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USING TIME-DRIVEN ACTIVITY-BASED COSTING TO SUPPORT LIBRARY MANAGEMENT DECISIONS: A CASE STUDY FOR LENDING AND RETURNING PROCESSES

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Abstract

With the rapid increase in demand of new digital services, the high cost of information, and the dramatic economic slowdown, libraries have been pressured to improve their services at lower costs. To cope with these conditions, library managers must improve their knowledge and understanding of cost behavior, as well as be aware of the different costs involved in the library. Time-Driven Activity-Based Costing (TDABC) is a cost management technique that allows developing accurate cost information on a wide range of activities. Few case studies have been implemented in libraries regarding very specific processes such as inter-library loan and acquisition processes. More research is still needed to determine whether TDABC is useful and feasible to implement for a more extensive set of library activities. Through an analysis performed at an academic library in Belgium, this document introduces TDABC as a useful method for supporting lending and returning processes.

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USING TIME-DRIVEN ACTIVITY-BASED COSTING TO SUPPORT LIBRARY MANAGEMENT DECISIONS: A CASE STUDY FOR LENDING AND RETURNING PROCESSES[1]

Due to the recent economic crisis, the high cost of information, and the rising demand of services and information resources, libraries have been required to shift budgeting and spending priorities. As a consequence, several decisions have been made, such as cutting collection budgets, eliminating budgets for travel or conferences, freezing salaries, finding new ways to fund programs, and moving from physical to digital collections (Sudarsan 2006, McKendrick 2011). This evolution has forced libraries to prioritize their spending and minimize their costs, concentrating on key success factors such as cost efficiency, quality and innovations (Novićević and Ljilja 1999; Blixrud 2003, 15).

Library managers in these difficult circumstances are required to increase their understanding of library activities and their related costs in order to justify resource requirements and the creation of new services or face budget reductions. To do so, they must rely on valid information about the library processes and cost estimations, as well as differentiate the kind of "products" or "services" libraries provide to customers. For instance, there are no tangible products in libraries (except for scanning and photocopying) and the primary products are a wide range of services. Several studies on cost analysis and resource allocation for library services have been developed over the past forty years (Rouse 1975, Kaplan and Cooper 1998), in which traditional costing systems have been mainly used (Kaplan and Cooper 1998).

[1] As our case study was mainly performed in 2010, we wish to thank the KU Leuven Arenberg Campus Library staff at that period, especially to Ludo Holans (Head of the Library) and Christophe Nassen (Circulation responsible) for their big support and commitment during the data collection. Special thanks to the Flemish Interuniversity Council (VLIR), the University of Cuenca, and the National Secretariat of Higher Education, Science, Technology and Innovation of Ecuador (SENESCYT) for supporting this research project.

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This article introduces Time-Driven Activity-Based Costing (TDABC) as a useful costing system for librarians and library managers who want to perform a cost analysis in a simple and accurate manner. TDABC, which was initially developed for manufacturing processes to overcome the difficulties presented by traditional costing systems, is gaining special attention in academic libraries. This is because TDABC is a fast, accurate, and easy-to-understand method that only requires two parameters: the unit cost of supplying resource capacity and an estimated time required to perform an activity (Kaplan and Anderson 2007b). By implementing TDABC in libraries, key benefits are provided, such as the possibility of disaggregating values per activity to identify non-value added activities; benchmarking different scenarios to adapt best practices for performance improvement; and justifying decisions and choices such as staff recruitment, training and new service development (Siguenza-Guzman et al. 2013). This investigation presents a case study of the Loan and Return processes at the Arenberg Library of the Katholieke Universiteit Leuven (KU Leuven) to illustrate the applicability of TDABC in academic libraries with special attention to large-scale libraries. The remainder of this article is organized as follows. The next section presents the theoretical background of TDABC and its main characteristics and limitations. Then, the implementation of TDABC in a case study is analyzed, identifying key benefits and deployment limitations faced during the process. Finally, some conclusions and recommendations for future work are given in the last section.

Theoretical background: TDABC

The most well-known costing system is the so-called traditional costing, which consists of a single and static cost rate for allocating indirect costs of different processes to cost objects such as products or services (Kaplan and Cooper 1998). It works well when used in specific scenarios, such as in stable environments with small or fixed indirect costs, but it leads to inaccurate total product cost estimations in more complex environments (Kaplan and Cooper 1998, Tse and Gong 2009). As a result of the current wide offering of library

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products and services, these inaccuracies become critical in the ability to accurately describe the complexity of the cost structure (Tse and Gong 2009).

Activity-Based Costing (ABC) is an alternative costing technique specially promoted by Robert S. Kaplan and Robin Cooper (1988) in the mid-1980s. In the case of libraries, ABC performs a more accurate and efficient treatment of activity costs compared to traditional costing due to its accuracy in allocating indirect costs to different activities (Ellis-Newman, Izan, and Robinson 1996; Ellis-Newman and Robinson 1998; Goddard and Ooi 1998; Ellis-Newman 2003; Ching et al. 2008; Novak, Paulos, and Clair 2011). However, in practice, ABC is time consuming and costly, which is mainly a result of data collection performed by means of interviews (Kaplan and Anderson 2004). As a consequence, several companies have ceased updating their systems, and in some cases they have substituted more efficient approaches such as TDABC (Yilmaz 2008, 8; Wegmann and Nozile 2009).

TDABC is a new ABC approach developed by Robert S. Kaplan and Steven R. Anderson (2004) to overcome the difficulties of implementing and updating ABC systems. TDABC assigns resource costs directly to the cost objects using two easy-to-obtain sets of estimates: (1) the cost per time unit of supplying resource capacity to the activities and (2) an estimate of the time units required to perform an activity (Kaplan and Anderson 2004). To calculate the cost of activities under a TDABC system, six steps typically need to be performed (Everaert et al. 2008). These steps are illustrated in table 1.

