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Falsification of Time-Driven Activity-Based Costing (TDABC) and Instead What?

by

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Abstract. Aim: The main aim of the article is to conduct the falsification of TDABC. The secondary goal is to create a modified TDABC. The next objective is to find the ABC golden rule of resource allocation.
Research methodology: Falsification of reasoning is based on *modus tollendo tollens* of classical logic. Numerical examples are used as an equivalent of experiments in physics controlled with specific ABC models. Traditional and modified general TDABC and rate-based ABC models are applied.
Result of research: Three theorems falsifying TDABC are presented. The fourth theorem served to define the ABC golden rule of resource allocation. The immunizing stratagem enabled the creation of modified TDABC, called the general TDABC.
Originality/Value: Essential mathematical properties of TDABC and its implications for cost calculation, cost assignment to cost objects, and managing used and unused capacity are discovered. Three theorems as a falsifier of TDABC were derived from this model. The ABC golden rule of resource allocation was discovered. The modified, general TDABC was created. Using the golden rule of resource allocation, or determining the utilization coefficients of specific resources for complete utilization of practical time proved that traditional TDABC has become redundant.
Key words: falsifier, ABC golden rule of resource allocation, cost of resources supplied per time unit, unused capacity, cost driver rate, cost of resources supplied utilization coefficient, practical time utilization coefficient.

1. Preface

Gervais, Levant and Ducrocq have emphasized the advantages of the TDABC model, but they have gone on to say: "The concept of TDABC however remains unexplored in academic research" (2010: 2). One can agree with this view to a certain extent. However, it should be mentioned that certain problems have been identified with TDABC in the literature. These include the problem of measuring time errors (Ratnatunga and Waldmann, 2010; Cardinaels and Labro, 2008; Hoozée and Bruggeman, 2007), the problem of homogeneity and aggregation (Gervais, Levant, and Ducrocq, 2010), the problem of estimated transaction time errors in time equations (Hoozée, Vermeire, and Bruggeman, 2012), the problem of the accuracy of data obtained (Giannetti, Venneri, and Vitali, 2011), and the problem with the calculation of the capacity cost rate and estimation of the required capacity (Namazi, 2009).

It is interesting to note that Van der Merwe criticizes TDABC as it treats all costs as variable: "TDABC examples increment all costs in a budget scenario with no distinction as to fixed or proportional behavior" (2009: 26). In commenting on this issue it should be emphasized that after distinguishing between the cost of resources supplied and used, the last could be considered as variable. As stressed by Kaplan (2006: 131):

> "While the cost of acquiring resources, particularly capital resources, may be nonlinear with scale, the cost of using resources is linear – at least within the deterministic models that have proved adequate to date for modeling cost behavior in actual companies….The linearity of resources usage provided the basis for time-driven activity-based costing, a recent reformulation of ABC."

Based on academic research, it can be said that no one has investigated the essential mathematical properties of TDABC and their implications for cost calculating, cost assignment to cost objects, and managing used and unused capacity. The purpose of this paper is derived from this finding.

The main aim of this article is to conduct the falsification of TDABC. The checking of the theory, that is, the falsificating of its reasoning, is based on *modus tollendo tollens* of classical logic:

$$(t \Rightarrow p) \cap \sim p \Rightarrow \sim t \qquad (1)$$

According to Popper, “Let *p* be a conclusion of a system *t* statements which may consist of theories and initial conditions (for the sake of simplicity I will not distinguish between them)” (2004: 55). Written according to *modus tollendo tollens,* falsificating a conclusion means: “If *p* is derivable from *t*, and if *p* is false, then *t* also is false” (Popper, 2004: 56).

On this basis, the most important thesis on falsificationism was formulated: “By means of this mode of inference we falsify *the whole system* (the theory as well as the initial conditions) which was required for the deduction of the statement *p*, *i.e.* of the falsified statement” (Popper, 2004: 56). Sentence ~*p* is a falsifier, that is, it is the reverse sentence to prediction *p*.

To define the type of hypothesis that TDABC is that we will try to falsify, we will first relate it to the basic idea of ABC. Kaplan and Cooper defined the issues of cost accounting as follows: “(...) that measuring and managing used and unused capacity is the central focus of activity-based costing” (1998: 122). The basic equation of activity-based costing, which makes the extremely important distinction of costs of resources supplied and costs of resources used, can be seen to have close connection with the previous statement[1] and is presented in Scheme 1:

Cost of resources supplied = Cost of resources used + Cost of unused production capacity

Scheme 1. Basic equation of ABC
Source: (Kaplan and Cooper, 1998: 118)

Using inaccurately chosen costs (particularly historical costs) in the calculation of cost driver rates or using overstated, percentage resource drivers in the traditional ABC model could lead to the acceptance of ineffectiveness connected with regarding the costs of resources supplied as costs of resources used.

TDABC was created as a reaction to the occurrence of weaknesses in the traditional ABC model during its implementation and maintenance in large size companies (Kaplan and

[1] For the first time this equation was presented, see Cooper and Kaplan (1991, 1992)

Anderson, 2004). These authors stated that using surveys of time, prepared from reports by employees providing information about percentages of their time spent on various performed activities as the basis for defining the resource cost driver rates and the number of the employed, in organizations that often exceed a couple of tens of thousands of people, and the high frequency of their submission, creates an extremely labor-consuming and costly system. During the development of the system we can observe the quite frequent loss of accuracy and delays, as well as its nuisance value and declining accuracy.

Additionally there appear to be two other weak points in such a model. First of all, in their reports employees usually submitted percentage shares that added up to 100%, being afraid of using real data to reduce employment. Therefore, full resource utilization is always achieved. As a result, it is impossible to perform cost analysis of unused capacity according to the basic ABC equation for company management. Secondly, while being very complex, the model has problems with describing the complexity of operations. Taking that into account leads to an increase in the number of cost driver rates and further increased costs and other deficiencies of such a system. On the other hand, its omission would result in inaccuracies in defining the size of costs. As a result, many companies have resigned from using activity-based costing.

