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A COST MANAGEMENT SYSTEM FOR INFORMATION TECHNOLOGY[1]

SISTEMÁTICA PARA O CONTROLE GERENCIAL DOS CUSTOS DE TECNOLOGIA DA INFORMAÇÃO

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ABSTRACT

Information Technology (IT) has become a key element for most organizations. For this reason and because of the lack of more structured methodologies for implementing IT chargeback, the objective of this article is to propose a cost management system for IT. The focus is on the company's business units and/or products as the cost objects. The main contribution is to establish an interface between cost management modern techniques and IT with the proposition of a structured method. The results of some implementations are also presented as a case study.

Keywords: IT, costs, IT chargeback, cost management system, control.

RESUMO

A Tecnologia da Informação (TI) se tornou um elemento chave para as organizações. Por essa razão, e devido à falta de uma metodologia estruturada para a implementação do chargeback de TI, o objetivo deste artigo é propor uma sistemática de custeio para a TI. Os objetos de custos são as unidades/produtos das empresas. A maior contribuição deste artigo está no estabelecimento de uma interface entre o ambiente de TI e as modernas técnicas de gestão de custos por meio da proposição de uma sistemática estruturada para o custeio dessa área. Os resultados de implementações são combinados e apresentados na forma de estudo de caso.

Palavras-chave: TI, custos, chargeback de TI, sistema de gestão de custos, controle.

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INTRODUCTION

The use of Information Technology (IT) has become widespread, not only as management support but also as a method of differentiation to stay competitive (Yasin, 2012). IT has been perceived as a differential in the past, but, these days, it is a prerequisite for maintaining corporate competitiveness. According to Chou *et al.* (2014), IT is now considered a key factor for economic growth and a driver of innovation processes. Because of its importance for organizations, not only at strategic but also at operational levels, IT costs have increased, and they currently represent a significant portion of companies' indirect costs (Luzzini *et al.*, 2013). Thus, IT costs need to be carefully accounted and attributed to specific processes or user groups/departments responsible for the consumption of IT resources in order to not encourage overutilization (Agarwala *et al.*, 2008).

Regarding cost management to IT, the existing solution is the chargeback, which measures and controls the costs incurred in IT activities. In other words, chargeback systems aim to allocate IT costs to the business units that use IT services (Friedman and Grayson, 1996). The origin of IT chargeback dates back to a time when a company purchased mainframes that were used by all the departments in the organization. Chargeback was the method by which the IT area would charge the other areas of the organization for the use of this resource. Meanwhile, for chargeback to be implemented, a series of metrics needed to be collected. However, the tools available at that time were very expensive and did not have the required level of automation; thus, chargeback fell out of favor because of its high implementation costs and the small benefit from its use (Drury, 1997).

Over time, high competition and the constant IT development resulted in an improvement in its resources and processes. These improvements aimed to rationalize costs and increase efficiency, which drove the IT market to focus its efforts on the optimization of the use of available resources. These efforts resulted in the sharing of servers that had, until then, been used exclusively by departments/businesses, in addition to the use of virtual servers (Dukaric and Juric, 2013). The use of virtualization services allow a faster development of solutions and result in cost reductions through a more efficient use of resources. Although it is very difficult to allocate costs in a virtual infrastructure, virtual machines must also have their costs calculated to prove that they are less expensive than physical machines; this new environment represents a second chance for IT chargeback (Baars *et al.*, 2014).

Although the understanding of the chargeback importance, it is only at present that chargeback support tools are reaching maturity. Gerlach *et al.* (2002) research reveals that the most effective chargeback methods are those easily understood by internal customers. According to Agarwala *et al.* (2008), IT chargeback methods are too complex or to adhoc and fail to achieve the goal for which chargeback was implemented. Therefore, the difficulty of implementation remains a barrier for chargeback (Cummings, 2009). Furthermore, the literature does not show a structured systemization for its implementation clearly linked to the cost management literature.

