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A model for cost calculation and management in a multiproduct agricultural framework. The case for ornamental plants

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Abstract

The business dynamics of the agricultural sector generally call for a system of calculation and cost management that goes beyond output assessment and profit determination, and coordinates a tool that supports the decision-making process, thus facilitating the evaluation of different cultivation techniques, varieties and so on. Accordingly, this paper proposes using a cost model based on activities for calculating and managing production costs in multiproduct firms in the agricultural sector, using ornamental plant cultivation as a case in point. This particular case may be considered extremely difficult in terms of crop variety and likely destinations for the products (commercialization, self-supply, etc.). Consequently, the proposed model is transparent, flexible, simple to apply and understand, and easily adaptable to the peculiarities of firms in the agricultural sector in general.

Additional key words: activity based costing model, decision-making, multiproduction.

Resumen

Un modelo para el cálculo y gestión de costes en un entorno agrícola multiproducto. El caso de las plantas ornamentales

Las empresas del sector agrícola requieren un sistema de cálculo y gestión de costes que proporcione información más allá de la simple valoración del producto y de la determinación del resultado, sino que se demanda una herramienta conjunta que ayude en la toma de decisiones y facilite la evaluación de la utilización de diferentes técnicas de cultivos o diferentes variedades. Así, este trabajo propone usar un modelo de coste basado en las actividades para calcular y gestionar los costes de producción de las empresas agrícolas multiproductoras, empleando como caso de estudio el cultivo de plantas ornamentales, por considerarlo de mayor complejidad en términos de productos gestionados y destino de los mismos. El modelo propuesto es transparente, flexible, sencillo de aplicar y entender, y fácilmente adaptable a las características propias de otras empresas del sector agrícola en general.

Palabras clave adicionales: modelo de coste basado en las actividades, multiproducción, toma de decisiones.

Introduction

Ornamental plant businesses (nurseries, greenhouses, etc.) develop their activity in a highly competitive environment, which requires ensuring that production costs are rigorously controlled (Guijarro *et al*., 2001). Furthermore the sector is subjected to a seasonal demand and therefore the firms must adjust their production in order to optimize firms' productive capacity by taking into account market demand (especially prices) with the production cycles of each plant variety. This adjustment between supply and demand involves an accurate strategic production planning where the climatology may affect the achievement of the desired balance.

The multiproduct nature of these firms is determined by the crop cycle of the output and by its life span, making it necessary to work with different varieties to optimize firms' productive resources.

Considering the above, it is confirmed the need for a cost management flexible tool, which be easily adapt-

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able to new products and/or cultivation techniques. Indeed, Whipker *et al.* (1998) and Weddington (2003) believe that it is crucial to know and control production costs for a profitable ornamental plant business. A producer who understands and knows these costs is equipped with the best information to decide on the optimum number of plants to produce or the selling price policy. In short, to maintain the firm's success, it is not enough to reap quality harvests, but investment profitability must be ensured. For that purpose, production decisions cannot be based on intuition or experience, but on the rigorous analysis of the productive process, and the costs and income that it generates. This cost analysis facilitates appropriate price setting and the correct evaluation of the firm's stocks, so it will enable a more exact knowledge of profits.

Despite the importance of correct cost calculation in any sector—particularly in those with fiercely competitive environments—efforts made in the agricultural sector are insufficient. Most studies have focused on a single product and have been limited to merely calculating cost per surface area and week, based on accounting data, sharing fixed costs between various crops (according to the area occupied by each) and inadequately monitoring the most important indirect costs (essentially labor costs).

Hence, among the most recent studies that analyze the costs of tree or ornamental plant nurseries are those by Whipker *et al.* (1998), who only study two varieties of ornamental plants; Guijarro *et al.* (2001), who study production in tree nurseries; and Weddington (2003), who studies ornamental plant greenhouses and nurseries, using a full-costing model based on accounting data. There are also studies using the same structure and similar proposals within the framework of ecological agriculture. The most significant were Estes *et al.* (2003), who studied several vegetables, and Juliá-Igual and Peris (2006), who analyzed clementine production costs in Valencia, Spain.

In short, until now production costs of one or two crop varieties that can only be sold in a final stage of development have been studied, using accounting data. In this paper, production costs are calculated in an environment of multiproduction and self-supply, where different crops may be commercialized at various stages of the productive process or pass on to the next stage as semi-finished products for obtaining end products.

So, next section summarizes several characteristics of the studied sector that directly affect the cost calculation process and the model design. In section three, the use of an activity-based cost (ABC) model is defended and its adaptation to the sector under analysis is explained. Sections four and five provide an in-depth study of the practical application of the model proposed in the previous section. And finally, by way of conclusion, the most significant aspects to be considered when processing the most important cost entries are outlined.