Presented by Kaplan and Anderson, TDABC was supposed to be a remedy for discovered weaknesses of traditional ABC model. The following are the characteristics of this concept:

> "The new approach, which we call Time-Driven Activity-Based Costing, gives companies an elegant and practical option for determining the cost of capacity utilization of their processes and the profitability of orders, products and customers. TDABC enables companies to improve their cost management system, not abandon them. Managers obtain accurate cost and profitability information…" (Kaplan and Anderson, 2007: 4)

Using the results of the presented numerical example, the authors stressed the advantages of the new approach:

> "The report reveals the time required to perform the three activities, as well as their resource costs. It also highlights the difference between capacity supplied (both quantity and cost) and capacity used. Managers can review the $32,760 cost of the unused capacity and contemplate actions to determine whether and how to reduce the cost of supplying unused resources in subsequent periods" (Kaplan and Anderson, 2007: 13).

They also indicated the advantages of the new method of calculation. They claimed that in TDABC the method of calculating the cost of resources used per unit of time "allows the

ABC cost drivers to provide more accurate signals about the cost and the underlying efficiency of its processes" (Kaplan and Anderson, 2004: 134).

We have presented the statements of the authors of the TDABC, which will be the subject of falsification. However, there is still room for an explanation in the introductory remarks about what is meant in the case of the falsification of TDABC that the falsifier is a statement in which the result of an experiment is confirmed.

In management accounting, numerical examples play an important role as a research tool in illustrating theoretical concepts. However, there is a question about the status of those examples. Experiment, as is known, is most often not possible in economics. The construction of numerical examples should fulfill the conditions of acceptance that are an equivalent to experiments in physics conducted in a controlled environment, in the sense that these examples are controlled by a specific management accounting concept (Mielcarek, 2007: 67–71). The falsifier will therefore be a statement the outcome of numerical example controlled by the reconstructed TDABC, on the scale needed for this article that is contradictory with the claims of TDABC as presented by its authors. Generally contradictions are revealed between the claims of the authors about the concept and the claims resulting from their reconstructed concept.

2. Falsification on the basis of the TDABC reconstruction[2]

Falsification of the concept on the basis of its reconstruction means proving a discrepancy between what the authors claimed about the theory and what results from the reconstructed theory. Hence, in *modus tollendo tollens*:

$$(t \Rightarrow p) \cap (t_r \Rightarrow \sim p) \Rightarrow \sim t \qquad (2)$$

p will be the inference resulting from the system of statements *t* according to the authors of the *t* theory, *~p* is a deducible falsifier from reconstructed t_r theory, that is a contradictory

[2] Reconstruction of theory, that is, reconstructing its most important elements on the basis of the works of its creators is the

"…reconstruction of its paradigm, that is hard core of its scientific research program. In case of reconstructed management accounting concepts, its hard core consists of:
- assumptions of a specific concept,
- main theorems,
- main mechanisms of company functioning,
- main research methods" (Mielcarek, 2005: 58).

statement to the *p* prediction, whereas ~*t* will be a falsified theory in the approach presented by its authors.

As we mentioned in Section 1, the reconstruction will be conducted only to the extent that is necessary for the falsification of the TDABC concept. The concept is based on the implicitly accepted assumption that the costs of resources supplied are fully utilized for the complete utilization of practical time.[3]

Let us look closer at the consequences of this assumption. First of all, it determines that the way of calculating the cost of resources supplied per unit of practical time is

$$c_s = \frac{C_s}{T} \tag{3}$$

where:

c_s – cost of resources supplied per practical time unit,

C_s – cost of resources supplied to specific department,

T – total practical time of the employees employed in a specific department at a specific time, differing from theoretical time by all the typical work breaks (official breaks, job changes, training, meetings, etc.).

We will present Theorem 1 falsifying TDABC:

Theorem 1.

If practical time is fully utilized and cost per time unit of capacity is calculated according to (3) then the cost of resources used is always equal to any size of the cost of resources supplied.

To prove Theorem 1, we will define the size of the cost of resources used. In TDABC it is a product of the cost of resources supplied per unit of practical time and the time consumed by activities:

$$C_u = c_s T_{f1} + \ldots + c_s T_{fi} + \ldots + c_s T_{fm} = c_s (T_{f1} + T_{f2} + \ldots + T_{fm}) \tag{4}$$

The sum of total time used by each kind of activity is equal to the total practical time. Thus we may write

$$T = T_{f1} + \ldots + T_{fi} + \ldots + T_{fm} \tag{5}$$

[3] A full reconstruction of TDABC concept assumptions is presented in Mielcarek, 2007: 154–168.

Substituting (3) and (5) into (4) we can get:

$$C_u = \frac{C_s}{T} T = C_s \tag{6}$$

where:

T_{fi} – fully utilized time assigned to activity i,

i – the number of activity,

$i = 1 \ldots m$,

C_u – total cost of resources used.

The cost of resources used is always equal to any size of the cost of resources supplied, provided practical time is fully utilized. In other words, the fundamental assumption of TDABC is satisfied not only in the case presented by Kaplan and Anderson (2004, 2007) but also for any higher or lower size of the cost of resources supplied. The first fundamental flaw in TDABC is presented by (6). TDABC is unable to calculate properly the cost of resources used provided practical time is fully utilized; therefore, (6) is a falsifier of TDABC.

It is worth noting that due to (6) it is difficult to recognize the TDABC weaknesses. Anybody can check the example presented by Kaplan and Anderson (2004, 2007) that the assumption of fully utilized cost of resources supplied for fully utilized practical time is fulfilled, and they can omit the TDABC property that it is fulfilled for any size of cost of resources supplied.

Additional difficulties in the appropriate perception of TDABC properties arise from the fact that Kaplan and Anderson take and emphasize the importance of the following assumption of homogeneity: "…a departmental cost rate is valid only if the mix of resources supplied is about the same for each activity and transaction performed within the department. This assumption is violated if the activities and transactions done within the department use different resources" (2007: 49). It should be noted that this assumption does not protect against regularity expressed in formula (6) since it is fulfilled for any size of the cost of resources supplied with the same mix for each activity performed within the department.[4]

The next theorem falsifying TDABC is as follows:

Theorem 2.

[4] The homogeneity assumption is a consequence of TDABC's more fundamental assumptions that the costs of resources supplied are fully utilized for practical time utilization and that the cost of resources used is a linear function of cost of resources supplied.

If practical time is not fully utilized and cost per time unit of capacity is calculated according to (3), then the cost of resources used is a linear function of cost of resources supplied and the cost of resources supplied utilization coefficient is always equal to the practical time utilization coefficient for any size of cost of resources supplied.