Table 1: Time-Driven Activity-Based Costing steps (Everaert et al. 2008)

Time-Driven Activity-Based Costing steps	
Step 1	Identify the services or activities
Step 2	Estimate the total cost of each resource group
Step 3	Estimate the practical time capacity of each resource group
Step 4	Calculate the unit cost of each resource group
Step 5	Determine the estimated time for each activity
Step 6	Multiply the unit cost of each resource group by the estimated time for the activity

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TDABC starts estimating the cost of supplying capacity by identifying the different services or activities, their cost and their practical capacity. Then, the unit cost of each resource group is gathered by dividing the total cost by the practical capacity. The total cost of supplying resource capacity is defined as the cost of all the resources supplied to this department or process (e.g., staff, supervision, occupancy, equipment, technology, and infrastructure). Practical capacity is defined as the amount of time that employees work without idle time (Kaplan and Anderson 2007a). There are two ways to estimate practical time capacity: (1) assuming an 80 percent of theoretical capacity for people (excluding breaks, arrival and departure, communication, training, meetings, chitchat, etc.), and an 85 percent capacity for machines (excluding maintenance, repair, and scheduling fluctuations); and (2) calculating the real values adjusted for the institution (e.g., available working hours, excluding holidays, meeting and training hours; Kaplan and Anderson 2007b).

Once the cost of supplying capacity has been calculated, the estimated time for each activity is determined. This value can be obtained through interviews with employees or by direct observation; no additional surveys are required. Authors argue that precision is not critical, that a rough accuracy is sufficient because gross inaccuracies will be revealed either in unexpected surpluses or shortages of committed resources (Kaplan and Anderson 2007b). Unlike ABC, this value refers to the time that an employee spends doing an activity and not the percentage of time that it takes to complete one unit of that activity. In addition, through a simple time equation, it is possible to represent all possible combinations of activities (e.g., different types of products do not necessarily require the same amount of time to be produced). For each activity, costing equations are calculated based on the time required to perform an activity (Yilmaz 2008). This time is computed by time equations, which are the sum of individual activity times. Using these equations, it is possible to combine all the activities involved into one process with only one time equation. They are represented with the following expression (Kaplan and Anderson 2007b):

$$Time\ required\ to\ perform\ an\ activity = (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \cdots + \beta_i X_i)$$

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Where β_0 is the standard time to perform the basic activity (e.g., 5 minutes), β_1 is the estimated time for the incremental activity i (e.g. time required for the hand-in-robot to allocate the item in the correct box = 0.5 minutes), and X_i is the quantity of incremental activity i (e.g., number of items per loan = 2). Finally, costs are assigned to the cost object by multiplying the cost per time unit of the resources by the estimate of the time required for performing the activities.

TDABC in libraries

Little is known about applying TDABC in libraries. The first TDABC approach, given by Eli Pernot, Filip Roodhooft, and Alexandra Van den Abbeele (2007), uses TDABC for calculating interlibrary loan (ILL) costs. The paper offers a useful technique to reduce ILL resource costs or renegotiate ILL service prices. The authors conclude that TDABC could reduce the cost management of all library services because librarians can take appropriate actions to decrease the time needed for specific customer's requests. On the other hand, Kristof Stouthuysen and colleagues (2010) focus their analysis on the acquisition process. They describe TDABC as a useful system for small- to medium-size academic libraries. The authors define TDABC as a costing system that assists library managers in visualizing the acquisition process efficiencies and capacity utilization, leading to potential cost efficiencies. They also state that the study can be applied to complex or digitalized acquisition environments. These initial investigations show promising possibilities of using TDABC to provide accurate information on library activities. However, these studies have been applied to very specific settings, studying only particular processes with cases in small- and medium-size academic libraries. More research is still needed to identify whether the technique of TDABC is useful and feasible to implement for a more extensive set of library activities. In this context, the main objective of this article is to study whether TDABC can support loan and return processes in a large academic library.

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Case Study of Loan and Return Processes

A case study using TDABC was performed in the Circulation Department at the Arenberg Campus Library (CBA - Campusbibliotheek Arenberg) of the KU Leuven in Belgium. We focus on this unit because it is considered one of the most important departments of the library. Although nowadays digital libraries are becoming stronger, physical processes such as loan and return processes are still considered crucial activities within libraries because, as McKendrick (2011, 4) states: *"print still commands a lion's share of annual budgets*." The Circulation Department involves all the services related to lending processes, such as loaning, returning, reserving, renewing, paying fines, and providing basic reference services.

CBA is operated by approximately 20.5 full-time-equivalent employees (FTE), who give support to about 10,000 potential customers (Dekeyser and Holans 2003). To improve its cost efficiency, CBA has been obliged to use new technologies and to automate repetitive processes. In the case of the Circulation Department, the library has implemented lending and returning robots (lending robots named "chicos," as in "check in, check out"). With each chico robot, customers can borrow or return the items without any assistance. Alternatively, customers can also return the materials with a "hand-in-robot" that allows the return of items during hours the library is open without entering the library. The technology used for interacting with the robots and tagging the items is a Radio Frequency IDentification (RFID) system. Because of this interesting automation to improve cost efficiency, the processes of lending and returning have been selected to understand whether the decisions made at that time were the most appropriate. In the next sections, we illustrate the implementation of TDABC in the loaning and returning processes at CBA by applying six steps identified by Patricia Everaert and colleagues (2008).

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Step 1: Identifying the services or activities

The first step is to identify the main activities of the Circulation Department and the role that each staff member has in these activities. In order to do this, a round of interviews with the head of the library and the main desk staff (i.e., people in charge of those processes) was conducted.

Three main activities in the Circulation Department, WBIB lending (Wetenschappelijke BIBliotheek – scientific library), WMAG lending (Wetenschappelijke MAGazijn – scientific warehouse), and returning, were identified. Lending is the process of allowing users to borrow one or more items temporarily from the library. In the case of the CBA, the lending processes can be triggered with two types of materials: (1) WBIB items, which are bibliographic material (e.g., books or journals) located in open shelves, are directly available for customers without any assistance from the librarian. (2) WMAG items are only accessible to the library staff, because they are stored in compact shelves located in the basement. When a customer needs items from this repository, an online request must be filled. Returning is the process wherein customers return borrowed items to the library.

A second round of interviews was performed to obtain specific details about the different sub-activities of each process. This additional information was used to build flow charts of the activity sequences in the processes. It is important to remark that the least accurate flow occurred when superiors provided descriptions or when librarians presented a printed report of their estimations, which supports the findings of Eddy Cardinaels and Eva Labro (2008).

