APLICATION OF TIME-DRIVEN ACTIVITY-BASED COSTING IN THE PRODUCTION OF AUTOMOBILE COMPONENTS

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ABSTRACT

Time-Driven Activity-Based Costing (TDABC) was put forward by Kaplan and Anderson in 2004 to improve Activty-Based Costing (ABC). TDABC was designed to be simpler and more powerful than ABC, by means of better modeling of processes thanks to time equations. This paper describes a real implementation of TDABC and its determinants and, by means of tools used to analyze the adoption and success of innovations in accounting, it draws on the interest of such approach for manufacturing companies. Results show that TDABC gives more precise cost information than ABC and it allows companies to manage capacity and resources linked to capacity.

Keywords: cost, Accounting, Activity, ABC, Time-Driven, Time Equation, Case Study

1.- THE IMPORTANCE OF COST-ACCOUNTING SYSTEMS

Time-Driven Activity-Based Costing (TDABC) is a new approach of *Activity-Based Costing* (ABC) developed by Robert Kaplan and Steve Anderson [1, 2]. In this study, based on the experience of a supplier company of plastic parts for the automotive sector, we show the difficulties of ABC implementation in multiproduct and multiprocess companies and how TDABC can overcome them.

Manufacturers of parts cannot influence prices; therefore it gets necessary to offer the best selling price and to accomplish different requirements that include additional assembling and packaging activities that can act upon the cost of manufactured products. In such a dynamic environment and especially under the current economic crisis situation, it is relevant to know the cost specifically in order to assure the profitability of products, customers or orders, and to be able to negotiate conditions or to introduce operative improvements to save resources. Each cost-accounting system brings a different result, thus the different methods would lead to different decisions. Nowadays, various methods are applied [3, 4, 5]: traditional costing systems, ABC, TDABC, RCA (resources consumption accountability), *target costing*, *kaizen costing*, theory of constraints, *value chain analysis*, *total cost of ownership* or *balanced scorecard.* Karmarker, Lederer and Zimmerman [6] state that the reasons why one company uses one specific cost-accounting method and another company implements a different one are unknown. The authors empirically demonstrate (even though they regret that conclusions are weak) that the system is linked to physical characteristics of the productive process (layout, complexity, number of products) and that reports are an increasingly pursued objective. Castelló [7] assures that the most accurate system for each company depends on a series of factors such as the productive process nature, the strategy and the management structure of the company, the information needs or the leadership style. In our example, we show the adequacy of TDABC to the productive processes of a multiproduct and multiprocess company of the automotive sector. These companies commonly manufacture big demands of products that cover the different needs of the different customers. The manufactured products require multiple processes and one specific process is involved in the manufacturing of various products. From an accounting perspective, the problem arises when estimating the indirect costs of the manufacturing plant. Those costs are traced to a series of products that are different in a series of dimensions, so that each one is linked to some cost characteristic [8]. This manufacturing process implies a non-homogeneous consumption of resources, and therefore, it gets necessary to have a cost-accounting system that enables to capture this complexity and that assigns accurately the costs to products, in a simpler manner.

The case study analysed in this paper, considers that a specific cost-accounting system is implemented in the company, and at one point the company realizes that the adopted model leads to uncertain conclusions. Different signs [9] reveal that the costs of products, computed according to that cost-accounting system, are not correct: products with difficulties in their manufacturing promise to be very profitable even though they don not have high prices (this situation happens in the case analysed); it is not possible to explain why some products are more profitable than others, etc. Cooper [9] attributes these signs to an incorrect assignment of indirect costs, mainly influenced by the usage of volume-based assignment criteria or centres of cost or groups of cost that encompass various indirect costs with different behaviours. When the company decides to change the cost-accounting system, we get involved in the implementation of an accounting innovation. Since different approaches may be used for its analysis, we follow the integrating model of Martinez Ramos [10, 11] to know both internal and external pressures that influence the decision of adopting TDABC.

Cost-accounting accountability was first introduced to provide support to one specific productive model. When the structure of companies is quite different from that model, the results obtained do not fit with reality. Activity-Based Costing seems to overcome these problems. But, even though its goodnesses, it has low levels of adoption among companies and different authors analyse the causes of this paradox and the reasons of its implementation failure. Along time, other proposals have arise, as for example Time-Driven Activity-Based Costing that aims to correct the disadvantages of ABC. A more precise discussion on this topic can be found in Dyna website.

