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Capacity utilization analysis through time-driven ABC in a small-sized manufacturing company

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Abstract

Purpose – The purpose of this paper is to provide a case study about the capacity utilization analysis in a small-sized manufacturing company through the application of time-driven activity-based costing (TDABC). After a brief overview of development of the TDABC system, a detailed application of TDABC and capacity utilization analysis in a bakery is given.

Design/methodology/approach – This paper is based on a case study about the application of TDABC in a small-sized Greek manufacturing firm. In the case study, time equations were developed for the supporting, operating and manufacturing departments and product costs determined based on the model. Capacity utilization analysis made through the application of TDABC system.

Findings – The study shows that TDABC is more applicable in small-sized manufacturing companies because of their labor-intensive nature. In contrast to previous studies, authors argue that even in small firms simple excel sheets are not enough to capture the complexity of the time equations and business intelligence software and programming coding is required.

Research limitations/implications – Although the fundamental structure of TDABC is the same for all companies there is no strict form of application.

Practical implications – The practical implication of this paper is that each firm has unique characteristics that need to be reflected in the application of the TDABC model.

Originality/value – This paper contributes by providing insights into cost accounting in SMEs. More specifically, this paper contributes to the TDABC literature regarding the application of the system in small and medium sized manufacturing firms.

Keywords Time-driven activity based costing, Small-sized enterprises, Capacity utilization analysis, Time equations

Paper type Case study

1. Introduction

Managers of profit-seeking firms are tending toward cost reduction rather than cost control because of global competition, decentralization and decreased labor intensity. Cost reductions require maximum capacity utilization, so management of capacity and elimination of non-value-added activities are the most essential points. Traditional costing systems are not enough to meet the need for conducting capacity utilization analyses because they allocate overhead costs to products based on a volume-based cost driver, which leads to misinterpretation of results about product profitability.

The activity-based costing (ABC) system was developed in the 1980s to solve the problem of inaccurate allocation of overhead costs. ABC assigns overhead costs first to activities then to products or services (Bruggeman *et al.*, 2005). Although the model has enabled managers to get better profitability information, firms faced many problems, such

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as time-consuming surveying and the system's data processing costs, inflexibility when modification is needed and behavioral resistance to the system by managers and employees while implementing the ABC model in their companies. Stout and Propri (2011) state that these problems are particularly acute for small to medium-sized companies that are not likely to have sophisticated information processing systems.

The time-driven activity based costing (TDABC) model was developed as an alternative to the ABC model. This new system drives general ledger costs directly to departments unlike conventional ABC, in which general ledger costs are driven to hundreds of activities. TDABC has simplified the costing process by eliminating time-consuming interviews and surveys with employees. Small firms can benefit from TDABC more because of the use of its simplified parameters (Somapa *et al.*, 2012). Compared to ABC, TDABC provides management with a number of pragmatic solutions that can be used in small and medium-sized enterprises (Fladkjær and Jensen, 2011). The model allocates overhead and indirect costs to products or services according to the actual work demanded from the departments by these products or services. Allocation of costs under TDABC is mostly based on the firm's organizational structure – which department serves which. The design of the TDABC system changes from company to company to reflect the specific resource expense flows.

This paper discusses how TDABC can be applied in a small-sized manufacturing company with a different structure to large manufacturing firms. Musov (2017) claims that TDABC is an appropriate costing approach for SMEs because they are more labor intensive, and the system eliminates time-consuming interviews and surveys. There are few studies in the literature on the implementation of TDABC in small and medium-sized manufacturing firms (Öker and Adıgüzel, 2010; Stout and Propri, 2011; Barros and Ferreira, 2017; Wouters and Stecher, 2017; Lueg and Morratz, 2017; Ganorkar *et al.*, 2018, 2019). Application of TDABC in such firms has some differences than that in larger firms. The most distinct difference concerns the calculation of capacity cost rates (CCR). Under TDABC, groups of resources are generally determined on a departmental basis, with CCR calculated for each department. In small businesses, however, departments are generally nested, so calculation of departmental CCR is not meaningful. On the other hand, the implementation of TDABC with the support of existing ERP systems in large firms allows easy updating as well as greater accuracy (Varila *et al.*, 2007; Ruiz de Arbulo *et al.*, 2012; Siguenza Guzman *et al.*, 2013). In the case of SMEs with weaker ERP systems, TDABC can be built and maintained using relatively simple excel sheets (Somapa *et al.*, 2012).

Application of TDABC differs across industries, most significantly between manufacturing and service companies. Because previous studies show that it is easier to apply TDABC in service companies because of their labor-intensive nature (Öker and Adıgüzel, 2010), the literature includes reports of many TDABC applications in service companies like hospitals (Demeere *et al.*, 2009; Campanale *et al.*, 2014; Kaplan *et al.*, 2014, 2015; McLaughlin *et al.*, 2014; Donovan *et al.*, 2014; Akhavan *et al.*, 2016; Laviana *et al.*, 2016), hotels and restaurants (Dalci *et al.*, 2010; Everaert *et al.*, 2012; Riediansyaf, 2014) and libraries (Pernot *et al.*, 2007; Kont and Jantson, 2011; Siguenza Guzman *et al.*, 2014).

The remainder of the paper is organized as follows. The next section discusses the case company's background. Section 3 describes the application of TDABC in this small-sized manufacturing company, gives time equations, CCR calculations and allocation of cost from supporting to operating and manufacturing departments and then to product batches. Section 4 describes the TDABC capacity utilization analysis. The last section gives concluding remarks.

2. Company background

This study analyzes the activities taking place in a small-size manufacturing company producing bakery products in Greece[1]. The main objective of the company is to create

unique products with high nutrition value for the consumers. The company produces and distributes in its own retail shops products with short life cycles that are produced daily, such as bread, cookies, sweets, ice cream and others. The company also sells packaged products through its wholesale partnerships in order to be distribute them to retail shops in Greece or other countries.

There are five production departments that cover over 4.500 square meters, with each specialized to produce a different category of products. The company's daily production capacity can exceed 10 tones of finished products.

Until 2010, the company used a traditional costing system that gave inaccurate interpretations of the data and profitability calculations. Therefore, since 2011, the company has gradually migrated to the TDABC methodology, which provides correct calculations of the profitability per product, per product category, per client and per branch. This has enabled the company to continue expanding despite a difficult economic environment in Greece.

3. Application of TDABC

3.1 Application in small-sized companies

When implementing TDABC, the first step is identifying groups of resources that perform activities. CCR are then calculated by dividing the total cost of groups of resources by the practical time capacity of the group. Generally, groups of resources that are used to perform activities are classified in terms of departments. However, in most small businesses, departments cannot be classified accurately because generally one employee performs more than one function in the same area. This means that the calculation of CCR on a departmental (functional) basis does not produce meaningful results. For example, in the case company, one employee performs both the accounting and purchasing functions, so it is impossible to calculate different CCR for the two functions. We therefore calculated a single CCR for any employee who performs more than one function together. CCR is calculated as the total cost of resources divided by the practical time capacity of the employee. The total cost of resources includes the employee's salary and other support costs, like depreciation expenses or rent for the space used, depreciation of computers, machines or furniture used, electricity consumed in the area or by the computers, telecommunication expenses, etc. In this way, we can calculate the CCR for one employee rather than for a specific department, as we would do for larger firms.

To identify how much of the cost of supplying capacity is spent directly or allocated to other departments, we classified activities performed as corporate level, and supporting, operating and manufacturing activities.