Characteristics of the productive process from the perspective of a cost model design

As far as cost calculation and management is concerned, the sector presents four characteristics in its productive system that condition cost model design: nature of output, multiproduction, self-supply, and heterogeneity.

In relation to the first aspect, the control of stocks to fit the supply with the demand is very important, considering the limited span life of some outputs. With respect to multiproduction, it not only requires considering the existence of many different products at different production stages (end, semi-finished or ongoing) at any given time, but also the fact that a single plant variety may be produced using different techniques or by applying different resources. Moreover, the same product may follow the process (larger plant production), be used to generate new products (self-supply) or be commercialized in its current state. Finally, it should be remembered that the productive cycle does not necessarily coincide with the accounting cycle (certain varieties have a production cycle of less than a year, while others need a much longer period).

Despite this product heterogeneity, it can be differentiated three stages common to the production process (see Figure 1):

- *Production of plant material:* plant material (bulbs, seeds or cuttings) can be marketed just so or used for obtaining stock plants; bulbs and seeds are generally purchased externally, while cuttings are produced by the firm itself from a "mother plant".
- *Nursery production (stock plants):* a product midway between plant material and the plant itself, although it may be marketed directly. It may be purchased externally instead of being produced by the firm itself.
- *Plant production*: by using the stock plant as a base, different finished or semi-finished crops are