To prove Theorem 1 we will define not fully utilized practical time as:

$$T_u = T_1 + \ldots + T_i + \ldots + T_m < T \tag{7}$$

and the practical time utilization coefficient as

$$\frac{T_u}{T} = u_t \tag{8}$$

When we put (7) into (4) we get:

$$C_u = c_s T_u = c_s u_t T = \frac{C_s}{T} u_t T = u_t C_s \text{ [5]} \tag{9}$$

where:

T_u – not fully utilized practical time,

u_t – practical time utilization coefficient.

From formula (9) it may be concluded that the cost of resources used is the linear function of cost of resources supplied and its slope coefficient is determined by the practical time utilization coefficient. But Kaplan and Anderson claimed that the cost of resources used is a constant quantity for the specific practical time utilization coefficient. On this basis, it might be concluded that TDABC is not able to correctly determine cost of resources used when practical time is not fully utilized. Of course, this means that TDABC also cannot properly calculate the cost of unused capacity. Formula (9) occurs as a falsifier of TDABC.

The cost of resources supplied utilization coefficient can be expressed as

$$\frac{C_u}{C_s} = u_r \tag{10}$$

Modifying (9) and putting it in (10) we get

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[5] This formula reveals the TDABC's implicit assumption that the cost of resources used is a linear function of cost of resources supplied.

$$\frac{C_u}{C_s} = u_r = u_t \tag{11}$$

where u_r is cost of resources supplied utilization coefficient.

Formula (11) means that cost of resources supplied utilization coefficient is always equal to the practical time utilization coefficient regardless of how big is the cost of resources supplied. The conclusion is in contradiction to the obvious rule that the cost of the resources supplied utilization coefficient is not a constant, but it depends on the size of the cost of resources supplied, subject to a given practical time and its utilization coefficient.

Consequently, in a company which has a certain specified size of cost of resources supplied, there will be a calculated coefficient of its utilization; then, in a similar company having a higher cost of resources supplied the utilization coefficient will be the same, provided there is identical practical time and its utilization coefficient for both companies. In a reverse situation, that is a similar company with a lower cost of resources supplied, the utilization coefficients will be the same again. This means that, contrary to the opinions expressed by the authors of TDABC, it is not possible by using this concept to establish correctly the utilization coefficient of the production capacity and hence the cost of the unused production capacity coefficient. Regularities (9) and (11) are falsifiers of TDABC.

Theorem 3 falsifies TDABC as follows:

Theorem 3.

If the cost of resources supplied is fully utilized for fully utilized practical time, then one does not need to calculate the cost per time unit of capacity and derive cost-driver rates to assign costs to activities. Unit times of activities will be adequate.

The proof of Theorem 3 is as follows:

We set out the cost of resources used by specific activity performed within the department as

$$C_{ui} = c_s T_{ui} \tag{12}$$

where

$$u_{ti} = \frac{T_{ui}}{T} \tag{13}$$

and

$$T_{ui} = t_i A_i \tag{14}$$

and putting (13) in (12) we get

$$C_{ui} = c_s u_{ti} T = \frac{C_s}{T} u_{ti} T = u_{ti} C_s \tag{15}$$

where:

C_{ui} - cost of resources used by activity *i*,

T_{ui} - practical time used by activity i,

A_i - quantity of activity *i*,

u_{ti} – practical time utilization coefficient for activity *i*.

We do not need to calculate the cost per time unit of supplying resource capacity and the cost driver rate to assign cost of resources used to the activity. According to (14) the only parameter we need is unit time per activity. Finally, as in (15) only the practical time utilization coefficient for each activity is required.

Kaplan and Anderson claimed that, "For each group of resources, estimates of only two parameters are required: the cost per time unit of supplying resource capacity and the unit times of consumption of resource capacity by products, services, and customers" (2004: 133). Cost-driver rates are calculated by multiplying the two input variables (Kaplan and Anderson, 2004: 133).

This statement is in clear contradiction to the conclusion drawn from (15); for the assignment cost of resources used to activity is the required utilization coefficient of practical time for the activity, and this is determined by the unit time of the activity.

Finally, contrary to Kaplan and Anderson, the unit times of the consumption of resource capacity are only necessary to assign the cost of resources used to activities and determine total cost of resources used. Regularity (15) is falsifier of TDABC.

One may conclude from Theorems 1, 2, and 3 that TDABC embodies a conceptual error in its formation. Authors and users do not recognize the mathematical properties of TDABC that cause the falsification of claims about the advantages of this costing model. Measuring and managing used and unused capacity properly is impossible, inter alia because of the linear dependency of the cost of resources used on the cost of resources supplied.

3. Falsification by example

Falsification by example will mean using (1). To illustrate what the contradictions of using the TDABC concept can lead to, we will provide an example using initial data taken from the example of Kaplan and Anderson (2004: 133–135). In Table 1 we present the initial data necessary for calculating the cost of resources supplied per unit of practical time.

Table 1. Cost of resources supplied per unit of practical time

Specification	Quantity
Practical working time	700 000
Cost of resources supplied	560 000
Cost per minute of supplying capacity	0.8

Source: author's own research on the basis of Kaplan and Anderson (2004: 133–135).

From the initial data we may conclude that the cost of resources supplied per minute of practical time is USD 0.8. In Table 2 the cost-driver rates are calculated.

Table 2. Main parameters of TDABC

Activity	Unit time	Cost per minute of supplying capacity	Cost driver rates
Process customer orders	8	0.8	6.40
Handle customer inquiries	44	0.8	35.20
Perform credit check	50	0.8	40.00

Source: author's own research on the basis of Kaplan and Anderson (2004: 133–135).

It is assumed that in the department three operations are conducted. For each activity, the cost driver rates are calculated as a result of the multiplication of unit time by cost of resources supplied per unit of practical time. In Table 3 the used practical time and cost of resources used are calculated.

Table 3. Practical time and cost of resources used

Activity	Quantity	Unit time	Total time used	Cost-driver rate	Total cost assigned
Handle customer orders	51,000	8	408,000	6.40	326,400
Handle customer inquiries	1,150	44	50,600	35.20	40,480
Perform credit check	2,700	50	135,000	40.00	108,000
Total used			593,600		474,880
Total practical time and total cost of resources supplied			700,000		560,000
Unused capacity			106,400		85 120
Utilization coefficient			84.80%		84.80%

Source: author's own research on the basis of Kaplan and Anderson (2004: 133–135).