The costs of corporate-level activities are directly expensed in the P/L schedule and not included in the cost of production because these activities are independent from the volume and mix of business done. Activities are classified as supporting level if they are not directly influenced by the firm's production volume. Because supporting activities just serve other departments, their costs are allocated to the specific departments that demand this work based upon the actual work done by these departments.

Some activities are classified as operating if they directly serve the production departments or there is a connection between batches of products and these activities. The cost of the operating department's activities can be allocated either to production departments or batches of products directly depending on the nature of the activity. For example, product delivery to the branches is an operating activity, so its cost can be allocated to the products delivered.

Classification of activities of departments and how the costs of these activities flow are shown in Table I and Figure 1.

Department	Activities	Classification of activity	Allocation of cost
Accounting & Purchasing			
Act. 1	Checking outstanding balance for a client and receiving a payment	Operating	Batches of products
Act. 2	Checking outstanding balance for a supplier and making payment	Supporting	Departments served[a]
Act. 3	Monthly invoice archiving in folders	Corporate sustaining	Expensed
Act. 4	Recording invoices (from supplier) on ERP	Supporting	Departments served
Act. 5	Preparing monthly financial report	Corporate sustaining	Expensed
Act. 6	Preparing monthly payroll and making payments to employees	Supporting	Departments served
Act. 7	Preparing order list based on the demands from the departments	Supporting	Departments served
Act. 8	Preparing the monthly cash flow statement	Corporate sustaining	Expensed
Sales & Logistics Department			
Act. 1	Issuing invoices – sending documents to clients and retail shops	Operating	Batches of products
Act. 2	Receiving orders from customers	Operating	Batches of products
Act. 3	Notifying production departments about orders from retail shops	Operating	Production departments
Act. 4	Driving the car to retail shops and distributing (plastic boxes of) products	Operating	Batches of products
Maintenance Department			
Act. 1	Performing machine maintenance and services	Operating	Production departments (machine)
Act. 2	Performing maintenance for production departments	Operating	Production departments
Act. 3	Performing maintenance for other departments	Supporting	Departments served
Quality Control & HR Department			
Act. 1	Performing product quality control in departments	Operating	Production departments
Act. 2	Hiring new personnel	Supporting	Departments served
Act. 3	Giving seminars	Supporting	Departments served
Act. 4	Conducting R&D	Corporate sustaining	Expensed
Warehouses			
Act. 1	Receiving activity	Operating	Production departments
Act. 2	Put-away activity	Operating	Production departments
Act. 3	Picking activity	Operating	Batches of products
Act. 4	Shipment preparation	Operating	Batches of products
Washing Department			
Act. 1	Washing plastic boxes for bread, pastries, sweets and ice cream departments	Operating	Batches of products

Note: [a]See Table V for details about which departments benefit from these activities

Table I.
Classification of activities and resource expenses flow

3.2 Allocation of the cost of the supporting and operating departments

In the next step of applying the TDABC model, time equations were developed. The model assigns overhead costs to products or other departments through time equations. Rather than defining a separate activity for every possible combination of processes as in the ABC system, TDABC estimates time equations. These show the time consumed by an activity as

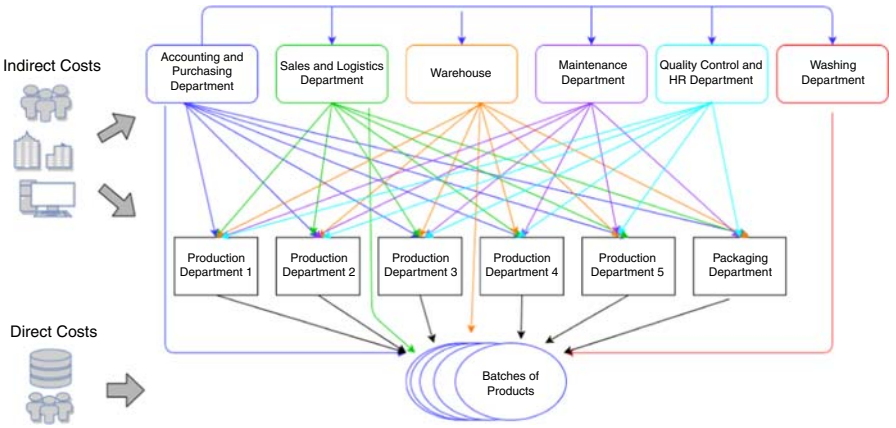

Figure 1.
Resource expenses flow in the case company

a function of different characteristics, called time drivers (Bruggeman *et al.*, 2005). TDABC captures the variability of activities by including the possible subtasks of these activities in the time equation (Siguenza Guzman *et al.*, 2013).

The time equations of each department are set to include multiple drivers for a single activity. Different sub-tasks of an activity have a different cost driver to reflect the complexity of each activity. Table II illustrates the activities, subtasks, time drivers and time consumed by each driver for the Accounting & Purchasing Department.

Through the activity analysis, time equations were made for the Accounting & Purchasing Department. For example, for the activity checking outstanding balance for a client and receive payment, the sub-tasks and their time drivers were determined and the following equation created:

5 min [number of agreements if no error found]

+20 min [number of agreements if error found]

+3 min [number of bank transfers received from clients]

+6 min [number of check payments received by clients]

+3 min [number of payments].

This activity is an operating activity and its cost is allocated to the batches of products that demand work from the department. Checking each agreement with the client "if no error found" uses 5 min of the department's resources. If an error is found in the agreement, then an additional 15 min consumed. Collections from the customer consume 3 min while the bank transfer and check payments consume 6 min. Scanning, saving, printing the document and then recording on the ERP consume 3 min for each payment.

The total time demanded by each client was then multiplied by the CCR of the department.

Table III illustrates the activities, subtasks, time drivers and time consumed by each driver for the Sales & Logistics Department.

For example, for the activity drive the car to retail shops and distribute the products in plastic boxes, the sub-tasks and their time drivers were determined, and the following equations established.

The departmental cost rate is valid only when the mix of resources supplied is the same for each activity and transaction performed within the department. However, it is not valid if

Subtask	Time driver	Time consumed	Time equation
Activity 1: checking outstanding balance for a client and receiving payment			
Compare outstanding balances	Number of existing agreements	5 min per agreement if no error found 20 min per agreement if errors found	5 min [number of agreement if no error found] + 20 min [number of agreement if error found] + 3 min [number of bank transfers received from clients] + 6 min [number of check payments received from clients] + 3 min [number of payment]
Payment received	Number of payments through Bank transfer Check	3 min per payment 6 min per payment	
Scan/save and print document	Number of payment	1 min per payment	
Record payment on ERP		2 min per payment	
Activity 2: checking outstanding balance for a supplier and making payment			
Compare outstanding balances	Number of agreements with suppliers	5 min per agreement if no error found 20 min per agreement if errors found	5 min [number of agreements if no error found] + 20 min [number of agreements if error found] + 5 min [number of new supplier] + 3 min [number of bank transfers to suppliers] + 6 min [number of payment by check to suppliers] + 3 min [number of payment]
Verify bank account if new	Number of new supplier	5 min per new supplier	
Make payment	Number of payments through Bank transfer Check	3 min per payment 6 min per payment	
Scan/save and print document	Number of Payment	1 min per payment	
Record payment on ERP		2 min per payment	
Activity 3: recording invoices (from supplier) on ERP			
Record invoice on ERP	Number of lines	0.25 min per line	0.25 min [number of lines] + 5 min [number of new suppliers] + 2 min [number of new raw materials]
Create new record if new supplier	Number of new suppliers	5 min per new suppliers	
Create new record if buying new raw materials, packaging materials, etc.	Number of new raw materials bought	2 min per new raw materials	

(*continued*)

Table II.
Time equations for accounting & purchasing department

Table II.

