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The integration of Time Driven-Activity Based Costing (TD-ABC) in a lean Manufacturing System for accurate product unit cost

A Case Study in Egypt

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Abstract

In today’s global market, considering customer needs in all changing business practices is a key tool to build strong competitive advantages. At the same time, with respect to lean manufacturing system, the current conventional costing methods are out of date. This study sets a framework that integrates Time-Driven Activity-Based Costing (TDABC) in a lean environment in a condition where shared resources are still present. The objective of this study is computing accurate product unit cost to support the lean manufacturing system to strengthen the competitive position. This case study is applied on one factory of a multinational manufacturing company operating in Egypt that moved to lean manufacturing recently. TDABC method is suggested to calculate a more accurate product unit cost for one of the factory products.

Key words: Activity-Based Costing (ABC), Time-Driven Activity-Based Costing (TDABC), lean manufacturing system, Product unit cost
1. Introduction

Due to the current strong competition, all companies aim to achieve competitive advantage and the price considers the most powerful competitive advantage. As consumers always seek to get their needs at the lowest price, the producers try to minimize the product cost per unit to meet those needs. The problem starts when the producers are not able to allocate the overhead costs over products to determine the accurate product unit cost. This problem sometimes leads to take wrong decisions for example, calculating inaccurate product unit cost leads to drop current profitable line or add a new unprofitable product line. So choosing the best costing methods play a significant role in minimizing those problems.

Cooper and Kaplan developed activity-based costing system early in 1980s trying to measure the cost per unit in each activity, but the pitfalls of ABC discovered by the time. Kaplan and Anderson introduced the time-driven activity-based costing in 2004 to recognize the unused time capacity and solve the ABC problems in determining accurate product unit cost. TDABC is an efficient tool that considers activities performed for each product and the time needed for each activity, so the product unit cost is accurately determined.

Also, the producers follow some management techniques to minimize the cost and provide their products with the cheapest market price. One of those brilliant techniques is the lean system which is a system that could be used in all business wasteful processes. It is used by management in manufacturing process to reduce the production wastes. It enables the manufacturer to produce the maximum capacity using the least resources.

To sum up, this research discusses the difference between using ABC and TDABC on the accuracy of determining product cost per unit and how the lean manufacturing system is helpful in gaining a competitive advantage among competitors in order to attain the maximum profit which is the main goal of any business.

2. Theoretical background

2.1. Activity-based costing (ABC)

ABC is released by Kaplan in 1980s as a method to link costs to the produced goods and services of an organization, and ABC model considers as an accounting method that identifies the activities that a firm performs and then assigns indirect costs to products. ABC system recognizes the relationship between costs, activities and products, and through this relationship, it assigns indirect costs to products less arbitrarily than traditional methods (BARRET 2005; Akanmu, et al., 2022; Nielsen, S. 2022). Indirect costs, such as
management and office staff salaries are sometimes difficult to assign to a particular product produced. ABC is mostly used in the manufacturing industry since it enhances the reliability of cost data, hence producing nearly true costs and better classifying the costs incurred by the company during its production process. But it failed to determine absolutely accurate product cost per unit.

The standard process for estimating ABC system contains of two steps. The first step starts by identify and collect the cost of resources that perform a variety of activities, then asks employees to approximate the percentage of their time spent or expect to spend on the main activities. The second one, uses the activity cost drivers rates to assign the cost of activities to cost object based on the transaction drivers (number of orders performed for each object) (Kaplan and Anderson 2003). Estimating the previous two steps lead to identify the main goal of ABC model by assign indirect costs to provide more accurate cost information about the resource demand/resource consumption of a firm’s cost objects (Namazi 2009; Stout & Propri 2011; Al-Halabi N. B., & Shaqqour, O. F. 2018; Neringa, et al., 2020).

Ayvaz and Pehlivanl (2011) found that Firms preferred to use ABC model for many reasons; for instance, ABC model helps the managers to analyze activities more correctly, use relevant cost information in budget, and estimate profitability of customer and product.

Moreover, High costs and time incurred to interview and survey people for the initial activity-based costing (ABC) model are the main difficulties that faced many firms and organization to apply the activity based costing system (Ayvaz and Pehlivanl 2011; Nielsen, S. 2022), and the difficulty of maintaining and updating the ABC system for instance: processes and resource spending change, increases occur in the diversity and complexity individual orders, and another problem related to traditional ABC models are difficult to scale (Pernot, et al. 2007; Almusawi et al., 2019; Quesado, P. & Silva, R. 2021). Also, adding new activities to the model, as to introduce heterogeneity within an activity, needs re-estimating the cost that should be assigned to the new activity.

Kaplan and Anderson (2007) Showed that implementing ABC model encountered the following pitfalls:
- Time-consuming and costly related to the interviewing and surveying process to collect data requiring significant resources commitments.
- Subjectively data from ABC model and the difficulty to validate it.
- The data for ABC model were expensive to store, process and report, subjective, and difficult to validate.
ABC model does not recognize unused capacity in the statements if time.
ABC model does not provide wide profitability opportunities because ABC model was local and theoretical.
Solving the problems related to ABC model, companies need to update it by re-analyzing the activities, re-determining the amount of time spent for activities which cause inappropriate and incorrect costing and timing results (Ayvaz & Pehlivani, 2011; Rankin, R. 2020; Binoy et al., 2023).