The total cost of resources used is calculated as the product of activity quantity and cost driver rate, and the total time used as a product of activity quantity and unit time. Total time used is 593,600 minutes and total cost of resources used is USD 474,880. The practical time utilization coefficient is 84.8% and this quantity is equal to the cost of the resources supplied utilization coefficient. This equality is in accordance with Theorem 2.

In Table 4 we will try to assign the cost of resources used to each activity with the practical time utilization coefficient.

Table 4. Total costs assigned to activities with practical time utilization coefficient

Activity	Quantity	Unit time	Total time used	Utilization coefficient	Total cost assigned
Handle customer orders	51,000	8	408,000	58.29%	326,400
Handle customer inquiries	1,150	44	50,600	7.23%	40,480
Perform credit check	2,700	50	135,000	19.29%	108,000
Total used			593,600	84.80%	474,880
Total practical working time and total cost of resources supplied			700,000		560,000
Unused capacity			106,400		85,120
Utilization coefficient			84.80%		84.80%

Source: author's own research on the basis of Kaplan and Anderson (2004: 133–135).

In Table 4, the practical time utilization coefficients were calculated as the ratio of total used time by the activity and total practical time. Total cost assigned to the activity was obtained by multiplying the practical time utilization coefficient and total cost of resources supplied. The total cost assigned to each activity, total cost of resources used, and total cost of resources used utilization coefficient are the same, as shown in Table 3. The example presented in Table 4 confirms Theorem 3 and regularity (15) and can be considered to falsify TDABC.

Leaving other quantities unchanged (including quantity of specific activities and their unit times), we will now increase the amount for the cost of resources supplied by 25%. The cost per minute of supplying capacity is shown in Table 5.

Table 5. Cost of resources supplied per unit of practical time with the cost increased by 25%

Specification	Quantity
Resource of practical working time	700,000
Cost of resources supplied	700,000
Cost per minute of supplying capacity	1

Source: author's own research.

The cost of resources supplied has been increased to USD 700,000, and the cost of resources supplied per unit of practical working time has been increased to 1 USD. In Table 6 we calculate main parameters after the increase of the cost of resources supplied.

Table 6. Main parameters of TDABC after the increase of cost of resources supplied

Activity	Unit time	Cost of resources supplied per minute of labor	Cost driver rates
Process customer order	8	1	8
Handle customer inquiry	44	1	44
Perform credit check	50	1	50

Source: author's own research.

The cost-driver rates have increased to USD 8, 44, and 50, respectively. It is a result which cannot be accepted. The cost driver rates should depend on the unit times of activities and be independent of cost of resources supplied. In other cases, a regularity will appear indicating that the higher cost of resources supplied, the higher cost driver rates. This means that using the TDABC concept leads to the sanctioning of resource waste and the supply of inaccurate information about costs, contrary to claims by Kaplan and Anderson.

Table 7 shows the calculation practical time and cost of resources used for the increased cost of resources supplied.

Table 7. Practical working time and cost of resources used for increased cost of resources supplied

Specification	Quantity	Unit time	Total time used	Cost driver rates	Total cost assigned
Handle customer orders	51,000	8	408,000	8.00	408,000
Handle customer inquiries	1,150	44	50,600	44.00	50,600
Perform credit check	2,700	50	135,000	50.00	135,000
Total			593,600		593,600
Total resources of practical working time and total cost of resources supplied			700,000		700,000
Unused production capacity			106,400		106,400
Utilization coefficient			84.80%		84.80%

Source: author's own research.

The total time used did not change because neither the unit time coefficient nor quantity of operations had changed. The cost of resources supplied utilization coefficient also did not change and is equal to the coefficient of total practical time utilized, according to formula (11). However, there was an increase in the cost of resources used and cost of production capacity unused. Table 7 can be considered as an example confirming the Theorem 2. Results presented in this table are falsifiers of TDABC. For constant unit times and quantity of activities the amount of the cost of used resources is constant regardless of costs of resources supplied, but from the original figures presented by Kaplan and Anderson a contrary conclusion can be drawn that the cost of resources used is determined by cost of resources supplied. Additional one can notice that for the fully utilized practical time the cost of resources used *ceteris paribus* will be equal to higher cost of resources supplied, i.e. USD 700,000. This result confirms Theorem 1 and falsifies TDABC.

Table 8 shows summary of the calculations in Tables 3 and 7.

Table 8. Summing up of the results of change in the size of costs of resources supplied

Specification	Initial cost of resources supplied	Increased cost of resources supplied by 25%
Practical time	700,000	700,000
Practical time used	593,600	593,600
Unused practical time	106,400	106,400
Utilization coefficient	84.80%	84.80%
Unused coefficient	15.20%	15.20%
Cost of resources supplied	560,000	700,000
Cost of resources supplied per unit of practical working time	0.8	1
Cost of used resources	474,880	593,600
Cost of unused resources	85,120	106,400
Utilization coefficient	84.80%	84.80%
Unused coefficient	15.20%	15.20%
Real utilization		474,880
Real lack of utilization		225,120
Utilization coefficient		67.84%
Unused coefficient		32.16%
Handling customer orders cost driver rate	6.40	8.00
Handling customer inquiries cost driver rate	35.20	44.00
Performance of credit check cost driver rate	40.00	50.00
Relation of the costs of used resources according to TDABC		1.25
Rate of increase of cost of used resources according to TDABC		25.00%

Source: author's own research.

If we assume that calculations for the initial cost of resources supplied are accurate, then in the situation where the cost of resources supplied is bigger and a company does not have any knowledge about the case with a lower value of the cost of resources supplied, using TDABC does not provide accurate information about cost driver rates, cost of used resources, cost of unused resources and utilization, and unutilized coefficients of cost of resources supplied.

TDABC overestimates the cost of resources used and the cost driver rate, and it underestimates cost of unused resources. According to TDABC, the cost of resources supplied utilization and unutilized coefficients are unchanged and determined by the coefficient of utilization of practical time. But due to the cost of resources supplied increase, the real utilization coefficient drops from 84.8% to 67.84% and unutilized cost coefficient grows from 15.2% to 32.16%. These indicators cannot be obtained with TDABC.

