

Using time-driven activity-based costing to improve the managerial activities of academic libraries

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Abstract

Nowadays, Academic libraries are required to provide high quality services despite their limited budget. Library managers should rely on valid information to keep the library's activities, resources and costs under control. In this paper, we present a case study implementation of Time-Driven Activity-Based Costing (TDABC) at the library of the University of Macedonia, Thessaloniki, Greece. The TDABC is a reliable accounting method that considers many aspects that may affect the employees' efficiency and performance. We adopted quantitative and qualitative methods to evaluate the library's loan and return processes. In particular, we: i) analyzed cost data, ii) interviewed the library's staff, and iii) recorded the duration for all relevant activities with a stopwatch. The activities' duration was recorded via direct observation. The data were collected during the academic year 2017-2018 to cover all the different academic periods. According to our results, the automation of repetitive processes in the circulation department may decrease significantly the operating costs. This may be achieved by reducing the number of staff and replacing them by robotic services. Implementing TDABC in the lending and return processes helped the library managers to determine which activities demand more time and are costly, and to analyze their respective causes.

Keywords: Time-driven activity-based costing, Academic libraries, lending and returning processes, Case study.

1. Introduction

The operation of academic libraries all over the world has been affected radically by changes in the socioeconomic environment. During the last decade, academic libraries have experienced large cost cuts due to reduced funding and the digitalization of services and resources. Limited budget resources led to the reduction of costs for staff training, subscription to electronic resources, operational expenses, etc. (McKendrick, 2011; Vandewalle, Verhaaren, & Cattrysse, 2014a; Kostagiolas, Banou, Vazaiou, & Kapellas, 2016; Sigüenza-Guzman, Van den Abbeele; Saunders, 2015). In order to provide quality services while keeping costs under control, library managers relied on valid cost estimates and adapted cost saving techniques (Stouthuysen, Swiggers, Reheul, & Roodhooft, 2010). The analysis of the activities' costs helped library managers to make resourceful decisions on how to allocate and effectively use library resources. The current analysis may also help managers determine which activities are the most important, and how to reduce costs related to non-added value activities (Ellis-Newman, Izan, & Robinson, 1996; Sigüenza Guzmán, Van den Abbeele, & Cattrysse, 2014b).

To achieve this, library managers should adopt a cost system that is simple and easy to implement. Many researchers (e.g., Pernot, Roodhooft, & Van den Abbeele, 2007; Siguenza-Guzman et al. 2014a) consider Time-Driven Activity-Based Costing (TDABC) to be a simple and useful costing system, which may help library executives to perform a cost analysis more efficiently.

This paper describes the development and application of the TDABC system to the academic library of the University of Macedonia, Thessaloniki, Greece. The University of Macedonia (UoM) is a public medium-sized higher education institution and is considered a representative case study for the Greek Universities. This case study focuses on one of the most important library's departments, the circulation department. Library circulation is a key function and an integral part for every academic library. The circulation department employs the largest number of librarians and thus, has high staff costs.

The paper is organized as follows: In the theoretical background section (§2), we briefly address the library's costing systems, and in particular the technique of TDABC. In the next section (§3), we describe the steps involved in the implementation of TDABC in the lending and returning process and discuss the findings of our analysis. Finally, we reach conclusions and suggest new studies for future research (§4).

2. Theoretical Background: Costing Systems in Libraries

Traditional costing systems may be appropriate for libraries under certain circumstances, such as in the case of libraries that have low indirect expenses and provide a few, basic services. However, these systems may not apply if indirect costs are more complex compared to direct costs, or if the library offers many services (Ellis-Newman and Robinson, 1998; Siguenza-Guzman, Van den Abbeele, Vandewalle, Verhaaren, & Cattrysse, 2013). Moreover, traditional cost accounting systems do not help library managers understand what causes the most important costs. On the contrary, Activity-Based Costing (ABC) works complementary to traditional cost accounting systems and may provide detailed cost information to administration (Vazakidis, Karagiannis, & Tsiailta, 2010).

Many researchers (e.g., Wegmann & Stephen, 2009; Kont, & Jantson, 2011) consider the Activity-based costing method as a management accounting innovation, since it may provide library managers with accurate information about the library's activities costs.

However, many managers who attempted to implement ABC have abandoned the effort due to the many restrictions they have encountered (Kaplan & Anderson, 2003). The ABC accounting model works well in a limited context, but it may be difficult to apply in organizations with many activities. In this case, the system is usually based on subjective information and the cost for operating the ABC model is high, because the accounting system needs to be updated regularly (Goddard, & Ooi, 1998).

These restrictions motivated Kaplan and Anderson (2007a) to develop a revised and easier version of the ABC, which is called Time Driven Activity Based Costing (TDABC).

This time-driven approach is a useful cost management technique that avoids the costly, time-consuming, and subjective activities of a conventional ABC system. It assigns the costs to the cost objects (i.e. the activities the organization performs for products, services, and customers), by estimating two parameters:

1. The cost per time unit of the resources used
2. The number of time units (usually minutes) consumed by the activities related to the cost objects. It is estimated with the use of a simple time equation that may represent all possible combinations of activities (e.g., different types of activities do not necessarily require the same amount of time to be performed). Using this method, it is possible to combine all the activities involved into one process with a one-time equation. A time equation is represented with the following expression (Kaplan and Anderson 2007b):

$$\text{Time required to perform an activity } t_{j,k} = (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_i X_i) \quad [1]$$

where $t_{j,k}$ = time required for event k of activity j , β_0 is the standard time to perform the basic activity, β_i is the estimated time for the gradual activity i , and X_i is the quantity of gradual activity i (e.g., number of items per loan).

The TDABC is applied with a step by step approach (Everaert, Bruggeman, Sarens, Anderson, and Levant, 2008). The costs are assigned to the costs objects, by multiplying the cost per time unit of the resources used, to the estimated time in time units required to perform the activities.

