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Time-driven activity-based costing: Theory, applications and limitations

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Abstract

The aim of this study is to explore the strategic applications and limitations of Time-driven Activity-based Costing (TDABC) and to evaluate the degree of accuracy of the proponents' arguments concerning its usefulness. In this study, published works directly related to this area from the period 2004-2015 are analyzed. This study reports TDABC's applications in strategic areas such as cost of production, unused capacity, price determination, customer profitability analysis, and modeling complex decisions in various small, medium, and large private, governmental, and nonprofit service and manufacturing organizations. However, since they are not based on any concrete empirical investigations, only future empirical studies can authentically reveal the advantages of this technique. TDABC also severely suffers from the following spheres: it lacks the ability to identify activities in the first implementation step, such as practical capacity costs rate, uniform capacity costs rate, managers' time estimation for each activity, determination of unused capacity, as well as lack of data accuracy, and limitations of managerial decision makings. As a result of these drawbacks, proponents' arguments regarding TDABC's usefulness and its widespread applications -in the future and around the world- are baseless.

Keywords

Activity-based Costing (ABC), Activity-based Management (ABM), Strategic Management, Time-driven Activity-based Costing (TDABC).

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Introduction

In 2003 and 2004 and more comprehensively in 2007a (p. 7), Kaplan and Anderson pointed out the major implementing problems of the Conventional Activity-based Costing (CABC) as follows:

- The interviewing and surveying process was time-consuming and costly.
- The data for the ABC model were subjective and difficult to validate.
- The data were expensive to store, process, and report.
- Most ABC models were local and did not provide an integrated view of enterprise wide profitability opportunities.
- The ABC model could not be easily updated to accommodate changing circumstances.
- The model was theoretically incorrect when it ignored the potential for unused capacity.

Consequently, in 2004 and more comprehensively in 2007a, Kaplan and Anderson presented the second version of the ABC entitled "Time-driven Activity-based Costing (TDABC)." They claimed that the major advantages of TDABC are as follows:

- It can be applied in any industry or company with complex cost objects.
- It avoids the costly, time-consuming, and subjective activity determination task of the CABC at the first implementation stage.
- It simplifies the cost calculation process.
- It is simpler and faster to build than CABC.
- It does not require costly and time-consuming interviews with the employees.
- It reports the exact amounts and values relating to a company's process efficiencies and unused capacities.
- It provides relevant information for managerial decision makings.
- It presents more accurate information about a company's complex activities by deriving suitable time equation models.

Therefore, the objective of this study is to investigate TDABC's strategic positioning in order to determine the accuracy of the preceding assertions by Kaplan and Anderson (2004 & 2007a) and other proponents concerning TDABC's advantages and applications. This study further aims to disclose the major weaknesses of TDABC that cannot be ascertained. In particular, the main aims of this study are to provide a brief analysis of the following inquiries:

1. What are the significant theoretical and mathematical infrastructures of TDABC which make it distinct from CABC and have been utilized by proponents?
2. What are the main strategic contributions of the TDABC that have been reported by proponents and have had a significant contribution to cost management literatures?
3. What are the limitations and constraints of the TDABC within the context of the strategic positioning of today's business?

In approaching these aims, a review of the major research published on TDABC research since 2004 is attempted with a particular attention geared towards the strategic positioning of the TDABC. In effect, this study is different from that of Siguenza-Guzman *et al.*'s (2013) study, in that only 36 articles were studied in the latter study using TDABC; however, their period of study was 2004-2012, and the focus of their work was basically on the review of TDABC's application in each article. This study, by contrast, is more compressive; using "Content Analysis" technique, it covers more than 70 publications for the period 2004-2015. Furthermore, the focus of this study is on the strategic positioning of the TDABC and the accuracy of the proponents' arguments concerning the usefulness of the TDABC. In addition, the limitations of the TDABC are also discussed from different theoretical and practical aspects. Therefore, several major contributions are expected to be generated. First, to date, no attempt has been made to provide a comprehensive study regarding the strategic positioning of the TDABC and its novelty. Second, it traces TDABC proponents' arguments concerning the advantages of TDABC and provides adequate positive and negative evidence in this regard. Third, it reveals the strategic contributions and

shortcomings of the TDABC system. Fourth, it helps professionals and scholars who may consider adopting this novel cost management technique in the future.