When analyzing the cost management literature, the main development in cost managements systems was the Activity-Based Costing (ABC) (Cooper and Kaplan, 1988). Since its appearance, the ABC has been adapted generating some of its variations: Time-Driven Activity-Based Costing (TDABC) (Kaplan and Anderson, 2004), Production Unit Effort (UEP) (Filomena *et al.*, 2011), and Cost Centers (CC) (Vogl, 2014). The ABC has been widely applied in large, medium and small companies in many different environments: logistics (Baykasoglu and Kaplanoglu, 2008), gas industry (Langmaak *et al.*, 2013), development costs (Qian and Ben-Arieh, 2008; Filomena *et al.*, 2009), cost simulation (Farr *et al.*, 2015), healthcare (Vanberkel and Moayed, 2016), manufacturing (Suthummanon *et al.*, 2011; Nachtmann and Al-Rifai, 2004), and construction projects (Di Gregorio and Soares, 2013). Even uncertainty has been incorporated in some ABC studies (Nachtmann and Needy, 2001, 2003).

Despite the popularity of the ABC method, it is widely known its difficult to be implemented which is opening ground for the TDABC (Everaert *et al.*, 2008). TDABC is viewed as method much easier to be implemented when compared to the ABC (Hoozée and Bruggeman, 2010) and has already been applied in many different environments: shared services (Becker *et al.*, 2009; Stouthuysen *et al.*, 2010; Siguenza-Guzman *et al.*, 2016), healthcare (Demmere *et al.*, 2009; Kaplan *et al.*, 2014; Yun *et al.*, 2015), pharmaceutical services (Gregório *et al.*, 2016), supply chain (Schulze *et al.*, 2012), infrastructure projects (Yang *et al.*, 2016). More recently, this method is also been also used in Cloud computing (Adeoti and Valeverde, 2014; Baars *et al.*, 2014).

Despite the benefits related to chargeback, the current literature does not present a systematized structure that connects the characteristics and peculiarities of the IT area with the cost management literature. Thus, this is the focus of our study: the proposition of a cost management system for IT. The proposed system uses concepts from different costing methodologies and presents a hybrid solution, i.e., a solution that uses concepts from different methods to systematize an adequate a solution. We use not only ABC but also TDABC depending on each cost object. We also provide a summary of results obtained in some Brazilian applications.

This article is divided into 4 sections as follows. After the introduction, the second section describes the proposed cost management system, and the third section presents the main results and indicators generated in the implementation process of the case study. The article's final considerations and recommendations for further research are presented in the last section.

COST MANAGEMENT SYSTEM FOR IT

Regarding its organization and structure, IT is, in general, divided into 2 operational areas: Development and Production. Production is typically subdivided into Support and Data Center. An IT organization may have either both areas or only one of them, depending on its focus. New specific applications for each business are developed in the Development area. According to Bilal *et al.* (2014), the Data Center is a network resources structure that uses communication infrastructure for data storage and application hosting. The follow-up of Data Center availability is performed in the Support area. The IT management paradigm is under the Data Center (Bilal *et al.*, 2014).

In general, Data Centers operate with excess capacity, which can be explained by different technical reasons. However, it is undeniable that this over capacity results in higher costs. According to McKinsey (2014), many IT managers are implementing cost reduction plans. The Data Center architecture has a direct impact on its costs (Hammadi and Mhamdi, 2014).

Technically, the traditional Data Center structure is organized in 3 layers: access, aggregation, and core (Hammadi and Mhamdi, 2014). The access layer consists of the structure of racks and switches. The switches of the access layer connect to other switches in the aggregation layer, which aggregate clusters of servers. This layer is called the aggregation layer. The third and last layer, the core layer, is the layer responsible for communication between the Data Center and external users.

The literature already shows new types of Data Center organizations that are different from the traditional model (Hammadi and Mhamdi, 2014). However, these new types have the same elements of the traditional organization and only differ in the manner in which these elements are connected. It does not depend of the architecture and the weight of each cost component, a large part of the costs is directly or indirectly linked to the servers. The proposed system of IT costs management is introduced in the next section.

IT operational costs are divided into 2 components: current expenses and fixed assets. This division derives from the classification of fixed assets items when they are purchased. In many cases, this classification is not observed, which does not prohibit the use of the system, although an *a posteriori* classification is very complex because it involves different items that are difficult to identify. In addition, these costs are of high value and may have a significant impact on the results; thus, they have to be treated differently to achieve a more accurate control of this specific item.