The TDABC method was first implemented at the interlibrary loan services of the Arenberg Library, of the Katholieke Universiteit of Leuven (Pernot, et al., 2007). The authors conclude that TDABC could reduce the cost management of all library services, because it disaggregates the cost per transaction and it identifies activities which are costly and inefficient. This information may help librarians to take appropriate actions and decrease the time needed for the patron's requests. The TDABC method considers many aspects not related to actual work performance, which may affect the employees' efficiency and performance. These aspects may be rest periods, personal time for breaks, arrival and departure, and communication time.

The TDABC may be a great method for mapping libraries' activities, because it may be tested and implemented to all the processes of each department. The TDABC method provides management with a detailed cost analysis of services and activities. It may help managers save time and reduce cost, by optimizing the most important activities and understanding what causes costs. It also provides important information about the activities with no added value, which may be omitted. The managers are better informed regarding the costs that may occur, when they transfer staff from other departments to cope with the increased demand of services during the beginning of the academic year (Stouthuysen et al., 2010; Akhavan, Ward, & Bozic, 2016; Anzai et al., 2017).

Stouthuysen et al., (2010) adopted the TDABC method for a small-sized academic library in a Belgian University to estimate the costs of the acquisition process. The authors claim that TDABC may assist managers in visualizing the efficiencies of the acquisition process and the capacity utilization. This information may lead them to efficient cost management.

However, Kont and Jantson (2011) argued that the ABC and TDABC models are both suitable for university libraries. The ABC system may only be implemented in collaboration with the University's accounting department. In contrast, the TDABC model may only be tested and implemented separately in each library department.

In 2015, the same authors (Kont & Jantson) adopted the TDABC method to analyze the cost of activities related to the acquisition process in the Estonian university libraries. The authors concluded that the TDABC method is well suited for a library setting, since it may evaluate many activities with complex time drivers, and it may provide accurate information identifying non-value-added activities. In general, the TDABC method seems to be one of the best tools when it comes to understanding cost behavior and refining a cost system for university libraries.

On the other hand, Siguenza-Guzman et al., (2014a) compared the costs of some specific activities performed by staff or robotic services on the loan and return processes, at the Arenberg Library of the Katholieke Universiteit Leuven (KU Leuven). The authors claim that TDABC may be applicable to large libraries, but the involvement of library staff during the TDABC implementation is considered crucial. They also conclude that TDABC leads to an effective process analysis and better decision-making by librarians and library administrators, and that the usage of robotic services will automate repetitive processes effectively. A second case study presented by Siguenza-Guzman et al., (2014b) describes the use of TDABC for a library cataloguing process. The authors conclude that TDABC is a useful method to perform cost analysis in cataloguing processes, and it may provide valuable data for managerial decisions. Another case study presented by Siguenza-Guzman, Auquilla, Van den Abbeele, and Cattrysse (2016) describes the implementation of the TDABC method at two Belgian libraries. They compared the workflow of ten library processes covering the most important library functions (i.e. acquisition, cataloging, circulation and document delivery). Their main conclusion is that the TDABC method may be used in libraries to enhance process benchmarking through the identification of best practices and opportunities for improvements.

3. Case Study of Loan, Renewal and Return Processes

The aim of our research is to apply the TDABC model to the department of circulation at the library of the University of Macedonia. The University's accounting system provides information about the expenditures of the central library services without an analytical breakdown of each activity. As a result, the library managers cannot evaluate the cost of the services. Accurate estimation of cost will help identify opportunities for cost saving in Greek university libraries. The results of our research will be valuable for the library's

executives, who express the willingness to analyze the activities' costs in order to use effectively the library's resources and improve customer service.

The circulation department is the service point where books and other materials are checked in and out of the library (Reitz, 2004). The department of circulation is considered as the most important department of the library, since it manages the loan and return processes. It also offers other specific services such as renewing, paying fines and shelving. We estimate the cost of the loan, renewal and return processes which are considered to be the most important services of the library. This unit is suitable for research, since most of the transactions and processes are repetitive and hence they can be automated. The use of TDABC is proposed to attain the automation of repetitive processes at a lower cost.

The academic library under study is the library and information center of the University of Macedonia, Thessaloniki. The University is a middle-sized educational institution with eight academic faculties, offering a broad range of undergraduate and post-graduate courses up to the doctoral level. The total number of students is estimated to be about 14.555 ("University of Macedonia", 2019). The library staff consists of approximately twenty-one full-time-equivalent employees (FTE). The University's accounting system provides information about the expenditures of the central library services without an analytical breakdown by activity. As a result, the library managers cannot evaluate the cost of the services.

To apply the TDABC model for the loaning and returning processes at the library of the University of Macedonia, we adopted both quantitative and qualitative methods (Kont, & Jantson, 2014). We followed a six-step approach, according to Everaert, Bruggeman, Sarens, Anderson, and Levant, (2008). These Time-Driven Activity-Based Costing steps are as follows:

1. Identify the most important processes. On this account, we interviewed using open questions, both the administrative employees and the library manager
2. Estimate the total cost of each resource group. The data was provided by the university's financial and human resources managers, based on the real cost data. All financial data were collected for the year 2016. According to the annual library's accounting reports and the university's financial and human resources managers, the total cost of the borrowing and return procedures is calculated from direct and indirect costs. The two main direct costs are staff labor and library management system (LMS). The indirect costs include stationery material, energy, telephone, electricity, support, training, depreciation of furniture and electronic equipment
3. Estimate the practical time capacity of each resource group (i.e. the amount of time that employees work without the estimation of idle time). The practical time capacity was estimated according to Kaplan & Anderson (2007a)

4. Calculate the unit cost of each resource group, by dividing the total cost of the resource (estimated in step 2) by the practical capacity (estimated in step 3) (Kaplan & Anderson, 2007a)
5. Determine the estimated time for each activity of a process, with the use of time equations. The time data was gathered from the researchers via direct observation, when the librarians physically performed the tasks. We conducted the data collection using a stopwatch during several days at different hours and with different employees. The observation data were written in a paper form, and processed electronically with the use of Microsoft Excel 2010. The data collection lasted one academic year 2017-2018 (January-December) in order to cover all the different academic periods, such as: the beginning of every semester, exams and holidays. During the first semester of 2017, we have recorded the time spent for the activities. To avoid bias, we validated the results with a second data collection during the next semester. Since the number of observations was large (100), we estimated the average time of each activity to facilitate time calculations (Siguenza-Guzman et al., 2014a). Kaplan and Anderson (2007b) argue that time recording precision is not critical. A rough accuracy is sufficient because it will reveal inaccuracies in unexpected surpluses or shortages of committed resources
6. Estimate the cost/activity (€), by multiplying the unit cost of each resource group (estimated in step 4) by the estimated time for the activity (estimated in step 5) (Yilmaz, 2008)

Although the time data collection for step 5 may be more time-consuming and uncomfortable for the staff being observed, the data is more reliable and representative and may lead to more accurate results. Moreover, the library's management and staff were very collaborative after we explained to them the necessity and importance of our research. According to Siguenza-Guzman et al., (2014a), their involvement and commitment is critical to the data collection and may increase the acceptance of the model. In many cases, the staff may become reactive to being watched and observed. Thankfully, in our case this didn't happen.