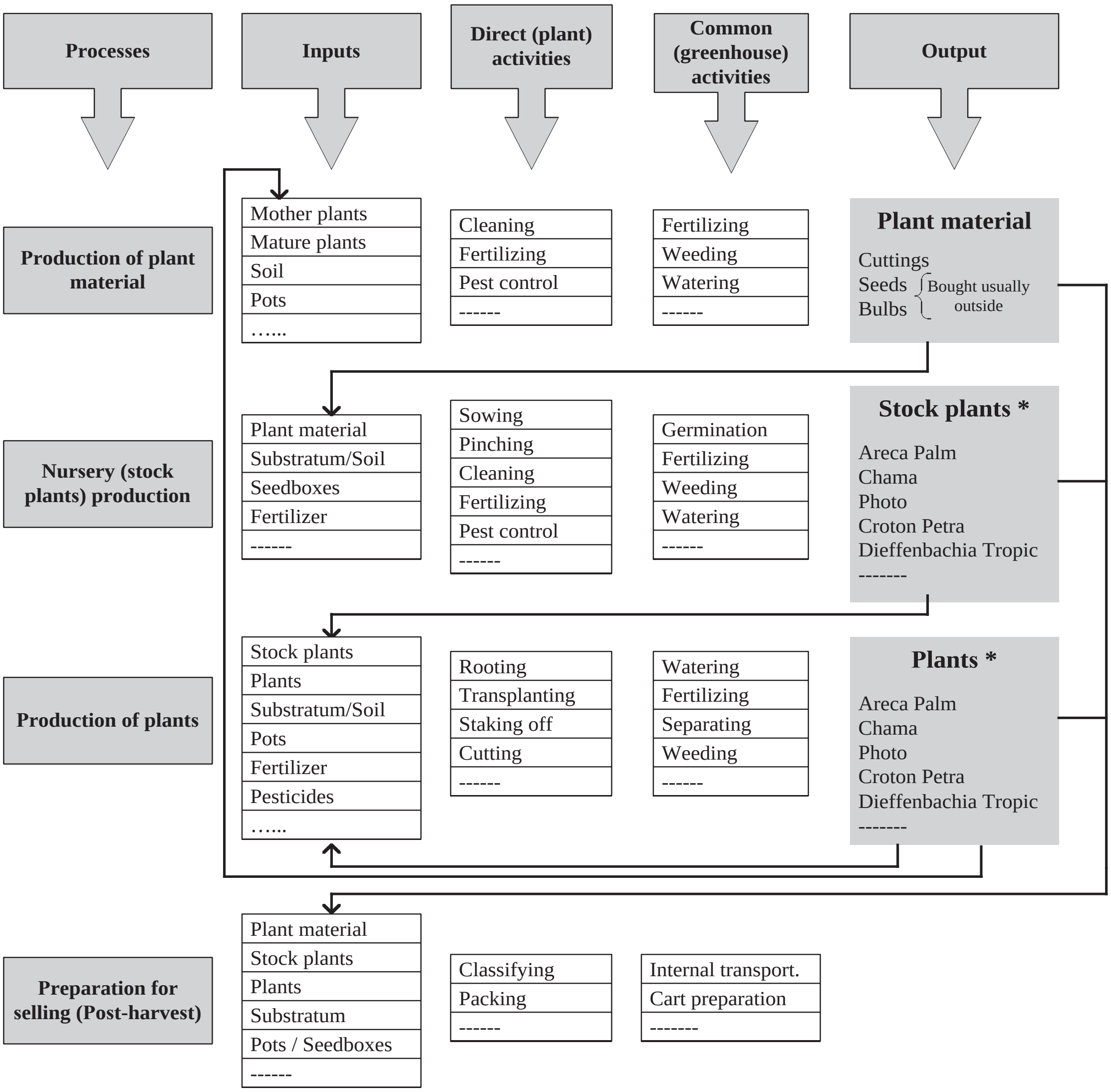

Figure 1. Technical diagram of the productive process. * Areca Palm (*Chrysalidocarpus lutescens* H. Wendland); Chama (*Chamaedorea elegans* Martius); Photo (*Epipremnum aureum* (Linden ex André) G.S. Bunting); Croton Petra (*Codiaeum variegatum* (L.) A. Juss.); Dieffenbachia Tropic (*Dieffenbachia amoena* Gentil). Source: own elaboration.

obtained. In some cases, the crop itself is self-supplied to create a larger format e.g. a 36 cm. Areca Palm pot is an end product and also the basic plant material for a 54 cm. Areca Palm pot, but it may also be used as a mother plant for producing basic plant material.

To sum up, there is a qualitative diversity (multiproduction) of products that consume common productive resources and which it is necessary to assess in order to reach an overall and individual determination of the cost and profit generated, and a suitable information system to back up decision-making related to production planning.

The ABC model and its adaptation to the sector

Justification of the ABC model

In the 1980s, many firms began to realize that their cost models were generating biased information about the costs supported by the company. They began to wonder whether the cost depended on volume, according to traditional methods, or on the existence of activities. For Cokins (1999), traditional models gradually become obsolete when overhead costs increased in weight, market diversity grew, and competition became stronger. As a result of this, it was proposed a new cost model adapted to contemporary production systems where multiple products share common costs.

In this new framework, traditional cost models became increasingly inaccurate because the indirect costs were not caused equally by all the products. Indeed, traditional cost models present a problem when are used to provide information for management decision: only production volume related measures are used to allocate overhead costs to products, even though many products do not consume indirect resources in proportion to the volume of products produced. This means that too much overhead cost is allocated to some products, while too little overhead cost is allocated to other products, so traditional cost system tends to distort product costs (Martin, 2006). This is the first reason to choose ABC to calculate the production costs of ornamental plants when they are produced in a multiproduction framework. It is easy to understand that one certain species need more cares (consume more resources) than others, independent of their volume of production[1].

The second reason, since ABC model is focused on activities, is that the costs (and by extension the profits) of using certain techniques or procedures can be evaluated. In this way, the same ornamental plant variety produced using different techniques have different costs and returns. This fact cannot be assessed adequately using traditional cost models.

Finally, ABC is more than a model to calculate product costs; it is a comprehensive management system which is generally used as a tool for planning and control. Therefore, the ABC model provides decision makers with relevant information about cost management that the traditional methods do not (Lee and Kao, 2001).

Considering the reasons above, it could be thought that the scant importance of studies undertaken in the sector is due to the widespread choice of full-costing as a method of cost calculation. Such a method is only viable in this sector when analyzing production of a single variety of ornamental plants produced using a single crop technique. Studying more than one product or the same product created using different techniques calls for an ABC model since costs are distributed in an undifferentiated way to products with different life cycles and characteristics that are created using different quantitative and qualitative activities. Furthermore, another significant limitation of traditional cost models is the use of accountancy to determine the results, making it necessary to separate accounting costs from internal costs.

Although the use of ABC contributes to improve some deficiencies of the traditional cost models, it is not free of limitations. ABC reflects a long-run perspective of production, in which almost all of the costs are variable, however in the short-run there are many committed costs as the cost of labor and some overhead resources which are fixed. Moreover, ABC ignores constrained (bottleneck) activities and the opportunity cost of using these activities' resources in the firm's operations (Kee, 2001). In this sense, it is valuable to integrate ABC with the theory of constraints (TOC) for making better operational decisions (Kee and Schmidt, 2000 and Sheu *et al*., 2003).