Current expenses are those related to IT labor, structure, and operation. These costs are normally divided in the cost center structure of the companies and are effectively paid in the period under analysis. However, fixed assets costs are typically consolidated in the same cost center. This consolidation occurs because of the difficulty in classifying these items and because of the large number of items. The costs are related to the immobilization of IT assets and are not effectively spent in the period; nevertheless, they must be considered for management purposes. Therefore, IT costs consist of the sum of the 2 components, as shown in Equation (1).

$$C_{total} = C_{depreciation} + C_{current} \qquad (1)$$

The system for current expenses is different from that of the fixed assets; thus, the steps of the current expenses are shown first, followed by the fixed assets. The steps for the current expenses are also divided into 2 stages: (i) development and (ii) production. Thus, the proposed system is structured according to Chart 1, and the total IT costs are obtained from the consolidation of this 3 elements.

To facilitate the understanding of the proposed steps, Chart 2 shows the list of variables to be used during the study. The M servers can be classified into 3 different categories: virtual, physical host, and physical non-host. The servers set M is described in Equation (2),

$$M = Z \cup Y \cup W \qquad (2)$$

where Z represents the virtual servers, Y the physical hosts, and W the physical non-hosts.

Regarding the depreciation costs, A represents all the fixed assets, whose items must be categorized. Equation (3) represents the set of fixed assets items and its classifications:

$$A = B \cup C \cup D \cup E \cup F \cup G \cup H \qquad (3)$$

B represents the items classified as exclusive of an object; C is composed of software items, D of storage items, E of server items, F of hardware items, G of switch items, and H of all other items denominated others.

Next, following the description presented in Chart 1, each step of the method is discussed.

PRODUCTION AND DEVELOPMENT COSTS

IT costs are divided into Production and Development. Therefore, the IT current costs linked to these 2 groups must be identified. Equation (4) shows the composition of current costs, and Equation (5) shows the components of the Production costs.

$$C_{current} = C_{development} + C_{production} \qquad (4)$$
$$C_{production} = C_{support} + C_{data\ center} \qquad (5)$$

Although they are different and originate from different activities, the Support costs must be treated together with the Data Center costs. The reason is that Support's goal is to maintain the Data Center in operation and to follow up its indicators.

Chart 1. *System structure.*

Step	Definition
2	Cost management system for TI
2.1	Production and development costs
2.1.1	Development
2.1.1.1	Determine N activities and their costs
2.1.1.2	Determine justified work hours per activity and per cost object
2.1.1.3	Calculate the cost/justified work hour for each activity
2.1.1.4	Determine the cost per object
2.1.2	Production (Data Center)
2.1.2.1	Classify the servers according to the objects and environments
2.1.2.2	Classify the servers according to their type: physical or virtual
2.1.2.3	Determine the processing capacity of the servers
2.1.2.4	Make adjustments
2.1.2.5	Determine the cost per unit of considered capacity
2.1.2.6	Determine the cost per server
2.1.2.7	Allocate the servers' costs to the objects
2.1.2.8	Allocate the servers' costs to the objects
2.2	Fixed assets
2.2.1	Items exclusive of an object
2.2.2	Items linked to server, hardware and switch
2.2.3	Items linked to software and storage
2.2.4	Other items

Chart 2. *List of variables.*

Variable	Definition
N	Set of IT development activities
J	Set of IT cost objects
M	Set of Data Center servers
Z	Set of Data Center virtual servers
Y	Set of Data Center physical host servers
W	Set of Data Center physical non-host servers
A	Total Fixed assets cost
B	Fixed assets cost exclusive of a cost object
C	Fixed assets cost of software items
D	Fixed assets cost of storage items
E	Fixed assets cost linked to servers
F	Fixed assets cost linked to hardware
G	Fixed assets cost linked to switch
H	Fixed assets costs of items not classified in variables B to G (others)
βz	Considered processing capacity of the virtual server
βy	Considered processing capacity of the host server
θ	Cost per considered processing unit
τ	Fixed assets cost of items E, F, and G per processing unit

DEVELOPMENT COSTS

Some of the development activities are specific to the conception of new applications or devices. These new applications and devices sometimes have their values included as assets, which means that they affect the fixed assets cost during their period of use. Nonetheless, these items are considered cost items, and whoever adopts the proposed system must decide whether these items will affect the cost or whether they will be considered assets for further depreciation.