The cost of resources used increases to the same degree as cost of resources supplied. In the example we presented, the increase of cost of resources supplied by 25% increases the cost of resources used by 25%, in spite of the fixed activity quantities and unit times. Such a relationship implies in (9) that the cost of resources used is a linear function of cost of resources supplied. It is necessary to stress that all of these regularities falsify TDABC.

4. Necessity of TDABC modification

The main goal of the paper has been fulfilled and we could stop at this point. But a step further will be made. We will call the falsified TDABC the traditional one; however, we will create a modified TDABC, called the general TDABC.

In the traditional TDABC there is the fundamental assumption that the complete use of resources supplied occurs with the full use of practical time. The most frequent cases when full use of practical time does not lead to the full use of all resources supplied are excluded[6]. Then, for any degree, the use of practical time is not equal to the cost of the resources supplied utilization coefficient.

The necessary modifications to the traditional TDABC in the face of falsifying theorems involve changing its fundamental assumption. We guess that the use of this immunizing stratagem (or conventional one) to protect TDABC from rejection is allowed (Popper, 1972: 15–16, 30; 1976: 42, 44; 2004: 60–63).

The suggested modification to the traditional TDABC fundamental assumption is as follows: cost of used resources is not higher than cost of resources supplied for the fully utilized practical time:

[6] TDABC's fundamental assumption that costs of resources supplied are fully utilized for practical time implies that in this case all resources are binding constraints; whereas, in the theory of constraints the assertion is formulated that the system can only have one binding constraint (Goldratt, 1990a: 53, 112–114, 183; 1990b: 123; Noreen, Smith, and Mackey, 1995: 32).

$$C_{uf} \leq C_s \tag{16}$$

This leads to the division of the cost of resources supplied into three parts, as compared with the traditional TDABC division into two parts for incomplete utilization of practical time:

$$C_s = C_{uf} + C_{nf} = C_u + C_{nfu} + C_{nf} \tag{17}$$

For each resource supplied coefficient *b* can be distinguished

$$b_j = \frac{C_{uj}}{C_{sj}} \tag{18}$$

This describes the relation between the cost of the individual resource used for fully utilized practical time and the cost of the individual resource supplied, and is called the cost of individual resource utilization ratio

where:

C_{nf} – cost of unused production capacity for full utilization of practical time,

C_{uf} – cost of resources used for full utilization of practical time,

C_u – cost of used resources for a specific coefficient of utilization of practical time,

C_{nfu} – increase of the cost of unused capacity caused by not full utilization of practical time,

b_j – cost of specific resource supplied utilization ratio,

C_{uj} – cost of resource *j* used for fully utilized practical time,

C_{sj} – cost of resource *j* supplied,

j – number of resource,

$j = 1...n$.

Traditional TDABC does not take into account the cost of unused production capacity for full utilization of practical time.

What are the consequences of the modification of the assumption behind the traditional TDABC method of calculating cost of resources per time unit? The change occurs in the numerator of the formula by the replacement of the cost of resources supplied with the cost of resources used for fully utilized practical time:

$$c_s = \frac{C_{uf}}{T} \tag{19}$$

The new method of calculation means that the equality of the utilization coefficients of the practical time and the cost of resources supplied will not occur. Equality will occur between the first coefficient and the utilization coefficient of the cost of resources used calculated on the basis of (19).

Let us compare the results of using traditional TDABC with the results of the new approach. To conduct this operation we will present the example of incomplete utilization of the cost of resources supplied for the full use of practical time. In the first step, in Table 9, we present the results of the division of the costs of resources supplied into particular categories and assumed coefficients of utilization of the cost of resources supplied for full utilization of practical time.

Table 9. Cost of used resources per unit of practical time in general TDABC

Resources	Cost of resources supplied	Coefficient *b*	Cost of resources used for full utilization of practical	Cost of resources per unit time
Remuneration of persons handling orders	150,000	100.00%	150,000	
Material resources	330,000	75.00%	247,500	
Other personal resources	80,000	71.875%	57,500	
Total	560,000	81.25%	455,000	0.65

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

In Table 9 the coefficient of utilization of the salaries of employees handling orders is 100% because with 100% of practical time utilization of those employees the resource for their salaries is 100% used. The analysis of the coefficient of utilization of material resources for full utilization of practical working time proved to be 75%. The coefficient for other personal resources is 71.875%. The overall average coefficient *b* for all resources is 81.25%. The cost of resources used is USD 455,000 and cost per time unit is equal to USD 0.65.

In the second step we will calculate cost of resources used, cost of unused production capacity, and coefficients of utilization of the costs of resources and practical time. The results are presented in Table 10.

Table 10. Equality of coefficients of utilization of costs of resources and practical time in general TDABC

Operation	Quantity	Unit time	Total time used	Cost driver rate	Total cost assigned
Processing customer orders	51,000	8	408,000	5.20	265,200
Handling customer inquiries	1,150	44	50,600	28.60	32,890
Performing credit check	2,700	50	135,000	32.50	87,750
Total			593,600		385,840
Practical time and the cost of resources used for fully utilized practical time			700,000		455,000
Unused production capacity			106,400		69,160
Utilization coefficient			84.80%		84.80%

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

In Table 10 the utilization coefficient of practical time is the same as in Table 3 because the quantities of individual activities and unit times of these activities did not change. The coefficients of utilizations are equal due to the new way of calculating the cost of resources used for full utilization of practical time presented in Table 9.

Kaplan and Anderson claimed that, as a result of the method of calculation of the cost of resources per time unit, TDABC allows "…the ABC cost drivers to provide more accurate signals about the cost and the underlying efficiency of its processes" (2004: 134). In Table 11 we make a comparison of the general TDABC with the traditional version, and test the claim made by the authors of TDABC.