Subtask	Time driver	Time consumed	Time equation
Activity 4: preparing monthly payroll and making payments to employees			
Prepare monthly payroll	Number of employees	10 min per employee	10 min [number of employees] + 0.20 min [number of lump-sum payments by e-banking] + 3 min [number of payment made through e-banking to a single employee] + 5 min [number of payments by cash] + 1.20 min [number of lump-sum payments] + 3 min [number of payments to a single employee]
Make payments	Number of payments	0.20 min per lump sum payments by e-banking (one payment for 80 employees) 3 min per payment if made to a single employee by e-banking 5 min per payment if paid by cash	
Saving payments in file and print document	Number of payments	1 min per payment	
Record payment transactions on ERP	Number of payments	0.20 min per lump-sum payment 2 min per payments to a single employee	
Activity 5: preparing order list based on the demands from the departments			
Open order list from ERP	Number of order lines	0.16 min per order line	0.16 min [number of order line] + 0.5 min [number of e-mails] + 7 min [number of phone calls] + 10 min [number of confirmation requests] + 10 min [number of price comparisons]
Send e-mail to supplier	Number of e-mails	0.5 min per e-mail	
Make phone call to supplier about the order	Number of phone calls	7 min per call	
Check if supplier requests confirmation on order	Number of confirmation requests	10 min per request	
Check if price comparison is needed between suppliers	Number of price comparisons	10 min per comparison	

Subtask	Time driver	Time consumed	Time equation
Activity 1: issuing invoices – transporting documents to clients and retail shops			
Create new record (invoice/transportation document)	Number of new records	0.08 min per record	0.08 min [number of new records] + 0.08 min [number of lines if invoice/delivery note issued by ERP] + 0.33 min [number of lines if invoice/delivery note was handwritten]
Issue invoice/delivery note through ERP to clients or retail shop of company	Number of lines	0.08 min per line	
Issue invoice/delivery note (handwritten if ERP has connectivity issues with database). After issuing the document, record on the client's record on ERP	Number of lines	(15 s per line to write it and 5 s per line to record on ERP)	
Activity 2: receiving orders from customers			
Receive an order file to the ERP	Number of orders from Regular customers Non-regular customers	0.66 min per order 2 min per order	0.66 min [number of orders if regular customer] + 2 min [number of orders if non-regular customers] + 0.58 min [number of line if order by fax] + 0.50 min [number of line if order by phone] + 5 min [numbers of orders if requires confirmation]
Enter order lines	Number of orders through: Fax Phone	0.58 min per line 0.50 min per line	
Confirm order	Number of orders requires confirmation	5 min per order	
Activity 3: notifying production departments about orders from retail shops			
Print order from retail shop	Number of orders	2 min per order	7 min [number of orders]
Deliver printed document to each production department	Number of orders	5 min per order	
Activity 4: driving car to the retail shops and distributing the (plastic boxes) products			
Drive to retail shops	Routes Branch 1 Branch 2 Branch 3 Branch 4 Branch 5	47.5 min per m^3 of car 1[a] 57.5 min per m^3 of car 1 55 min per m^3 of car 2 65 min per m^3 of car 2 120 min per m^3 of car 2	Time equation 1 (CCR of employee resources): 2.5 min [numbers of 2 pieces of box type 1] + 2 min [numbers of 4 pieces of box type 2] + 2 min [numbers of box type 3] + 4 min [numbers of 4 pieces of box type 1] + 3 min [numbers of 6 pieces of box type 2] + 1.4 min [numbers of 2 pieces of box type 3]

(*continued*)

Table III.
Time equations for Sales & Logistic Department

Table III.

Subtask	Time driver	Time consumed	Time equation
			Time equation 2 (CCR of vehicle resources): 95 min per m^3 [if products delivered to Branch 1] + 115 min per m^3 [if products delivered to Branch 2] + 110 min per m^3 [if products delivered to Branch 3] + 130 min per m^3 [if products delivered to Branch 4] + 240 min per m^3 [if products delivered to Branch 5]
Drop off the plastic boxes at retail shops	Number of boxes	2.5 min per 2 pieces[b] of box type 1	
	Box type 1	2 min per 4 pieces of box type 2	
	Box type 2	2 min per piece of box type 3	
	Box type 3		
Load empty plastic boxes into car	Number of boxes	2 min per 4 pieces[c] of box type 1	
	Box type 1	1.5 min per 6 pieces of box type 2	
	Box type 2	0.7 min per 2 pieces of box type 3	
	Box type 3		
Drive car back to factory	Routes	47.5 min per m^3 of car 1	
	Branch 1	57.5 min per m^3 of car 1	
	Branch 2	55 min per m^3 of car 2	
	Branch 3	65 min per m^3 of car 2	
	Branch 4	120 min per m^3 of car 2	
	Branch 5		
Drop off empty plastic boxes at washing department	Number of boxes	2 min per 4 pieces of box type 1	
	Box type 1	1.5 min per 6 pieces of box type 2	
	Box type 2	0.7 min per 2 pieces of box type 3	
	Box type 3		

Notes: [a]Branches 1 and 2 are located in city 1 while Branches 3, 4 and 5 are located in city 2. The drivers have to follow standard routes every day. Each driver goes to the branches in one of the two cities. Driving activity time is not enough alone to measure resource capacity. The capacity is measured in minutes consumed per cubic meter. The capacity cost rate of the vehicles is calculated by the following formula: [Total resource cost/(total time capacity × total cubic meters)]; [b]the types of plastic boxes have different sizes. Employees can carry two pieces of Box Type 1 or four pieces of Box Type 2 simultaneously when they are full. Plastic Box Type 3 is very big so it is not possible for someone to pick up two pieces of this type simultaneously; [c]when the boxes empty, employee can carry four pieces of Box Type 1, six pieces of Box Type 2 or two pieces of Box Type 3 together when loading empty plastic boxes

the activities within the department use different resources. In the case of the Sales & Logistics Department, separate CCR were calculated for employee resources and vehicle resources, so two different time equations were established for this activity because separate CCR were calculated for the different capacity resources.

Time equation 1[2] (CCR of employee resources):

2.5 min [numbers of 2 pieces of box type 1]
+2 min [numbers of 4 pieces of box type 2]
+2 min [numbers of box type 3]
+4 min [numbers of 4 pieces of box type 1]
+3 min [numbers of 6 pieces of box type 2]
+1.4 min [numbers of 2 pieces of box type 3].

Time equation 2 (CCR of vehicle resources):

95 min per m^3[if products delivered to Branch 1]
+115 min per m^3[if products delivered to Branch 2]
+110 min per m^3[if products delivered to Branch 3]
+130 min per m^3[if products delivered to Branch 4]
+240 min per m^3[if products delivered to Branch 5].

Table IV illustrates the activities, subtasks, time drivers and time consumed by each driver for the Warehouse Department.

For example, for the "put-away" activity the sub-tasks and their time drivers were determined to create the following equation. Two different time equations[3] were developed for this activity because two different CCR were calculated for different capacity resources.

Time equation 1 (CCR for employee resources):

2 min per pallet [if Warehouse 1]+4 min per pallet [if Warehouse 2]
+8 min per pallet [if Warehouse 3]+10 min per pallet [if Warehouse 4]
+0.10 [number of boxes if weight per box is up to 15 kg]
+0.25 [number of boxes if weight per box is more than 15 kg and up to 25 kg]
+2 min [number of boxes if full pallet].