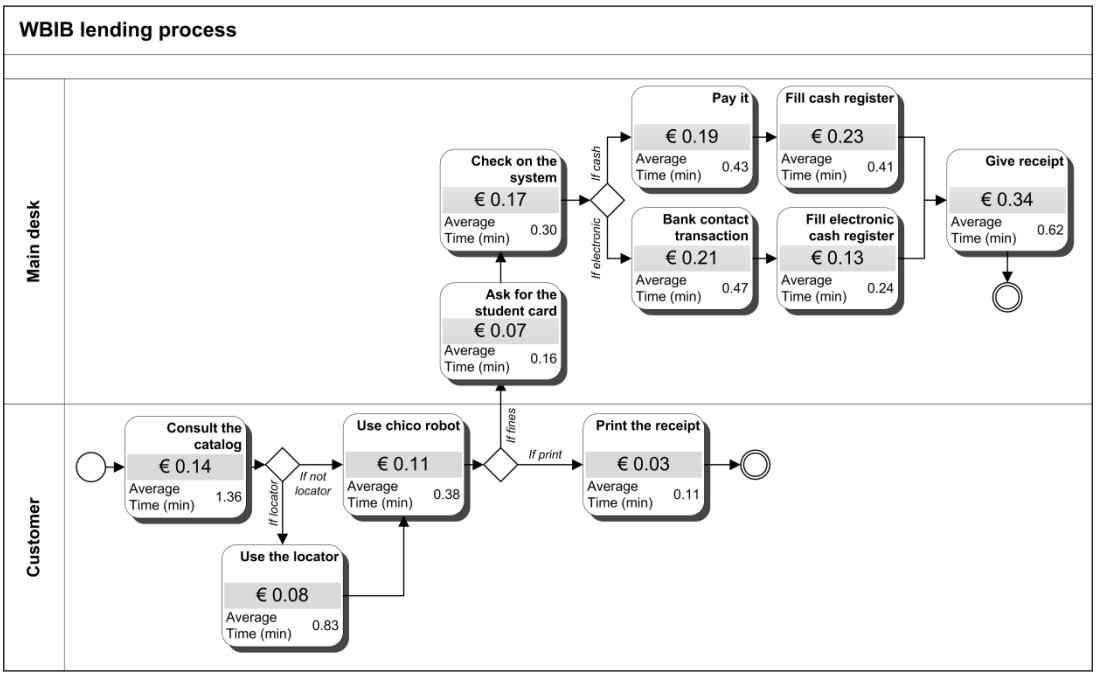
MS Visio and MS Excel were used to create a graphical representation of the tabular information. In each of the following figures, the beginning of each process is represented by a closed circle ●. Each figure is divided by horizontal lines to represent each of the actors involved in the process (e.g., customer, closed-stack responsible, main desk). These lines allow one to easily identify the different actors and resources involved in every specific activity. A diamond

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◆ depicts the different options that a process has in a specific moment, such as the two possibilities to bring an item from the closed stack if it is an evening or a day shift. The rounded rectangles represent the different activities, the average time consumed as well as its inquired cost. The end of a process is represented by the symbol ◉.

In the case of WBIB items (fig. 1), the customer and the main desk are the two actors involved. The process starts when a customer consults the catalogue to get an item. It is possible to find the physical place of the item by using the locator (i.e., a web system helps to locate library items); otherwise, the customer can go directly to the corresponding shelf. If the customer decides to borrow the item(s), the customer then puts them on the chico robot. If the customer has outstanding fines, the transaction is not performed until the fine is paid through an electronic transaction or in cash at the main desk. Finally, the customer can also print a receipt, which includes the details of the borrowed items.

Figure 1: WBIB Lending Process



In the WMAG Lending Process (fig. 2), four actors are involved: the customer, the main desk, a student library employee (SLE, i.e., a student hired to perform reshelving and classification activities), and the closed stack responsible. This process starts similarly to the previous one. However, in this case, the locator does not appear because it is not an open-shelf item. The customer requests the item online and receives it from the main desk. CBA has two kinds of staff shifts. In the mornings, a librarian works in the closed stack section and is responsible for sending the item to the main desk. During the evenings, the closed stack area is closed. Hence, an SLE goes to the closed stack and brings the item to the main desk. In any case, employees will ensure that the item is tagged (RFID system) before giving it to the customer. At this moment, the customer has two alternatives: (1) he or she can borrow the item, which results in the same procedure as the WBIB Lending, or (2) he or she can return the item, in which case the librarian deletes the request. If the item has also been requested by another customer, the librarian sends an e-mail message to the other customer, prints the request, and puts the item on a special shelf. Otherwise, if there is not a request for the item, the librarian returns the item to the closed stack in order to be reshelved.

The Returning Process (fig. 3) is triggered by the customer returning the item. In this process, two actors are involved: the customer and an SLE. The customer has two possibilities of returning: (1) He or she can return the item by the chico robot and print the receipt as proof of the returning. The robot has a plate where the customer puts on the borrowed items in order to make them recognizable for the computer. The customer can place a maximum of five items on the plate at one time. (2) He or she can return the item by hand in the robot and print the receipt. Using this machine, the customer is required to put the items one by one.

In the first case, during the evenings an SLE goes to the hand-in-robot with the book truck and returns the items. The objective of this activity is to accelerate the items' classification by the corresponding cluster (i.e., book collection divisions). In the second case, this activity is not necessary because the items are already sorted when the customer puts the items in the hand-in-

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robot. In any case, once the items have been classified by the hand-in-robot, an SLE will sort the items in the cluster; and then reshelf the items.