Table 11. Comparison of traditional and general model of TDABC

Activities	Traditional TDABC	General TDABC
Cost of resources supplied	560,000	560,000
Cost of resources used	474,880	385,840
Cost of unused capacity for full utilization of practical time	0	105,000
Cost of unused resources supplied in comparison with full utilization of practical time	85,120	69,160
Total cost of unused production capacity	85,120	174,160
Coefficient of utilization of the cost of resources supplied	84.80%	68.90%
Cost of resources to calculate cost per time unit	560,000	455,000
Practical time	700,000	700,000
Cost of resource per unit of practical time	0.80	0.65
Processing cutomer orders – cost driver rate	6.40	5.20
Handling customer inquiries – cost driver rate	35.20	28.60
Performing credit check – cost driver rate	40.00	32.50
Rates overstating	23.08%	

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

We can see in Table 10 that the traditional model of TDABC omits the fact that the cost of resources supplied may not be fully utilized for full utilization of practical time. Due to this, the coefficient of the utilization of the cost of resources supplied in the TDABC general model is lower than the same coefficient for traditional model (only 68.9% compared to 84.8%). In other words, the traditional TDABC model in most cases overstates the coefficient of utilization of the cost of resources supplied by as many percent as it overstates the cost of resources used for the calculation of the cost of resources per time unit, that is, by 23.08%. Therefore, it understates the cost of unused production capacity.

The traditional model also overstates cost driver rates in comparison with the TDABC general model. Again the quantity of this overstatement is 23.08%, that is as much as the cost per time unit is overstated.

Generally, it can be said that TDABC traditional model leads to overstatement of cost driver rates and cost of resources used and understatement of cost of unused production capacity.

5. Utilization coefficients of specific resources

It has been suggested in Section 4 that modification of TDABC requires using the utilization coefficients of individual resources supplied for full utilization of practical time. The coefficients are not known within the traditional TDABC method; therefore, a new problem appears, which may be formulated by the question: How we can calculate the coefficients *b*? It will be useful to discover the ABC[7] golden rule of resource allocation to solve this problem.

5.1. ABC golden rule of resources allocation

If we divide practical time allocated to activity *i* by the unit time of activity *i* then we will obtain the maximum quantity of activity *i* (maximum production capacity of practical time) which may be presented as:

$$A_i = \frac{T_i}{t_i} \tag{20}$$

Cost of resource *j* used by activity *i* is the product of the cost driver rate of activity *i* using resource *j* and number of activities determined by (20):

[7] The ABC model is considered in the version presented in Kaplan and Cooper (1998) or in Mielcarek (2007).

$$C_{uij} = r_{cij} A_i \tag{21}$$

and hence for each resource

$$A_i = \frac{C_{uij}}{r_{cij}} \tag{22}$$

which can be developed for all resources supplied to the department and consumed by individual activity *i*

$$\frac{C_{ui1}}{r_{ci1}} = \ldots = \frac{C_{uij}}{r_{cij}} = \ldots = \frac{C_{uin}}{r_{cin}} = A_i = \frac{T_i}{t_i} \tag{23}$$

where:

C_{uij} - cost of resource *j* used by activity *i*,

r_{cij} – ABC cost driver rate of activity *i*, using resource *j*.

Formula (23) reveals that the assumption claiming that for complete use of practical time all supplied resources are fully utilized is the result of a deeper relationship. Therefore, this assumption should be replaced by more fundamental assumptions that:

Assumption 1) Relations of specific costs of resources supplied to cost driver rates of activity *i* using resources from *1* to *m* are equal for all resources:

$$\frac{C_{si1}}{r_{ci1}} = \ldots = \frac{C_{sij}}{r_{cij}} = \ldots = \frac{C_{sin}}{r_{cin}} \tag{24}$$

Assumption 2) The relations (24) are defined by the relation of practical time *i* to unit time *i*,

$$\frac{C_{si1}}{r_{ci1}} = \ldots = \frac{C_{sij}}{r_{cij}} = \ldots = \frac{C_{sin}}{r_{cin}} = A_i = \frac{T_i}{t_i} \tag{25}$$

Assumption 1) is a necessary condition for complete utilization of supplied resources for full utilization of practical time, and Assumption 2) is a necessary and sufficient condition of this rule. This way we found the ABC golden rule of resource allocation for any organizational unit, defining the necessary and sufficient condition for full utilization of all resources supplied. We can formulate this as follows:

> For the organizational unit one should deliver as many specific resources so that the relation of cost of resources supplied to activity cost-driver rate will be equal to the relationship of the practical time using these resources to the unit time. Then, for full practical time utilization specific resources will be fully utilized.

The cost of resources supplied should be as follows:

$$C_{sij} = r_{cij} A_i = r_{cij} \frac{T_i}{t_i} \tag{26}$$

The cost of resources supplied as determined by the ABC golden rule of resource allocation is the product of the ABC activity cost driver rate and the ratio of practical time allocated to individual activity and unit time of this activity.

An example is presented that takes into account the ABC golden rule of resource allocation. In the first step, the cost of supplied and fully utilized resources calculated for the full utilization of maximum production capacity of practical time is found in Table 12.

Table 12. Maximum production capacity of practical time

Activity	Total time used	Unit time	Maximum quantity
Handle customer orders	481,132	8	60,142
Handle customer inquiries	59,670	44	1,356
Perform credit check	159,198	50	3,184
Total	700,000		

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

In Table 12, the total practical time was assigned to individual activities and maximum production capacities of practical time were obtained with formula (20).

In the second step the cost of individual resources supplied and used for fully utilized practical time was found, as presented in Tables 13, 14, and 15.

Table 13. Cost of supplied resource 1 (remuneration of persons handling orders); fully utilized for full practical time utilization

Activity	ABC cost-driver rate	Total time used	Unit time	Cost of supplied resource 1
Handle customer orders	1.80	481,132	8	108,255
Handle customer inquiries	7.77	59,670	44	10,542
Perform credit check	9.80	159,198	50	31,203
Total		700,000		150,000

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

Table 14. Cost of supplied resource 2 (material resources); fully utilized for full practical time utilization

Activity	ABC cost driver rate	Total time used	Unit time	Cost of supplied resource 2
Handle customer orders	3.20	481,132	8	192,453
Handle customer inquiries	11.01	59,670	44	14,929
Perform credit check	12.60	159,198	50	40,118
Total		700,000		247,500

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

Table 15. Cost of supplied resource 3 (other personal resources); fully utilized for full practical time utilization

Activity	ABC cost driver rate	Total time used	Unit time	Cost of supplied resource 3
Handle customer orders	0.70	481,132	8	42,099
Handle customer inquiries	2.45	59,670	44	3,323
Perform credit check	3.79	159,198	50	12,078
Total		700,000		57,500

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13)

For the known company activity cost driver rates in Tables 13, 14, and 15, the cost of fully utilized supplied resources for practical time full utilization was derived with (26). The cost of individual resources supplied is USD 150,000, 247,500 and 57,500, respectively. Exactly the same results are assumed in Table 9.