Time equation 2 (CCR for storage)[4]:

([Date that a good was taken out from warehouse]–[Date that a good was stored]) × 1440.

The subtask for transferring the accepted goods from the collection area to Warehouses 1, 2, 3 and 4 consumes 2, 4, 8 and 10 min, respectively. Storing goods on the warehouse shelves subtask consumes 0.10 min for the plastic boxes up to 15 kg, and additional 0.15 min required for boxes between 15 and 25 kg. However, for the full pallets stored in the warehouses, 2 min of the resources are consumed. The total time consumed, which is obtained from the first equation, was multiplied by the CCR calculated for employee resources. From the second equation, we obtained the total time inventory stay in the

Table IV.
Time equations for Warehouse Department

Subtask	Time driver	Time consumed	Time equation
Activity 1: receiving activity			
Accept goods	Number of purchase orders	1 min per order	1.08 min [number of purchase orders] + 2 min [number of pallets] + 0.33 min [number of single boxes] + 0.33 min [number of damage reports]
Finding the order from ERP		0.08 min per order (0.08 min)	
Compare the initial quantities with the actual one received			
Check (count) the quantities, and basic quality demands (expiration date, temperature) and check for damage	Number of Pallets Boxes	2 min per pallet 0.33 min per box	
Prepare damage report for the damaged goods (raw materials, packaging materials, etc.) and notify the supplier	Number of damaged reports	15 sec per damage report	
Notify the supplier about the damaged goods		5 sec per damage report	
Activity 2: put-away activity			
Transfer (drive the trolley of one pallet of similar or mixed goods) accepted goods from collection area to warehouse departments	Number of pallets transferred to Warehouse 1 Warehouse 2 Warehouse 3 Warehouse 4	2 min per pallet [if Warehouse 1] 4 min per pallet [if Warehouse 2] 8 min per pallet [if Warehouse 3] 10 min per pallet [if Warehouse 4]	Time equation 1 (CCR for employee resources): 2 min [numbers of pallets if Warehouse 1] + 4 min [numbers of pallets if Warehouse 2] + 8 min [numbers of pallets if Warehouse 3] + 10 min [numbers of pallets if Warehouse 4] + 0.10[number of boxes if weight per box is up to 15 kg] + 0.25 [number of boxes if weight per box is more than 15 kg and up to 25 kg] + 2 min [number of boxes if full pallet] Time equation 2 (CCR for storage): ([Date that a good was taken out from warehouse] – [Date that a good was stored]) × 1440
Store goods (raw materials, packaging materials, etc.) in the warehouse shelves	Number of boxes	0.10 min per box [if weight per box is up to 15 kg] 0.25 min per box [if weight per box is more than 15 kg and up to 25 kg] 2 min per box [if full pallet]	
Storage	Number of units	([Date that an item was taken out from warehouse] – [Date that an item was stored]) × 1440	

(*continued*)

Table IV.

Subtask	Time driver	Time consumed	Time equation
Activity 3: picking activity			
Receiving (picking list) demands from production departments	Number of deliveries	10 min per delivery 2 min per delivery [if extra request is from PD3, PD4 and PD5) 5 min per delivery [if extra request is from PD2] 8 min per delivery [if extra request is from PD1]	10 min [numbers of delivery] + 2 min [numbers of delivery if extra request is from PD3 or PD4 or PD5) + 5 min [numbers of delivery if extra request is from PD2] + 8 min [numbers of delivery if extra request is from PD1] +1 min[number of lines] +0.10 min [numbers of boxes if weight per box is up to 15 kg] + 0.25 [numbers of boxes if weight per box is more than 15 kg and up to 25 kg] + 2 min [numbers of boxes if full pallet]+5 min [numbers of pallets if driving trolley to PD3, PD4 and PD5) + 10 min [numbers of pallets if driving trolley to PD 2] + 12 min [numbers of pallets if extra driving trolley to PD1]
Create a buying order list if stock on shelves is below critical levels (check, make note, record on ERP)	Number of lines	1 min per line	
Pick goods (raw materials, packaging materials) from warehouse shelves for distribution to production departments	Number of boxes	0.10 min per box [if weight per box is up to 15 kg] 0.25 per box [if weight per box is more than 15 kg and up to 25 kg] 2 min per box [if full pallet]	
Drive trolley with goods to production departments	Number of pallets transferred	5 min per pallet [if driving trolley to PD3, PD4 and PD5) + 10 min per pallet [if driving trolley to PD2] + 12 min per pallet [if extra driving trolley to PD1]	
Activity 4: shipment preparation			
Pick final goods and load them to trucks to deliver to clients or branches	Number of boxes	5 min	5 min [number of boxes] + 2 min [number of boxes if products are located in Warehouse 1] + 4 min [number of boxes if products are located in Warehouse 2] + 8 min [number of boxes if products are located in Warehouse 3] + 10 min [number of boxes if products are located in Warehouse 4] + 0.16 min [number of type 1 plastic boxes] + 0.33 min [number of types 2 & 3 plastic boxes if not full pallet] + 0.088 min [number of types 2&3 plastic boxes if full pallet] + 0.16 min [number of carton boxes if not full pallet] + 0.08 min [number of carton boxes if full pallet of 25 carton boxes]
Drive trolley to pick up products depending their storage location	Number of boxes	2 min if Warehouse 1 4 min if Warehouse 2 8 min if Warehouse 3 10 min if Warehouse 4	
Pick up products depending on their packaging characteristics and number (full pallet or not)	Number of boxes	0.16 min per plastic box (type 1) 0.33 min per plastic box (type 2 & 3) *0.088 min* per plastic box (type 2 & 3) if full pallet) 0.16 min per carton box 0.08 min per carton box if full pallet	

warehouses, which was multiplied by the CCR calculated for the storage resources (see Table VII for CCR calculations).

When applying TDABC in the company, the overhead costs of the supporting departments allocated to other departments were based on the actual work demanded from those supporting departments. Table V shows the actual work demanded from some of these departments for each activity performed.

Note that the cost of checking outstanding balance for a client and receive payment (Activity 1) of the Accounting & Purchasing Department was directly allocated to batches of products because this activity is directly related to production volume. In contrast, monthly invoice archiving on folders (Activity 3) is a corporate level activity so its cost is expensed directly in the P/L schedule.

Table VI shows the assignment of the costs of support departments to the other departments based on the actual work demanded from each department. Through time equations, the total time demanded by other departments was determined and multiplied by the CCR of the department which is shown in Table VII.

TDABC generally assumes that capacity is measured by the time available from people and equipment. However, there are examples when time is not used to measure resource capacity, such as measuring a department's capacity in terms of area in square meters. Table VII shows the CCR calculations for the supporting and operating departments. When classifying departments, we adhered to the company's own classifications made. The total capacity costs of the departments, which include employee salaries, and supporting costs, like depreciation or utilities, were divided by total practical time capacity of the employees.

3.3 Cost allocation for production departments

The same procedures were also applied to the company's six production departments:

(1) Production Department 1 produces breads and double-baked breads.

(2) Production Department 2 produces cookies and biscuits.

(3) Production Department 3 produces pastry.

(4) Production Department 4 produces sweets and chocolate.

(5) Production Department 5 produces ice cream.

(6) Packaging Department.

The following section provides example CCR calculations for Production Department 2 and the Packaging Department while the time equations are explained for two products in Production Department 2: cookies (ID 10320) and biscuits (ID 10325).