Figure 2: WMAG Lending Process

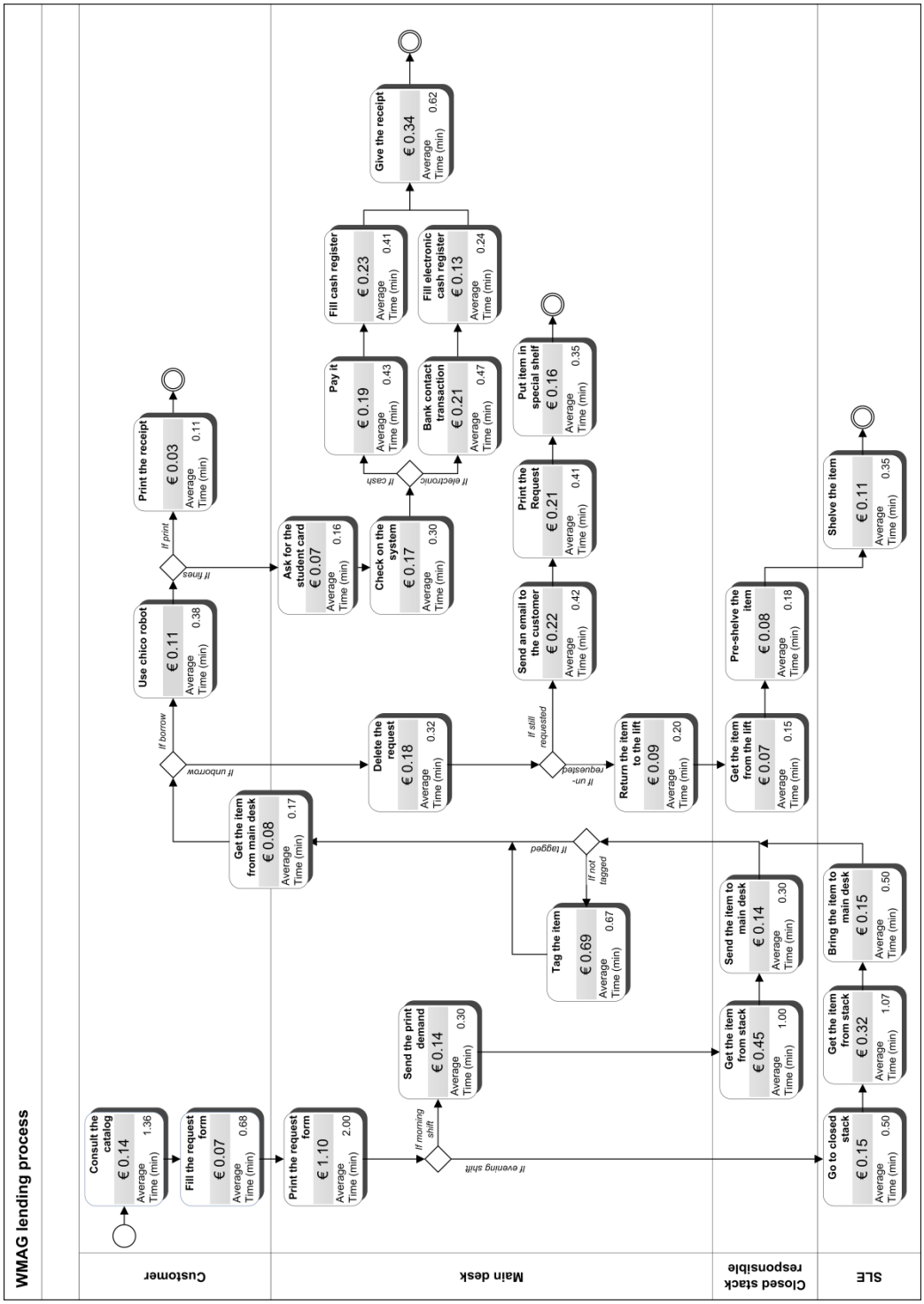
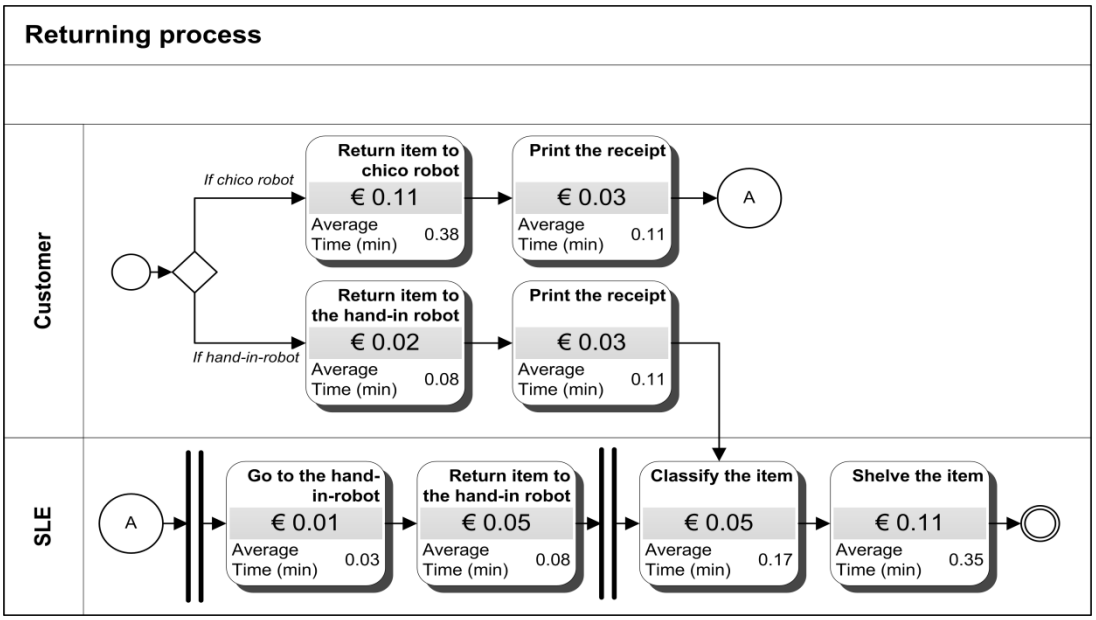


Figure 3: Returning Process



Step 2: Estimating the total cost of each resource group

The total cost for the processes of lending and returning consists of four main direct costs: staff costs, machines costs, library management systems (LMS) costs and SLE costs. Due to differences in the staff salaries performing the activities, the average salary is used for the staff cost. Each salary is calculated by the monthly gross salary plus the social security contribution. This represents the full cost of an employee. According to the head of the library, the total number of personnel assigned to the three processes represents 1.5 FTE. This value corresponds to several people working different percentages of their time as a comparable number to full-time employees. It corresponds to about € 4,110 on a monthly basis.

The cost of an SLE is about € 441.37 monthly. The head of the library reported having an average of five students per month, each working forty hours (total job students $= 5 \times 40 \frac{\text{h}}{\text{m}} = 200 \frac{\text{h}}{\text{m}}$). If we want to report the equivalence in FTE, we should consider that a staff member works thirty-eight hours/week (equals one FTE). If we assume four weeks per month, the corresponding FTE for SLE is 1.32 $\left(\text{FTE} = 200 \frac{\text{h}}{\text{m}} \div \left(38 \frac{\text{h}}{\text{w}} \times 4 \frac{\text{w}}{\text{m}}\right) = 1.32 \text{ FTE}\right)$, equivalent to € 582.60 monthly.