The organization of this study is as follows: First, it presents a general theoretical framework of the study, followed by the research method. Second, it discloses the major findings regarding the strategic positioning of the TDABC's applications in various domains, including manufacturing as well as service industries. Third, the major limitations of the TDABC are briefly discussed. Finally, the conclusion and discussion, limitations, and further suggestions are presented.

Theoretical development of the TDABC

Figure 1 illustrates the basic theoretical premises of the TDABC graphically.

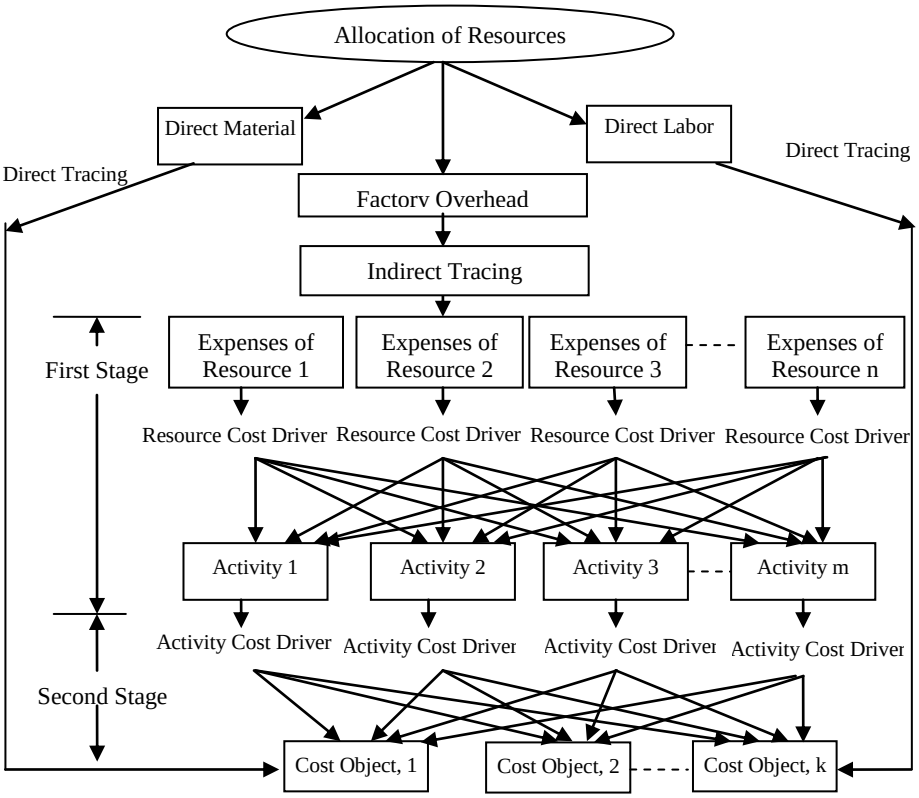

Fig. 1. Major elements of the conventional ABC system

In comparison with a conventional ABC system, TDABC posits at least six significant differences: First, it extracts "time" as the primary cost driver for cost objects. Second, TDABC, at the beginning, eliminates the first step of the traditional ABC implementation process, (see for example, Kaplan & Anderson, 2004 and 2007a; Siguenza-Guzman, 2014), that is, determination of different "activities". TDABC skips the first cost assignment process of the CABC and solely follows the second assignment process of CABC by utilizing time to drive costs directly from resources to cost objects (Hoozee, 2013; Schuhmacher & Burkert, 2014). Third, TDABC simplifies the costing process by eliminating the need for interview and surveys employees for the allocation of resource costs to activities before deriving them down to costs objects. Instead, it allows managers to "estimate" the time required to perform the activities. Fourth, TDABC determines the "used capacity" as well as the "unused capacity" unequivocally by basing the predetermined overhead cost rates on the "practical capacity" which is assumed to be about 80 to 85% of the ideal capacity (Kaplan and Anderson, 2004 & 2007; Hoozee, 2013). Fifth, TDABC can accommodate complexities of actual production or services and incorporates variations in utilizing resources by formulating different time equation models (see, e.g., Everaert, Bruggeman & Decreus, 2008; Everaert *et al*., 2008; Anderson Prokop & Kaplan, 2007; Madhok *et al*., 2015). Sixth, the traditional ABC system is a "push" cost management model. That is, costs are first assigned to "activities" (primary assignment), and then the activity costs are attributed to selected "cost objects" (secondary assignment; Cooper, 1987a, & b). However, TDABC is a "pull" cost management model (Özbayrak, Akgün & Türker, 2004) which operates based on two estimations: 1. capacity cost rate, and 2. estimated time required for each activity (Kaplan & Anderson, 2004; and 2007a). The calculation approach of the TDABC is based on the following formula:

TDABC Approach:

$$\text{Total Cost Of Each Activity} = AR \times ST_i \quad \text{(i)}$$

1. AR=Capacity Cost Rate = $\dfrac{\text{Costs of Capacity Supplied}}{\text{Practical Capacity of Resources Supplied (in time)}}$ (ii)

2. ST_i = Estimated Unit Time for Each Activity × Actual Quantity of Each Activity (iii)

TDABC mechanism can also be described mathematically (see also Homburg, 2005; Özbayrak, Akgün & Türker, 2004). Let

$$TC = DMC + DLC + OVC \quad (1)$$

where

DMC = Direct Material Costs

DLC = Direct Labor Costs

OVC = Overhead Costs.

Direct material costs and direct labor costs are attributed to the selected cost objects (e.g., products) directly; thus, they do not seek any cost allocation. However, overhead costs must be assigned.

TDABC attempts to formulate different time equations which would reflect time resource consumption of the activities. Thus, the time exerted (t) to perform an event (e) of activity (i) can be mathematically shown as follows (Everaert and Bruggeman, 2007: 18).

$$t_{i,e} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots + \beta_p x_p \quad (2)$$

where

$t_{i,e}$ = time required to perform event (e) of activity (i)

β_0 = constant amount of time for activity (i) independent of the characteristics of event (e)

β_1= time consumption for one unit of time driver 1 when x_2, x_3, ... x_p are held constant.

x_1= time driver 1, x_2 = time driver 2, ..., x_p = time driver p

P = the number of time drivers that determine the time required to perform activity (i).

By multiplying the time required for a designated activity by the cost per time unit, the cost of an individual event (e) of activity (i) is equal to:

$$c_{e,i} = t_{i,k}, c_n \quad (3)$$

where

c_n= the cost per time unit (minute) of resource pool (n)

$t_{i,k}$ = the time consumed by event (k) of activity (i).

The total cost of a cost object is determined by adding all the activity costs as follows:

Total costs of a cost object = DMC + DLC + $\sum_{n=1}^{N}\sum_{i=1}^{I}\sum_{k=1}^{M} t_{i,k}.C_n$ (4)

where

C_n = cost per time unit (minute) of resource pool (n)

$t_{i,k}$ = time consumed by event (k) of activity (i)

I = number of activities

M= number of resource pools.

A significant assumption underlying the TDABC approach reflected in the above equations is that it proportionality exists between resource costs and the cost driver consumption, and their relationship is a linear function. In addition, in assigning overhead costs, it is implicitly of both proportionality and repeatability assumptions (Homburg, 2005: 387).

In formulating the above time equation models, the type of "time drivers" considered is also essential. Time drivers are those characteristics that would affect the required time for operating a selected activity. They could be presented as a "continuous variable" (e.g., weight of a pallet or distance in kilometers), a "discrete variable" (e.g., number of units, orders, or customers), an "indicator variable", or a dummy variable, (e.g., the type of delivery -by air versus by a car, the type of customers- old versus new; Everaert and Bruggeman, 2007: 17-18). These time drivers could be expanded into related time models to reflect the true and complete nature of the peculiar characteristics of the resource activity (time) involved. Thus, they can facilitate the creation of accurate time models.

Time equation models can also accommodate multiple drivers and their interaction for a selected activity. As such, the general form of the model can be presented as follows (Everaert and Bruggeman, 2007: 18):

$$t_{j,k} = B_0 + B_1X_1 + B_2X_2 + B_3X_1X_2 \quad (5)$$

This model can be extended to accommodate situations in which more than two cost drivers and the effects of their interactions are present. Everaert and Bruggman (2007) provided practical examples of companies in Belgium that have employed the preceding models. This significant feature of the TDABC does not exist in CABC systems. In CABC, only one activity driver is considered for each activity, and more than one activity driver is necessary for defining an accurate costing; however, different activities must be defined.