DETERMINE THE DEVELOPMENT ACTIVITIES AND ALLOCATE THEIR COSTS TO THEM

Initially, it is suggested to divide Development costs in N activities through specific drivers. Each of these activities is composed of the costs of collaborators, structure, and other costing items linked to each activity. The division of the Development costs in activities facilitates their understanding and the management of the area. Each activity may represent a project, a service group, a focus area, etc. Equation (6) shows the total Development cost.

$$C_{development} = \sum C_{n'}\, n \in N \tag{6}$$

DETERMINE THE JUSTIFIED HOURS PER ACTIVITY AND PER OBJECT

After the cost of each of the activities linked to Development is determined, an operational control on the collaborators of this area must be implemented. In this control, the collaborators must justify their working hours by annotating them. Initially, this control can be performed in electronic timesheets that must contain the following information: collaborator, period of performance of the activity, linked activity, costing object that required the activity, and number of worked hours. It must be highlighted that the requiring object has to be linked to the objective of the cost management system, in this case, the business units and/or products of the company.

CALCULATE THE COST/JUSTIFIED WORKED HOUR FOR EACH ACTIVITY AND DETERMINE THE COST PER OBJECT

With the cost of each activity and the implementation of the control of Development activities, it is possible to gather the total number of justified worked hours per activity for each period under analysis. Therefore, the calculation of the cost per justified worked hour, α, in the period under analysis is performed. If h_n is the number of justified worked hours for each activity, then Equation (7) shows the cost per justified worked hour for Development activities.

$$\alpha_n = \frac{C_n}{\sum h_n}, \forall \text{ n} \qquad (7)$$

DETERMINE THE COST PER OBJECT

After α_n is determined and after the justified worked hours of each activity for each object, h_{nj}, are identified, the consolidation of the total cost per costing object must be performed. Equation (8) shows the total cost per considered costing object.

$$C_j = \sum \alpha_n \text{ X } h_{nj}, \text{ n} \in \text{N and } \forall \text{ j} \qquad (8)$$

Next, the procedures for calculate the production are presented.

PRODUCTION COSTS

The Production cost is composed of the Data Center and the Support costs. As noted above, these 2 cost items are treated in the same manner; thus, the following steps apply to both of them.

CLASSIFY THE SERVERS ACCORDING TO THE ENVIRONMENT AND THE OBJECTS THAT USE THEM

Ideally, the cost calculation must be performed for each Data Center item. However, because of the high complexity and the large amount of information that would be necessary, it is sought to understand how these items relate to each other to perform the calculation for groups of items. Thus, it is assumed that the servers are the largest cost items in the Data Center and that the other items are part of the structure that supports the servers' operation. For this reason, the methodology consolidates the costs of the different items and treats them together with the servers' costs. Therefore, it is necessary to identify all of the servers in the Data Center and classify them according to two criteria: the environment and the objects that use them.

The classification of the environments may or may not be necessary. The subdivision of the environments is indicated to identify the differences in both its structuring and the type of processing that they perform. This classification aims to facilitate the management of different environments. Regarding the objects that use each server, they must be aligned with the objectives of the cost management system.

CLASSIFY SERVERS ACCORDING TO THEIR TYPE: PHYSICAL OR VIRTUAL

After the servers are identified according to the objects that use them and the environment where they perform, they must be classified according to their type: physical or virtual.

DETERMINE THE PROCESSING CAPACITY OF EACH SERVER

The Data Center has numerous servers whose objective is to process data. Therefore, the relative processing capacity of each server must be determined. The cost per unit of processing capacity is the same, independent of where it is, but the cost per server is different because of the servers' different processing capacities.

