IL GOVERNO AZIENDALE TRA TRADIZIONE E INNOVAZIONE

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Società Italiana di Ragioneria e di Economia Aziendale

ECONOMIA - *Ricerche*

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Sommario

AN APPLICATION OF TIME-DRIVEN ACTIVITY-BASED COSTING IN A HOSPITAL SETTING

Michele Bertoni[1], Bruno De Rosa[1], Alessio Rebelli[2], Fabrizio Zanconati[1]

1. Introduction

In recent decades, the percentage of GDP devoted to national health systems has increased in most countries (Reinhardt et al., 2004; Perotti, 2006; Pammolli and Salerno, 2011; WHO, 2000, 2010; McKinsey Global Institute, 2008; Armeni & Ferrè, 2013; Scheggi, 2012). In 2012, OECD countries spent an average 9.5% of GDP on healthcare, up from an average total spend in 2000 of 7.8% (OECD Health Statistics, 2014). As healthcare ranks among the largest economic sectors in many countries (Ditzel et al., 2006), it is unsurprising that governments have been looking for suggested ways of reducing healthcare spending. The gradual introduction of Diagnosis-Related Groups (DRG) to fund healthcare providers is an example of such efforts. Under this system, any additional resources used to treat a patient - because of different quality standards or specific clinical decisions, for example - does not translate into an increase in hospital reimbursement, so shifting the cost risk from the insurers (private or governmental) to the providers of healthcare (Cardinaels and Soderstrom, 2013). Hospitals have reacted by introducing cost containment measures that include governance models and cost accounting systems designed around corporate precedents. However, simply transferring systems and methods from for-profit corporations to providers of healthcare services may lead to erroneous results (Alexander and Weiner, 1998), especially as decisions concerning the appropriateness of various medical treatments cannot be based exclusively on cost information.

In such a complex environment, cost accounting systems must provide a level of detail and a depth of analysis that reflects the complexity of the processes being measured. In this sense, ABT (Activity Based Techniques) represent an undoubted improvement over traditional measurement systems in providing valuable information for process management interventions - that is, for Activity-Based Management and Business Process Reengineering.

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2. Pros and cons of using ABC in healthcare institutions: from abc to tdacb

Since its inception, ABC has proved especially useful as an information tool in support of management decision-making (Baker, 1998). In fact, ABC's capacity to increase the visibility of organizational processes and their cost drivers may lead managers to eliminate non-value costs and to improve the efficiencies of existing processes (Demeere, 2009). Based on the formal recognition of the "multiple level variability" of underlying costs, the theoretical roots of ABC usually ensure the increased accuracy of cost measurement processes. This enhancement is critical in contexts in which complexity plays a crucial role (Grisi, 1997; De Rosa, 2000). Yet despite its perceived attractiveness, the rate of adoption of ABC has remained generally low, even in the healthcare sector, mainly because of the difficulties and costs associated with its practical implementation. ABC systems are usually "expensive to build, complex to sustain, and difficult to modify" (Kaplan and Anderson, 2007, p. 7). Furthermore, during the evolutionary path from theory to practice, some important pitfalls of ABC gradually began to emerge (Kaplan & Anderson, 2004). These drawbacks are linked principally to the unwieldy and subjective procedure for the appraisal of resource usage within the conventional ABC framework. Traditional ABC methodology relies on individuals' subjective estimates of their past and future behavior in ascertaining activities' costs. This may cause "measurement errors" at the level of activity costs, due to (1) the inability of personnel to properly recollect or gauge the time spent on working activities and (2) the incorporation of voluntary bias in responses. Kaplan and Anderson (2004) acknowledged that "a subtle and more serious problem arises from the interview and survey process itself. When people estimate how much time they spend on a list of activities handed to them, they invariably report percentages that add up to 100. Therefore cost drivers rates are calculated assuming that resources are working at full capacity". That practice often leads to overestimates of the resources used for activities, with ensuing underappraisal of levels of unused capacity.