Loans and returns are mainly done by machines and the yearly cost associated with their maintenance, repair and inspection is about € 30,400 (including VAT [value added tax]). The value includes the costs associated with the maintenance of the RFID robots (chico and hand-in-robot) and the gate antennas (security). The yearly cost incurred with LMS is about € 17,050.

Based on the library accounting reports, there are two main types of indirect costs: (1) € 3,000 for machine overhead costs on a yearly basis (e.g., computer supplies, hardware, software) and (2) € 191,060 for staff overhead costs on a yearly basis (e.g., management, secretary, accounting, training, meetings staff, stationery material).[2] Because staff and SLE are associated with the second overhead, this cost is divided by the total number of FTE (FTE staff + FTE job student $= 20.5 + 1.32 = 21.82$), resulting in a yearly overhead of € 8,756 per FTE (€ 730 per month).

Step 3: Estimating the practical time capacity of each resource group

There are two ways to get the value of the practical time capacity of each resource group: (1) a percentage of the theoretical capacity, assuming the practical full capacity is about 80 percent for people and 85 percent for machines; and (2) calculating or counting the real values according to the library situation (Kaplan and Anderson 2007b). In order to simplify the study, the first option has been selected.

In the case of the machines and LMS, the practical capacity is set equal to the time that library is open, that is, for weekdays from 9 a.m. until 10 p.m. and for Saturdays from 9 a.m. until 1 p.m. (Dekeyser and Holans 2003). This means that on a theoretical basis machines and LMS are available during sixty-nine hours per week. Assuming fifty-two weeks per year, the practical capacity for machines and LMS is 182,988 minutes/year $\left(85\% \times 69\frac{hours}{week} \times 60\frac{min}{hour} \times 52\frac{weeks}{year}\right)$.

[2] There are certain values that are not required to be included as indirect costs because they are paid by the university and not charged to the library (e.g., electricity, heating, transportation, telephone; Ellis-Newman and Robinson 1998).

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For staff capacity, thirty-eight hours per week are accounted for the theoretical capacity. This results in 7,296 minutes/month $\left(80\% \times 38\frac{hours}{week} \times 4\frac{weeks}{month} \times 60\frac{min}{hour}\right)$. Considering 1.5 FTE for the lending and returning processes, the practical capacity for staff is 10,944 min/month.

Finally, regarding the SLE capacity, the theoretical capacity is forty hours/month (according to regulations by the law); the practical capacity for each SLE is 1,920 minutes/month $\left(80\% \times 40\frac{hours}{month} \times 60\frac{min}{hour}\right)$. Considering 1.32 FTE for SLE, the practical capacity is 2,534.4 minutes/month.

Step 4: Calculate the unit cost of each resource group

The cost per unit time is calculated by dividing the total cost of the resource (step 2) by the practical capacity (step 3). The machine overhead is added to the machines costs and LMS, and the staff overhead is added to the staff and the SLE costs. The resulting costs are presented in table 2.

Table 2: Unit cost per resource group

Unit cost per resource group

Cost Type	Calculations	Cost per Minute (€/min)
Machines costs	$= (€\ 30{,}400/182{,}988) + (€\ 3{,}000/182{,}988)$ $= 0{,}17 + 0{,}01$	0.18
Library Management System	$= (€\ 17{,}045/182{,}988) + (€\ 3{,}000/182{,}988)$ $= 0{,}09 + 0{,}01$	0.10
Staff labor costs	$= (€\ 4{,}110/10{,}944) + (€\ 730/10{,}944)$ $= 0.38 + 0{,}07$	0.45
SLE costs	$= (€\ 582{,}60/2{,}534.4) + (€\ 730/10{,}944)$ $= 0.23 + 0.07$	0.30

Step 5: Determine the time estimation for each activity

The required time to perform an activity was gathered through direct observation. The data collection was conducted multiple times using a

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stopwatch during several days at different hours in the first semester of 2010, and the results were validated through a second data collection in the following semester in order to avoid possible biases. Since we made a large number of observations, the average time of each activity was taken as reference to facilitate the calculations.

- *WBIB Lending Process*

A customer consults the catalogue to get an item (1.36 minutes), and then the physical place of the item can be identified by using the locator (0.83 minute). If the customer decides to borrow the item(s), the customer puts it (them) on the chico robot (0.38 minute). In case the customer has outstanding fines, the transaction cannot be performed until the fine is paid by an electronic transaction (0.71 minute) or in cash (0.84 minute) at the main desk. In any case, the librarian will ask for the student card to check on the system the value to be paid (0.46 minute), and will give a receipt to the customer as proof of payment (0.62 minute). Finally, if the customer desires, he or she can also print the borrow register (0.11 minute). The resulting equation is as follows:

WBIB Lending Process

$$\begin{aligned} &= 1.36 \times (number\ of\ items) + 0.83 \times (number\ of\ items)\ \{if\ locator\} \\ &+ 0.38 + [(1.08 + 0.71\{if\ electronic\} + 0.84\{if\ cash\})\{if\ fines\}] \\ &+ 0.11\{if\ print\ receipt\} \end{aligned} \quad (1)$$

There are certain parameters that can influence the formula (e.g. if the customer uses the locator or goes directly to the shelf). These situations are represented by dummy variables (Boolean values; Everaert and Bruggeman 2007). The dummy variable is zero when the optional activity is not used in a specific situation. Otherwise, the dummy is one when the activity is part of a particular process. In equation (1), dummy variables are $\{if\ locator\}$, $\{if\ electronic\}$, $\{if\ cash\}$, $\{if\ fines\}$, and $\{if\ print\ receipt\}$.

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- *WMAG Lending Process*

The WMAG Lending Process starts similarly to that shown in equation (1) (1.36 minutes). Subsequently, the customer requests the item (0.68 minute) which is automatically printed by the main desk (2.00 minutes). In the morning shift, the printed request is sent to the closed stack by the lift (0.30 minute), the closed stack responsible gets the item from the stack (1.00 minute) and sends it back to main desk (0.30 minute). In the evening shift, an SLE goes from the main desk to the closed stack (0.50 minute), gets the item (1.07 minutes) and carries it to the main desk (0.50 minute). If the item is not tagged, the employee will tag it (0.67 minute) and then give it to the customer (0.17 minute). An individual tag costs € 0.30, including VAT.

