APPLICATION 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 Activity-Based Costing (ABC). TDABC was designed to be simpler and more powerful than ABC, by means of better modelling of processes thanks to time equations.

This paper describes a real implementation of TDABC and its determinants and, by means of tools used to analyse 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 company that manufactures plastic parts for the automotive sector, we show the difficulties that may arise in the implementation of ABC in multiproduct companies with multiple processes and how TDABC can overcome them.

Manufacturers of parts cannot influence prices. They have 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 yields a different result and so each method may lead to a different decision. Nowadays, various methods are applied in practice [3, 4, 5]: traditional costing systems, ABC, TDABC, RCA (Resources Consumption Accounting), target costing, kaizen costing, theory of constraints, value chain analysis, total cost of ownership or balanced scorecard. Karmarkar, Lederer and Zimmerman [6] state that the reasons why one company uses one specific cost-accounting method while another company implements a different one are unknown. The authors empirically demonstrate (even though they regret that conclusions are weak) that the costing system is linked to physical characteristics of the process (layout, complexity, number of products) and to the frequency of reports. Castelló [7] assures that the most accurate system for each company depends on a series of factors such as the nature of the manufacturing process, 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 manufacturing processes of a multiproduct company with multiple processes in the auto-parts industry. These companies commonly manufacture big demands of products that cover the different needs of the different customers. The manufactured products require multiple processes and each 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 several dimensions, so that each one is linked to some aspects of cost [8]. This king of manufacturing process implies a non-homogeneous

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consumption of resources, and therefore, it gets necessary to have a cost-accounting system that can capture this complexity and accurately assign the costs to products, in a simple 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 false conclusions. Different signs [9] reveal that the costs of products, computed according to a particular costing system, are not correct: products with difficulties in their manufacturing promise to be very profitable even though they do 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 allocation of indirect costs, mainly influenced by the usage of volume-based allocation criteria or the usage of cost centres or cost pools that encompass indirect costs with different behaviours. When a company decides to change the cost-accounting system, it gets involved in the implementation of an accounting innovation. Since different approaches may be used for its analysis, we follow the Martinez Ramos' integrating model [10, 11] to know both internal and external pressures that influence the decision of adopting TDABC.

Traditional cost accounting was introduced in a certain moment in time to provide support to a specific manufacturing model. When the current structure of companies is quite different from that model, the results obtained do not match reality. Activity-Based Costing seems to overcome these problems. But, despite its virtues, the levels of adoption of ABC among companies are low -different authors have analysed the causes of this paradox and the reasons for the failure of its implementation-. Over time, other proposals have arisen, as for example Time-Driven Activity-Based Costing that aims to correct the disadvantages of ABC. A more precise discussion on this topic (in Spanish) can be found in Dyna website (http://www.revistadyna.com/dyna/documentos/pdfs/_adic/5105-2.pdf).

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

2.1.- MOTIVES

A review of the literature reveals that TDABC is an adequate cost-accounting system for companies that undertake tasks in one or another way depending on a series of parameters; with abundance of indirect costs that are not immediately linked to the cost object (indirect costs that are not proportional to volume of production). Under this context, the authors thought that TDABC could be useful in manufacturing plants with multiple products and multiple processes [12] because they fulfilled the premises above.

As TDABC is a new system, it seemed that a massive survey process would not be the optimal methodology to be used for the study, since many companies would not probably know the system or would not desire to be the first adopters (the same 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 company with multiple processes, 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 analyse in this article refers to the implementation of TDABC in a manufacturing plant of parts for automobiles, 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 Ingeniería e Industria.

2.2.- METHODOLOGY

TDABC did not replace the previous ABC system, but they both coexisted (and still coexist) since they are not mutually exclusive [13, 14]. TDABC was only implemented in the manufacturing department and in the department of engineering and projects where volume drivers disguised capacity problems and previous costing systems 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 by final products (not by manufacturing processes) and identifying the time equations that better modelled those new processes.

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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), and thus different interviews were conducted. Historical data on the projects were 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 the 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 depreciation, consumptions and tasks involved in the injection process. For each of these tasks, ABC defined an activity. With the 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. The company was making the error of considering cost-volume drivers to compute costs, even though the activities did not depend on volume considerations.

ABC would make us divide the 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. The 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
Other supplies	10,000	2
Miscellaneous	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 shift 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,

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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 of pieces	**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 pieces (€/piece) (14 €/h according to Table 3)	**0.266**	**0.174**
Replacement of moulds	**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 moulds (€/piece) (28 €/h according to Table 3)	**0.116**	**0.085**
Maintenance of moulds	**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 moulds (€/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.

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

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
Other supplies	0.017	0.017	0.017	0.017
Miscellaneous	0.078	0.078	0.078	0.078
Subtotal	**0.583**	**0.583**	**0.583**	**0.583**
Inspection of pieces	0.087	0.087	0.266	0.174
Replacement of moulds	0.087	0.087	0.116	0.085
Maintenance of moulds	0.087	0.087	0.139	0.108
Total Cost	**0.844**	**0.844**	**1.104**	**0.950**

Table 4: Cost estimation on the injection process of products A and B.