In the next paragraphs, we present a step by step description of the application of the TDABC model at the library of the University of Macedonia, Thessaloniki, Greece. In detail:

3.1 Step 1: Identify the most important processes

We interviewed the head of the library and the main desk staff to identify the most important processes. According to the staff, the five most significant processes are the following: i) lending process of the main collection, ii) lending process of the reserve collection, iii) return process through the main collection, iv) return process through the drop box, and v) renewal process. In particular:

1) *Lending process of the main collection.*

The lending process allows users to borrow items temporarily from the library. The process starts when a patron (student, professor, citizen) brings one or more item(s) to the library's lending desk to borrow them from the main collection. The main collection refers to most of the library's circulating books. This collection doesn't include material such as journals, reference material, reserve, audiovisual and literature material

2) Lending process of the reserve collection.

The reserve collection is created by the faculty professors and the librarians, and contains materials essential to coursework, such as required or recommended readings. It also contains books that are heavily used by students. The undergraduate or postgraduate students have access to this collection

3) Return process through the main collection by physical presence of the patron (RP1).

The patron brings the borrowed item(s) at the library's circulation desk

4) Return process through the main collection (RP2).

If the patron wishes to return the borrowed item(s) when the library is closed, she/he may use the drop box located outside the library's main entrance

5) Renewal process

If the patron wishes to renew the loan period, this can be done in the following ways: i) by physical presence at the borrowing department, ii) by phoning and iii) by carrying out the renewal process herself/himself, via the on-line library catalog

3.2 Step 2: Estimate the total cost of each resource group

According to the annual library accounting reports, the total cost of the borrowing and return procedures is calculated from direct and indirect costs.

The two main direct costs are as follows:

- Staff labor costs: According to the manager of the library, the total number of personnel assigned to the above processes represents five full-time librarians (5 FTE). The total monthly cost is about € 10,370, and the total yearly cost is about € 124,440
- Library Management System (LMS) costs: The yearly cost is approximately € 7,656. This value includes the costs associated with the hardware (gate antennas, RFID technology) and software (Microsoft Office, etc.) of the library

There are also two main types of indirect costs on a yearly basis:

- € **224,028** for staff overhead costs (e.g., IT officer, accounting, management, stationery material, energy, telephone, cleaning)
- € **20,145** for LMS overhead costs (e.g., depreciation of: electronic equipment, library bookshelves and office furniture)

3.3. Step 3: Estimate the practical capacity time of each resource group

Practical capacity is defined as the amount of time that employees work, without the estimation of idle time (Kaplan & Anderson 2007a). In order to calculate the practical capacity of each resource group, we assume a 80% of theoretical time capacity for people, and a 85% for machines excluding maintenance and repair time (Kaplan, & Anderson, 2007b, pp. 52–53). According to these assumptions, various sources of downtime such as breaks, arrival and departure time, communication and meetings, account for 20% of personnel time. Another way to estimate practical capacity is to calculate on average how many days per month employees and machines work, and how many hours or minutes per day employees or equipment are available to do actual work, after subtracting time for scheduled breaks, training, meetings, and maintenance. In order to simplify the estimations of our study, we selected the first choice.

According to the Greek labor law, the staff has to work forty hours per week (theoretical capacity). We estimate the practical capacity as:

$$80\% \times 40 \text{ hours / week} \times 52 \text{ weeks/year} \times 60 \text{ min/hour} = 80\% \times 124,800 \text{ min} = 99,840 \text{ min/year}$$

According to step 2, there are 5 FTE for the lending and returning processes, so the practical capacity time for staff is $99,840 \text{ min/year} \times 5 = 499,200 \text{ min/ year}$.

With LMS, the theoretical time capacity is set equal to the time that the library is open. That is, for weekdays from 8:00 a.m. until 8:00 p.m. and for Saturdays from 8:30 a.m. until 3:00 p.m. This accounts in total for 66.5 hours per week. Thus, the practical capacity for LMS is $= 66.5 \text{ hours} \times 85\% \times 52 \text{ weeks/year} \times 60 \text{ min/hour} = 176,280 \text{ min / year}$.

3.4. Step 4: Calculate the unit cost of each resource group

The time unit cost [2] is calculated by dividing the total cost of the resource (step 2) by the practical capacity (step 3).

$$\text{Cost per time unit} = \text{total cost of the resource} / \text{practical capacity} \quad [2]$$

The LMS overhead is added to the LMS costs, and the staff overhead is added to the staff costs. An overview of the resulting costs involved in our analysis is presented in Table 1.

Resource Group	Calculations	Cost per minute (€/min)
Staff labor costs	$(124,440/499,200) + (224,028/499,200) = 0.25 + 0.45$	0.70
LMS	$(7,656/176,280) + (20,145/176,280) = 0.044 + 0.114$	0.16

Table 1: Unit cost per resource group

3.5. Step 5: Determine the estimated time for each activity

According to the TDABC method, it is very important to emphasize that the main question is not about how much time an employee spends doing an activity, but how long it takes her/him to complete one unit of that activity. In our study, we recorded the estimated time using a stopwatch for each activity, via direct observation during several days at different hours. The time equations estimate the sum of activity times. In the following paragraphs, we describe for each process these estimations (Kaplan & Anderson, 2007b) using time equations:

1) Lending process of the main collection.