The servers have different configurations that affect their processing capacities. However, it is not possible to use all of these specifications to determine the relative capacity of each server because doing so would require gathering a large amount of information. For this reason, two critical configurations are identified with regard to the servers' capacity to process information. The first configuration is the number of CPUs in each server (Choi *et al.*, 2015). The second configuration is the number of Cores that each server presents. The relevance of the number of cores was defined with some IT specialists during the process. These 2 indicators, CPUs and Cores, are proportional to processing potential, i.e., the higher they are, the larger the server's capacity. Although these indicators seem to be a good way to determine servers capacity, neither the academy nor the specialists in the area can, exactly, know how to determine the server capacity (Kant and Won, 1999; Doshi *et al.*, 2015). The number of simultaneous users, buffer cache correction, systems standby rates and other metrics could also be used to determine capacity (Choi *et al.*, 2015).

Thus, the processing capacity per server and the total capacity of the Data Center are defined by Equations (9) and (10), respectively.

$$\textit{Processing capacity}_m = \prod \textit{CPU}_m \times \textit{Core}_m, \text{ m} \in M \qquad (9)$$

$$\textit{Processing capacity}_{total} = \sum \prod \textit{CPU}_m \times \textit{Core}_m, \text{ m} \in M \qquad (10)$$

In cases in which the objective is to consider all the servers as homogeneous, the same number of CPUs and Cores must be considered for all of them. In this case, the result of Equation (9) gives the same weight for each server and, consequently, the same allocated cost per server.

This method for considering processing capacity assumes a linear relationship between the processing capacity and the product of CPUs by Cores. This assumption is a limitation of the proposed system and must be investigated in future studies.

MAKE ADJUSTMENTS

Adjust the considered capacity of the virtual servers

The virtual servers share the physical structure made available by the physical servers; the actual processing capacity is shared among the virtual machines. Therefore, it is necessary to use a reduction factor of the capacity of the virtual servers, i.e., the considered capacity is different from the processing capacity. This reduction factor consists of considering only 1 Core when the server is virtual. Equation (11) shows the considered processing capacity, β, of the virtual servers,

$$\beta_z = \sum CPU_z,\ z \in Z \qquad (11)$$

Adjust the considered capacity of the host servers

This step is the same as in the case of virtual servers that share the structure made available by the physical servers; the host servers, which are the base of the virtual servers, have their structure shared by several virtual servers. Therefore, the host servers, which are virtualization servers, have their costs already allocated to the virtual servers, and no cost must be charged to them. Equation (12) shows the considered capacity of the host servers,

$$\beta_Y = 0,\ \forall\ Y \qquad (12)$$

Once again, these reduction factors of the considered capacity are a limitation of this system. Future studies should better investigate this issue. However, this is the first attempt in the current literature to address this issue.

CALCULATE THE TOTAL CONSIDERED CAPACITY

After the processing capacity of each server and the capacity adjustments to the virtual and host servers are defined, it is possible to calculate the total considered capacity, λ, of the Data Center, as shown in Equation (13):

$$\lambda = \sum CPU_w \times Core_w + \sum CPU_z,\ w \in W \text{ and } z \in Z \qquad (13)$$

CALCULATE THE COST PER UNIT OF CONSIDERED CAPACITY AND ALLOCATE THE COSTS TO THE SERVERS

After λ, Equation (13), is determined, the cost per relative considered processing unit, θ, is calculated, as shown in Equation (14):

$$\theta = \frac{C_{production}}{\lambda} \qquad (14)$$

With the result of Equation (14) and the considered capacity per server, the cost of each of the servers in the Data Center is determined. This cost is defined as a function of the server's class and configuration. Equations (15) and (16) show the cost per virtual server and non-host physical server, respectively:

$$Server_z = \theta \times CPU_z \qquad (15)$$

$$Server_w = \theta \times CPU_w \times Core_w \qquad (16)$$

DEDICATED SERVER

Servers dedicated to a single cost object have their costs allocated directly.

SHARED SERVER

Regarding shared servers, it is necessary to apply a technical driver to determine how much capacity each object uses.