2.- CASE STUDY. IMPLEMENTATION OF TDABC IN COMPLAS, SA

2.1.- MOTIVATION

A review of the current published literature reveals that TDABC is an adequate cost-accounting system for companies that undertake tasks in one way or another depending on a series of parameters, with abundance of indirect costs that are not immediately linked to the cost object (indirect costs are not proportional to volume of production). Under this context, the authors thought that TDABC could be useful in industrial multiprocess and multiproduct companies [12] in order to accomplish the previous premises.

As it was quite a rather new system, it seemed that a massive interview process would not be the optimal methodology to be used for the study, since many companies would not probably know the system and would not desire to be the first adopters (the same situation happened with ABC). Under an informal way, we found out that a Spanish company had already implemented the method and we requested for its cooperation in order to deepen in the reasons, the methodology and the results and finally compare the practical experience with the theoretical framework. That company was a multiproduct and multiprocess company, which had previous experience in ABC implementation and needed more precise cost estimations, because of the particularities of its sector.

The practical case study that we will analyse refers to the implementation of TDABC in a manufacturing plant of parts for the automotive sector, Complas SA (we have changed the name of the company due to confidentiality reasons). Different structured and semi-structured interviews were conducted with the person in charge of the manufacturing plant during the implementation process. The reader can find more information in the website of Dyna.

2.2.- METHODOLOGY

TDABC did not replace the previous ABC system, but they both coexisted (and still coexist) since they are not reciprocally exclusive [13, 14]. TDABC was only implemented in the manufacturing department and in the department of engineering and projects, in those works were volume drivers disguised capacity problems or that were not capable of reflexing the consumption of resources of each product mix.

The analysis consisted in:
a) Defining new processes, studying the causes that determined their consumption for final products (not for manufacturing processes) and identifying the time equations that better described the consumption of those new processes.
b) Defining new activities included in the traditional processes, and identifying the time equations that determined the product-by-product consumption.

In the manufacturing area, the implementation of TDABC required different measures (distances, times, speeds), while different interviews were conducted and historical data of the projects was used in the engineering department. In this last department, the tasks involved in each project were analysed and different data such as the distance from customers and the business travels (hours of flying) were taken into account. The result showed that some steps were common and others were very different for different pieces and customers (for example, CAD activities, mould developments and travels).

In following pages, we implement the methodology to the injection process and we compute the costs of two pieces by using TDABC. Finally, we compare the result with the one obtained with ABC.

For the calculation of costs, it is necessary to include amortizations, consumptions and tasks involved in the injection process. For each of these tasks, ABC defined an activity. With ABC system the company assigned the total cost of a series of activities of the injection process considering only one driver (machine-hours). The analysis of activities

revealed that some of activities were homogeneous while others consumed more or less resources depending on the product. It was making the error of considering cost-volume drivers to compute the calculations, even though the activity did not depend on volume considerations.

In ABC we had to divide activities of inspection, replacement of mould and maintenance of moulds into as many sub-activities as tasks undertaken, since the times of those tasks depended on the piece (see table 3). In that way, each product would gather up the precise cost, and not an average cost.

Table 1 shows the calculation of costs per machine-hour of the concepts involved in the injection process. The cost of a specific activity (for example, the set-up of moulds) may already include the cost of direct labour, the cost of supervision, the cost of the machine, etc. In table 1, the annual cost of maintenance, according to data of the analysed company, is 70,000 euros. If we divide it by 5,760 machine-hours (as considered by the company), it returns a maintenance cost of 12 euros per machine-hour. Those activities that will become a group of resources in TDABC and that will require a time equation for a precise definition have been marked with an asterisk (*).

Concepts (Activities)	**Annual cost (Euros/year)**	**Cost driver (Euro / machine-hour)**
Maintenance of the plant	70,000	12
Inspection of pieces *	50,000	9
Replacement and set-up of moulds *	50,000	9
Maintenance of moulds *	50,000	9
Supervision of processes	60,000	10
Depreciation of machinery	100,000	17
Depreciation of buildings	6,000	1
Power supply, gas, water.	45,000	8
General supplies	10,000	2
Other supplies	45,000	8
Total	**406,000**	

*Table 1: Computing the costs per machine-hour of the concepts involved in the injection process. *Activities that require a subsequent analysis.*

From data in table 1, ABC computes the costs of products (A or B). The results obtained are depicted in table 4, assuming a production of 100 pieces of model A and 100 pieces of model B per hour.