The patron searches the library's electronic catalog, to find out if at the present time a copy of the item is available for lending. If it is available for lending and the patron desires to borrow it, he notes down its call number (i.e. unique identification number for every title in the collection) and looks it up at the main collection's book stack. If he finds it, he brings it to the library's main desk.

The first available librarian at the circulation desk asks for the patron's borrowing card (TIME 1). In order to start the lending transaction, she/he uses the borrowing card's barcode to open the patron's record into the library's circulation subsystem (part of the Library's Operating System-KOHA) (TIME 2).

If the patron has a pending fine, the transaction cannot be performed according to the current library's lending regulation, until the fine is paid at the lending desk. The librarian will inform the patron about the amount to be paid (TIME 3). After the fine is paid at the main desk by cash (TIME 4) or credit card (TIME 5), the librarian updates the online form in the library's operating system (TIME 6) and gives the receipt to the patron as a proof of payment (TIME 7).

The librarian enters one by one the barcode(s) of the item(s) into the patron's record (TIME 8). To complete the lending procedure, the librarian stamps the due date of the item on the attached card on the last page of the lending item (TIME 9).

Finally, the librarian desensitizes the lending item using the appropriate equipment and handles it to the patron (TIME 10).

Each process may have standard and situation-specific (optional) activities. The situation-specific activities are represented by dummy variables. If a situation-specific activity is carried out, the dummy variable's value is 1. If there is no situation-specific activity, the dummy's variable's value is 0 (Everaert & Bruggeman, 2007). Dummy variables in our case are: *{if electronic}*, *{if cash}* and *{if fines}*.

The resulting equation which presents the total time of lending process of the main collection is as follows:

$$\text{SUM1} = \text{TIME1} + \text{TIME2} + [(\text{TIME3} + \text{TIME4} \text{ {if cash}} + \text{TIME5} \text{ {if electronic}} + \text{TIME6} + \text{TIME7} \text{ {IF FINES}})] + \text{TIME8} (\text{NUMBER OF ITEMS}) + \text{TIME9} \times (\text{NUMBER OF ITEMS}) + \text{TIME10} \times (\text{NUMBER OF ITEMS})$$

[3]

In our case study, there are three different cases regarding lending item(s) from the main collection:

Case A. This is the most common situation. The patron is borrowing the item(s) without paying a fine. The time required to perform this process is:

$$\text{Sum1 of case A} = \text{time1} + \text{time2} + \text{time8} + \text{time9} + \text{time10} = 0.20 + 0.25 + 0.10 + 0.18 + 0.22 = \mathbf{0.95 \text{ min}}$$

Case B. The patron is borrowing an item, but he has to firstly pay a fine with cash, about her/his previous transactions. The time required to perform this process is:

$$\text{Sum1 of case B} = \text{time1} + \text{time2} + \text{time8} + \text{time9} + \text{time10} + [(\text{time3} + \text{time6} + \text{time7}) + (\text{time4} \text{ {if cash}} \text{ {if fines}})] = 0.95 + [(0.16 + 0.25 + 0.58) + 0.38] = \mathbf{2.32 \text{ min}}$$

Case C. The patron is borrowing an item, but he has to firstly pay a fine with a credit card, regarding her/his previous transactions. The time required to perform this process is:

$$\text{Sum1 of case C} = \text{time1} + \text{time2} + \text{time8} + \text{time9} + \text{time10} + [(\text{time3} + \text{time6} + \text{time7}) + (\text{time5} \text{ {if electronics}} \text{ {if fines}})] = 0.95 + [(0.16 + 0.25 + 0.58) + 0.35] = \mathbf{2.29 \text{ min}}$$

2) Lending process of the reserve collection.

The patron searches the library's electronic catalog, to find out if the lending item she/he is interested in belongs to the library's collections, and if at the present time a copy is available for lending.

If she/he desires to borrow it, she/he notes down its call number and takes it at the library's lending desk. The first available librarian in the circulation desk looks the item(s) up in the reserve collection's book stack, using the call number(s) provided by the patron (TIME 1).

Subsequently, the lending process of the reserve collection is similar to the lending process of the main collection. The equation which estimates the total time of the lending process of the reserve collection is as follows:

$$\text{SUM2} = \text{TIME1} + \text{TIME2} + \text{TIME3} [(\text{TIME4} + \text{TIME5} \text{ {if cash}} + \text{TIME6} \text{ {if electronic}} + \text{TIME7} + \text{TIME8} \text{ {IF FINES}})] + \text{TIME9} (\text{NUMBER OF ITEMS}) + \text{TIME10} \times (\text{NUMBER OF ITEMS}) + \text{TIME11} \times (\text{NUMBER OF ITEMS})$$

[4]

In our case study, there are three different cases to lend the item(s) from the reserve collection:

Case A. The patron is borrowing the item(s) without paying a fine. The time required to perform this process is:

$$\text{Sum2 of case A} = \text{time1} + \text{time2} + \text{time3} + \text{time9} + \text{time10} + \text{time11} = 0.40 + 0.20 + 0.25 + 0.10 + 0.18 + 0.22 = \mathbf{1.35 \text{ min}}$$

Case B. The patron is borrowing the item(s), but he has to firstly pay a fine with cash, about her/his previous transactions. The time required to perform this process is:

$$\text{Sum2 of case B} = \text{time1} + \text{time2} + \text{time3} + \text{time9} + \text{time10} + \text{time11} + [(\text{time4} + \text{time7} + \text{time8}) + (\text{time5}) \{\text{if cash}\} \{\text{if fines}\}] = 0.95 + [(0.16+0.25+0.58)+0.38] = \mathbf{2.72 \text{ min}}$$

Case C. The patron is borrowing the item(s), but he has to firstly pay a fine with a credit card, about her/his previous transactions. The time required to perform this process is:

$$\text{Sum2 of case C} = \text{time1} + \text{time2} + \text{time3} + \text{time9} + \text{time10} + \text{time11} + [(\text{time4} + \text{time7} + \text{time8}) + (\text{time6}) \{\text{if electronics}\} \{\text{if fines}\}] = 1.35 + [(0.16+0.25+0.58) + 0.35] = \mathbf{2.69 \text{ min}}$$

3) Returning process through the main collection by physical presence of the patron (RP1).