Define the drivers

When shared servers are used, it is necessary to identify a metric that represents how much of the available structure each object uses during the period of analysis. Each environment may present a different technical driver.

The choice of the driver depends on the implemented structure and the nature of the processing performed in the environment. A driver must be defined for each environment. It must be noted that the same driver can be used in more than one environment if it represents the actual use of more than one environment. They must be determined with the joint participation of the IT technicians because these professionals have a better understanding of the processes performed and more capacity to identify and define the drivers to be used.

Allocate the costs of shared drivers to the cost objects

Once the drivers to be used in each environment are defined, the cost of each server is allocated to the different cost objects that use them. Thus, the cost per costing object consists of how many units of processing capacity are allocated to each object. Equation (17) shows the calculation of the percentage of cost of each server to be allocated to each of the objects considered in the study.

$$Capacity_{jm}\,(\%) = \frac{driver_j}{\sum_{i=1}^{J} driver_j} \qquad (17)$$

FIXED ASSETS COSTS

After the determination of the system to allocate current costs to the cost objects, the next step is the definition of the costing system of fixed assets items. These correspond to previously acquired items that are being depreciated. It is important to note that these costs are not actually spent during the period of analysis but must be considered for management purposes.

The classification of the fixed assets items is detailed in Table 1, and Equation (18) shows the composition of these costs:

$$C_{fixed} = \sum C_a,\ a \in A \qquad (18)$$

ITEMS EXCLUSIVE OF AN OBJECT

Items classified in Step 4.2 as belonging exclusively to a costing object, (B), must have their costs directly allocated to them.

ITEMS CORRESPONDING TO SERVER, HARDWARE, AND SWITCH

Items classified in Step 4.2 as server, (E), hardware, (F), and switch, (G) must be allocated only to the physical servers according to their relative processing capacity. Equation (19) shows the fixed assets costs of these items per unit of relative processing capacity, τ.

$$\tau = \frac{Cost}{processing\ unit} = \frac{\sum C_i}{\sum CPU_k \times Core_k} \qquad (19)$$

, i ∈ E, F, G and k ∈ Y, W

The fixed assets cost per physical processing capacity is determined without reducing the considered capacity of the host servers. Then, the total cost allocated to the host servers is redirected to the virtual servers by the number of servers, Z. The allocation is direct for the dedicated servers, and in the case of shared servers, the allocation process is similar to that described in Step B.7.2.

ITEMS CORRESPONDING TO SOFTWARE AND STORAGE

Items classified in Step 4.2 as software, (C), and storage, (D), must have their costs allocated to the virtual and physical non-host servers. It seems reasonable to consider that these items are not linked to processing capacity. Thus, each server must have the same cost because these items are used homogenously by the servers, independent of processing capacity. Equation (20) shows the cost to be allocated per server.

$$Cost\ per\ server = \sum \frac{C_i}{|Z| + |W|},\ i \in C, D. \qquad (20)$$

It can be observed that and represent the cardinality of each server set. After the cost per server is determined, the costs of the dedicated servers are directly allocated to the objects, whereas the shared servers use an allocation process similar to that described in Step B.7.2.

OTHER ITEMS

For the items classified in Step 4.2 as others (H), the suggestion is to allocate them to the objects according to the proportion of use of the Data Center bottleneck driver. This process is performed through the participation of each object in the considered driver, as shown, previously, in Equation (17).

CONSOLIDATE THE COSTS PER OBJECT

After the system and its 3 components are defined, it is necessary to consolidate the costs per costing object. The final allocated cost per costing object has 3 components: Development, Data Center and fixed assets. Equation (21) shows the final allocated cost per costing object.

$$Cj = \sum \alpha_n \times h_{nj} + \theta \times CPU_{zj} + \theta \times CPU_{wj} \times Core_{wj} + C_{Bj} + \tau \times CPU_{Wj} \times Core_{Wj} + \tau \times CPU_{Yj} \times Core_{Yj} + C_i \times \frac{Z_j + W_j}{Z + W} + C_{Hj} \qquad (21)$$

CASE STUDY

The case study is based on medium and large-size companies from the financial industry that are present throughout Brazil. The cost objects, activities, and environments were kept with a generic nomenclature to preserve the companies' data. The numbers used in the case study were modified to maintain the companies' confidentiality.