The cost model for this company was created under the philosophy of having multiple CCRs for single machines or groups of machines used in the production departments. Each production department has various machines that are not used together or for all tasks and steps in each product's production process. This enables us to measure costs more accurately, instead of using only one CCR for all the machinery in the department. A single CCR was calculated for those machines in the same department that perform identical tasks. For example, if a department has five ovens that are identical in their characteristics and production capacity, we used a single CCR. In this way, the productivity of a machine or group of machines can be measured and unused capacity managed. Tables VIII and IX show the CCR calculations for Production Department 2 and the Packaging Department.

Table X shows the time equation for the production of cookies (ID 10320) in Production Department 2.

Table V. Actual time demanded from some of supporting and operating departments[a]

	To:	Accounting & Purchasing Department	Sales & Logistics Department	Maintenance Department	Quality Control & HR Department	IT Department	Warehouse Department	Washing Department	Production Department 1	Production Department 2	Production Department 3	Production Department 4	Production Department 5	Packaging Department	Corporate	Batches of products
Accounting & Purchasing Department	Activity 1:															378
	Activity 2:		594	537	80	192	938	160	1,093	886	1,557	1,199	63	938	892	
	Activity 3:														4,500	
	Activity 4:		2,042	624	184	103	1,079	85	1,496	1,096	2,981	2,489	79	665	511	
	Activity 5:														2,500	
	Activity 6:	230	574	230	400	0	230	230	2,856	1,410	3,003	1,392	115	467		
	Activity 7:		2	6	18	0	1,779	6	1,164	953	2,043	1,155	89	251	1	
	Activity 8:														4,623	
	Total (min)	230	3,211	1,397	682	296	4,025	481	6,610	4,344	9,585	6,235	346	2,320	13,027	378
Sales & Logistics Department	To:	Accounting & Purchasing Department	Sales & Logistics Department	Maintenance Department	Quality Control & HR Department	IT Department	Warehouse Department	Washing Department	Production Department 1	Production Department 2	Production Department 3	Production Department 4	Production Department 5	Packaging Department	Corporate	Batches of products
	Activity 1:															11,623
	Activity 2:															14,848
	Activity 3:								1,521	1,521	1,521	1,521	892	177		
	Total (min)	0	0	0	0	0	0	0	1,521	1,521	1,521	1,521	892	177	0	26,471
	Activity 4(min)															207,495
	Activity 4 (m^3)															25
	Total (min*m^3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,187,375
Warehouse	To:	Accounting & Purchasing Department	Sales & Logistics Department	Maintenance Department	Quality Control & HR Department	IT Department	Warehouse Department	Washing Department	Production Department 1	Production Department 2	Production Department 3	Production Department 4	Production Department 5	Packaging Department	Corporate	Batches of products
	Activity 2 (min)								499,320	473,040	446,760	341,640	367,920	131,400		
	Activity 2 (m^3)								450	500	520	100	50	150		
	Total (min*m^3)								224,694,000	236,520,000	232,315,200	34,164,000	18,396,000	19,710,000		
	Activity 1:								5,113	3,863	9,538	7,252	184	1,818		
	Activity 3:															44,289
	Activity 4:															25,308
	Total (min)	0	0	0	0	0	0	0	5,113	3,863	9,538	7,252	184	1,818	0	69,597

Note: [a]Accounting & Purchasing, Sales & Logistics and Warehouse Departments' activities are given as examples

Table VI.
Assignment of cost of supporting and operating departments to other departments

Part 1: Total time Demanded by Other Departments and Products																			
	Accounting & Purchasing Department	Sales & Logistics Department	Maintenance Department	Quality Control & HR Department	IT Department	Warehouse Department	Washing Department	Production Department 1	Production Department 2	Production Department 3	Production Department 4	Production Department 5	Packaging Department	Corporate	Batches of products	(A) Total capacity used	(B) Total Practical Capacity	(B-A) Unused /Excess Capacity	Unused /Excess Capacity %
Accounting & Purchasing Department[a]	230[b]	3,211	1,397	682	296	4,025	481	6,610	4,344	9,585	6,235	346	2,320	13,027	378	53,166 min	117,445 min	64,279 min	54%
Sales & Logistics Department (Employee capacity)	0	0	0	0	0	0	0	1,521	1,521	1,521	1,521	892	177	0	26,471	33,623 min	117,445 min	83,822 min	71%
Sales & Logistics Department (vehicles capacity)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,187,375	5,187,375 min*m^3	7,986,284 min*m^3	2,798,909 min*m^3	35%
Warehouse (employee capacity)	0	0	0	0	0	0	0	5,113	3,863	9,538	7,252	184	1,818	0	69,597	97,365 min	117,445 min	20,080 min	17%
Warehouse (storage capacity)	0	0	0	0	0	0	0	224,694,000	236,520,000	232,315,200	34,164,000	18,396,000	19,710,000	0	0	765,799,200 min*m^3	930,312,000 min*m^3	164,512,800 min*m^3	17%
Maintenance Department	0	0	0	0	0	0	0	50,400	24,360	31,920	21,420	3,360	21,840	0	0	153,300 min	117,445 min	–35,855 min	–30%
Quality Control & HR Department	0	0	0	0	0	0	0	78,462	43,738	67,095	48,146	6,331	31,105	0	0	274,877 min	234,892 min	–39,985 min	–17%
Washing Department	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95,342	95,342	117,445 min	22,103 min	19%

(continued)

Table VI.

Part 2: Allocation of Support Departments' Costs																		
	Accounting & Purchasing Department	Sales & Logistics Department	Maintenance Department	Quality Control & HR Department	IT Department	Warehouse Department	Washing Department	Production Department 1	Production Department 2	Production Department 3	Production Department 4	Production Department 5	Packaging Department	Corporate	Batches of products	(A) Amount Allocated	(B) Total Cost[c]	(B-A) Unallocated (Expensed Directly)
Accounting & Purchasing Department	46.89 €[d]	655.74 €[e]	285.27 €	139.27 €	60.45 €	822.02 €	98.25 €	1,349.76 €	887.16 €	1,957.34 €	1,273.19 €	70.62 €	473.88 €	2,660.28 €	77.19 €	10,857.30 €	23,983.98 €	13,126.68 €
Sales & Logistics Department (Employee capacity)	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	221.85 €	221.85 €	221.85 €	221.85 €	130.07 €	25.77 €	0.00 €	3,861.44 €	4,904.67 €	17,132.00 €	12,227.33 €
Sales & Logistics Department (vehicles capacity)	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	44,507.68 €	44,504.87 €	68,518.00 €	24,013.13 €
Warehouse (employee capacity)	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	387.96 €	293.13 €	723.69 €	550.26 €	13.96 €	137.97 €	0.00 €	5,280.81 €	7,387.78 €	8,911.39 €	1,523.61 €
Warehouse (storage capacity)	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	69.40 €	35.75 €	244.81 €	65.77 €	0.62 €	21.04 €	0.00 €	0.00 €	437.39 €	55,955.36 €	55,517.97 €
Maintenance Department	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	6,751.98 €	3,263.46 €	4,276.25 €	2,869.59 €	450.13 €	2,925.86 €	0.00 €	0.00 €	20,537.27 €	15,733.90 €	–4,803.37 €
Quality Control & HR Department	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	16,023.08 €	8,931.89 €	13,701.70 €	9,832.05 €	1,292.94 €	6,352.03 €	0.00 €	0.00 €	56,133.68 €	34,955.43 €	–21,178.25 €
Washing Department	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	21,500 €	21,500 €	26,488 €	4,988 €