The ABC golden rule of resource allocation will enable the cost of resources supplied per unit time to be calculated using cost driver rates and the unit time of activity *i*:

$$c_{si} = \frac{C_{si}}{T_i} = \frac{C_{si1} + \ldots + C_{sij} + \ldots + C_{sin}}{T_i} = \frac{r_{ci1}A_i + \ldots + r_{cij}A_i + \ldots + r_{cin}A_i}{T_i} =$$

$$= \frac{(r_{ci1} + \ldots + r_{cij} + \ldots + r_{cin})A_i}{T_i} = \frac{r_{ci1} + \ldots + r_{cij} + \ldots + r_{cin}}{\frac{T_i}{A_i}} = \frac{r_{ci1} + \ldots + r_{cij} + \ldots + r_{cin}}{t_i}$$

$$c_{si} = \frac{r_{ci1} + \ldots + r_{cij} + \ldots + r_{cin}}{t_i} \quad (27)$$

The cost of supplied resources per unit of practical time is the ratio of the sum of ABC cost driver rates to the time unit of specific activity consuming these resources. Contrary to TDABC, it is necessary to calculate as much the cost of resources supplied per unit time ratios as number of individual activities. Therefore we have formulated following theorem:

Theorem 4.

If Assumption 2) is fulfilled and we calculate cost of resources supplied per unit time with (27) and practical time is fully utilized, then the cost of resources supplied is fully utilized for each resource.

Formulas (25) and (27) present the way to overcome the weaknesses of TDABC analyzed in this paper. When we know (27), we can calculate the cost of resources supplied and also used by individual activity:

$$C_{si} = c_{si} T_i = \frac{r_{ci1} + r_{ci2} + ... + r_{cin}}{t_i} T_i \qquad (28)$$

Table 16 presents the cost of individual activities and total cost of resources used.

Table 16. Cost of activities and total cost of resources used

Activity	Cost of supplied resources per unit of practical time	Practical time used	Cost of activity
Handle customer orders	0.71250	481,132	342,807
Handle customer inquiries	0.48256	59,670	28,794
Perform credit check	0.52387	159,198	83,399
Total		700,000	455,000

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

In Table 16, new information was obtained. In accordance with (27) and (28), the cost of individual activities was determined. The total amount of the cost of individual activities is equal to the sum presented in Table 9.

The cost of resources used with the fully utilized practical time, the cost of individual activities, and the total activity costs were calculated, due to the discovery of ABC golden rule of resource allocation. It is impossible to obtain the correct figures with TDABC.

5.2. Specific resource utilization

A case will now be investigated where the ABC golden rule of resource allocation is not fulfilled:

$$\frac{C_{si1}}{r_{ci1}} \neq ... \neq \frac{C_{sij}}{r_{cij}} \neq ... \neq \frac{C_{sin}}{r_{cin}} \neq A_i = \frac{T_i}{t_i} \qquad (29)$$

The consequences of breaking the golden rule for specific resources utilization coefficients are as follows:

$$b_j = \frac{C_{uj}}{C_{sj}} < 1 \qquad (30)$$

Cost of resources used by specific activity is equal to

$$C_{uj} = C_{u1j} + ... + C_{uij} + ... + C_{umj} \qquad (31)$$

and cost of specific resource used by specific activity is determined by the number of specific activities and the cost driver rate of activity using specific resource

$$C_{uij} = A_i r_{cij} \qquad (32)$$

We substitute (32) into (31)

$$C_{uj} = A_1 r_{c1j} + ... + A_i r_{cij} + ... + A_m r_{cmj} \qquad (33)$$

and then (33) into (30)

$$b_j = \frac{A_1 r_{c1j} + A_2 r_{c2j} + ... + A_i r_{cmj}}{C_{sj}} = \frac{T_1 r_{c1j}}{t_1 C_{sj}} + \frac{T_2 r_{c2j}}{t_2 C_{sj}} + ... + \frac{T_m r_{cmj}}{t_m C_{sj}} =$$

$$= \frac{r_{c1j}}{t_1 \frac{C_{sj}}{T_1}} + \frac{r_{c2j}}{t_2 \frac{C_{sj}}{T_2}} + ... + \frac{r_{cmj}}{t_3 \frac{C_{sj}}{T_m}} \qquad (34)$$

The traditional TDABC cost driver rate for specific activity using specific resources can be expressed as follows

$$r_{ij} = t_i \frac{C_{sj}}{T_i} = t_i c_{ij} \qquad (35)$$

Hence, after substituting (35) into (34) finally we get

$$b_j = \frac{r_{c1j}}{r_{1j}} + ... + \frac{r_{cij}}{r_{ij}} + ... + \frac{r_{cmj}}{r_{mj}} \qquad (36)$$

Factor b_j is the relation between cost of specific resource *j* used for fully utilized practical time and cost of specific resource supplied. The first cost is unknown within TDABC. In accordance with (36), it is sum of the ratios of the ABC activity cost driver rate and traditional TDABC cost driver rate.

The utilization coefficient of cost of resources supplied for fully utilized practical time is calculated in two steps. An illustration of the first step is found in Table 17.

Table 17. Individual cost driver rates for material resources

Activity	Practical time used	Cost of material resources supplied	Cost of resource supplied per individual time unit	Unit time	Individual cost driver rate
Handle customer orders	481,132		0.69	8	5.49
Handle customer inquiries	59,670		5.53	44	243.34
Perform credit check	159,198		2.07	50	103.64
Total	700,000	330,000			

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

In Table 17 cost of resources supplied per individual time unit was determined with dividing the cost of material resources supplied by practical time used for each activity. Individual cost driver rate is the product of the cost of resources supplied per individual time unit and unit time.

The second step of utilization coefficient of cost of resources supplied for fully utilized practical time calculation is shown in Table 18.