The patron brings the item(s) at the library's circulation desk. The first available librarian in the circulation desk collects the item(s) from the patron (TIME 1) and inputs its/their barcode(s) into the circulation subsystem of the library's operating system. The librarian checks if the patron's name is correct (TIME 2). If any pending fines appear in the system, the librarian asks for the patron's borrowing card to check the amount to be paid. The patron may pay the total amount or a part. The librarian will inform the patron about the amount to be paid (TIME3). The fine is paid at the lending desk by cash (TIME 4), or by a credit card (TIME 5). The librarian updates the operating system-KOHA (TIME 6) and gives the receipt to the patron as a proof of payment (TIME 7). The librarian sensitizes the item(s) (TIME 8) and places it/them at the return item trolley (TIME 9). Every morning and every midday all the librarians of the morning shift sort the returned items and place them in the shelf (TIME 10).

The resulting equation which presents the total time of the return process through the main collection by physical presence of the patron (RP1) is as follows:

$$\mathbf{SUM3} = \text{TIME1} \times (\text{NUMBER OF ITEMS}) + \text{TIME2} \times (\text{NUMBER OF ITEMS}) + [(\text{TIME3} + \text{TIME4} \{\text{IF CASH}\} + \text{TIME5} \{\text{IF ELECTRONIC}\} + \text{TIME6} + \text{TIME7} \{\text{IF FINES}\}) + \text{TIME8} \times (\text{NUMBER OF ITEMS}) + \text{TIME9} \times (\text{NUMBER OF ITEMS}) + \text{TIME10} \times (\text{NUMBER OF ITEMS})]$$

[5]

In our case study, there are three cases to return item(s) through the main collection:

Case A. The patron returns the item(s) without paying a fine. The time required to perform this process is:

$$\text{Sum3 of case A} = \text{time1} + \text{time2} + \text{time8} + \text{time9} + \text{time10} = 0.12+0.10+0.22+0.15+1.2 = \mathbf{1.79 \text{ min}}$$

Case B. The patron returns the item(s), but he has to pay firstly a fine with cash, about her/his previous transactions. The time required to perform this process is:

$$\text{Sum3 of case B} = \text{time1} + \text{time2} + \text{time8} + \text{time9} + \text{time10} + [(\text{time3} + \text{time6} + \text{time7}) + (\text{time4}) \{\text{if cash}\} \{\text{if fines}\}] = 1.79 + [(0.16+0.25+0.58)+0.38] = \mathbf{3.16 \text{ min}}$$

Case C. The patron returns the item(s), but he has to pay firstly a fine with a credit card, about her/his previous transactions. The time required to perform this process is:

$$\text{Sum3 of case C} = \text{time1} + \text{time2} + \text{time8} + \text{time9} + \text{time10} + [(\text{time3} + \text{time6} + \text{time7}) + (\text{time5}) \{\text{if electronics}\} \{\text{if fines}\}] = 1.79 + [(0.16+0.25+0.58) + 0.35] = \mathbf{3.13 \text{ min}}$$

4) Returning process through the main collection (RP2).

If the patron wishes to return the borrowed item(s) when the library is closed, he can use the drop box located outside the library's main entrance.

The librarians collect the items from the drop box every day (Monday-Friday) at 8:00 a.m. (TIME 1). Then, they enter into the circulation subsystem the barcodes of all the items collected from the drop box (TIME 2). They also enter in the information system the number of the items returned to the library drop box (TIME 3).

Then, they sensitize all the returned items (TIME 4) and place them in the return trolley (TIME 5). If the patrons have any pending fees, the librarians inform them by phone (TIME 6). If the returned item is reserved from another user of the library, a message will appear in the information system. The librarian completes the return procedure and then phones the patron who made the reservation to collect the lending items from the library (TIME 7). Every morning and midday the librarians sort the returned items and place them in the shelf (TIME 8).

The resulting equation which presents the total time of the returning process (using the drop box) is as follows:

$$\mathbf{SUM4} = \text{TIME1} \times (\text{NUMBER OF ITEMS}) + \text{TIME2} \times (\text{NUMBER OF ITEMS}) + \text{TIME3} + \text{TIME4} \times (\text{NUMBER OF ITEMS}) + \text{TIME5} \times (\text{NUMBER OF ITEMS}) + [\text{TIME6} \times (\text{NUMBER OF PATRONS}) \{\text{IF FINES}\}] + [\text{TIME7} \times (\text{NUMBER OF PATRONS}) \{\text{IF REQUESTS}\}] + \text{TIME8} \times (\text{NUMBER OF ITEMS}) \quad \mathbf{[6]}$$

In our case study, there are three cases regarding returning item(s) through the drop box:

Case A. The patron returns the item(s) in the drop box without paying a fine. The time required to perform this process is:

$$\text{Sum4 of case A} = \text{time1} + \text{time2} + \text{time3} + \text{time4} + \text{time5} + \text{time8} = 1.10 + 0.10 + 0.27 + 0.22 + 0.15 + 1.2 = \mathbf{3.04 \text{ min}}$$

Case B. The patron returns the item(s) in the drop box, but he has to firstly pay a fine with cash, regarding her/his previous transactions. The time required to perform this process is:

$$\text{Sum4 of case B} = \text{time1} + \text{time2} + \text{time3} + \text{time4} + \text{time5} + \text{time8} + \text{time 6 \{if fines\}} = 3.04 + 0.35 = \mathbf{3.39 \text{ min}}$$

Case C. The patron returns the item(s) in the drop box, but there is a reservation from another patron. The time required to perform this process is:

$$\text{Sum4 of case C} = \text{time1} + \text{time2} + \text{time3} + \text{time4} + \text{time5} + \text{time8} + \text{time 7 \{if reservations\}} = 3.04 + 0.30 = \mathbf{3.34 \text{ min}}$$

5) *Renewal process.*

The patron may choose one of the following options to renew the lending item(s): a) attend the borrowing department physically, b) call the library, and c) carry out online the renewal herself/himself. If the patron attends the borrowing department, the first available librarian in the circulation desk asks for the patron's borrowing card. To start the renewal transaction, the librarian inputs the borrowing card's barcode into the library's circulation subsystem (KOHA) and scans one by one all the barcode(s) of the lending item(s) (TIME 1). The renewal procedure is completed, when the librarian stamps the due date on the attached card on the last page of the lending item(s) (TIME 2).