Notes: [a]We ignored reciprocal allocation between supporting and operating departments because only Accounting & Purchasing Department serves to other departments and amounts are very small to affect the results. In the contrary case, reciprocal allocation of supporting and operating departments' cost is needed; [b]these numbers are obtained from Table V which shows detailed activity analysis; [c]total costs of departments are determined from the trial balances of the company. The cost of resources like electricity, depreciation or water allocated to the departments by using suitable cost drivers. For example; kws for electiricity, square meters for depreciation of the building, numbers of employees for water etc; [d]total time demanded by the Sales & Logistic department from Accounting & Purchasing Department multiplied with the CCR of Accounting & Purchasing Department (see Table VII for CCR calculations of Supporting and Operating Departments)

Department	Types of capacity	Capacity costs (€)	Numbers of employees	Total time capacity provided (min)	85% of capacity provided	CCR
Accounting & Purchasing Department	Employee	23,983.00	1	138,171	117,445[a]	€0.2042
Sales & Logistics Department	Employees (office)	17,132.46	1	138,171	117,445	€0.1458
	Drivers & Vehicles	68,518.54	2	276,342	234,891×34 m^{3b}	€0.00858 per m^3 per min
Maintenance Department	Employee	15,733.00	1	138,171	117,445	€0.1340
Quality Control & HR Department	Employee	34,955.00	2	276,343	234,892	€0.1488
Warehouse Department	Employee	8,911.39	1	138,171	117,445	€0.0759
	Storage	55,955.36		525,600	525,600×1,770 m^{3c}	0.0000601 per m^3 per min
Washing Department	Employee	26,488.00	1	138,171	117,445	€0.2255

Notes: [a]CCR for employees was calculated based on the assumption that there are 52 weeks in a year and six working days in each week, which totals 313 days, including holidays. There are 288 net working days after deducting 25 days of holidays. Total working hours per year were calculated as (288 days×8 h) = 2,303 while there were a total of 138,171working minutes per year. Practical capacity was assumed to be 85 percent of the theoretical capacity of employees (138,171×0.85) = 117,445; [b]the total practical capacity of vehicle resources was calculated by multiplying the practical time capacity of two drivers (138,171×2) by the car's volume in cubic meters (34m^3). The CCR for vehicle resources was then calculated by dividing the capacity cost by the total m^3×min capacity; [c]the capacity of warehouse storage was measured in min×m^3. By assuming warehouses are available for the full year (365 days×24 h×60 min), the time capacity was calculated and multiplied by the storage capacity (1,170m^3)

Table VII.
Capacity cost rate calculations

We calculated the indirect costs incurred in Production Department 2 and the Packaging Department for one batch of cookies (ID 10320) using the time equation and CCRs calculated for Production Department 2 and the Packaging Department as follows:

$$\begin{aligned}
&280\ \text{min} \times \text{CCR}_{(\text{production employees})} + 15\ \text{min} \times \text{CCR}_{(\text{mixer 120 lt})} + 60\ \text{min} \times \text{CCR}_{(\text{oven})} \\
&\quad + 40\ \text{min} \times \text{CCR}_{(\text{trolley})} + 12\ \text{min per m}^2 \times \text{CCR}_{(\text{elevator 2})} \\
&\quad + 135\ \text{min} \times \text{CCR}_{(\text{packaging department's employees})} \\
&\quad + 45\ \text{min} \times \text{CCR}_{(\text{packaging machine mod 850})} + 10\ \text{min} \times \text{CCR}_{(\text{production printer})} \\
&\quad = 280\ \text{min} \times 0.08171\ €/\text{min} + 15 \times 0.01463\ €/\text{min} \\
&\quad + 60\ \text{min} \times 0.11369\ €/\text{min} \\
&\quad + 40\ \text{min} \times 0.001943836\ €/\text{min} \\
&\quad + 12\ \text{min per m}^2 \times 0.000012\ €/\text{min per m}^2 \\
&\quad + 135\ \text{min} \times 0.09524\ €/\text{min} + 45\ \text{min} \times 0.01905\ € \\
&\quad + 10\ \text{min} \times 0.00190\ €/\text{min} = 43.73\ €.
\end{aligned}$$

The total indirect cost of one batch of cookies (ID 10320) also includes costs allocated by operating departments. The cost of different batches produced for the different clients within the year vary because the costs of raw materials and packaging materials change,

Resources	Capacity costs[a] (€)	Total time capacity (min)	Capacity cost rate (CCR)[b]
Stove	1,260.01	302,400	€0.00417
Flour dosometric machine	328.35	302,400	€0.00109
Mixer AR80	1,112.31	302,400	€0.00368
Mixer XBE60	286.93	302,400	€0.00095
Mixer 120 lt	4,423.85	302,400	€0.01463
Cutting machine[c]	3,236.93	302,400	€0.01291
Conveyor Belt 1	171.54		
Conveyor Belt 2	248.46		
Conveyor Belt 3	248.46		
Ice trimmer machine	705.85	302,400	0.00233
Machine for producing cookies	748.46	302,400	€0.00248
Machine for grinding raw materials	363.85	302,400	€0.00120
Film wrapping machine	210.00	302,400	€0.00069
Oven 1[d]	4,793.83	1,814,400	€0.11369
Oven 2	5,916.91		
Oven 3	5,916.91		
Oven 4	5,916.91		
Oven 5	5,916.91		
Oven 6	5,916.91		
Almond crusher machine	225.39	302,400	€0.00075
Recipe execution station	303.54	302,400	€0.00100
Refrigerator	1,647.26	1,051,200[e]	€0.00157 per min per m^3
Water cooler machine	510.00	302,400	€0.00169
Production 2 employees	56,278.47	688,800	€0.08171
Elevator 2[f]	175.99	1,512,000 min×m^2	0.000012 per min per m^2[g]
Trolley[h]			€0,001943836

Notes: [a]Capacity costs of resources include depreciation, electricity used by the machine, maintenance materials used for the machine etc. Some of these costs are direct costs like depreciation and maintenance materials used for the machines. To allocate indirect costs to the resources suitable cost drivers are used. For example; kws for electricity used. Capacity costs of resources also include cost allocated from supporting and operating departments to the production departments; [b]the CCRs for the machines for every department were calculated based on the assumption that the machines are available 14 h per day and 12 months per year, since the factory produces daily bakery products. Thus, to determine how many minutes that a machine can operate (excluding five days for regular maintenance repairs per year), we calculated 14 h/day×60 min/h××360 operating days. The CCRs for machines like refrigerators that store products were calculated by dividing the annual depreciation and operating expenses by their useable volume in cubic meters. This result was divided by converting the 365 days of the year into minutes to find the cost per m^3 per min. The CCR for the production department for ice cream was calculated differently since this department does not operating throughout the year; [c]we grouped these machines because the cutting machine does not work without the conveyor belts; [d]we grouped these machines and obtained a single CCR because they have identical characteristics and perform identical work; [e]the refrigerator has a storage capacity of 2 m^3 while its annual operating time is (365 days×24 h per day×60 min per hour) = 525,600 min. The total capacity of the refrigerator is (2 m^3×525,600 min) = 1,051,200 min×m^3; [f]there are two elevators. One connects Production Department 1 with the lower floor where the Packaging Department is located while the second elevator connects the Packaging Department with the other departments below. Although Elevator 2 is also used by other departments, its CCR calculation is shown here; [g]the CCR can be calculated based on the time and the space (m^2) that the trolleys occupy to send them from Production Department 2 to the Packaging Department, and send back the empty trolleys to Production Department 2 after the products have been packed in sealed bags. Elevator 2 has a maximum capacity of 5 m^2 and can take six trolleys. The operating time per year (excluding maintenance) is 302,400 minutes. The total capacity of Elevator 2 is (302,400 min×5 m^2) = 1,512,000 min×m^2; [h]the trolleys are transferred from Production Department 2 to the Packaging Department. They remain in each department for variable times depending on the task. The CCR for the trolleys when they are in Production Department 2 is €0.001943836 while the CCR when they are in the Packaging Department is €0.001277883. For Production Department 2, the trolleys have an annual cost of €595.98. These costs derive from the department where they are located, based on the space that they occupy and any maintenance that they require. We assume that they are available for (14 h per day×60 min per hour×365 days per year) = 306,600 min per year. To calculate the CCR, we divided the total annual cost by the time capacity (€595.98/306,600 min)