The company has 9 different activities in the Development area: some are linked to specific projects, whereas others are determined by the specialty of the collaborators, and one of the activities is for outsourced personnel. It must be noted that this division is not mandatory and that it is only mandatory that one collaborator can be allocated to only one activity. In the case of Production, 3 environments are used: environments 1 and 2 are very much alike regarding the processing they perform but are divided into 2 because they are dimensioned in an isolated manner. The third environment, which is the smallest, performs a different type of processing.

Table 1 shows the result of the implementation of the proposed system. The case study is not presented in detail because of a lack of space and because it is a reproduction of the steps defined in the previous section.

Table 1 shows that the other areas of the organization are informed of the results, with the values detailed by type of activity (Development, Data Center, and fixed assets) and their

Table 1. *Results of the system implementation.*

	Object 1	Object 2	Object 3	Object 4	Object 5	Object 6	Type
Activity 1	60,069	17,497	0	45,762	0	40,337	DEVELOP.
Activity 2	130,215	25,085	53,235	258,656	83,329	116,894	DEVELOP.
Activity 3	11,913	5,221	1,493	14,660	8,523	5,287	DEVELOP.
Activity 4	39,072	0	7,077	93,070	0	52,311	DEVELOP.
Activity 5	36,372	25,993	20,537	119,387	9,893	11,139	DEVELOP.
Activity 6	152,781	16,936	9,911	172,647	74,075	67,393	DEVELOP.
Activity 7	0	0	0	77,515	0	0	DEVELOP.
Activity 8	9,517	2,232	2,222	19,292	2,061	0	DEVELOP.
Activity 9	16,740	6,212	0	26,504	10,185	3,156	DEVELOP.
Environment 1	129,423	23,638	18,486	19,959	19,955	51,200	PROD.
Environment 2	890,313	64,106	135,239	42,110	172,154	331,391	PROD.
Environment 3	364,514	18,987	19,071	50,308	42,742	143,998	PROD.
Exclusive of an object	75,504	98,736	29,040	238,128	110,352	29,040	FIXED
Server, Hardware, Switch	227,982	23,376	22,897	25,052	35,446	89,448	FIXED
Software, Storage	312,981	37,210	32,640	39,465	55,340	126,464	FIXED
Others	92,788	7,982	6,732	59,566	4,486	19,346	FIXED
TOTAL	**2,550,183**	**373,211**	**358,579**	**1,302,081**	**628,541**	**1,087,405**	

components. This action enables the IT area to communicate its costs to the organization and explain how they were generated. However, the other areas of the organization have to understand how the costs were generated and, therefore, rationalize them.

Table 1, also, presents the quantitative results of the implementation, and the participation of each item in the total cost to be allocated to the objects is shown in Figure 1. The objects have different compositions of their total costs either because they are at different points in their life cycle or due to technical reasons. It must be noted that the determination of the costs is the first step in implementing an IT management system and that the analyses that result from the identification of these costs and the factors that contribute to their formation may bring effective benefits to the organization.

This type of analysis drives the other areas of the organization to evaluate the actual need to use IT resources and at what level they should do so. Nevertheless, IT must improve the internal efficiency of its services, which will have a positive impact on the costs transmitted to other areas as well. For this reason, some performance indicators are developed for the IT area, as described in Chart 3.

Regarding the systems' development activities, an indicator that represents the ratio of the justified to the available workhours is generated from the control timesheets. The available workhours are calculated according to the working hours of each collaborator, the working days in the period, and the number of collaborators. The justified workhours are taken from a controlling timesheet. The indicator is shown in Chart 3.