The translation from ABC to TDABC may be done in a very simple way. We may add all concepts assigned to the injection department (the ones in table 1) and we may divide them by the annual capacity of the department. We would obtain a simpler cost-accounting method than ABC. But, in our case study, we have to maintain ABC and on the other hand, the costs that we would obtain would not have the desired accuracy since the tasks of the injection process are related to the type of product manufactured. For that reason, we will use TDABC only in the tasks of inspection of pieces, replacement of moulds and maintenance of moulds. These tasks will be now defined as a group of resources or processes; in fact, developers of TDABC already foresaw it [2]. The annual cost of resources involved in each group of resources or processes is evaluated, as shown in table 2.

Inspection of pieces	**Values**	**Replacement of mould**	**Values**	**Maintenance of mould**	**Values**
Annual cost according to Table 2	50,000 €/year	Annual cost according to Table 2	50,000 €/year	Annual cost according to Table 2	50,000 €/year
Capacity	3,600 h/year	Capacity	1,800 h/year	Capacity	1,800 h/year
Price per hour	14 €/h	Price per hour	28 €/h	Price per hour	28 €/h

Table 2: TDABC – Cost per time unit of groups of resources inspection of pieces, replacement of moulds and maintenance of moulds.

From the estimation of times for each task and costs per unit of time, TDABC enables to obtain the costs of inspection, replacement of moulds and maintenance of moulds for each type A and B of piece (table 4). For the calculation of costs, table 3 acts as a time equation.

Use of TDABC in the injection process	Piece A	Piece B
Inspection	**Duration (s/piece)**	
Remove piece	10	20
Revise head A	10	5
Revise head B	10	5
Test 1	16	5
Test 2	18	5
Pack up	5	5
Total time (seconds/piece)	**69**	**45**
COST inspection of piece (€/piece) (14 €/h according to Table 3)	**0.266**	**0.174**
Replacement of mould	**Duration (s/piece)**	
Open machine	2	2
Set-up of the mould	2	1
Prepare connections	3	1
Put mould	3	3
Peripheral Set up	2	1
Close machine	3	3
Total time (seconds/piece)	**15**	**11**
COST replacement of mould (€/piece) (28 €/h according to Table 3)	**0.116**	**0.085**
Maintenance of mould	**Duration (s/piece)**	
Open mould	5	5
Set-up of the mould	2	1
Prepare connections	3	1
Put mould	3	3
Peripheral Set up	2	1
Close machine	3	3
Total time (seconds/piece)	**18**	**14**
COST maintenance of mould (€/piece) (28 €/h according to Table 3)	**0.139**	**0.108**
TOTAL COST (€/piece)	**1.104**	**0.950**

Table 3: Cost estimation of products A and B with TDABC.

If we now add the rest of costs to the costs from table 3, we obtain the total cost of injection for piece A and B (we do not consider the cost of primary materials). In table 4, we present the results obtained with TDABC+ABC and the results obtained previously with ABC with the aim to compare both.

Cost of injection	Cost per piece (€/piece)			
Method >	**previous ABC**		**TDABC+ABC**	
Costs	**Piece A**	**Piece B**	**Piece A**	**Piece B**
Maintenance of the plant	0.122	0.122	0.122	0.122
Supervision of processes	0.104	0.104	0.104	0.104
Depreciation of machinery	0.174	0.174	0.174	0.174
Depreciation of buildings	0.010	0.010	0.010	0.010
Power supply, gas, water.	0.078	0.078	0.078	0.078
General supplies	0.017	0.017	0.017	0.017
Other supplies	0.078	0.078	0.078	0.078
Subtotal	**0.583**	**0.583**	**0.583**	**0.583**
Inspection of piece	0.087	0.087	0.266	0.174
Replacement of mould	0.087	0.087	0.116	0.085
Maintenance of mould	0.087	0.087	0.139	0.108
Total Cost	**0.844**	**0.844**	**1.104**	**0.950**

Table 4: Cost estimation for the injection process in products A and B.

3.- DISCUSSION

In this paper we aimed to analyse the capacity of TDABC for the modelling of a company's processes. We also aimed to obtain better information about costs than we would obtain with ABC. The results show that the operations of the analysed company may be modelled with TDABC, so that we would obtain precise information of costs in a simple way. The ABC model already implemented in the company provided an average cost per piece. TDABC enables to obtain a different cost depending on the piece is A or B. In practice field, the results have made possible to see the so

significant cost of some auxiliary processes (the management of materials turned to be as important as the assembling process). The results also facilitate a deeper knowledge of the use of resources (mainly of indirect labour), by comparing the hour used with the hour paid, and making clear the inefficiencies of the departments [14]. Finally, a new approach on the cost of pieces based on the route they follow inside the factory has been obtained.