Table VIII.
CCR calculations for Production Department 2

Resources	Capacity costs (€)	Total time capacity (min)	Capacity cost rate (CCR) (€)
Packaging machine mod.Sim[a]	11,624.08	302,400	0.06631
Packaging machine mod.250	4,640.17		
Check weightier machine	1,370.94		
Vertical belt	1,823.95		
Round movable table	594.05		
Metal detector	1,209.43	302,400	0.00400
Packaging machine mod.850	5,760.80	302,400	0.01905
Horizontal packaging machine	4,726.56	302,400	0.01563
Production printer	573.95	302,400	0.00190
Employees in packaging department	26,241.40	275,520	0.09524

Note: [a]We grouped these machines since they do not operate independently

Table IX.
CCR calculations for the packaging department

		Cookies	
Subtask	Time driver	Time consumed	Calculation of cost for cookies
Collect raw materials from the department's daily storage shelves	Number of batches	8 min (production employees)	8 min × $CCR_{(production\ employees)}$
Prepare recipe by checking the weight of each ingredient in the scale. Put raw materials in the mixer		8 min (production employees)	8 min × $CCR_{(production\ employees)}$
Mix raw materials in the mixer		15 min (if mixer 120 lt)	15 min × $CCR_{(mixer\ 120\ lt)}$
Take out mixed materials and shape by hand by cutting into pieces. Lay the pieces onto metal sheets. Place the metal sheets into trolleys		252 min (production employees)	252 × $CCR_{(production\ employees)}$
Put trolleys into oven to bake cookies		60 min (oven machine)+ 4 min (production employees)	60 min × $CCR_{(oven)}$ 4 min × $CCR_{(production\ employees)}$
Take trolleys out of oven and leave them until the product temperature falls		40 min (product stays on the trolley)+ 4 min (production employees)	40 min × $CCR_{(trolley)}$ 4 min × $CCR_{(production\ employees)}$
Load trolleys into elevator and transfer to Packaging Department		12 min (elevator)+ 4 min (production employees)	12 min per m^2 × $CCR_{(elevator\ 2)}$+ 4 min × $CCR_{(production\ employees)}$
Pack products into sealed bags and pack bags in cartons		90 min if packaging is 400 gr/package (employee time) + 45 min (group of 4 different packaging machines if packaging is 400 gr/package)+ 10 min (print labels for the carton boxes if product is 400 gr/package) 45 min if package if 5 kg/box (only employees' time, no packaging machines needed)	135 min × $CCR_{(packaging\ department's\ employees)}$ + 45 min × $CCR_{(packaging\ machine\ mod.850)}$ + 10 min × $CCR_{(production\ printer)}$

Notes: [a]Only one of the different types of cookies produced in Production Department 2 given as an example. Each type has different time equation

Table X.
Time equation for the production of cookies (ID 10320)[a] in Production Department 2

specific clients have different waiting times in the warehouses and the frequency and volume of clients' orders fluctuate. Table XI shows the average cost for a single product produced in Production Department 2 and packaged in the Packaging Department.

Table XII shows the time equation for biscuits (ID 10325) production in Production Department 2.

Activity location	Cost per batch (€)	Cost per unit (€)
Raw materials	169.26	0.6994
Production Department 2	*30.00*	0.1240
Packaging Department	*13.73*	0.0567
Accounting & Purchasing Department	22.35	0.0924
Sales & Logistics Department	34.89	0.1442
Warehouse Department	29.48	0.1218
Washing Department	0.00[a]	0.0000
Total product cost	299.71	1.2385

Note: [a]The Washing Department was not involved in the process for this specific product

Table XI. Total cost of one batch/unit of cookies (ID 10320)

		Biscuits	
Subtask	Time driver	Time consumed	Calculation of cost for biscuits
Collect raw materials from department's daily storage shelves	Number of batches	8 min (production employees)	8 min × $CCR_{(production\ employees)}$
Prepare recipe by checking the weight of each ingredient in the scale. Put raw materials in mixer		8 min (production employees)	8 min × $CCR_{(production\ employees)}$
Mix raw materials in the mixer		18 min (mixer 80 lt)	18 min × $CCR_{(mixer\ 80\ lt)}$
Take out mixed materials and place in dough divider machine. Lay pieces onto metal sheets. Load metal sheets onto trolleys		35 min (cutting machine and conveyor belts) + 114 min (production employees)	35 min × $CCR_{(cutting\ machine\ and\ conveyor\ belts)}$ 114 min × $CCR_{(production\ employees)}$
Put trolleys into ovens to bake		40 min (oven machine) + 12 min (production employees)	40 min × $CCR_{(oven)}$ 12 min × $CCR_{(production\ employees)}$
Take trolleys out of the ovens and leave to cool		40 min (product stays on the trolley) + 4 min (production employees)	40 min × $CCR_{(trolley)}$ 4 min × $CCR_{(production\ employees)}$
Load trolleys into elevator and transfer to Packaging Department		12 min (elevator 2)+ 4 min (production employees)	12 min per m^2 × $CCR_{(elevator\ 2)}$ 4 min × $CCR_{(production\ employees)}$
Place products into sealing bags and then into cartons		35 min if packaging is 380 gr/package (employees in packaging department) + 45 min × packaging machine mod.850) + 10 min (printing labels for cartons, employees in packaging department) 20 min if package is 5 kg/box. (only employees time, no packaging machines needed)	55 min × $CCR_{(packaging\ department's\ employees)}$ 45 min × $CCR_{(packaging\ machines)}$ + 10 min × $CCR_{(production\ printer)}$

Table XII. Time equation for biscuits (ID 10325) production in production department 2

We calculated the cost of one batch of biscuits (ID 10325) by using the time equation and CCRs calculated for Production Department 2 and the Packaging Department as follows:

$$\begin{aligned}
&150\ \text{min} \times \text{CCR}_{(\text{production employees})} + 18\ \text{min} \times \text{CCR}_{(\text{mixer 80lt})} + 35\ \text{min} \\
&\quad \times \text{CCR}_{(\text{cutting machine and conveyor belts})} \\
&\quad + 40\ \text{min} \times \text{CCR}_{(\text{oven})} + 40\ \text{min} \times \text{CCR}_{(\text{trolley})} + 12\ \text{min per m}^2 \times \text{CCR}_{(\text{elevator 2})} \\
&\quad + 55\ \text{min} \times \text{CCR}_{(\text{packaging department's employees})} + 45\ \text{min} \times \text{CCR}_{(\text{packaging machines})} \\
&\quad + 10\ \text{min} \times \text{CCR}_{(\text{production printer})} \\
&\quad = 150\ \text{min} \times 0.08171\ €/\text{min} + 18\ \text{min} \times 0.00368\ €/\text{min} \\
&\quad + 35\ \text{min} \times 0.01291\ €/\text{min} \\
&\quad + 40\ \text{min} \times 0.11369\ €/\text{min} + 40\ \text{min} \times 0.001943836\ €/\text{min} \\
&\quad + 12\ \text{min per m}^2 \times 0.000012\ €/\text{min per m}^2 \\
&\quad + 55\ \text{min} \times 0.09524\ €/\text{min} + 45\ \text{min} \times 0.01905\ € \\
&\quad + 10\ \text{min} \times 0.00190\ €/\text{min} = 23.50\ €.
\end{aligned}$$