When designing an ABC model, the first step is to identify the principal and auxiliary activities and to determine the cost drivers of these activities (Martin, 2006). In this sense, Cooper (1989) considered the number of cost drivers to be decisive, but finding a balance between the complexity of the system and making a cost calculation as accurate as possible is complicated (Homburg, 2001). For that purpose, it was necessary to assess the relative importance of each activity and the need to control it specifically or jointly.

In a second step, the cost drivers transfer activity costs to the products. This is how the model assigns indirect costs to cost objects in two stages (Cooper, 1990). During the first stage, costs are assigned to activities depending on the resources they consume. In a second stage, activity costs are assigned to services, products, projects etc., in proportion to the amount of activities that they consume through the adequate cost drivers.

In this way, the ABC model seeks to deal with the fact that many overhead costs vary not with the volume of items produced but with the range of the items, i.e. the complexity of the production processes (Mohan and George, 2006). Under ABC, product costs consist of its direct costs plus a share of overheads related to the number of cost driver units its production causes. Accordingly, output cost is shaped by two components:

[1] A numeric example where ABC and traditional cost models are compared can be found in Cooper and Kaplan (1988) or Martin (2006), among others.

- *Direct costs.* Consumption directly and unequivocally associated with output, such as seeds, bulbs, cuttings, pots, tubs, etc.
- *Overhead or indirect costs.* Resources consumed and needed for general (watering, cleaning, etc.) and particular (e.g. pest treatments) tasks required by the various products.

ABC model adaptation to the sector. Activity identification and control

Adaptation of the general ABC model to this sector is not complex. It basically consists of determining the direct consumption and demand of activities and tasks required by each product. So, the central axis of the proposed model is based on the follow-up and control of these two components. For activity control, it is proposed a system of daily work reports in which each worker or group of workers related to the productive activities record the tasks undertaken throughout the day. In this sense, a highly significant aspect is the correct identification and grouping of the activities and tasks associated with the productive process. In the studied case, the tasks are grouping according to the cost object: greenhouse, crop/plant and production area. In this way, it is monitored the types and amounts of activities required in every part of the production process through a measurement, such as used man hours, for the different product varieties.

The information contained in the work reports is complemented by information related to inputs consumed by each crop (seeds, cuttings, bulbs, tubs, pots, etc.); pesticides and fertilizer treatments, which constitute direct product costs.

It is also designed an analytical cost sheet or cost matrix that would summarize the proposed cost calculation model. This analytical sheet is divided into the following sections:

- The cost objects (stock plant, plants or crops) for which the costs will be calculated (Table 1 – panel A).
- The direct cost component (Table 1 – panel B). The direct costs are grouped into two types of consumption: main input and other consumption.
- The indirect cost component (Table 1 – panel C). The activities are grouped into three sections: stay cost, greenhouse activities with their respective tasks (watering, separating, etc.), and plant activities (rooting, transplanting, etc.).
- Determination of output cost (Table 1 – panel D). For calculating the cost of each plant or crop until the desired development stage, the direct inputs for each plant (showed at Table 1 – Panel B) are added to the indirect cost (stay cost, greenhouse activities cost and plant activities cost computed at Table 1 – panel C).

Finally, a set of activities and tasks not directly associated with the production process, such as commercial and administrative tasks, remains to be assessed. The same procedure as that designed to calculate production costs is followed to assess commercial tasks, while administrative and other remaining tasks are considered as firms' structural costs.

Another important question in the design of the proposed cost model is the distinction between expenses and costs when each cost element is assessed. The firm has contracted or committed to a series of expenses, adjusted to the anticipated production volume, for the purpose of obtaining planned products and/or services; these are operating expenses. However, costs do not refer to committed expenses but to consumed ones. In this way, output assessment only considers really consumed (costs) and not committed (expenses) resources in the proposed model. When both concepts do not coincide, the difference should be considered a sub-activity cost to be analyzed and managed, but not attributed to production. Let us take like example the labor cost that are most important in this sector: when 3500 labor hours have been contracted at a total cost of 28000 € and only 3000 hours have been consumed in the production process, the expense of 24000 € that has really been consumed is what must be attributed to the product.

Indeed, Juliá-Igual and Peris (2006) found that labor costs have more weight in total production costs. This result is also in line with that obtained by Brumfield *et al.* (1982), and Weddington (2003), who concluded that labor costs are higher by far, irrespective of the segment analyzed (wholesaler, retailer), without taking into account unpaid labor (owner, family and friends), which may be important particularly in the case of small firms. Estes *et al*. (2003) do bear in mind the man hours undertaken by the owner and/or family help, and subsequently include them in the imputation process, which it is considered reasonable. In this case, the proposal is faced with a cost that has no accounting record.