Another problem is that the conventional ABC model uses a single activity driver rate for each activity cost pool defined. The activity cost rate so obtained is an average of the costs of activities performed, which may be hypothetically heterogeneous, and this potentially distorted cost information may mislead managers and operators. One possible solution is to expand the number of activity cost pools, so acknowledging an increased number of activities. However, such an expansion augments the complexity of the cost measurement model, increasing development and maintenance costs. An alternative approach requires the employment of both duration and intensity drivers, which estimate the differing usage of resources linked to different levels of complexity of activities performed. While these drivers generally yield a more accurate cost figure, they are also more difficult to measure and are therefore more expensive to store, process and report. To address these pitfalls, a different approach known as Time-Driven Activity-Based Costing (TDABC) has more recently been devised and tested in healthcare environments (Kaplan & Porter, 2011). According to Kaplan and Anderson (2004), TDABC is "simpler, cheaper and far more powerful than the conventional ABC approach". It improves on the existing ABC framework in two ways. First, it simplifies costing systems by eliminating the need to interview and survey personnel in allocating resource costs to activities performed. In fact, while the original ABC framework requires "resource drivers" to trace expenditure to work activities, the revised approach invites managers to estimate directly the resource demand imposed by each transaction. Second, TDABC uses the capacity cost rate to drive departmental resource costs to cost object by assessing the demand for resource capacity implicit in activity levels. The practical effect of this new way of computing costs is that a clear distinction is made between used and unused resource capacity. The improvement achieved by the new framework rests mainly on two pillars: the design and use of "time equations" and computation of the so-called "capacity cost rate". The combined use of these two conceptual tools means that TDABC can easily reflect variations in the aggregate demand for resources induced by different types of transaction (Kaplan & Anderson, 2004).

Time-driven ABC recognizes that different groups (pools) of resources are used in performing activities of different kinds. For each of these groups, the total period cost is therefore compounded, aggregating all resource costs associated with the observed activity. This encompasses each person's full compensation, including salary, payroll taxes, pension costs and fringe benefits. It also includes the costs of all other resources that enable the workers to properly perform the activities assigned to them.

These typically include a pro rata share of costs related to employee supervision, space (the offices each staffer uses), and the equipment, information technology, and telecommunications each uses in the normal course of work. In this way, the cost of many of the organization's shared or support resources can be assigned to the resources that directly interact with the patient. (Kaplan and Porter, 2011, p. 52)

In academic medical centers, a specific measurement issue arises. As many physicians spend significant amounts of their time on research and teaching activities, the percentage of time spent on clinical work should be determined in order to properly separate these two clusters of costs.

Clearly, compounding the "capacity cost rate" also requires estimation of resource supply capacity. Within the TDABC framework, capacity assessment relates to "practical capacity", generally expressed in units of time.

The next step of the TDABC methodology involves assessment of the time required to perform a transactional activity, either by means of direct observation or by interviewing operators. In this phase, TDABC displays its full potential. Because it does not require the simplifying assumption that all transactions are the same, TDABC ensures correct appraisal of the economic effects of complexity. The unit time estimates are, in fact, designed to allow for variation according to the activity's specific characteristics or attributes. These "attributes" represent the "drivers" that cause the increase in level of complexity of a specified transaction, each referring to an increase in resource consumption to be assessed. Once recognised, this intensification in resource utilization can be proportionally added to the time required to perform the basic process. Rather than defining a separate activity for each possible variation in activity attributes, the time-driven approach estimates resource demand by means of a time equation. The accuracy of the TDABC model lies in its ability to capture resource consumption from diverse transactions simply by adding more terms to the time equation. While taking account of increased variety and complexity, a typical TDABC model usually requires fewer equations than the number of activity pools used in a conventional ABC system.

3. Case study: an application of time-driven activity-based costing

The case study that follows summarizes the results of research seeking to improve theoretical and operational frameworks for process analysis and activity-based costing (ABC) at the *Azienda Sanitaria Universitaria Integrata* (Teaching Hospital) in Trieste, Italy. The entity is a product of the integration of the pre-existing hospitals of Trieste and the Faculty of Medicine and Surgery at the University of Trieste.