Implementing TDABC was not the unique option. Another option was to revise the existent ABC model and correct its deficiencies, updating its values and considering if a more accurate driver than machine-hours existed for each activity, since machine-hours were definitely not an appropriate driver. Maybe, under this option we would reach the same level of detail in ABC. For that, it is necessary to separate each activity into numerous subactivities, and then estimate the consumed resources for each one or use multiple drivers. This process of assignments of costs among the subactivities, as is commonly done in ABC with interviews, has a high degree of bias. In practice, these sophistications are not done because we usually give priority to simplicity than precision. Moreover, in a dynamic environment, the mix of products has important variations and each combination forces to a different cost assignment. These would be neither practical nor viable, because of the volume of calculations that implies.

Probably, other systems would be also suitable, but the company would not permit the use of systems that dismantled the existent ABC method. For these reasons, the responsible people decided to implement TDABC in a specific part of the company. The implementation of TDABC is complex since it requires the analysis of processes, the definition of groups of resources or activities, the definition of time equations and the measurement of times (aspects for which the responsible person does not always find support), but one implemented is relatively simple to maintain up to date by updating the time equations for new products. The responsible of costs in the company assures that the objectives defined at the beginning of the process have been accomplished. TDABC system has enabled to identify where the company gained and where lost and the reasons for that. The responsible expose that the system was precise, easy to maintain and a great help in real time to analyse deviations in costs. TDABC made possible to completely modify the system of offers, and in the engineering department, it helped to balance the team-works.

In table 5, we summarise the adoption of TDABC in Complas, SA with the model of Martinez Ramos [11]. It shows the determinants of the change in the accounting system of the company. These determinants delimitate the success or failure options of the new system [15].

Internal and external pressures	Motivators	Increase in the complexity (many products and processes), with many indirect tasks. Competitiveness levels of the sector. Influence of the accounting literature.
	Agents of change	Real lose of profitability. Demands from the finance director of the group (CFO).
Factors (Favour or difficult the adoption)	Enablers	Support from Management and CFO. Existence of a previous cost-accounting system (ABC). Usual use of accounting information.
	Barriers	Absence of cooperation due to an absence of convincement of some responsible people about the goodness of the system and a fear about the reveal of a copious capacity. Need to maintain ABC. Obsolete previous data. Absence of instruction of workers.
	Leader	Wishes from the responsible of costs.

Table 5: Factors with influence on the adoption of TDABC in Complas, SA, following the integrative model of Martínez Ramos [11].

Then, it arises the question whether is it possible to consider that the implementation was successful. Firstly, it is important to clear what may be understood as a success and as a failure in the implementation of the cost-accounting system. The topic is not trivial and the literature on it, specifically referred to ABC system, is extensive [15]. Considering its simplicity and capacity to capture the multidimensional aspects of the success, we will use the integrative model of Foster and Swenson [16] which takes into account four dimensions: the use, the decisions, the economy, and the evaluation of the management. From a perspective of use, TDABC in Complas, SA has the spatial extension and the compatibility with TDABC that was desired. It offers the information required (a correct calculation of costs to be used in the preparation of offers) and reveals improvement and capacity management. It use could be made extensive to other areas (for example quality or production). From the perspective of decisions, the cost-accounting system has the desired utility. It has a limited use because it could also be used in aspects such as production scheduling, lot size definition, or workloads definition. However, the division of the company in departments according to

the functions has the inconvenient that each department is centred into its own objectives and does not get involved in the objectives of other departments. In that way, production is centred in the manufacturing to accomplish the lead times and refuses accounting aspects. Moreover, it is possible that production mistrusts from accounting because innovations in production have not historically been positively reflected in the accountability [17] or just because production considers accountability as a threat [18]. Even the heads of the plant may see cost accounting as something that is only useful for reports and not for management [6]. From a perspective of an economic dimension, TDABC use has facilitated that offers were not ruinous for the company, since real costs of products are known. Finally, the evaluation performed by the company is positive.

The responsible of the implementation was convinced that unlike other models, TDABC helps to orient the company towards its future costs and anticipate the needs of capacity, by means of time equations. By introducing volume data, we obtain capacity and resources associated to those capacity scenarios. However, the system has not provided more results because another one replaced the responsible, and because other heads of the company had not a clear interest on the implementation of TDABC since they considered that these are only data. In the 7 CS model of Shields and Young [19] (*Culture, Continuous education, Champion, Controls, Compensation, Change process* y *Commitment*) this situation would correspond to the absence of a winner that propels the system and to an absence of compromise -probably due to an existent organizational culture that has traditionally favoured to work under a specific manner-. Nevertheless, TDABC has revealed the existence of copious resources, which is a compromised situation in a company for some heads or responsible people and obviously, it has facilitated to offer real costs to customers, which was an initial objective.