4. Capacity utilization analysis

Perhaps the most beneficial tool of TDABC is the capacity utilization analysis conducted through the model (Öker and Adıgüzel, 2010; Stouthuysen *et al.*, 2010). When applying the model, the practical capacities of resources like machines, equipment and employees are determined and compared with the actual usage of the capacities at the end of the measurement period. The last two columns of Table VI show the unused or excess capacities of the supporting and operating departments. Table VI compares the total capacity used with the practical capacity of the departments. Capacity is generally measured thorough the employee time available for the supporting and operating departments apart from the storage capacity of the "Warehouse" Department and the driver and vehicle capacity of the "Sales & Logistics" Department. These are measured as "minute*m^3." The findings indicate that all the employees of the supporting and operating departments are working under capacity except for the "Maintenance" and "Quality Control & HR" Departments. These findings can be used by management when making performance evaluations.

Table XIII shows the capacity utilization of resources per year in Production Department 2.

According to the analysis, the cookies producing machine, grinding machine and film wrapping machine had the greatest excess capacities at 38, 15 and 5 percent, respectively. Because these machines are not used by other departments, the unused capacity cannot be transferred to other departments. The company cannot reduce their excess capacity because there is only one of each machine, and they are all required for production.

The capacity utilization of employee resources was 88 percent. The products produced in each production department require different skills from the employees. Therefore, although employees that can work in Production Department 1 can also work in Production Department 2, they cannot work in Production Department 3 (pastry), Production Department 4 (sweets) or Production Department 5 (ice cream) without retraining.

In the TDABC model of the case company, only the cost of the capacity used is allocated to products while unused capacity is directly expensed in P/L. The costs of the excess capacities of the machines are not included in the inventoriable product costs. The overhead of unused capacity is expensed immediately as it is incurred whereas the overhead of used capacity is inventoried until the accounting period during which the manufactured goods are sold. In the TDABC model of the case company, there is no variable-fixed cost

Resources	Available capacity (min)	Consumed capacity[a] (min)	Capacity utilization (%)
Stove	302,400	235,872	78.00
Flour dosometric machine	302,400	276,817	91.54
Mixer AR80	302,400	205,632	68.00
Mixer XBE60	302,400	166,320	55.00
Mixer 120 lt	302,400	214,704	71.00
Cutting machine	302,400	205,632	68.00
Conveyor Belt 1			
Conveyor Belt 2			
Conveyor Belt 3			
Ice trimmer machine	302,400	214,704	71.00
Machine for producing cookies	302,400	114,912	38.00
Machine for grinding raw materials	302,400	45,360	15.00
Film wrapping machine	302,400	15,120	5.00
Oven 1	1,814,400	1,614,816	89.00
Oven 2			
Oven 3			
Oven 4			
Oven 5			
Oven 6			
Almond crusher machine	302,400	214,704	71.00
Recipe execution station	302,400	276,817	91.54
Refrigerator	302,400	287,885	95.20
Water cooler machine	302,400	286,675	94.80
Employees in production Department 2	688,800	610,208	88.59

Notes: [a]Consumed capacity of each resource calculated according to actual production during one-year period. Based on the time-equations developed (see Tables X and XII as examples), we determined how many minutes of each asset required making production during one-year period

Table XIII. Capacity utilization analysis for Production Department 2

segregation. Separating variable and fixed components of overhead and calculating a different CCR for each could be a better way of costing. Figure 2 illustrates how the direct and indirect costs were allocated in the case company.

Tse and Gong (2009) also state the benefits of the recognition of idle resources in TDABC. Under traditional volume-based costing models and the ABC model, all overhead costs of the

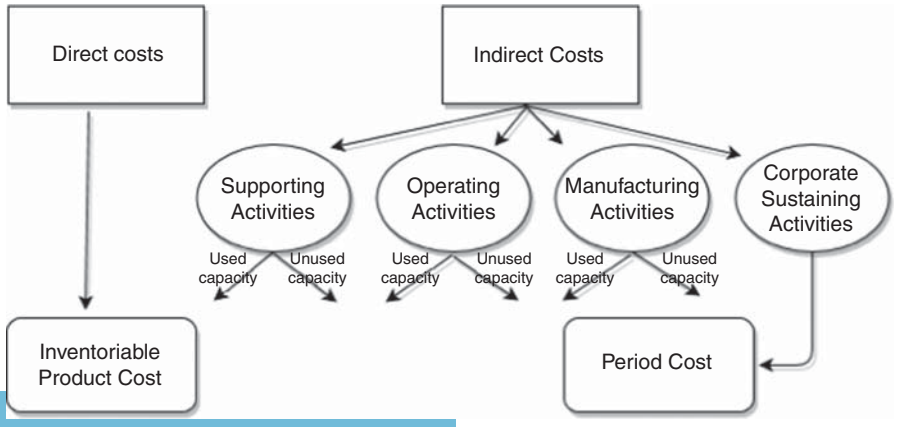

Figure 2. Allocation of cost in the case company

period are recognized as product costs. Any difference between the total overhead cost and allocated overhead is regarded as an error in the allocation process and adjusted at the end of the period. However according to TDABC, only resource costs consumed by the products are treated as product costs while idle resource costs are treated as period costs (Tse and Gong, 2009).

Capacity analysis through TDABC provides two benefits to companies. First, because TDABC does not allocate the cost of unused capacity to products, it provides more accurate information on product costs. Second, companies can improve operational efficiency by reducing idle capacity, either through increased production volume or elimination of idle resources.

5. Conclusion

This study has offered a comprehensive application of TDABC in a small-sized manufacturing company. Siguenza Guzman *et al.* (2013) suggest that it is important that TDABC is implemented by independent researchers rather than its creators to provide unbiased evaluations of the system. Previous studies have discussed the advantages and disadvantages of TDABC. One of the most important advantages is its simplicity because it only requires two parameters: CCR and time consumptions. The second advantage mentioned in previous studies is the ability of the time equations to reflect complex operations. Third, TDABC allows for a capacity utilization analysis. However, there are also many criticisms. One is that TDABC can be subjective and requires a considerable amount of data. Having conducted our own implementation, we agree with most of the advantages. Especially for small-sized companies, determining time consumption through estimations or direct observations is easier than for larger firms, which decreases the subjectivity of employees. On the other hand, in contrast to previous studies, we argue that simple excel sheets are not enough to build and maintain a TDABC model even in small firms. Rather, business intelligence software and programming coding is required to capture the complexity of the time equations.

Finally, although the fundamental structure of TDABC is the same for all companies in the use of time equations and calculating CCRs, there is no strict form of application. Instead, it can vary from company to company according to the organization chart and resource expenses flows between departments and from departments to products. That is, each firm has unique characteristics that need to be reflected in the application of the model.

Notes

1. The company is real but the quantities have been changed to maintain confidentiality.
2. Subtasks of "Drop off the plastic boxes at retail shops," "Load empty plastic boxes into car" "Drop off empty plastic boxes at washing department" performed by employees. So, only these subtasks' times are included in time equation 1.
3. The first equation shows pushing the costs of the warehouse employee to the departments that he/she serves and the second equation shows pushing the costs of storage of the raw materials onto the batches.
4. Days stored multiplied by 1,440 (24 h×60 min) to convert it to the number of minutes.

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