This indicator allows the top management to control the productivity of the development team and to calculate the expected justified cost/hour from the estimated costs and the percentage goal of justified workhours. The crosscheck for

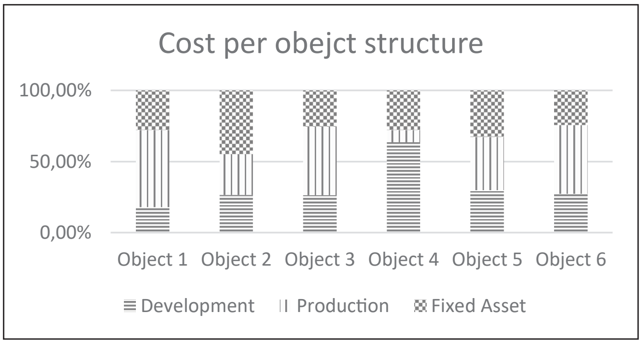

Figure 1. *Cost composition per costing object.*

Chart 3. *Indicator of justified workhours.*

Number of collaborators	20
Workload	8.8
Working days	22
Availability	3872
Justified workhours	2402
% Justified	62.04%

the estimate with the actually achieved allows measuring the differences and helps define the size of the team.

The calculation of the cost per server according to the implemented system allows the company to compare its servers' cost with that of other organizations if these data are available. This calculation allows the company to compare its Data Center efficiency with that of other companies. The follow-up of the ratio between the costs of a virtual and a physical server is also fundamental for the company. This follow-up may justify, or not, the use of virtual machines. In the case of the focus companies in this case study, the ratio between the costs of the physical and the virtual servers is approximately 2.44. This indicator can be compared to that of other companies or to data from IT institutions to check whether it is aligned with the market and can facilitate possessing adequate Data Center structuring and dimensioning.

The Data Center indicators are important not only for external comparisons but also as indicators of internal relative efficiency. Given that the Data Center processing costs are basically directed to the objects as a function of the amount of information exchanged, the smallest environment is the only environment that does not use this driver; if the objects are dimensioned in the same manner, then it is expected that the cost per exchanged piece of information is the same per object. Table 2 shows the rationality of the calculation of the cost per exchanged piece of information per costing object in Environments 1 and 2.

If the objects are dimensioned in the same manner, the cost per exchanged piece of information is the same for all of them. However, according to Table 2, object 4 is the object with the highest compatibility between its current level of activity and its Data Center dimensioning. Companies should investigate these differences and understand their causes. An example of one possible reason for these differences could be the importance of object 1, where risks of not having space for clients' transactions could not be acceptable. It is difficult to define an ideal value for this indicator; nevertheless, it is an important tool for the internal benchmarking of the Data Center with regard to the efficiency of the processing space allocated per object.

FINAL CONSIDERATIONS

The main goal of this article was to propose a cost management system for IT focusing on company's business units and/or products as the cost objects. The proposed system was implemented in some companies, as described in the case study. Difficulties were found during the implementation process. The understanding of some IT processes and how to calculate their costing were challenging. The definition of the drivers to be used in the Data Center and the classification of fixed assets were obtained with many discussions with experts, but they definitely present improvement opportunities.

As a means by which to continue adopting and standardizing a system to support the management control of IT costs, the following are recommendations for future research: (i) apply the system to other companies with different structures to validate it and propose adaptions and/or improvements; (ii) in the case of companies with ticketing software in their Data Centers, i.e., software that identifies how long each application runs in the servers, compare their results with those from the system outlined in the present study to understand the differences and the reasons for the differences; (iii) understand how the issue of Data Center dimensioning affects the different objects and seek methods to reduce the gap between used and available capacities; (iv) investigate whether the CPU x Core product is the best indicator of the processing capacity of a server; and (v) investigate whether the CPU x Core relationship with the processing capacity is linear and, if it is not, identify this relationship. The proposed system does not aim to be applicable to all possible IT area structures, and changes may be required depending on the environment.

Table 2. *Processing cost per exchanged piece of information.*

	Object 1	Object 2	Object 3	Object 4	Object 5	Object 6
Cost Environment 1	129.423	23.638	18.486	19.959	19.955	51.200
Cost Environment 2	890.313	64.106	135.239	42.110	172.154	331.391
Exch. pieces of info.	145.804.937	12.543.547	10.578.703	93.601.747	7.048.727	30.399.256
Cost/exch. piece of info.	0,007	0,007	0,015	0,001	0,027	0,013

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