This case study was conducted within the Anatomical and Histological Pathology Unit of the hospital. Anatomical pathology is a medical specialty concerned with the diagnosis of disease, based on the macroscopic, microscopic, biochemical, immunologic and molecular examination of organs and tissues. The main activities performed by the Anatomical and Histological Pathology Unit of the Hospital can be summarized as follows:

Cytopathology;

Histopathology;
Immunohistochemistry;
Molecular biology;
Autoptic examinations.

Cytopathology is the branch of pathology that studies and diagnoses diseases at the cellular level, examining samples that are usually liquid. Histopathology studies tissues and organs (solid samples) originated by biopsies or autopsies. These samples normally require preparation, which involves processing histological sections and placing them onto glass slides. Immunohistochemistry and molecular biology, respectively, involve the detection of antigens in cells and the study of the molecular basis of biological activity to answer specific predictive and diagnostic questions. Usually, only the largest anatomical and histological pathology units (as in the present case study) have the necessary resources to conduct such analyses. The aim of the present study was to apply the TDABC methodology to the examinations performed by the Unit, in order to determine their cost. The cost data gathered within the current entity cost system, in fact, lacks the granularity required to correctly "trace" resource consumption to specific activities or processes. The cost data resulting from our research, therefore, although based on data provided by the existing cost accounting system of the hospital, constitute an original application of the TDABC methodology, performed in order to assess its feasibility in a complex healthcare environment. We believe the unit we examined, given the modularity of its activities, the standardization of some procedures, and the large volumes of some examinations, can represent a valid test field for the TDABC methodology. Moreover, teaching hospitals present some specific issues with the application of the methodology, not found in other healthcare institutions, namely the time devoted by physicians to teaching and research and the contribution of medical students. In this sense, our analysis can offer some hindsight on the improvement of the TDABC model in complex environment.

With reference to the cost rate of resource capacity supply, the most important element is the cost of personnel. Three categories of staff are involved in the Unit's processes: physicians, laboratory technicians and administrative staff. The capacity cost rates for these three groups are quite dissimilar.

To determine cost rates, we measured the average cost of personnel for the Unit in the period 2010–2012 (at the time of the study, the personnel costs for 2013 were not yet available). To calculate the practical capacity of the Unit, we assumed that physicians normally work 38 hours per week, and technicians and administrative staff work 36 hours per week. Taking account of part-time personnel, parental leave, paid leave and other events that may affect the actual number of hours worked, we determined the total hours per year as 1,482 for technicians and 1,414 for physicians. To correctly calculate the cost rate of personnel, we also needed to have regard to the peculiarities of the Teaching Hospital of Trieste, where University physicians are also involved in teaching and research activities. By interviewing the personnel, we estimated that University physicians devoted 50% of their total working hours to those duties. We decided against including the figurative costs of medical students (who receive no remuneration from the hospital), as their contribution to the activities of the Unit in this specific context is most likely offset by the supervisory and training tasks performed by the physicians.

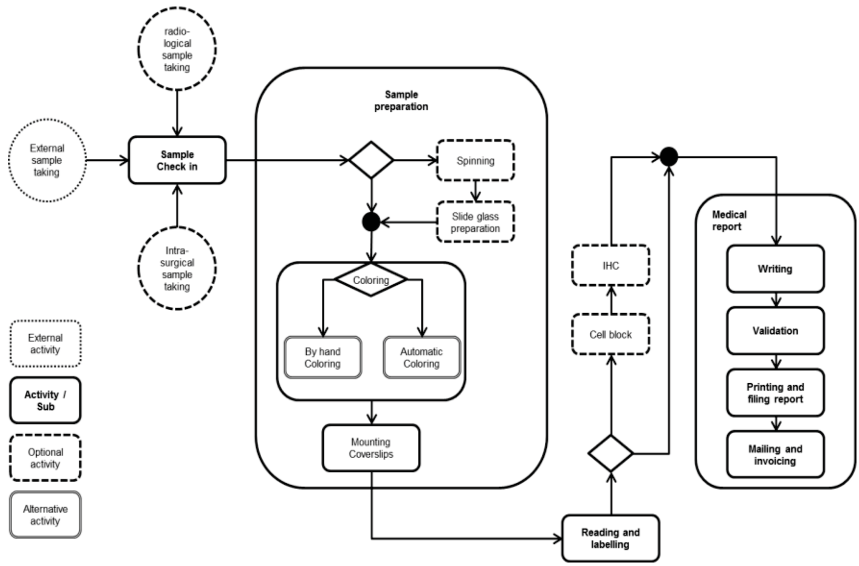
Converting the number of employees to full-time equivalents, we determined that the personnel available to the Unit comprised 8 physicians, 14.9 technicians and 5.61 administrative staff. In terms of the practical capacity of these resources, we calculated the capacity cost rate for these three categories of employees using the following formula:

$$\text{Capacity cost rate} = \frac{\text{Cost of capacity supplied}}{\text{Practical capacity of resources supplied}}$$

The results were as follows:
Physicians: €62 per hour;
Technicians: €25 per hour;
Administrative staff: €22 per hour.

The next step in the application of the TDABC model is to estimate the time required to perform a transactional activity. To this end, we produced a detailed map of all the processes performed by the Unit in order to measure the time required to perform the various activities. For example, Figure 1 summarizes the typical process for a cytopathology examination.

Figure 1: Process map of a typical cytopathology examination



Not all tasks performed by the Unit involve the same activities; more importantly, the process flow is modular, meaning that more complex instances involve more activities. Typically, exams requiring more than one slide glass involve longer examination times, and exams with a positive result require a greater number of activities than negative exams. This higher degree of complexity translates into longer times required to perform those tasks, making the TDABC approach particularly apt for measuring the increased cost associated with the complexity of the examination.

Using the TDABC approach, once the relevant processes were identified, we estimated the time required to perform activities in order to calculate the cost of personnel involved. For example, Table 2 (http://www.sidrea.it/activity-based-costing-hospital-setting/) reports the activities required to perform a specific cytopathology examination: a fine-needle aspiration biopsy (code E-0013). Volumes and time estimates are also shown.

Table 1 explains the codes for parameters used in Table 2, along with the total numbers processed in 2013. The data reported represent the different processes identified for this specific examination, along with the number of their instances. The parameters indicate the processes needed in order to perform an examination. The different possible combinations of these processes constitutes the main source of complexity for this activity.

Table 1. Description of parameters and total instances of exam E-0013

ID	Parameters	Qty
R	Registration (i.e. number of examinations performed)	2,093
GS	Glass slides	6,567
RX_T	Radiological sample taking	1,947
INS_T	Intrasurgical sample taking	751
INS_GS	Intrasurgical glass slides	738
IHC	Immunohistochemistry	91
CB	Cell block	974
EX+	Positive examinations	1,208
EX?	Dubious or inadequate exams (included in negative exams)	84
EX-	Negative examinations	885
GM/H&E	GIEMSA/H&E stain	1,320
PPN	Papanicolau stain	5,985

The data reported in Table 2 (http://www.sidrea.it/activity-based-costing-hospital-setting/) represent the time spent by physicians, technicians, and administrative staff in performing the activities listed in Table 1. The column "Attribute" reports the code of the task listed in Table 1, while "Value" is the number of instances of that specific attribute in the period considered. The time necessary to complete the activity is reported on a per unit basis (expressed in seconds) and as a total for the period (in hours). The measurements were taken directly by the research team. The data reported in Table 2 enabled us to define the time equation - a simple algorithm that explains the level of resource consumption, taking into account the existence of specific characteristics (attributes) that increase the level of complexity of transactions performed. For each type of diagnostic exam, we first assessed the required time to perform the "standard" activity. In the Unit we studied, three categories of personnel are normally involved in the process: physicians, technicians and administrative staff. The standard time equation demanded an appraisal of the time spent performing the activity in its basic form by each of these groups. For a fine-needle aspiration cytopathology examination (E-0013), the basic time equation has the following structure:

$$TE_s = TE_p(GS, R) + TE_t(GS, R) + TE_a(R)$$

where

- TE_s is the standard time equation;
- TE_p is the time required by physicians to perform the activity in its standard configuration;
- TE_t is the time spent by technicians in performing the standard activity;
- TE_a is the time required by administrative personnel to perform the standard activity;
- GS is the number of glass slides;
- R is the number of registrations (i.e. the number of examinations performed).