Research method

In this study, in order to explore TDABC's potent contributions following proponents' arguments regarding the advantages of TDABC, "content analysis approach" (Smith, 2015) was adopted. Hence, first and foremost, a search for "Time-driven Activity-based Costing (TDABC) literature" was attempted via Proquest ABI/ inform Global databases, Online Academic Databases (OAD), ISI Web Of Science (WOS), Science Direct and Google Scholar (GS) for the period of 2004 to 2015. More than 70 relevant journal articles, books and chapters of books directly related to the topic were found. Second, these studies were classified and coded based upon their content into the following elements of TDABC: general description, theoretical foundations, case studies (services and manufacturing), and advantages and drawbacks in order to achieve the aim of this study. Third, materials regarding each preceding part, along with other publications that were somehow related to the designated parts of the TDABC, were coded and cross checked.

Findings

TDABC strategic applications

Kaplan and Anderson (2007a) claimed the successful implementation of TDABC in more than 200 firms. In their initial study (2004) and also their more comprehensive research (Kaplan & Anderson, 2007a), they provided a number of case studies which have implemented TDABC in different strategic industries such as manufacturing, banks,

financial institutions, service, and even nonprofit organizations. Later studies of Kaplan & Anderson, (2007b, & 2007c), Anderson, Prokop & Kaplan (2007) and Everaert *et al*. (2008b) are actually a duplicate of the Kaplan and Anderson's (2007a) publication. Other TDABC studies can be summarized as follows:

Manufacturing realm

Everaert *et al*. (2008b) applied the TDABC model to a real logistics department of a wholesaler company in Belgium. The model provided a whole range of costs for each drop-off in comparison with CABC which existed and reported a single-cost per drop-off. Regarding profitability analysis, CABC system could not distinguish between a customer with a simple request and a customer who demanded time-intensive drop-off operations. However, this was not the case for the TDABC model. Furthermore, TDABC provided better understanding of the profitability of logistics service strategies, higher efficiency of the logistic process, and superior opportunity for internal benchmarking (pp. 185-187).

Hoozee and Brugggeman (2010) also studied the effect of the TDABC implementation in four warehouses in the Belgian division of a company. They reported that TDABC had a positive effect on the cost structures and distribution services of the company. Somapa, Cools & Dullart (2012) also reported the implementation of the TDABC for a small-sized road transport and logistics company. They found that TDABC is especially useful for small-sized companies that adopt simplified parameters.

Oztaysi, Baysan and Akpinar (2007) applied TDABC to Radio Frequency Identification (RFID) technology to evaluate the economic justification of the application. They found that TDABC was an appropriate technique for investment analysis and comparison of various systems. Stout and Propri (2011) also implemented TDAB as a pilot study to a medium-sized electronic company which had already adopted CABC. They found that:

1. Since TDABC operates based upon recognized time equations and ERP systems, its maintenance is easier than CABC systems.

2. TDABC does not assure accuracy, but it provides a more accurate cost data than CABC, and it allows the alignment of products and customer costs with resource consumption.
3. Medium-sized companies can adopt TDABC to allocate support costs to products, customers, and orders with the aid of the ERP.

TDABC has also been applied for guiding management with sustainable decision problems in animal husbandry. In particular, Bryon *et al*. (2009) employed TDABC for an actual farm case study to compare its four weekly batches furrowing system with weekly furrowing, based on economic, sociological, and ecological aspects. TDABC was adopted to estimate required labor hours, floor space, nutrient emissions, and revenues of both systems. The results showed that investments were 5% higher, but the labor hours needed were 6% lower in the four-week system (p. 1). In addition, labor input was more concentrated in time in order to be more easily scheduled. This finding was considered as an extra social advantage for the four-week system. Moreover, profit grew with 14.9 euro per hour labor in the four-week system under average price conditions, while nutrient surplus only increased by 5%. Data Envelopment Analysis (DEA) revealed a positive trade-off between economic and ecological performances (p. 2). In effect, the results of this study demonstrated that the TDABC approach is useful to quantify both the economic and ecological impacts of a strategic production decision and may even be extended to a sociological context.

TDABC's usefulness has also been presented by Tse and Gong (2009). They showed that a significant advantage of TDABC over CABC is related to TDABC's determination of the idle capacities and its costs based on the fact that under TDABC, idle capacity's cost will remain in the cost pools and is not allocated to products, and costs are considered as a period cost rather than a product cost. Monroy, Nasiri and Pelaez (2012) also concluded that, although TDABC is not prescribed by GAAP for financial report purposes, it is useful in the decision making process, and can be applied at the product and process level, and for operational control.