3.- DISCUSSION

In this paper we aimed to analyse the ability of TDABC for modelling 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. While the ABC system already implemented in the company provided an average cost per piece, TDABC enables to obtain a different cost value depending on the type of piece (A or B). In practice, 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 assembly process). The results also facilitate a deeper knowledge of the use of resources (mainly of indirect labour), by comparing the amount of labour-hours used with the amount of labour-hours 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 the company had. Another option was to revise the existent ABC system 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 have reached the same level of detail in ABC than in TDABC. To achieve that, it is necessary to separate each activity into numerous sub activities, and then to estimate the consumed resources for each one or use multiple drivers. This process of assignments of costs among the sub activities, as is commonly done in ABC with interviews, is highly biased. In practice, these sophistications are not done because more priority is given to simplicity than to 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 implied.

Probably, other costing systems would be suitable, but the company did not allow the use of systems that dismantled the existent ABC method. For these reasons, the people in charge decided to implement TDABC in a specific area 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 person in charge does not always find support), but once implemented it is relatively simple to keep up to date by updating the time equations for new products. The cost manager in the company assures that the objectives that had been defined at

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the beginning of the process have been accomplished. TDABC has enabled to identify where the company makes a profit and where it loses money and the reasons for that. The manager stated that the system is accurate, easy to maintain and it is a great help in real time in order to analyse deviations in cost. TDABC made possible to completely modify the system offers for customers were made, 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 framework created by 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 loss 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 middle management about the goodness of the system and the fear caused by the consequences of revealing the existence of free capacity in departments. Need to keep ABC. Obsolete previous data. Absence of instruction of workers.
	Leader	Wishes from the cost manager.

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

Next, it is necessary to answer the question whether it is possible to consider that the implementation was successful. Firstly, it is important to clear what may be understood as success or failure in the implementation of cost-accounting systems. The topic is not trivial and the literature on it, specifically referred to ABC, is extensive [15]. Considering its simplicity and capacity to capture the multidimensional aspects of success, we will use the comprehensive model by 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. Its usage 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 scheduling, lot size definition, or workload definition. However, the division of the company in departments according to their 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, Operations is devoted to accomplish manufacturing lead times and it is no interested in accounting. Moreover, it is possible that Operations mistrusts Accounting because innovations in production have not historically been positively reflected in the cost figures [17] or just because Operations considers Accounting as a threat [18]. Even plant managers may see cost accounting as something that is only useful for reports and not for management [6]. From the viewpoint of economic results, TDABC has made possible that offers to customers were not ruinous for the company, since real costs of products are known. Finally, the evaluation performed by the company is positive.

The cost manager was convinced that, unlike other models, TDABC can forecast the future costs of the company and the needs of capacity by means of time equations. By introducing volume data, we obtain

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capacity and resources associated to those capacity scenarios. However, the system has not provided more results because the cost manager that implemented the system has been replaced, and because other managers do not seem interested in the implementation of TDABC since they consider cost information to be mere data. In the 7 CS model by Shields and Young [19] (Culture, Continuous education, Champion, Controls, Compensation, Change process and Commitment) this situation would correspond to the absence of a champion that leads 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 idle resources, which is an embarrassing situation in a company for some managers, and obviously it has facilitated to offer real costs to customers, which was an initial objective.

On the other hand, to 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]. In consequence, the success of the implementation can be considered partially achieved [20].

According to Fitó and Slof [21], taking a costing system (such as TDABC) to standardized level of usage depends on 16 different parameters, grouped in 6 areas. Table 6 summarizes the characteristics of each factor. No factor seems 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 person who implemented it is no longer in the same plant.
Management factors	In the future, other decisions from the headquarters of the multinational company about the adoption or substitution of TDABC at 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 is made in separate tools.
Operative factors	Quick implementation, but the replacement of the cost manager has deterred the continuation of the process. Initiated in 2008, it is 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 some of the adopter have finally abandoned it. Kaplan and Anderson, aware of the practical limitations of ABC, decided to simplify its operation developing TDABC.

The literature on TDABC is relatively scarce so far. 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. Studies in literature are usually centred on the definition of time equations. Consequently, the analysis of the case study presented in this paper

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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. For this reason, this paper 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 the added value of defining a reference scenario in future implementations of TDABC.

In the paper we have introduced some drawbacks of ABC in a real company: difficulties to model variable activities and difficulties to estimate, periodically, the time devoted to perform different activities depending on the production mix. Even though, in theory, these aspects could be solved, in practice businesses adopt simpler approaches (as for example the amount of machine-hour is commonly used as a driver) and data become obsolete.

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 company with multiple processes, 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 with a stopwatch, 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 to the time equations when new products are implemented or when work methods change.

The change from ABC to TDABC was promoted by changes in the environment (major competitive pressure and productive complexity) and the new costing system was implemented because of the existence of a leader or "champion" [19] who believed in it. The company decided to modify its cost-accounting system in order to have accurate and precise information about costs and to be able to make offers to customers. The users argue that the new system provides the details of costs needed to improve their offers to customers; therefore, the objective has been accomplished. There is not an interest to extend TDABC to other departments or to use it for other tasks. The success of the implementation can be classified as a partial success [20] according to its limited use in the company, but its application seems to become something standardized and ordinary [21].

The main limitation of this work is the typical one of empirical research that stands on case studies. Each case has its particularities and it is difficult to make generalizations. The characteristics of the analysed factory are not common to all the companies, but they are similar to the ones that can be found in other companies in the same industry. Extensions of this work could be the study of TDABC in other types of companies and the applications of TDABC as a tool for operations management.

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