This important conceptual difference when considering expense and cost also extends to the existence of differences in assessment criteria between financial

Table 1. Analytical sheet of costs

A.	Stock Plant		Plant		
	Areca Palm	**Chama**	**Areca in 36 cm pot**	**Areca in 54 cm pot**	**Chama in 36 cm pot**
	1 unit	**1 unit**	**1 unit**	**1 unit**	**1 unit**
B. *Direct costs*	**12.47 €**	**5.82 €**	**1.19 €**	**4.03 €**	**0.85 €**
Main consumption	*11.73 €*	*5.08 €*	*1.01 €*	*3.71 €*	*0.67 €*
– Seeds / Cuttings / Bulbs	Seeds	Seeds			
	800 g	220 g			
	10.73 €	4.08 €			
– Substratum / peat	4. L	4. L	2.5 L	5. L	1.1 L
	1.00 €	1.00 €	0.63 €	1.25 €	0.28 €
– Self-supply			Stock plant	Areca 36 cm	Stock plant
			1 Unit	1 Unit	1 Unit
			0.38 €	2.14 €	0.21 €
Others consumptions	*0.74 €*	*0.74 €*	*0.18 €*	*0.32 €*	*0.18 €*
– Pots			0.18 €	0.32 €	0.18 €
– Seedboxes	0.74 €	0.74 €			
C. *Indirect costs*	**1.23 €**	**1.91 €**	**0.77 €**	**0.65 €**	**0.74 €**
Stay cost (per week)	0.72 €	1.34 €	0.21 €	0.13 €	0.18 €
– Stay type	Germination	Germination	Normal	Normal	Normal
– # of weeks	Normal	Normal	Minimum	Normal	Maximum
	15	28	40	20	58
– Cost for week/100 m^2	33.50 €	33.50 €	3.15 €	3.15 €	3.15 €
– Ocupation Rate /100 m^2	Optimum	Optimum	Optimum	Economical	Economical
	700 Units	700 Units	600 Units	500 Units	1,000 Units
Greenhouse activities	0.06 €	0.10 €	0.10 €	0.06 €	0.09 €
– Watering, Hrs/week/100 m^2:	0.030 h	0.030 h	0.050 h	0.050 h	0.050 h
Cost per hour 8.52 € h^{-1}	3.83 €	7.16 €	17.04 €	8.52 €	24.71 €
– Weeding, Hrs/week/100 m^2:	0.030 h	0.030 h	0.130 h	0.130 h	0.130 h
Cost per hour 5.5 € h^{-1}	2.48 €	4.62 €	28.60 €	14.30 €	41.47 €
– Fertilizing, Hrs/week/100 m^2:	0.000 h	0.000 h	0.020 h	0.020 h	0.020 h
Cost per hour 0.02 € h^{-1}	0.00 €	0.00 €	0.02 €	0.01 €	0.02 €
– Separating, Hrs/week/100 m^2:	0.020 h	0.020 h	0.060 h	0.060 h	0.060 h
Cost per hour 5.5 € h^{-1}	1.65 €	3.08 €	13.20 €	6.60 €	19.14 €
– Others, Hrs/week/100 m^2:	0.380 h	0.380 h	0.004 h	0.004 h	0.004 h
Cost per hour 5.5 € h^{-1}	31.35 €	58.52 €	0.88 €	0.44 €	1.28 €
Plant activities	0.47 € h^{-1}	0.47 € h^{-1}	0.47 € h^{-1}	0.47 € h^{-1}	0.46 € h^{-1}
– Rooting, 5.5 € h^{-1}					
– Seedbox, 5.5 € h^{-1}	14 U h^{-1}	13 U h^{-1}			
– Transplanting, 5.5 € h^{-1}	67 U h^{-1}	98 U h^{-1}	67 U h^{-1}	67 U h^{-1}	98 U h^{-1}
– Watering, 5.5 € h^{-1}					
– Cutting, 5.5 € h^{-1}					
– Staking off, 5.5 € h^{-1}					
– Others, 5.5 € h^{-1}			14 U h^{-1}	14 U h^{-1}	13 U h^{-1}
D. Total cost (direct costs + indirect costs)	**13.71 €**	**7.73 €**	**1.97 €**	**4.68 €**	**1.59 €**
Units in each stock plant	40 U	40 U	1 U	1 U	1 U
Unit cost	**0.34 €**	**0.19 €**	**1.97 €**	**4.68 €**	**1.59 €**
Rejection Rate	10.0%	10.0%	10.0%	10.0%	10.0%
	0.03 €	0.02 €	0.18 €	0.44 €	0.14 €
Ajusted unit cost	**0.38 €**	**0.21 €**	**2.14 €**	**5.12 €**	**1.73 €**

Source: own elaboration.

accounting and cost valuation in order to mainly calculate fixed assets depreciation.