Then the customer has two alternatives: (1) *Borrow the item*: put the item on the chico robot and perform the borrowing procedure (0.38 minute). The transaction will not be made unless all outstanding fines are paid, similarly to equation (1). The process finishes by printing the receipt as a proof to the lending (0.11 minute). (2) *Return the item*: the librarian deletes the request (0.32 minute). If the item has another request, the librarian sends an email message to the customer (0.42 minute), prints the request (0.41 minute), and puts the item in a special shelf (0.35 minute). Otherwise, the librarian returns the item to the closed stack (0.35 minute) for it to be reshelved (0.53 minute).

$$
\begin{aligned}
&\boldsymbol{WMAG\ Lending\ Process} = \\
&1.36 \times (\text{number of items}) + 0.68 \times (\text{number of items}) + 2.00 + \\
&(0.30 + 1.00 \times (\text{number of items}) + 0.30)\{if\ morning\ shift\} + \\
&(0.50 + 1.07 \times (\text{number of items}) + 0.50)\{if\ evening\ shift\} + 0.67 \times \\
&(\text{number of items})\{if\ not\ tagged\} + 0.17 + \\
&(0.38 + [(1.08 + 0.84\ \{if\ electronic\ \} + 0.71\ \{if\ cash\})\{if\ fines\}] + \\
&0.11\{if\ print\ receipt\})\{if\ borrow\} + \\
&[0.32 + (0.42 + 0.41 + 0.35)\{if\ still\ requested\} + (0.20 + 0.15 + 0.18 + \\
&0.35)\{if\ not\ new\ request\}] \times (\text{number of items})\{if\ unborrow\}
\end{aligned}
\qquad (2)
$$

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- *Returning Process*

There are two options to return item(s): (1) by the chico robot (0.38 minute), printing the receipt as a proof to the return (0.11 minute), and leaving the item in the book truck, or (2) by the hand-in-robot (0.08 minute) and printing the receipt (0.11 minute). In the first case, during the evenings, an SLE goes to the hand-in-robot with the book truck (0.03 minute) and returns every item (0.08 minute). In both cases, the hand-in-robot will classify the items by the corresponding cluster, and an SLE will sort the items in the cluster (0.17 minute) and then reshelf the items (0.35 minute). The last two values are calculated using an average batch of items that an SLE classifies per cluster.

$$\begin{aligned}\boldsymbol{Returning\ Process} = \\ 0.38\{if\ chico\ robot\} + 0.08(\text{number of items})\{if\ hand\ in\ robot\} + \\ 0.11\{if\ print\ receipt\} + \\ [0.03 + 0.08 \times (\text{number of items})]\{if\ chico's\ robot\} + (0.17 + 0.35) \times \\ (\text{number of items})\end{aligned} \tag{3}$$

Step 6: Multiply the unit cost of each resource group by the time estimate for the activity

Eventually, a cost table is built by multiplying the unit cost per time and the time needed for the activity. Tables 3-5 present the costs incurred in each activity. The first column in each of these tables lists the activities identified in the process, and the second column shows the average time for each event. The third column indicates the accumulated costs of each resource group, and the fourth column calculates the resulting cost incurred in the activity. The fifth column describes the dummy variable conditioning the activity, and the sixth column includes the resource group involved in each activity. Each table is divided by standard and optional activities to separate the values influenced by the dummy variables.

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Table 3: WBIB Lending Process Cost Table

WBIB Lending Process

	Activity	Average Time (min)	Cost (€/min)	Cost (€)	Dummy Variable	Resources	#
Standard Activities	Consult the catalogue	1.36	0.10	0.14		LMS	a
	Use chico robot	0.38	0.28	0.11		Chico robot + LMS	b
	Subtotal	**1.74**		**0.25**			
Optional Activities	Use the locator	0.83	0.10	0.08	*if locator*	LMS	c
	Print the receipt	0.11	0.28	0.03	*if print receipt*	Chico robot + LMS	d
	Ask for the student card	0.16	0.45	0.07	*if fines*	Main desk	e
	Check on the system	0.30	0.55	0.17	*if fines*	Main desk + LMS	f
	Pay it	0.43	0.45	0.19	*if fines, if cash*	Main desk	g
	Fill Cash Register	0.41	0.55	0.23	*if fines, if cash*	Main desk + LMS	h
	Bank contact transaction	0.47	0.45	0.21	*if fines, if electronic*	Main desk	i
	Fill Electronic Cash Register	0.24	0.55	0.13	*if fines, if electronic*	Main desk + LMS	j
	Give receipt	0.62	0.55	0.34	*if fines*	Main desk + LMS	k
	Subtotal	**---**		**---**			
TOTAL		**---**		**---**			
(A)	$a + b + d\,\{if\ print\ receipt\}$ $1.36 + 0.38 + 0.11\,\{if\ print\ receipt\} = 1.36 + 0.38 + (0.11 * 1) = 1.85\ \text{min}$ $0.14 + 0.11 + 0.03\,\{if\ print\ receipt\} = 0.14 + 0.11 + (0.03 * 1) = €\,0.28$						
(B)	$a + b + \{[(e + f + k) + [(i + j)\{if\ electronic\ \}]]\{if\ fines\}\}$ $1.36 + 0.38 + [(1.08 + 0.71\,\{if\ electronic\ \})\{if\ fines\}] = 1.36 + 0.38 + 1.08 + 0.71 = 3.53\ \text{min}$ $0.14 + 0.11 + [(0.58 + 0.34\,\{if\ electronic\ \})\{if\ fines\}] = 0.14 + 0.11 + 0.58 + 0.34 = €\,1.17$						
(C)	$a + b + \{[(e + f + k) + [(g + h)\{if\ cash\}]]\{if\ fines\}\}$ $1.36 + 0.38 + [(1.08 + 0.84\,\{if\ cash\})\{if\ fines\}] = 1.36 + 0.38 + 1.08 + 0.84 = 3.66\ \text{min}$ $0.14 + 0.11 + [(0.58 + 0.42\,\{if\ cash\})\{if\ fines\}] = 0.14 + 0.11 + 0.58 + 0.42 = €\,1.25$						