Table 18. Utilization coefficient of cost of material resources supplied for fully utilized practical time

Activity	Individual cost driver rate	ABC cost driver rate	ABC cost driver rate to individual cost driver rate
Handle customer orders	5.49	3.20	58.32%
Handle customer inquiries	243.34	11.01	4.52%
Perform credit check	103.64	12.60	12.16%
Coefficient *b*			75.00%

Source: author's own research on the basis of Kaplan and Anderson (2004: 135; 2007: 10–13).

In Ttable 18 the ABC cost driver rates are derived from Table 14. The utilization coefficient *b* was determined with (36). This coefficient is found to be 75% and is equal to that one assumed in Table 9. It is completely impossible to determined it within TDABC since for full utilization of practical time each resource is, according to this costing model, also fully utilized despite the fact that in the most cases the ABC golden rule of resources allocation is not fulfilled in companies.

6. Concluding remarks

In Section 2 we conducted the falsification of TDABC; more precisely, analyzing the mathematical properties of traditional TDABC allowed us to discover its several falsifiers. We proved that its application does not allow for accurate determination of the cost of resources supplied and cost of unused production capacity. Moreover, we demonstrated in

Section 3 that its use leads to an overstatement of activity cost driver rates and cost of resources used and an understatement of the costs of unused production capacity.

There are two possibilities of saving TDABC from rejection. First of all, using the ABC golden rule of resource allocation could enable TDABC's fundamental assumption to be fulfilled and implemented in conditions which relate to the objective range of this costing model. In other words, the first way of saving the concept is to lower particular costs of resources supplied to the levels defined by the ABC golden rule of resources allocation.

Secondly, it is possible to modify the way the cost of resources per unit of time are estimated by taking into account the fact that for fully used practical time specific resources are not fully utilized. For each resource one should calculate the utilization coefficient for the extreme case and in the numerator of the formula for the cost of resource supplied per time unit put cost of resources used for complete utilization of practical time. Both methods should give the same results.

In most cases, full implementation of the golden rule will not be achievable, but even its partial application leads to higher utilization coefficients of the specific costs of resources supplied. Process improvements and cost savings are achieved as a result of capacity management.

Using both ways of saving traditional TDABC means that it is essential to perform disaggregation of this model. It requires first of all defining the cost driver rates for activities using specific resources. This separate problem should be correctly solved. Consequently, a database will be created, necessary for using the two-stage or one-stage ABC model. Precise presentation of this issue would require the writing of a new article.

Both ways have destructive consequences for traditional TDABC. On the one hand, implementing it has been rejected on the basis of the falsification; on the other hand, the attempt to adjust TDABC to real conditions in the company, either by applying ABC golden rule of resource allocation or by determining the utilization coefficient of specific resources for complete utilization of practical time, leads to obtaining a set of information that makes the use of the aggregated, traditional TDABC redundant. The conditions are fulfilled using the two-stage ABC rate-based model presented by Kaplan and Cooper (1998) or the general one-stage ABC model created by Mielcarek (2005, 2007) instead.

References

Cardinaels, E., and Labro, E. (2008) "On the Determinants of Measurement Error in Time-Driven Costing." *Accounting Review*, 83 (3).
Cooper, R., and Kaplan, R. S. (1991) "Profit Priorities from Activity-Based Costing." *Harvard Business Review*, May–Jun.
Cooper, R., and Kaplan, R. S. (1992) "Activity-Based Systems: Measuring the Costs of Resource Usage." *Accounting Horizons*, September.
Gervais, M., Levant, Y., and Ducrocq, C. (2010) "Time-Driven Activity-Based Costing (TDABC): An Initial Appraisal through a Longitudinal Case Study." *Journal of Applied Management Accounting Research*, 8 (2).
Giannetti R., Venneri, C., and Vitali, P. (2011) "Time-Driven Activity-Based Costing and Capacity Cost Management: The Case of a Service Firm." *Cost Management*, 25 (4).
Goldratt, E.M. (1990a) *The Haystack Syndrome: Sifting Information Out of The Data Ocean*. North River Press, Great Barrington.
Goldratt, E. M. (1990b) *What is this Thing Called Theory Of Constraints and how Should it be Implemented?* The North River Press, Great Barrington.
Hoozée, S., Vermeire, L., and Bruggeman, W. (2012) "The Impact of Refinement on the Accuracy of Time-driven ABC." *ABACUS*, 48 (4).
Hoozée, S., and Bruggeman, W. (2007) "Towards Explaining Cost Estimation Errors in Time Equation-Based Costing." *Working Paper*. Universiteit Gent, 07/486.
Kaplan, R.S., and Cooper, R. (1998) *Cost and Effect: Using Integrated Cost Systems to Drive Profitability and Performance.* Harvard Business School Press, Boston.
Kaplan, R. S., and Anderson, S. R. (2004), "Time-Driven Activity-Based Costing." *Harvard Business Review*, 11 (November).
Kaplan, R. S., and Anderson, S. R. (2007) *Time-Driven Activity-Based Costing: A Simpler and More Powerful Path to Higher Profits.* Harvard Business School Press, Boston.
Kaplan, R. (2006) "The Competitive Advantage of Management Accounting." *Journal of Management Accounting Research*, 18.
Merwe, A. Van der (2009) "Debating the Principles: ABC and its Dominant Principle of Work." *Cost Management*, 23 (5).
Mielcarek, J. (2005) *Teoretyczne podstawy rachunku kosztów i zasobów – koncepcji ABC i ABM* [*Theoretical Foundations of Cost and Resources Accounting – ABC and ABM Concept*]. Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań.
Mielcarek, J. (2007) *Ogólny model jednoetapowy a Time-Driven ABC* [*One Stage General Model and Time-Driven ABC*]. Wydawnictwo Target, Poznań.
Namazi, M. (2009), "Performance-Focused ABC: A Third Generation of Activity-Based Costing System", *Cost Management*, 23 (5).
Noreen, E., Smith, D., and Mackey, J. T. (1995) *The Theory of Constraints and its Implications for Management Accounting.* The North River Press, Great Barrington.
Popper, K. R. (1972) *Objective Knowledge: An Evolutionary Approach.* Oxford University Press, London.
Popper, K. R. (1976) *The Unended Quest: An Intellectual Biography*. Fontana, London.
Popper, K. R. (2004) *The Logic of Scientific Discovery*. Routledge, London.
Ratnatunga, J., and Waldmann, E. (2010) "Transparent Costing: Has the Emperor Got Clothes?" *Accounting Forum*, 34 (3/4).