Note how the amount of time spent by personnel in performing a diagnostic exam may vary in accordance with specific parameters. For fine-needle aspiration cytopathology examination E-0013, the relevant parameters are the "number of registrations" (R) and the "number of glass slides used" (GS). The following equation captures the relation between these attributes and the total length of the process:

$$TE_p(GS,R) = GS \times Microscopic\ examination_p + R \times Reporting_p + R \times Validation_p$$

$$TE_t(GS,R) = R \times Registration_t + GS \times Spinning_t + R \times Coverslips_t + R \times Labelling_t + R \times ValidationOfReporting_t$$

$$TE_a(R) = R \times Registration_a + R \times Reporting_a + R \times FilingReporting_a + R \times MailingReporting_a$$

Assuming use of one glass slide, we can then express in seconds the time required to perform the examination as follows:

$$\begin{aligned} TE_s(1,1) = TE_p(1,1) + TE_t(1,1) + TE_a(1) \\ &= (1 \times 420_p + 1 \times 600_p + 1 \times 60_p) \\ &+ (1 \times 120_t + 4 \times 6_t + 1 \times 20_t + 1 \times 60_t) \\ &+ (1 \times 600_a + 1 \times 120_a + 1 \times 60_a + 1 \times 30_a) \\ &= 1080_p + 224_t + 810_a. \end{aligned}$$

Although the times calculated in the previous equation are expressed in the same unit (seconds), it would not be appropriate to calculate their total sum. In fact, the economic value associated with the three times is different, as each measures the consumption of resources pertaining to a different cost pool. It is possible, however, to determine the different costs by multiplying times by the relevant capacity cost rate (€62 per hour for physicians, €25 per hour for technicians, €22 per hour for administrative personnel). For the configuration described above, the total cost of the examination is approximately €25.

The TDABC approach allows us to analyze the increase in costs associated with a different configuration of parameters. For example, if the examination requires four glass slides rather than just one (so increasing complexity), the time equation would read as follows:

$$\begin{aligned}TE_s(4,1) = TE_p(4,1) + TE_t(4,1) + TE_a(1) \\ = \left(4 \times 420_p + 1 \times 600_p + 1 \times 60_p\right) \\ + (1 \times 120_t + 4 \times 6_t + 1 \times 20_t + 1 \times 60_t) \\ + (1 \times 600_a + 1 \times 120_a + 1 \times 60_a + 1 \times 30_a) \\ = 2340_p + 224_t + 810_a.\end{aligned}$$

In this case, the total cost is approximately €47.

The complexity of processes can also be expressed by taking account of the optional activities required in specific instances, which can be incorporated into the time equation by means of "dummy" variables. For example, we can consider the following optional activities:

$$\begin{aligned}TE = TE_s(4,1) + \Big(INS_T \times Intrasurgical_p + RX_{T \times Radiologist_p} + EX^+ \\ \times SampleFiling_p\Big) \\ + (INS_T \times Intrasurgical_t + PPN \times Coloring_t + GM/H\&E \\ \times ManualColoring_t) + \Big(EX^{(-|?)} \times SampleFiling_a\Big).\end{aligned}$$

The assessment of time generates the following results:

$$\begin{aligned}TE = TE_s(4,1) + \left(0|1 \times 1800_p + 0|1 \times 1800_p + 0|1 \times 60_p\right) + (0|1 \\ \times 1800_t + 0|1 \times 10_t + 0|1 \times 15_t) + (0|1 \times 30_a)\end{aligned}$$

If
INS_T = 1,
RX_T = 0,
$EX^+ = 1$,
PPN = 1, and
GM/H&E = 1,

we obtain the following result:

$$TE = 2340_p + 224_t + 810_a + (1 \times 1800_p + 0 \times 1800_p + 1 \times 60_p) + (1 \times 1800_t + 1 \times 10_t + 1 \times 15_t) + (0 \times 30_a) = 4200_p + 2049_t + 810_a.$$

In this latter case, the total personnel cost increases from €47 to about €92.50. The TDABC approach therefore enables the creation of a modular cost system, which can readily accommodate variants and deviations from the standard flow of activities - an extremely useful feature in healthcare cost accounting.