If the renewal is done by phone, the patron reads the barcode number of her/his card or academic ID or states her/his name. The librarian renews the lending item(s) and informs the patron about the new return date (s) (TIME 1), and the possibility to renew online the lending item(s).

The resulting equation which presents the total time of the renewal process through the main desk is as follows:

$$\mathbf{SUM5 = TIME1 \times (NUMBER OF ITEMS) + TIME2 \times (NUMBER OF ITEMS) \quad [7]}$$

The time required to perform this process is:

$$\text{Sum5} = \text{time1} + \text{time2} = \mathbf{0.28 \text{ min}}$$

The resulting equation, which presents the total time of the renewal process when one calls the library, is as follows:

$$\text{SUM6} = \text{TIME1} \times (\text{NUMBER OF ITEMS}) \quad \mathbf{[8]}$$

The time required to perform this process is:

$$\text{Sum6} = \text{time1} = \mathbf{0.58 \text{ min}}$$

3.6. Step 6: Estimate the cost/activity

We have constructed several cost tables (Tables 2-7) to estimate the cost per activity (€). These tables are divided horizontally by standard and optional activities, which are related to the dummy variables. These tables are also divided vertically, into the following seven columns:

1. The first column presents the order of each activity, as we describe it in step 5
2. The second column describes the activities included in each process
3. The third column shows the average time for each activity, as it is calculated from the data recorded via direct observation
4. The fourth column calculates the unit cost per minute of each resource group. According to the resources related to the activity (column 7), we add the relevant unit cost per minute as it is estimated in step 4
5. The fifth column is the most important one, since it shows the total activity cost, that is calculated by multiplying the average time per activity (column 3) by the cost per minute (column 4)
6. The sixth column describes the dummy variable that determines the specific activity, as it described in step 5
7. The seventh column describes the resource groups involved in each activity
8. The eighth column assigns an abbreviation to each activity

In the bottom part of tables 2 to 4, we have included three cases of processes (A, B and C). According to case A, a patron is borrowing or returning the item(s) at the main desk without paying a fine. In case B, the patron is borrowing or returning the item(s) and pays a fine in cash, for a previous transaction. In case C, the patron is borrowing or returning the item(s) and pays a fine with a credit card, for a previous transaction.

In the following paragraphs, we describe for each process the estimations with the use of cost tables:

1) Lending process of the main collection.

In this case study, we analyzed the total cost of the lending process in the main desk of the library through two different cases (Tables 2 and 3). According to our results, paying fines electronically is slightly less expensive (1.6 percent) than paying in cash, because

the assistance of a librarian is required in both cases. However, if a customer does not have to pay a fine, the cost is reduced by 60 percent.

Standard Activities	1.	2. Activity	3.	4. Cost (€/min)	5. Cost (€/activity)	6. Dummy Variable	7. Resources	8. (#)
	Time		Average Time (min)					
Standard Activities	1	The librarian asks for the student card	0.2	0.7	0.14		Staff labor costs	a
	2	The librarian opens the patrons' record	0.25	0.86	0.22		Staff labor costs & LMS	b
	8	The librarian Inputs the item's barcode into the patron's record	0.1	0.86	0.09		Staff labor costs & LMS	c
	9	The librarian stamps the due date of the item(s)	0.18	0.7	0.13		Staff labor costs	d
	10	The librarian desensitizes the item(s)	0.22	0.86	0.19		Staff labor costs & LMS	e
		Subtotal		0.95		0.77		
Optional Activities	3	The librarian Informs the patron about the amount to be paid	0.16	0.7	0.11	if fines	Staff labor costs	f
	4	The fine is paid in cash	0.38	0.86	0.33	if fines, if cash	Staff labor costs & LMS	g
	5	The fine is paid by an electronic transaction	0.35	0.86	0.3	if fines, if electronic	Staff labor costs & LMS	h
	6	The librarian updates the online form	0.25	0.86	0.22	if fines	Staff labor costs & LMS	i
	7	The librarian gives a receipt	0.58	0.86	0.5	if fines	Staff labor costs & LMS	j
(A)	Cost of the lending process at the main desk (without fines) = $a+b+c+d+e = 0.14+0.22+0.09+0.13+0.19= \text{€ } 0.77$							
(B)	Cost of the lending process at the main desk (with fines paid in cash) = $a+b+c+d+e +[(f+i+j)+(g) \text{ {if cash}}]\{\text{if fines}\}\{\text{if fines are paid in cash}\}=$ $0.77+ [(0.11+0.22+0.50)+0.33]= \text{€ } 1.93$							
(C)	Cost of the lending process at the main desk (with fines paid with a credit card) = $a+b+c+d+e +[(f+i+j)+(h) \text{ {if electronics}}]\{\text{if fines}\}\{\text{if fines are paid by electronic transaction}\} =$ $0.77+0.83+0.30= \text{€ } 1.9$							

Table 2: Cost of the lending process at the main desk (cases a, b and c)

2) Lending process of the reserve collection.

The cost of the lending process of the reserve collection is €1.05 (Table 3), which is 27% higher compared to the lending process of the main collection (€0.77). This difference is because the

lending process of the reserve collection includes an extra activity (time 1) (i.e. the librarian has to look up for the item(s) in the reserve collection's book stack).