Gervais Levant and Ducrocq (2010) studied the longitudinal effects

of TDABC on a Belgian wholesaler company during four-year operations. They concluded that TDABC can partially solve some of the CABC criticisms, particularly with respect to the costs and complexities of implementing the system, but the data gathering process of the TDABC is still substantial and problematic. Somapa, Cools and Dullaert (2010, 2011) also studied the development of the TDABC model in a small-sized road transport and logistics company in Thailand. They reported some difficulties associated with the preparation of adequate data to develop appropriate time equation models and time tracking systems. Ratnatunga, Tse and Balachandran (2012) also employed the TDABC system to a case study in an international manufacturing company in Sri Lanka which produced activated carbon. Their findings, however, did not reveal the prescribed TDABC advantages over CABC systems and showed that TDABC had similar implementation obstacles as CABC. The company's complexities were independent of country-specific factors and, in the simplest form of the model, TDABC generated the same decision information errors as CABC.

In general, TDABC's empirical studies in this domain are scarce and the findings of several case studies are contradictory. Most case studies have reported the usefulness of TDABC for small, medium, and large companies, but others have shown that the advantages claimed by TDABC proponents over CABC are baseless. Due to the dearth of TDABC empirical studies for the analysis of this factor, an exact conclusion cannot be drawn at present.

Service realm

TDABC has also been applied in service industries. In fact, its application in this area is more than the field of manufacturing. The major attempts in this sector are as follows:

Everaert and Bruggman (2007) derived various mathematical time equation models for a sales order processing activity of a Belgian's sales department under the following conditions: 1. when a two-way interaction in time-drivers exists, 2. when a three-way interaction in time-driver exists, and 3. when changing time drivers occurs in the

department (pp. 18-20). They concluded that TDABC can be adjusted rapidly and inexpensively in order to reflect changes in the operating and external environment of the organizations.

Reddy, Venter and Olivier (2012) also applied the TDABC for the management activities required for Digital Forensic Readiness (DFR). Through the application of in-depth analysis and simulation, they showed that TDABC's cost information is useful for DFR decisions in large organizations.

Regarding the area of Information Technology (IT), Adioti and Valverde (2014) studied TDABC's applications in managing the cost of IT service and its exertion for cost reduction. They found that two variations (out of six) of the incident type of services cost more than 75% of the overall cost of that incident type, and TDABC is an effective tool for identifying costly processes which allows managers to make strategic decisions about cost control and charging various services.

TDABC has also been mathematically applied in other service industries. Pernot, Roodhooft and Van den Abbeese (2007) adopted TDABC in order to accurately determine the costs and revenues of the Inter-Library Loan (ILL) services of the KuLeuven Arenberg Library. They concluded that "borrowing cost appears to range from £4.23 (for the simplest article delivery) to £14.79 (for the most complex book loan), while incoming request costs range from £2.12 (for the simplest article delivery) to £8.93 (for the most complex article delivery)" (p.12). The most significant contribution of this study is the exhibition of analysis in disaggregating per-transaction costs based on activity analysis. Most importantly, the analysis permits optimal managerial decision making concerning the pricing of each service according to the utilized resources and complexities which could lead to outsourcing of some activities. Stouthuysen *et al*. (2010) also studied and reported the usefulness of TDABC in cost determination of libraries. Siguennza- Guzman *et al*. (2014) also implemented TDABC in a Belgian academic library in order to determine the cost of lending and returning books. They concluded that TDABC is a useful method for supporting and returning process costs of the library.

In the area of hospitality management, Dalci, Tanis and Kosan (2010) implemented TDABC for Customer Profitability Analysis (CPA) in a four-star hotel with 100 rooms in Turkey. The findings revealed that "some of the customer segments which were found unprofitable under the conventional ABC method were determined profitable using TDABC. The case study also revealed the cost of the idle resources devoted for the front office, housekeeping, food preparation, and marketing activities" (p. 609). Hajiha and Safari Alishah (2011) also examined TDABC's implementation effects in a large hotel in Iran, and concluded that TDABC provides more relevant data regarding customers' cost and profitability of the hotel. By employing the Delphi technique and testing the hypothesis, they concluded that there is a significant difference between costs and also profitability of different customer groups in the TDABC system and that of the traditional system of the hotel. Terungwa (2012) also showed the usefulness of the TDABC on the CPA of a restaurant in Nigeria. He found that TDABC provides a more accurate cost data on CPA, and managers can make use of the time equations to calculate the necessary time required to deliver a unit of service to customers, thus determining the price of services and increasing profitability.