The cost elements[2]

Direct costs and self-supply

Direct costs comprise the set of elements that can be directly identified with the end product (stock plant or crop) and therefore their imputation presents no difficulties. These elements have been grouped into two categories: main consumption and other consumption. The first group is made up of raw material, such as seeds, cuttings, bulbs and substrates, etc. It is important to point out that self-supply is common in this type of production. In other words, a produced output, such as an Areca Palm stock plant, becomes raw material or direct cost for the production of another type of plant, such as 36 cm. Areca Palm pot, which in turn may be sold on the market or self-supplied to get for example an 54 cm Areca Palm pot (see Table 1-panel A).

The section, other consumptions, contains what are known as add-on elements. These elements or components are added to the output, but undergo no transformation during the production process, e.g. pots, tubs, etc.

Technically, identifying and attributing direct costs is not really a problem. However, a technical chart is advisable for each type of crop, indicating the amounts of plant material and standard add-on elements, as well as the number of average occupation units in 100 m^2 and the number of average weeks estimated for production. This information is particularly important for dynamic firms that produce significantly high amounts and varieties of crops.

Indirect costs

In handling of indirect costs, the core of the proposed model, the basics of the ABC model is followed. Therefore, the activity monitoring and management is fundamental. Using the work report model[3], it is attempted to assess and analyze the firm's main activities undertaken by monitoring the work factor (measured in man-hours or units of man-hours), which is one of the principal cost components of firms in this sector.

It is identified three main groups of activities with their respective tasks. In the "Greenhouse Activities" group, it is included all tasks directly connected to a greenhouse or plot, which, therefore, affect all the crops occupying the area in question. The "Plant Activities" group includes the specific tasks performed on each crop. Finally, the "Land Activities" group includes a set of tasks which are related to the maintenance and general conservation of the production area or greenhouse and will be part of the stay cost. It is also established three main cost concepts (see Table 1 – panel C): stay cost, greenhouse activities cost, and plant activities cost.

Stay cost

The "stay cost" concept refers to the estimated consumption of the output[4] for the use of facilities, greenhouses or growing areas during growth or plant development. Due to the state of the plant or the species type or technical decisions, some greenhouses or plots are equipped with different technology, they use different productive resources or they are in different state of conservation. The availability of these different areas involves utility costs: basically depreciation and maintenance in optimal conditions for production (see Table 4). If all greenhouses are similar, an average rate can be used for them all without distinguishing between the types of stay.

Considering stay cost individually, that is, according to the type of plot used for each crop, will enable us to come much closer to the resource consumption required by each type of crop, according to the technical requirements and conditions of stay.

It has been distinguished three types of stay for the proposed example: germination, normal and external. The germination stay corresponds to that spent in the areas designated for germination, which require more investment, specific technical equipment and special

[2] In order to facilitate the understanding of the practical application of the proposed model, the results obtained for a firm of the sector are showed. The financial and economic features of this firm, for the year 2007, are showed in Table 2 and Table 3, respectively.
[3] This report must be adapted to the characteristics of each firm and particularly to the type and variety of products produced. In this case, it would be necessary to carry out a detailed analysis of the set of most important tasks for each activity.
[4] One of the important variables associated with each species or crop is the time required for vegetative development measured in weeks, which involves the need to "stay" at the plantation or firm.

Table 2. 2007-Financial sheet of the sample firm

Cost of goods	311,116 €
Labor cost	419,213 €
Other operating costs	288,277 €
Net sales	1,070,582 €
Operating profit	51,967 €
Total assets	4,327,280 €

Source: own elaboration.

conditions, such as heating, which increase cost per week. Normal stay corresponds to the average cost for using a standard greenhouse (estimated average depreciation and maintenance). External stay cost refers to outdoor agricultural areas of minimum investment and maintenance and therefore a lower stay cost.

The stay cost is estimated for short time periods (day, week, or month) and is transferred to the crop according to the number of days of stay weighted by the density rate (units per 100 m^2).

Greenhouse activity cost

The "greenhouse activities cost" is associated with resources used by the tasks undertaken at the plot or greenhouse during the plant production period. The underlying idea is that occupied plots require a series of tasks to maintain the quality of productive capacity and of the existing crops. These are maintenance tasks that have no direct relation to the plants or crops, though these are the end targets. Such tasks are orientated to maintaining the capacity and quality of the production process, e.g. cleaning, watering, and so on.