Table 4: WMAG Lending Process Cost Table

WMAG Lending Process

	Activity	Average Time (min)	Cost (€/min)	Cost (€)	Dummy Variable	Resources
Standard Activities	Consult the catalogue	1.36	0.10	0.14		LMS
	Fill the request form	0.68	0.10	0.07		LMS
	Print the request form	2.00	0.55	1.10		Main desk + LMS
	Get the item from main desk	0.17	0.45	0.08		Main desk
	Use chico robot	0.38	0.28	0.11		Chico robot + LMS
	Subtotal	**4.59**		**1.49**		

Optional Activities	Get the item from stack	1.60	0.45	0.72	*if morning shift*	Closed stack resp.
	Get the item from stack	2.07	0.30	0.62	*if evening shift*	SLE
	Tag the item	0.67	1.03*	0.69	*If not tagged*	Main desk + LMS + machines + tags*
	Print the receipt	0.11	0.28	0.03	*if borrow*	Chico robot + LMS
	Ask for the student card	0.16	0.45	0.07	*if fines*	Main desk
	Check on the system	0.30	0.55	0.17	*if fines*	Main desk + LMS
	Pay it	0.43	0.45	0.19	*if fines, if cash*	Main desk
	Fill Cash Register	0.41	0.55	0.23	*if fines, if cash*	Main desk + LMS
	Bank contact transaction	0.47	0.45	0.21	*if fines, if electronic*	Main desk
	Fill Electronic Cash Register	0.24	0.55	0.13	*if fines, if electronic*	Main desk + LMS
	Give the receipt	0.62	0.55	0.34	*if fines*	Main desk + LMS
	Delete the Request	0.32	0.55	0.18	*If un-borrow*	Main desk + LMS
	Return the item to the closed stack	0.53	0.45	0.24	*If un-borrow, if not new request*	Closed stack resp.
	Shelve the item	0.35	0.30	0.11	*If un-borrow, if not new request*	SLE
	Send an email to the customer / Print the request	0.83	0.55	0.43	*If un-borrow, if still requested*	Main desk + LMS
	Put item in a special shelf	0.35	0.45	0.16	*If un-borrow, if still requested*	Main desk
	Subtotal	**---**		**---**		
TOTAL		**---**		**---**		

* € 1.03 = main desk + LMS + machines + tags = 0.45 + 0.10 + 0.18 + 0.30 (individual tag costs)

Table 5: Returning Process Cost Table

Returning Process

	Activity	Average Time (min)	Cost (€/min)	Cost (€)	Dummy Variable	Resources
Standard Activities	Shelve the item	0.35	0.30	0.11		SLE
	Subtotal	**0.35**		**0.11**		
Optional Activities	Return item to chico robot	0.38	0.28	0.11	*if chico robot*	Chico robot + LMS
	Print the receipt	0.11	0.28	0.03	*if chico robot or if hand-in-robot*	Machines + LMS
	Return item to the hand-in-robot	0.08	0.28	0.02	*if hand-in-robot*	Machines + LMS
	Go to the hand-in-robot	0.03	0.30	0.01	*if book truck*	SLE
	Return item to the hand-in-robot	0.08	0.58	0.05	*if book truck*	SLE + Machines + LMS
	Classify the item	0.17	0.30	0.05	*if book truck*	SLE
	Subtotal	**---**		**---**		
TOTAL		**---**		**---**		

To calculate the total cost of a sub-process, one first identifies the different activities that appear in this specific situation. The fifth column of the costing tables that contains the dummy variables helps us to identify which optional activities are going to be used for the calculation. In the bottom part of table 3, three different examples of sub-processes are included to illustrate how the total cost is calculated. Case A represents the most common situation of a customer taking the item from the shelf, borrowing it, and finally printing the receipt. Case B and C correspond to a customer who is trying to borrow an item, but first he has to pay a fine of previous transactions. In case B, the customer pays the fine through an electronic transaction, whereas in case C he pays the fine in cash.

Based on these costing tables a costing analysis process, by means of a what-if analysis, can be performed. For instance, it is possible to analyze the cost of returning three items through all possible cases: (1) by the chico robot, (2) by the hand-in-robot, and (3) manually with the assistance of a librarian.

If a customer returns the items through the chico robot, this value (0.38 minute) is not multiplied by the number of items because these machines allow the customer to return up to five items at the same time on the plate. Then a receipt could be printed as proof or returning (0.11 minute). Those values are multiplied by the cost that represents the maintenance of the machines (€ 0.18) and LMS (€ 0.10). Table 6 provides an overview of this example.

Table 6: Returning Process through the chico robot

Returning Process through the chico robot					
	Activity	**Average Time (min)**	**Cost (€/min)**	**Cost (€)**	**Resources**
Activities	Shelve the item	0.35*3	0.30	0.32	SLE
	Return item to chico robot	0.38	0.28	0.11	Chico robot + LMS
	Print the receipt	0.11	0.28	0.03	Machines + LMS
	Go to the hand-in-robot	0.03*3	0.30	0.03	SLE
	Return item to the hand-in-robot	0.08*3	0.58	0.14	SLE + Machines + LMS
	Classify the item	0.17*3	0.30	0.15	SLE
TOTAL		**2.38**		**0.78**	

If the items are returned by the hand-in-robot, the customer is required to place the items one by one onto the machine. In this case, that time value (0.08 minute) is multiplied by the number of items the customer returns. The final receipt will be only one, even if the customer returns many more items. The results can be seen in table 7.

Table 1: Returning Process through the hand-in-robot

Returning Process through the hand-in-robot					
	Activity	**Average Time (min)**	**Cost (€/min)**	**Cost (€)**	**Resources**
Activities	Shelve the item	0.35*3	0.30	0.32	SLE
	Print the receipt	0.11	0.28	0.03	Machines + LMS
	Return item to the hand-in-robot	0.08*3	0.55	0.13	Machines + LMS
	Classify the item	0.17*3	0.30	0.15	SLE
TOTAL		**1.91**		**0.63**	

If the items are returned manually with a librarian, the customer gives the items to the main desk. The librarian scans each item by hand to enter into the system (0.20 minute) and then rewrites the RFID tag to specify that the item is in the library again (0.32 minute). In order to do this the librarian places the item in the RFID station. Finally, the employee leaves the items in the book truck. Table 8 contains the results.