TDABC has also been applied in hospitals and health care industries. In fact, the published TDABC's articles in this domain are more than those in any other fields -manufacturing and service industries. Demeere, Stouthuysen and Roodhooft (2009) showed how TDABC costing approach could be applied to five outpatient departments, and provided an evidence of the benefits of applying that system in the hospital management field. Hence, this study enhanced TDABC's applications to nonprofit organizations. Kaplan and Porter (2011) and O'Brian and Rasch (2013) have also demonstrated the potent advantages of the TDABC. The latter study concluded that the application of TDABC does not only lead to a greater Rate of Return (ROI) on Electronic Medical Records' investments in the hospitals, but also identifies strategic areas in which hospitals can make or lose money. In addition, TDABC applied costs on the entire patient encounter, regardless of the location of services. In effect, it is the

next generation of the Decision Support System and is much more advanced than the Ratio of Cost to Charges and Relative Value Unit systems which are now prevalent in most hospitals. Oker and Ozyapc (2013) also determined the costs of the unused capacity that was allocated to both open and laparoscopic surgeries. They showed that managers, via the implementation of TDABC, could eliminate the cost of the unused capacities from their cost determination of the operations; hence, the cost of each surgery can be understood better and the optimal number of employees required for each operation or service would be determined. Recently, Kaplan *et al*. (2015) applied TDABC to determine the cost of care in men benign prostatic hyperplasia. They concluded that in comparison with the stand alone urology clinic visit, invasive diagnostic testing would increase costs by 150%. In addition, a 400% cost variance exists between the most and the least medical treatments. Besides, TDABC is useful for measuring costs across an entire care pathway. Recently, Mandigo *et al*. (2015) also applied the TDABC to improve limited health care resources in the Mirebalais hospital of Haiti. Their major aim was to expand the role of TDABC in process improvement and accurate cost determination tool to identify the costs of the hospital operations and optimize the technique for exerting resource-based activities in order to provide accurate care procedures and services costs. They found that the direct costs of the uncomplicated vaginal delivery was $62, caesarean delivery was $249, breast cancer was $1393, and a mastectomy $282. Thus, the indirect costs of the hospital were 26-28% of the total costs, and the salaries were the largest percentages of the total costs (51-72%). They concluded that TDABC exhibits the potentials for optimizing input resources and can be applied as a cost reduction tool. It would also improve budget forecasting, and it makes prudent financing decisions.

In contrast to the preceding studies, Ratnatunga and Waldman (2010) in their study evaluated the various costs associated with Australian Competitive Grants' research proposals. They concluded that TDABC was inappropriate for teaching and research departments since other accurate estimators could provide superior information.

In general, various advantages have been reported for TDABC. However, due to the fact that TDABC has only been propagated in 2004, and since then only a limited number of practical studies have been conducted in this area and most of them are anecdotal, a true judgment concerning TDABC's merits is yet to be ascertained; therefore, future empirical researches need to be conducted in this regard.

Strategic limitations of the TDABC

This section is devoted to a brief investigation of Kaplan and Anderson (2004 & 2007) and other proponents' arguments concerning TDABC's usefulness and applications which were discussed in the introduction of this article.

1. Although TDABC can be applied to various industries, its application is limited to situations in which "Time" can be exerted as the only cost driver.

2. Lack of activity identification, at first stage, deviates TDABC significantly from major and principal fundamentals of the "Activity-based Costing" (Namazi, 2009). If "Activities" are not identified distinctly at the beginning, and a single holistic cost rate is calculated for the whole department, it is tantamount to returning to the traditional volume-based cost accounting systems which were criticized by Kaplan and Cooper (1988), and Cooper (1989).

3. Although it appears that TDABC approaches simplicity, accurate determination of the practical capacity costs and capacity rate and absorbing a uniform capacity cost rate for all the department's activities have emerged as new obstacles (Namazi, 2009). As Barrett (2005: 37) points out:

"Time-driven ABC is simple to deploy only in a department that performs a single activity. In such a scenario, the total costs of the direct and indirect resources can be divided by the available resource to give a cost per unit of resource. However, most departments perform two or more activities that consume direct and indirect resources in different proportions, so some form of survey is required".

4. Although it appears that building a TDABC model is easier than creating a CABC model, that is not always the case because "time-driven ABC requires as much data collection as does traditional ABC. Each time a model is refreshed and recalculated, the duration drivers should be updated." (Barrett, 2005: 39).