These tasks are assessed through a common cost inductor: average man-hours per week per 100 m^2 devoted to the performance of each task.

The information collected through the work report sheet allows to assess economically each task/activity, as well as to evaluate their overall and individual (per greenhouse and plot) efficiency and efficacy. In other words, it can be compared the different investment and technologies applied to each growing area and evaluate the repercussion on the efficacy and efficiency with which the tasks are undertaken. In short, the performance of each plot according to the tasks performed can be easily assessed.

In order to economically assess the hourly cost of each task, it shall be identified and assessed the consumption of resources required. In this way, these indirect costs shall be assigned to each plant or crop, by weighting the latter by the number of weeks' stay in the growing area and the average rate of occupation per 100 m^2 of each crop.

Plant activity cost

The "plant activity cost" is related to tasks or "specific treatments" individually required by each crop; that is, such tasks are identified with a specific species. Taking the work report sheet as a reference, task demand, and therefore the resource consumption specifically demanded by each crop, can be monitored, and demand can be assessed through a common cost inductor such as the average units of man-hours applied. Thus, the adequate handling of information contained in the reports shows us the average activities required by each crop, as given in Table 5.

Likewise, in order to economically assess the hourly cost of each task corresponding to plant activities, resource consumption required for task performance is identified, and assessed and weighted by the average units/hour associated with each species or plant.

Estimation of final cost and complementary analysis

Having estimated the direct and indirect costs through economic and financial assessment of the activities, the total cost of the stock plants and crops will be the sum of both these components (see Table 1 – panel D). However, this cost should first be corrected by incorporating the normal rejection rate or decline[5] associated with each crop to obtain the adjusted cost of each one. It is important to bear in mind that, if the rejection rate notably exceeds the established tolerance ratio, due to a plague or other extreme conditions, such loss should be considered as an unusual result for the financial year and not as a higher production cost.

[5] The rejection rate is the percentage of crops that have not been successful or have not passed the minimum quality requirements set down by the firm. For the sample firm used as example, the average decline rate is 10%, although Whipker *et al*. (1998) consider 3% in their study on ornamental plants.

Table 3. 2007-Economical sheet of the sample firm

Sold units	38,000
Amount of operative workers	17
Amount of administrative workers	5
Greenhouse area (m²)	41,500
External area (m²)	37,000
Amount of species produced	18

Source: own elaboration.

This is a step-by-step estimation of the production cost, to which should be added the costs of the activities and tasks associated with marketing each crop, and, for the purposes of analyzing the firm's overall results, the non operative activity costs, which are structural and not part of the product cost.

Once the costs have been estimated, a set of analyses can be performed for getting complementary information particularly important for management and decision-making. Given that most firms in the sector follow a multi-crop production system, an overall analysis of efficiency[6], productivity and performance may be especially useful to establish a "standard crop" that includes the characteristics of all the crops developed by the firm.

Therefore, by taking into consideration the calculated costs, the production and the expected sales prices for the period (Table 6), it can be identified the standard crop (Table 7), whose units produced and sales price are the respective weighted means of the total of each of these variables, with the importance of each crop in terms of units produced over the total production of the firm as a weighting factor.

It is also interesting to compare the results obtained in terms of maximum productive capacity (calculated by assuming the full use of productive resources, without considering dead time), the normal capacity (which is usually between 70 and 80% of the maximum capacity and is calculated taking into account normal interruptions to the productive process, e.g. change of crop, etc.), and the anticipated or planned capacity.

By using these two tools: the concept of standard crop and the different levels of productive capacity, two important analyses can be performed. On the one hand, the study of the incomes, costs and margins of the standard crop, and on the other, the determination of the break-even point.

The first case consists of gradually calculating the different margins considered for each of the capacity levels defined. Thus, the gross contribution margin is calculated as income minus production and non operative costs. This gross margin should be sufficient to cover the difference that may exist between period costs and estimated period costs. Once this difference has been considered, the gross operating margin is obtained and finally it is get the period margin when costs not linked to the operation (financial expenses, additional costs, provisions, etc.) are also subtracted.

In the second case, the break-even point is calculated in three points for each level of capacity (normal, maximum and planned), resulting in operating, production, and period break-even points. Consequently, the operat-

Table 4. Detail of stay cost calculation

	Germination growing surface	Normal growing surface	External growing surface
Total area (m²)	1,367	18,055	2,500
Anual depreciation (€)	2,060.54	23,886.77	1,100.00
Anual maintenance (€)	490.61	5,687.33	650.00
Anual heating costs (€)	21,260.00	0.00	0.00
Total anual cost (€)	**23,811.15**	**29,574.09**	**1,750.00**
Anual cost per 100 m² (€)	1,741.85	163.80	70.00
Week cost per 100 m² (€)	33.50	3.15	1.35
Average weekly stay cost per 100 m²		**4.84 €/week/100 m²**	

Source: own elaboration.