Table 2: Returning Process through the librarian staff

Returning Process through the library staff					
	Activity	**Average Time (min)**	**Cost (€/min)**	**Cost (€)**	**Resources**
Activities	Return item manually into the system	0.20*3	0.55	0.33	Main desk + LMS
	Rewrite the RFID tag	0.32*3	0.73	0.70	Main desk + Machines + LMS
	Print the receipt	0.11	0.55	0.06	Main desk + LMS
	Leave the items in the book truck	0.10	0.45	0.05	Main desk
	Go to the hand-in-robot	0.03*3	0.30	0.03	SLE
	Return item to the hand-in-robot	0.08*3	0.58	0.14	SLE + Machines + LMS
	Classify the item	0.17*3	0.30	0.15	SLE
TOTAL		**2.61**		**1.46**	

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Implications

The TDABC analysis provides many insights into the costs of the lending and returning processes. This, in turn, leads to several implications and recommendations. From the example on the returning process, it is evident that the time and cost of returning three items manually is very high in comparison with the same activity performed by the robots. If the items are returned by the chico robot, we obtain a reduction in costs of 47 percent. If this task is performed through the hand-in-robot, the cost is 20 percent less in comparison to the chico robot. Based on these figures it is recommended to automate as much as possible the returning process, as this will lead to significant cost reductions.

Although, most of the processes in the Circulation Department have been automated, there are still some activities that can be improved. For instance, in table 3 the total cost of a WBIB lending process is analyzed through three different cases. The TDABC analysis shows that paying fines electronically is slightly less expensive than paying in cash (6 percent), as in both cases the assistance of a librarian is required. However, if a customer does not have to pay a fine, the cost is reduced by 76 percent. Based on these findings, potential improvements can be undertaken, such as performing awareness-raising campaigns about returning items on time or paying fines at the time of enrollment at the University.

Other what-if analysis can be done between the activities performed by an SLE or a librarian, such as reshelving the materials. An interesting discussion is also to analyze the most expensive activities, for instance, printing requests in the WMAG process (€ 1.10). Taking into account the incurred costs for such an activity and the environmental impact caused, one may consider automating this activity by setting alerts to the system when a new request is performed.

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Conclusions

Because of the current economic conditions of our times and because of limited resources, academic libraries are called to search for efficient methods to balance their limited budgets with the services provided. Hence, the costs and time consumed by activities, processes and resources are extremely important and of high interest to library managers in identifying non-value-added activities, finding and adapting best practices, and justifying decisions and choices. In this article, a case study of the Time-Driven Activity-Based Costing implementation on the loan and return processes at the Arenberg Campus Library of the KU Leuven was conducted. This case study has illustrated through six simple steps how this method can be used in carrying out a cost analysis in a simple, easy-to-understand and accurate manner.

Several important insights have emerged from the case study. The first important insight is that the amount of time required to collect the duration of activities and to document the activity flows is relatively limited compared to the insights gained from the analysis. The duration of activities was gathered by direct observation since the most accurate data were collected when librarians physically performed the tasks. Although in the beginning, this process is more time consuming, nonetheless, the final model considers real and detailed values about the library activities. Therefore, a trade-off between measurement time and accuracy must be considered. To document the activity flows, rounds of interviews with library managers and staff were done to identify the activities, resources and responsibilities. A second important insight is that software tools and the ease of presenting results help to decrease implementation time, and allow for better communication and validation. MS Office suite programs, such as Visio and Excel, were integrated to store, analyze and create graphical representations of the activity flows. As a consequence of this clear graphical representation, librarians were able to easily understand the sequences and their responsibilities in each process, and consequently, this allowed us to validate the collected information straightforwardly. Finally, a third important insight is that the involvement and commitment of the library staff are critical

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to the data collection in increasing the acceptance of the model. Therefore, motivation and an explanation of the measurement purpose are fundamental for achieving the desired commitment with staff. In the case of a large library, this requirement is even more critical since the number of employees gives rise to different types of opinions and attitudes regarding the process. This case study shows that TDABC is applicable to large libraries as well but that involvement of library staff is crucial.

A real situation that libraries face is the decision to automate repetitive processes. In this case study this is analyzed through three different situations of the returning process. With a simple but interesting example, we compare the costs of some specific activities performed by staff or machines. As we can see, the use of robots is well justified to automate these repetitive processes, especially in the cases of costly labor and in high number of activities.

This case study also illustrates some important benefits of TDABC such as the following: (1) better understanding of the costs' origins due to the disaggregated cost, time and resources per activity and of activities to be improved or discarded (e.g., including alerts in the LMS when a new request is available instead of printing requests); (2) an improved alternative evaluation for comparing different scenarios (e.g., manual activities vs. automated); (3) enhanced communication to analyze the cause of specific problems with stakeholders (librarians) that can easily understand the methodology applied; at the same time, librarians can justify the increase of wages or the development of the new services based on their responsibilities and the time required to perform them; (4) adaptability when, for instance, it is required to switch resources in busy periods, as when adding more staff to strengthen the user attention process is required to cope with the increased demand at the beginning of every semester; as demand increases (customers require extra attention to get familiar with the library), a shift from other areas for a specific period of time can be made; activities that were relegated for this cause can be prioritized during periods of low demand (e.g. when classes have ceased).

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In summary, although at first glance, TDABC may seem more difficult to implement and to require more intensive data collection compared to a traditional costing system, our investigation shows that TDABC in practice is simple and easy to understand when the six steps identified by Everaert and colleagues (2008) are followed. Furthermore, the potential benefits accruing from the TDABC implementation such as the accuracy to calculate the costs of library services, the possibility of performing benchmarking analysis, disaggregating values per activity, and justifying decisions and choices, validates the effort required to collect the data. An interesting avenue for future research is to perform a TDABC analysis on the user reference process. Considering that this kind of task does not follow a structured and systematic sequence (i.e., activities are addressed as they come in), as is in the case of our study, we expect that this analysis requires more effort and expertise. As a consequence, time analysis could be less accurate and more difficult to interpret. Additionally, a benchmark study is an interesting project to be done with libraries without fully automated loan and return processes.

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