	1. Time	2. Activity	3. Average Time (min)	4. Cost (€/min)	5. Cost (€/activity)	6. Dummy Variable	7. Resources	8. (#)
Standard Activities	1	The librarian looks the item(s) up in the reserve collection's book stack, using the call number(s) provided by the patron	0.4	0.7	0.28		Staff labor costs	a
	2	The librarian asks from the patron a student card	0.2	0.7	0.14		Staff labor costs	b
	3	The librarian opens the patron's record	0.25	0.86	0.22		Staff labor costs & LMS	c
	9	The librarian inputs the item's barcode into the patron's record	0.1	0.86	0.09		Staff labor costs & LMS	d
	10	The librarian stamps the due date of the item(s)	0.18	0.7	0.13		Staff labor costs	e
	11	The librarian desensitizes the item(s)	0.22	0.86	0.19		Staff labor costs & LMS	f
			Subtotal	1.35		1.05		
Optional Activities	4	The librarian informs the patron about the amount to be paid	0.16	0.7	0.11	if fines	Staff labor costs	g
	5	The fine is paid in cash	0.38	0.86	0.33	if fines, if cash	Staff labor costs & LMS	h
	6	The fine is paid by an electronic transaction	0.35	0.86	0.3	if fines, if electronic	Staff labor costs & LMS	i
	7	The librarian updates the online form	0.25	0.86	0.22	if fines	Staff labor costs & LMS	j
	8	The librarian gives a receipt	0.58	0.86	0.5	if fines	Staff labor costs & LMS	k
(A)	Cost of the lending process regarding the reserve collection (without fines)= $a + b + c + d + e + f = 0.28 + 0.14 + 0.22 + 0.09 + 0.13 + 0.19 = \text{€}1.05$							
(B)	Cost of the lending process regarding the reserve collection (with fines paid in cash)= $a + b + c + d + e + f + [(g + j + k) + (h) \{if\ cash\} \{if\ fines\}] \{if\ fines\ are\ paid\ in\ cash\} =$ $1.05 + [(0.11 + 0.22 + 0.50) + 0.33] = \text{€}2.21$							

(c)	Cost of the lending process regarding the reserve collection (with fines paid with a credit card)= $a + b + c + d + e + f + [(g + j + k) + (i) \text{ {if electronics}}] \text{ {if fines}} \text{ {if fines are paid by electronic transaction}} = 1.05 + 0.83 + 0.30 = \mathbf{\text{€}2.18}$
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Table 3: Cost of the lending process regarding the reserve collection (cases a, b and c)

3) Returning process through the main collection by physical presence of the patron (RP1).

A costly activity during the return process (Tables 4 and 5), is sorting the items in the cluster and then shelving them (€0.84). This standard activity takes place both when the patron returns items at the main desk and through the drop box. In the case of items being returned at the main desk, the total cost is increased by 64 percent, whereas when the patron returns items using the drop box the total cost increases by 35 percent. In this activity all shift librarians participate. It could be argued that this activity does not require specialized knowledge but only attention, and should be carried out by students (SLE) who are either trainees or fellows.

	1. Time	2. Activity	3. Average Time (min)	4. Cost (€/min)	5. Cost (€/activity)	6. Dummy Variable	7. Resources	8. (#)
Standard Activities	1	The librarian receives the item(s) from the patron	0.12	0.7	0.08		Staff labor costs	a
	2	The librarian Inputs the item's barcode into the library circulation subsystem	0.1	0.86	0.09		Staff labor costs & LMS	b
	8	The librarian sensitizes the item(s)	0.22	0.86	0.19		Staff labor costs & LMS	c
	9	The librarian places the item(s) on the return trolley	0.15	0.7	0.11		Staff labor costs	d
	10	The librarian sorts and shelves the item(s)	1.2	0.7	0.84		Staff labor costs	e
		Subtotal		1.79		1.31		
	Optional Activities	3	The librarian informs the patron about the amount to be paid	0.16	0.7	0.11	if fines	Staff labor costs
4		The fine is paid in cash	0.38	0.86	0.33	if fines, if cash	Staff labor costs & LMS	g
5		The fine is paid by an electronic transaction	0.35	0.86	0.3	if fines, if electronic	Staff labor costs &	h

							LMS	
	6	The librarian updates the online form	0.25	0.86	0.22	if fines	Staff labor costs & LMS	i
	7	The librarian gives a receipt	0.58	0.86	0.5	if fines	Staff labor costs & LMS	j
(A)	Cost of the return process at the main desk (without fines) = $a + b + c + d + e = 0.08 + 0.09 + 0.19 + 0.11 + 0.84 = \mathbf{€1.31}$							
(B)	Cost of the return process at the main desk (with fines paid in cash) = $a + b + c + d + e + [(f + i + j) + (g) \{if\ cash\} \{if\ fines\} \{if\ fines\ are\ paid\ in\ cash\}] =$ $1.31 + [(0.11 + 0.22 + 0.50) + 0.33] = \mathbf{€2.47}$							
(C)	Cost of the return process at the main desk (with fines paid with a credit card) = $a + b + c + d + e + [(f + i + j) + (h) \{if\ electronics\} \{if\ fines\} \{if\ fines\ are\ paid\ by\ electronic\ transaction\}] = 1.31 + 0.83 + 0.30 = \mathbf{€2.44}$							

Table 4: Cost of the return process at the main desk (cases a, b and c)

4) Returning process through the main collection (RP2).

It would be interesting to examine and analyze the most expensive activities that take place, such as the collection of the item(s) from the drop box (Activity cost = € 0.95) (Table 5). The TDABC analysis shows that the return of the lending item(s) through the drop box is 46 percent more costly compared to the return to the main desk. The activity's cost is high, because the time consumed on this activity is very high (1,1 min), since the librarian has to walk from the main office to the drop box which is located outside the library's main entrance, and then unlock it to pick up the lending item(s).