[6] Hodges *et al.* (1997, 2000) consider that one of the most exact measurements of cost efficiency in a firm is the analysis of costs per unit of income, although it is also interesting to know the costs per unit of the cultivated area.

Table 5. Average of activities required by each crop and number of units handled hourly according to task and crop

Task	Crop	Amount of tasks	Total of hours	Total of units	Units/hours Ratio
Rooting	Croton	10	42.50	2,996	70.49
Seedbox	Areca	42	12.75	182	14.27
	Chama	18	18.80	253	13.46
	Others	65	42.20	2,828	67.01
Transplanting	Areca	33	998.10	67,311	67.44
	Chama	52	522.75	51,249	98.04
	Croton	83	269.95	21,114	78.21
	Others	68	778.50	42,071	54.04

Source: own elaboration.

ing break-even point enables us to establish the number of units of standard crop and expected income required to cover production costs and non operative costs. The production break-even point determines the number of units of standard crop and expected income required to cover production costs, non operative costs and the differences between costs and operating expenses for the period. Finally, the period break-even point consists of establishing the potential incomes and units sold corresponding to the standard crop that are needed to cover all costs and expenses for the period.

Conclusions

By way of conclusion, it shall be highlight the most important aspects of the proposed management and cost calculation model and the sector chosen for practical application.

Firstly, the proposed model is extremely flexible and adapts to the different firm segments in the ornamental plants sector (wholesalers versus retailers, etc.), as well as to any multiproduction agricultural business.

Moreover, internal costs instead of accounting data are used as a source of data. This is one of the most important differences of this proposal vis-à-vis the studies undertaken until now, along with regarding manpower costs (the most important amount along with water and fertilizer consumption) as variable and not fixed costs. This consideration stems from the fact that previous proposals use accounting data, which means that the costs committed to manpower do not depend on the final level of production attained by the firm. In this regard, this paper follows Weddington (2003) who recommends a detailed follow-up of manpower costs in order to study the effectiveness of certain production techniques, crop types, etc.

The importance of the concept “stay cost“ also should be considered, since it includes both fixed and variable costs and facilitates calculating the cost of the same variety or plant at a different stage of maturity.

Table 6. Gross margin of each crop

	Stock Plant		Plant		
	Areca palm	**Chama**	**Areca 36 cm pot**	**Areca 54 cm pot**	**Chama 36 cm pot**
Total cost (€ U^{-1})	0.38	0.21	2.14	5.12	1.73
Direct cost + rejection rate	0.35	0.16	1.36	4.47	0.99
Indirect cost	0.03	0.05	0.78	0.65	0.74
Average sale price (€ U^{-1})	0.90	0.70	2.90	4.60	1.76
Gross margin (€ U^{-1})	0.52	0.49	0.76	-0.74	0.03
Expected sales (€)	90,000.00	25,000.00	85,000.00	3,000.00	23,750.00

Source: own elaboration.

Table 7. Gross margin of the standard crop

		% on total cost
Total cost	1.22 €	100.0%
– Direct cost	0.82 €	67.2%
– Indirect cost	0.40 €	32.8%
Average sale price	1.76 €	
Gross margin	*0.54 €*	
Density in 100 m^2	691	
Amount of stay weeks	31	

Source: own elaboration.

In short, the advantage of using the ABC model is achieving a more objective assignation criterion for indirect costs as well as the differentiation between several products and technologies in the cost calculation process. Furthermore, it is possible to estimate the production value, establish prices and product policies, analyze committed and absorbed costs (internal costs), and analyze the effectiveness and efficiency of the activities and their tasks.

On other hand, the advantage of the proposed model is that a financial analysis of resource consumption is undertaken as well as the estimation of economic variables, such as the average man hours per week needed for watering, etc. This enhances and extends the possibilities of analysis, particularly comparative analysis between firms in the same sector, by isolating the financial component of the variables and concentrating on resource consumption in economic terms. Moreover, the proposed model can be used to perform individualized quantitative, qualitative, statistical, and performance analyses (hours/hectares, plants/hour, etc.), of utmost importance for decision-making in the following areas: technical, management, monitoring, and cost optimization. However, for management purposes, it is not enough to calculate cost, since the results obtained must be compared with average segment costs; according to Brumfield and Jenkins (1987) and Weddington (2003), average costs vary substantially between one segment and another.

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