4. Conclusions

The practical application to the Unit of the TDABC methodology proved very effective, enabling integration of the costs of a number of different examinations in a way that was both accurate and simple to obtain. This outcome owes to the modularity of the time equation, which is the main innovation afforded by this technique. Data obtained by this method are characterized by high information content because they enable comparison of the costs of diagnostic treatments with different intrinsic levels of complexity. This facilitates "what-if" analyses for study of the economic effect of changes in the mix of examinations offered. In addition, the approach enabled us to determine rates of saturation of resources; in the present case study, for example, productive capacity was almost completely exhausted. In its concrete application to the Anatomical and Histological Pathology Unit, time-driven ABC has therefore shown itself capable of providing meaningful cost information quickly and inexpensively, offering a transparent, scalable methodology that is relatively easy to implement and update. This case study examined all the "attributes" used to diversify the cost of activities in accordance with their level of complexity as already recorded in an existing database used for operational purposes. The capacity of TDABC to incorporate existing data in determining accurate and appropriate costings increases the value of operational information already recorded. As an example, the number of glass slides used to perform a specific diagnostic exam and the number of diagnostic exams with negative outcome - information already present in the hospital database - were used by the TDABC team as indicators of the level of specific activities performed by physicians, technicians and administrative personnel. This allowed differentiation of those costs of diagnostic exams characterized by differing intrinsic levels of complexity for the activity performed.

One additional feature of TDABC is that it facilitates useful analyses of the evolution of cost structure as caused by hypothetical changes in cost drivers (“what-if” analyses). It also allows forecasting and assessment of the demand for resources implicit in different levels of treatments. One of the most interesting applications of the time equations to the Unit was the formal determination of capacity utilization rate. Bottom-up application of the time equation allowed the research team to verify that the rate of utilization of overall capacity (physicians and technicians) was very high (close to 96%). This is consistent with the overload during peak periods as described by workers in the Unit.

Another benefit of the analysis was its thorough appraisal of the complexity of services provided by the Unit. This highlighted how DRG tariffs refer to standard procedures that inevitably oversimplify the variety of services actually provided. One may therefore conceive of the DRG tariff as an average of costs corresponding to different services that, share the same formal description but use different levels of resources by virtue of their differing complexity. The detailed analysis of activities performed by the Unit enabled us to highlight a remarkable variability in costs for services belonging to the same tariff class. As the norm for average costs, the information implicitly provided by the DRG tariff is unsuitable for management of processes to improve their efficiency and effectiveness.

The simulation highlighted how the TDABC methodology can increase the decision usefulness of the information provided by the cost accounting system in environments characterized by high complexity, unpredictability and modularity of the processes. The application of the model in a real life scenario, using actual data and mapping the actual process of the organization, shows the feasibility of the approach in healthcare. The limitations can be identified in the estimation of the time physicians dedicate to teaching and research and in the inclusion of labor cost only in the capacity cost rate. Further steps of the research will require to tackle these issues, along with the problem of the medical students contributing to the various processes of the organization, that we did not consider in this study.

In conclusion, the granularity of the information provided by TDABC can assist users in correctly identifying the “root causes” of costs and so offers a wealth of opportunities to increase healthcare efficiency and effectiveness. As health policies and health systems across the European Union become increasingly interconnected in terms both of patient and professional mobility across the EU (see for example Directive 2011/24/EU), these characteristics may prove extremely valuable for the design of reimbursement systems with realistic tariffs.

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