5. TDABC adds one more unnecessary step to the ABC's time implementation process because it requires the manager to be involved in the process of the time estimation. This process does not only increase the costs of collecting the required information, but also makes it time-consuming and creates dissymmetry of information. This is in sharp contrast with the findings of agency theory, information theory, and information economics literatures due to the fact that it may lead to noise, production of costly information, and creation of dissymmetry of information. As pointed out by Adkins, "[A]ny estimation process is prone to error. A one minute flaw in a time estimate multiplied by thousands of transactions can greatly skew the results. In fact, such a modest estimation error could possibly be greater than it would under traditional ABC" (Adkins, 2008:3).

Barrett (2005) contends that TDABC's proponents argue that TDABC leads to accuracy, but to date, there is no empirical evidence to support this finding. Furthermore, their assertion that, as a rule of thumb, practical capacity can be considered about 80 to 85% of the theoretical full capacity indicates the inaccuracy of TDABC (p. 37).

Several case studies have also revealed TDABC's obstacles in estimating employees' times embedded for each activity. For example, Hooze and Bruggeman (2010), via a case study, demonstrated that operational employees of the company under investigation felt that they were under pressure and controlled when TDABC was being implemented. Gervis *et al*. (2010) reported that some key managers and employees were strongly opposed to TDABC when they identified the time spent on each activity. Reddy (2011) pointed out the difficulty of employees' resistance during TDABC time implementation process. Cardinals and Labro (2008) found that a significant overestimation bias would occur when employees present their time estimation in minutes.

6. In calculating the cost of unused capacity, TDABC studies did not consider the capacity resources and costs' behavior completely. For instance, Kaplan and Anderson (2004 & 2007) assumed that all customer service department's costs are "committed costs" in that only committed resources and costs may lead to unused capacities and costs, and no consideration has been given to "flexible resources and costs" (see, Kaplan & Atkinson, 2005). Thus, if the customer service department maintains some flexible costs such as direct material costs in a "Just-In-Time", or power costs, or labor costs for only the amounts used, there would be no unused capacity and costs because the amount of costs and resources supplied would be exactly equal to the amount demanded. In these situations, TDABC cannot disclose any information relating to the unused resources and costs. Moreover, it can be shown that CABC methods do not always overestimate the costs of performing activities, and there may be situations in which TDABC encounters with the "overused capacity" and not the "unused capacity" resources (Namazi, 2009). On the other hand, since TDABC is mainly based upon the cycle time information of a department's activities, it could disclose the unused capacity information just for one particular consumed resource.

7. TDABC's advantage for decision making is limited for the following reasons:

A) TDABC assumes that the relationship between activities and resources consumed is linear, absolute, and certain. But, in reality, many managerial decision makings such as C-V-P analysis, profitability determination, capital investment decisions, and product life cycling are made under the conditions of uncertainty, and the prevalent relationship may be non-linear, fuzzy, and uncertain (see. e.g., Geri and Ronen, 2005; Alinezhad *et al*., 2013). As demonstrated by Babad and Balanchandran (1993), when diseconomies of scales become prevalent, the linear proportionality existing between activity cost and cost driver volume is violated, and thus TDABC tends to underestimate marginal costs. Maher and Marias (1998) and Noreen and Soderstrom (1994) have also empirically shown that

employing ABC based on the assumption of a linear relationship between costs and activities yields poor approximations to actual expenditures, and, as such, TDABC can be considered as an approximate method for decision-making.

B) TDABC ignores constraints on activity resources and bottlenecks.

C) Principally, managerial decisions must follow the concept of "relevant information" (see, for example, Kaplan & Atkinson, 2005) which is not equivalent to the concept of the absorption costs information.

D) TDABC's information is useful only when the type of decision is unambiguously defined (Hicks, 2005; Cokings and Hicks, 2007).

8. TDABC, by deriving "activity" time-equation models, may not necessarily generate more accurate cost information, because:

A) Time equation models are based upon linearity and certainty assumption. These assumptions, of course, are very restrictive. In addition, as Koonce *et al*. (2007) demonstrated, when time equations are developed, at least two errors may emerge: 1) the error associated with forming appropriate equations, and 2) the error associated with input data utilized in the equations. Consequently, managerial decisions based on TDABC information would be pruned and misleading, to the extent that these errors would prevail.

B) Time equations will not reduce the process complexities (Tse and Gong, 2009), and they run the risk of costs transparency estimation.