	1. Time	2. Activity	3. Average Time (min)	4. Cost (€/min)	5. Cost (€/activity)	6. Dummy Variable	7. Resources	8. (#)
	Standard Activities	1	The librarian receives the item (s) from the drop box	1.1	0.86	0.95		Staff labor costs & LMS
2		The librarian updates the circulation subsystem	0.1	0.86	0.086		Staff labor costs & LMS	b
3		The librarian fills in the "drop box returns" statistics form	0.27	0.86	0.23		Staff labor costs & LMS	c
4		The Librarian sensitizes the item(s)	0.22	0.86	0.19		Staff labor costs & LMS	d

	5	The librarian places the returned item(s) on the return trolley	0.15	0.7	0.11		Staff labor costs	e
	8	The librarian sorts and shelves the item(s)	1.2	0.7	0.84		Staff labor costs	f
	Subtotal		3.04		2.41			
Optional Activities	6	The librarian informs the patrons about their fines through phone calls	0.35	0.7	0.25	if fines	Staff labor costs	g
	7	The librarian informs the patrons via telephone about collecting the item(s) from the library	0.3	0.86	0.33	if reservations	Staff labor costs	h
(A)	Cost of the return process with the drop box (without fines) = $a + b + c + d + e + f = 0.95 + 0.086 + 0.23 + 0.19 + 0.11 + 0.84 = \text{€ } 2.41$							
(B)	Cost of the return process with the drop box (with fines) = $a + b + c + d + e + f + g(\text{if fines}) = 2.41 + 0.25 = \text{€ } 2.66$							
(C)	Cost of the return process with the drop box (there are reservations for the lending item(s)) = $a + b + c + d + e + f + h(\text{if reservations}) = 2.41 + 0.21 = \text{€ } 2.62$							

Table 5: Cost of the return process with the drop box (cases a, b and c)

5) Renewal process

The renewal cost is presented in two cases: a) the patron attends the borrowing department physically (Table 6) or b) The patron calls the library (Table 7). There is also a third case which will not be examined (i.e. online renewal of the lending item(s)), since there are no activity costs, because the assistance of a librarian is not required.

Standard Activities	1. Time	2. Activity	3. Average Time (min)	4. Cost (€/min)	5. Cost (€)/activity	6. Dummy Variable	7. Resources	8. (#)
	1	The librarian Inputs the item's barcode or the patron's borrowing card	0.1	0.86	0.086		Staff labor costs & LMS	a
	2	The Librarian stamps the due date of the item(s) on the attached card	0.18	0.7	0.13		Staff labor costs	b

		Subtotal	0.28		0.22			
(A)	Cost of the renewal process at the main desk = a + b = 0.086+0.13= € 0.22							

Table 6: Cost of the renewal process at the main desk

The renewal by telephone is the most expensive renewal process (€0.50), since the patron usually does not provide immediately to the librarian all the necessary information (i.e. the barcode number of his/her card or academic ID). As a result, the time required for this activity is higher, compared to the renewal process at the main desk.

standard Activities	1. Time	2. Activity	3. Average Time (min)	4. Cost (€/min)	5. Cost (€)/activity	6. Dummy Variable	7. Resources	8. (#)
	1		The patron reads the barcode number of her/his card and the librarian informs her/him about the new return date	0.58	0.86	0.5		Staff labor costs & LMS
		Subtotal	0.58		0.5			
(A)	Cost of the renewal process by telephone = a = € 0.50							

Table 7: Cost of the renewal process by telephone

4. Discussion

According to the results of our study, the staff cost related to the lending process is the most important cost source. The staff cost may be reduced significantly, if the library employs students on a temporal basis. Activities that do not require specialized knowledge, such as sorting the items in the cluster and re-positioning materials on the shelf may be carried out by trainee students (SLE). This is a widespread practice in libraries (White, 1985) both in Europe and in the USA. More recently, SLE have taken more challenging and enriching tasks, such as promoting the library through their social networks and helping permanent staff to use new technologies (Adeogun, 2016; Rinto, Watts, & Mitola, 2017); White, 1985). The result is a new academic library where student assistants participate actively in the library's duties (Han, Wang, & Luo, 2014, p. 467), and become "partners" and "collaborators" (Walton, 2010, p. 118). This may be a win-win relationship (Benjamin, & McDevitt, 2018). To cut training costs, the library staff may

adopt blended learning (Gounopoulos et al., 2017) and educate SLE not only face – face, but also online with the use of an e-learning platform.

The activity of collecting the item(s) from the drop box has a high cost. However, this activity is very important for the patrons, because it allows them to avoid paying a fine. The return of the lending item(s) through the drop box allows the patrons to return the borrowed item(s) on time, even when the library is closed.

The process with the lower cost is the online renewal of the lending item(s). According to the statistical data of the information system, most of the lending items are renewed online. This has been achieved due to repeated campaigns from the library staff.

The Library of the University of Macedonia has recently implemented the policy of informing customers in order to return the items in time and avoid fines. The information system sends three automated email reminders to the patrons about fines. One and two weeks after the lending period for borrowed item(s) has expired, the information system sends two automated emails with the amount of fine to be paid and suggests ways to return or renew the borrowed material. According to statistical data from the information system, the amount of the fines was reduced by 32 percent during the first year of the operation of this procedure, and by 41 percent, during the second year of operation. This procedure was made feasible thanks to the awareness campaigns carried out by the library's staff.

The automation of repetitive processes in the circulation department may decrease significantly the operating costs. This may be achieved by utilizing more efficiently the staff and by adopting robotic services. Due to the severe economic recession during the last years, the Greek libraries are called to develop new services along with the current staff. The library of the University of Macedonia is currently in a state of reorganization. The administration of the library expresses the willingness to use new technologies (Radio Frequency Identification system) to reduce costs and improve customer service. The library has bought a robot for the borrowing and returning process. Other libraries have also used technology efficiently and reduced the activities costs. The circulation department at the Arenberg Campus Library of the KU Leuven has automated the lending procedures with the use of robotic services and Radio Frequency Identification (RFID) (Siguenza-Guzman et al., 2014a). As a result, they managed to automate high cost repetitive processes.

An important benefit of our study is the analysis of the most expensive activities. According to the results of our study, the application of the TDABC may be adjusted rapidly and inexpensively to the changes of the organization's operating and external environment. This adjustment may be done by adding new activities to processes or by updating the cost rate or the unit estimates.

The TDABC method may help library managers to make sound decisions with respect to the optimal resource allocation and the improvement of the activities' efficiency.

However, there are few limitations in this study. We did not evaluate the process of patrons searching for books on the online catalogue, which is part of the lending process, because we cannot accurately estimate the time consumed. This process may be carried out in various places (at the library, at home) and by using various means (the library's computers, their own computers, smartphones, etc.).

Our results show that the application of TDABC may also prove its usefulness in other more complex or more digitalized processes of libraries. In a future research, a benchmarking analysis may also be useful.

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