Arrange a reliable cost-accounting system in the field of information exchange between automotive companies and their suppliers, is an element that contributes to assure long-term relationship [3]. The success of the implementation could be classified as a partial success [20].

According to Fitó and Slof [21], the accomplishment of TDABC of a standardized use depends on 16 different parameters, grouped in 6 areas. Table 6 summarizes the characteristics of each factor. There seems no to be factors that clearly point to break up the system but neither to extend it.

Factor	Discussion
Strategic factors	TDABC development is local and does not take part in the strategy of the multinational company. There is not a leadership that propels its extension inside the company.
Individual characteristics	There is not enough training about TDABC. The responsible of its implementation is no longer in the company.
Management factors	In the future, other orders from the multinational about its adoption or substitution under a corporate level could exist. There is not a leadership that propels its extension inside the company.
Technological factors	It is compatible with ABC. Development of tables of cost for engineering in separate tools.
Operative factors	Quick implementation, but the replacement of the responsible has imitated the continuation of the process. Initiated in 2008, still operative in 2012.
External factors	Competition and the economic crisis sharpen the need for a major control of costs. This could beneficiate the use of TDABC as a strategic tool.

Table 6: Factors that influence the standardized use of TDABC [21] in Complas, SA.

4.- CONCLUSIONS

A literature review shows that ABC is considered as an innovative method in cost-accounting management. However, very few companies have implemented it and from the ones that have adopted the model, many have abandoned it. Kaplan and Anderson, aware of the practical limitations of ABC, decided to simplify its operation developing TDABC.

For the moment, the literature on TDABC is relatively scarce. Very few empirical studies analyse the implementation of TDABC and most of them are centred in the service sector, because in that sector the labour force is a very important factor and tasks have multiple variation sources. These studies are usually centred on the definition of time equations. Consequently, the analysis of the case study presented in this paper contributes to give response to investigators that have eluded the lack of empirical investigations that provide a deeper knowledge about the implementation processes of new management tools.

In this work we have analysed the implementation of TDABC in an industrial company, reason for which it contributes to widespread the knowledge about the implementation processes of an accounting innovation, providing information about the determinants for the implementation and about the success or failure of the implementation. Making a theoretical construction based on the business practice, especially of an emergent theory as the one that concerns to TDABC, has a value added that enables to define a reference scenario in future implementations of TDABC cost-accounting system.

In the paper we have introduced some inconvenient of ABC in a real company: difficulties in the fit with variable activities and difficulties in the periodic estimation of times devoted to activities based on the production mix. Even though these aspects could in theory be overcome, in practice businesses adopt simpler as for example machine-hour is commonly used as a driver and as reveal the obsolescence of data.

Unlike other articles, this paper analyses a case where TDABC coexists with ABC. It models the costs of the injection process by means of time motion studies and time equations. Unlike other works, we have shown that TDABC can consider an activity as a group of resources and it can model it through time equations that allow to specify the complexity of real operations in a multiproduct and multiprocess company, and to assign a different cost to each product, avoiding the increase the defined activities in order to adapt the cost accounting system to the complexity and diversity of processes. Thus, TDABC in the analysed company is more precise, flexible and simple than ABC. The comparison made clarifies the cost tracking in one and other case. In other previous publications [22], the developers of TDBC have been involved in the implementation. In the present paper, Spanish engineers have designed the system.

In spite of the possible estimation errors, in an industrial environment where tasks are repetitive and can be timed, the use of TDABC is justified. Since the mix of products changes periodically, ABC would have to recalculate the new assignment of time (which is expensive, long and subjective). With TDABC it is only necessary to make modifications when new products are implemented or when work methods are changed.

The change of system was propelled by changes in the environment (major competitive pressure and productive complexity) and it was implemented because of the existence of a driver responsible or "winner" [19]. The company decided to modify its cost-accounting system in order to have precise information about costs and to be able to make offers to customers. The users argued that the new system provides the details of costs needed to improve the offers; therefore, the objective has been accomplished. There is not an interest to extend it to other departments or to give it other used. The success of the implementation can be classified as a partial success [20] according to the limited use of it in the company, but its application seems to become something standardized or routine [21].

The main limitation of this work is the own of empirical investigations that stand in case studies. Each case has its particularities and it is difficult to make generalizations. The characteristics of the analysed factory do not represent the industrial diversity, but they fit with the profile of companies of its sector. Extensions of this work could be the study in other companies of the industrial sector and the implementation of TDABC as a management production tool.

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