C) Time equations fail to consider the effects of a designated "process" on cost estimation,

D) Time equation models are developed for each activity individually, and the interaction effects of the activities are ignored.

The claim of TDABC's accuracy has also been questioned by some academics and practitioners. For example, Datar *et al*. (1993) pointed out that management often expends resources to activities

"simultaneously" and not sequentially and gradually. Ittner (1999) maintained that employees' time estimations are often inaccurate. Also, Schuhmacher and Burkert (2014) showed that TDABC will generate more accurate estimates than the traditional ABC model only when the number of selected tasks per activity by participants varies. However, when the designated activities are homogeneous, neither approach is more accurate. In addition, when the estimation correction is not attempted by the participants for consistent bias, it results in underestimation of bias which leads to significantly less accurate estimation of the TDABC than CABC.

In sum, some of the professionals' and academicians' observations with respect to the general merits of the TDABC are as follows: Barrett (2005) maintains that:

"Proponents of time-driven ABC suggest that it removes the need for time-consuming and costly surveys, and that it is more accurate than traditional ABC. Both of these claims are debatable" (p. 36).

Adkins (2008) has also rejected the proponents' arguments about the merits of the TDABC by raising the following five myths about time-driven ABC:

1. TDABC is a revolutionary new methodology.
2. It is the panacea for estimating costs.
3. It is easier to develop and maintain.
4. It drives faster and better business decisions.
5. Only certain vendors can operate TDABC.

Finally, Ratnatunga *et al*. (2012) concluded that TDABC posits similar implementation complexities as CABC systems. The summary of their findings is thus shown below:

"In summary, this case study determines that TDABC model is ABC in sheep's clothing. In its extreme form, TDABC provides decision information as erroneous as that produced by traditional volume allocations. As such, we predict that TDABC will result in even fewer implementations sustaining than ABC has managed (p. 294)."

Discussion and concluding remarks

The following points can be inferred from this study:

Since 2003 to date, TDABC is being implemented in some small, medium, and large private and public companies. Most published TDABC articles are in the domain of health care and hospital costs, largely in the US and European countries.

Most conducted TDABC's case studies are genuine (e.g., Kaplan and Anderson, 2007a; Siguenza Guzman *et al*., 2013; Adioti and Valverde, 2014; Mandigo *et al*., 2015), but the amount of empirical study in this domain is scarce. The findings of several case studies are also contradictory. Most of them (for example, Kaplan and Anderson, 2004 & 2007; Everaert and Bruggeman, 2007; Demeere *et al*., 2009; Monroy *et al*., 2012; Kaplan *et al*., 2015) have reported the usefulness of TDABC for strategic decision making situations. However, some others (for example, Ratnatunga & Waldman, 2010; Somapa, Cools & Dullaert, 2010 & 2011; Ratnatunga, Tse and Balachandran, 2012) have shown that TDABC proponents' claims regarding TDABC's advantages are baseless. Since there is no in-depth study that analyzes these factors, the exact conclusion about the extent of the effect of these variables cannot be evaluated unambiguously.

Some practitioners and academic scholars (Barrett, 2005; Adkins, 2008; Namazi, 2009; Wu *et al*., 2011; Siguenza Guzman *et al*. 2013 & 2014) have also pointed out the deficiencies of the TDABC and have argued that TDABC proponents' claims about some advantages of TDABC cannot be justified.

A review of the TDABC literature shows the rate of the TDABC adoption, and its widespread applications in the world appear to be much slower than the adoption rate of the CABC, and the applications of TDABC are yet to gain similar popularity as CABC.

Therefore, it can be concluded that TDABC suffers from following strategic shortcomings:

A) Structural shortcomings which are related to theoretical, basic assumptions, and calculation procedures of the technique,

B) Practical deficiencies which emerged in the implementation process of the model,

C) Lack of adequate empirical support, and

D) Lack of consideration of behavioral issues.

These factors strongly hinder the findings and long-term sustainability of the TDAB as well as its future developments. In addition, they hamper TDABC proponents' assertions and are influential in not materializing the TDABC proponent's arguments.

Suggestions for future research

Future researchers should conduct potent empirical studies relating to TDAB in different directions: 1. examining the assumptions, infrastructures, and foundations of the TDABC, 2. analyzing the effects of significant exogenous and endogenous contextual variables affecting the TDABC, 3. examining the advantages claimed by the proponents and disadvantages discussed by the opponents, and 4. comparing the superiority of TDABC over CABC and conventional systems from various aspects.

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