-1343	-920	-496	-73	351	774	1198	1621	2045	2468
23	-1497	-1055	-612	-169	274	716	1159	1602	2045	2487	2930
24	-1228	-766	-304	158	620	1082	1544	2006	2468	2930	3392
25	-958	-477	4	485	967	1448	1929	2410	2892	3373	3854
26	-689	-188	312	813	1313	1814	2314	2815	3315	3816	4316
27	-419	100	620	1140	1660	2179	2699	3219	3739	4258	4778
28	-150	389	928	1467	2006	2545	3084	3623	4162	4701	5240
29	120	678	1236	1794	2353	2911	3469	4027	4586	5144	5702
30	389	967	1544	2122	2699	3277	3854	4432	5009	5587	6164

This contribution addresses these needs by proposing a system which supports Activity-Based Costing and can significantly improve the management of farms. In this section, we discuss the contribution to Farm Management Information Systems literature and we evaluate the benefits of introducing Activity-Based Costing in farms.

Information processing in farms can be significantly improved by introducing structured techniques, which rely on solid managerial approaches and accounting methods. The design of a module that supports managerial decision making processes complements existing solutions (Sørensen, Fountas, et al., 2010), offering the possibility to integrate data from multiple sources.

Key users and informants provided rich insights about how farms can benefit from clear and specific information based on real data, but filtered and summarized with proven and reliable approaches. One main point raised by interviewees was having a system accessible from mobile applications and not hosted on local servers, but in a cloud based environment, to avoid the risks of losing data and the maintenance costs of the server infrastructure in their farms. FamrBO was created to be eas-ily migrated on the cloud: it can be accessed through web browsers also from mobile devices with the same scalable interfaces designed with Microsoft LightSwitch technology. This solution is geared toward offering a flexible FMIS hosted in a cloud-based environment accessible through simple web interfaces, which can be designed using the same language for both desktop and mobile devices.

While many software houses are offering systems which integrate cost analysis, the introduction of highly customized methodologies could expose farmers to the risk that their decisions are not based on reliable approaches. The FarmBO prototype is designed to grant a high level of coherence with the Activity-Based Costing methodology.

Traditional accounting and cost calculation systems are sufficiently accurate when most of the cost items can be easily assigned to a single activity or product; they offer the advantage that they need a relatively low input of information and if the share of overheads is low the allocation errors deriving from a lack of more specific information may be negligible.

However, Activity-Based Costing in farm management is potentially able to provide many benefits, mainly because of the intrinsic nature

of farming as a multi-activity business. This is especially true in situations where the relative importance of durable multi-purpose assets and fixed costs burden is high.

A more reliable, accurate, and timely costing method based on Activity-Based Costing, therefore, would be beneficial to farm managers who need financial information to effectively support strategic and tactical decision-making in several farm management areas, such as crop rotations, introduction of new crops, farming process improvement, investment and disinvestment decisions. Another important area could be product pricing, although for most agricultural firms price is an exogenous variable rather than a variable decided by the manager. However, by comparing market price information and forecasts with a more accurately quantified cost of the single product, the farm manager increases the chances of making the right decision.

Another relevant area where Activity-Based Costing could impact the agricultural supply chain is the possibility for associated farmers organizations (such as cooperatives, consortia, etc.) to better plan their production and marketing activities and to provide more insightful advice to their associates.

A more accurate costing method would also be helpful in supporting the negotiations and decision-making when defining inter-professional agreements between farmers associations and processors and/or distributors. The knowledge of detailed and accurate cost data from the associates through an organization-wide database would support not only marketing and supply chain management, but could also provide background information for the identification of inefficiencies and weaknesses that need to be improved and help the farmer's association to plan extension and support actions addressed to those who need them the most.

An important element which makes Activity-Based Costing on one hand more useful and on the other hand more accessible/feasible to farms and farming-related companies is that agriculture-based businesses are making increasingly intensive use of information in several production and management processes (e.g., for quality management or food safety management purposes).

In addition, farm management is increasingly requiring greater flexibility and adaptation to rapidly changing market conditions; this makes it necessary to avoid under and over-costing situations due to inaccurate allocation of overheads and common costs with concurrent activities, which is a typical problem of traditional costing methods.

As stated before, the high degree of data intensity required by Activity-Based Costing has been (and still is) an important barrier to adoption. However, the evolution of technologies applied to farming can contribute to allow farm managers to automatically generate or recover existing data that may be the source of information necessary to define the cost drivers and to easily and effectively use the Activity-Based Costing approach. There could be many sources of extra-accountancy data, e.g.: software applications designed to support farmers and farm managers to control quality assurance parameters; digital controllers used to verify and record the working conditions of equipment such as tractors, pumps, sprayers and combines; robots and other automatic equipment with portable sensors as well as on-site sensors which are used in precision farming to verify and record several parameters referring to soil, crops, animals and the environment in which they live.

The design of a new farm management information system, therefore, should also include a management oriented accountancy/cost analysis module because this would allow the farm manager to consider key economic variables together with the technical aspects of his activity. In an inverse way, it could be hypothesized that the adoption of precision agriculture tools and techniques could be facilitated if these tools also provide guidance to the farmers in performing an economic evaluation of their activity.

A first direction for future research involves the possibility to introduce a linear programming module in FMIS, which evaluates different combinations of crops, taking into account the boundaries imposed by climate, costs, machines and other resources, and maximizing profits.

A second possibility is the design of an integrated solution between FMIS and machines, defining the interfaces and the communication protocols to support a completely automatic process of data collection. The variety of tools, machines, and equipment along with the differences between standards requires the use of a flexible staging area where data is consolidated and validated before being used in the FMIS. The integration process between data sources and FMIS is a long pathway where standards play a key role in shaping technological developments. In the current embryonic situation, the emergence of new unifying paradigms is still possible. In this context, different business models can be created. One could mirror the android business ecosystem where a flexible and open source platform is coupled with a market where small and big software houses propose their applications.

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