2.2. Time-driven activity-based costing (TDABC)
Kaplan and Anderson (2003) introduced the time-driven activity based costing (TDABC), a revised version of activity based costing (ABC), to decrease the drawbacks and overcoming some of the downsides of traditional allocation system (ABC), allows for more heterogeneity in activities, orders, and customer behavior. Another reason helped (Kaplan & Anderson 2003; Al-Halabi N. B., & Shaqqour, O. F. 2018; Diste, et al., 2020) to propose this model is that ABC model failed to offer a cost-effective and sustainable cost management solution (allocation resource costs into activity cost pools) (Ratanatunga, et al. 2012; Irem K., & Veyis N. 2023).
The philosophy of TDABC based on duration drivers instead of transaction drivers, duration drivers represent by time drivers. Transactional cost drivers count the number of times to perform an activity, but firms need to use durational cost drivers when the resources required to perform each occurrence of an activity vary. So in this case, counting the number of times to perform an activity provides an incorrect estimate if the resource required accomplishing the work (Everaert & Bruggeman 2007; Diste et al., 2021).

Kaplan and Anderson (2003) found that TDABC model can be used by organizations to help them in understanding cost and profitability of delivering their products and services with lower costs and short time, and TDABC identifies which customers are profitable and which are not; also, it identifies useless capacity of workers which leads to designing a new recruitment system.

While, McGowan (2009) changed the way of obtaining data on time required to perform activities which facilitate and speed up the whole process, and found that Time equation is an important feature of TDABC that allow for variations in resources capacity demand for each variant of activity time.

2.3. The differences between ABC and TDABC
BARRET (2005) and McGowan (2009) found that TDABC model differs from ABC model in that it takes the analysis down from the high-level activity volume to a scientific understanding of costs, profitability and
process efficiency, and suggests to remove the need for time consuming and costly surveys, and that is more accurate than ABC model. Namazi (2009) and Ratnatunga, et al. (2012) summarized the differences between TDABC model and ABC model in five points:

1. Time is the main cost driver for different cost objects (product, service, department, customer, and transaction), time drivers are variables that determine the time needed to perform an activity.
2. TDABC eliminates the first stage of allocation costs of the traditional ABC model: the identification of different activities.
3. TDABC model eliminates the processes of interview and survey employees for allocating resources costs to activities before assigning them to cost objects.
4. TDABC model estimates unused capacity by calculating the predetermined overhead costs rate upon the practical capacity.
5. TDABC uses multiple drivers to define the cost of an activity, but in ABC model uses one activity driver for each activity (Everaert and Bruggeman 2007).

Applying TDABC, the firms need to estimate of only two variables: estimating the practical capacity of committed resources and their cost, and estimating unit time required to perform a transaction or an activity. The unit time estimate uses instead of the process of interviewing people in traditional model (ABC), direct observation can be used to obtain time estimates in new model TDABC(Kaplan & Anderson 2007, Pernot, et al. 2007, Ayvaz & Pehlivanl 2011; Tran, U. T., & Tran, H. T. 2022).

TDABC model starts by eliminating the need for the time-consuming, subjective, interview and survey process to define resource pools (Stout and Propri 2011). It assigns resources costs directly to the cost objects using two sets of estimates: estimates the cost of supplying resources capacity and calculate the capacity cost rate, then uses the cost rate to assign supplying resources costs to cost objects (Everaert, et al., 2008; Dieste, et al., 2019).

2.4. Benefits of applying TDABC model
The shifting process from ABC model to TDABC model provides more benefits for any firm (McGowan 2009; Kaplan, et al., 2014; Dieste, et al., 2019):
1. Decrease the number of activities to maintain.
2. Elimination of duplication and waste.
3. Increase the accuracy of cost estimation based on actual observations of processing time and actual transaction data.
4. It is easier to increase model accuracy and granularity.
5. The model is easier to validate.
6. The model provides explicit information on processes operating at or beyond capacity.
7. The model helps the managers to understand the profitability of products and customers.

TDABC is simpler, less costly, faster to implement, more powerful than ABC model, dynamic calculation of capacity, and the practical capacity of the resources supplied, not actual utilization, is the basic capacity to calculate cost driver rates. Using TDABC helps firms to determine the cost and capacity utilization of their processes, the profitability of products and improve their cost management systems in a cheaper and faster way (Kaplan & Anderson 2007; Hoozee, S., & Hansen, S. C. 2017; Rankin, R. 2020).

Two reasons are clarified that TDABC simplifies the ABC model: the first reason is reducing the number of activities and the analysis process takes place at the level of the department, and the second is limitation to collect information from different services because of the use of standards. (Kaplan & Anderson, 2004; Sancha, et al., 2020)

The converting process from ABC model to TDABC model is a simple process. Relationships between resource cost pools, activities and cost objects in the ABC model can be adapted to ‘resource groups’ in the TDABC model using multiple time-based drivers to assign costs to cost objects or using a single time-based driver if the data has complexities (Ratnatunga, et al., 2012; Sriyono, S. 2020).

Moreover, TDABC model provides information about the difference between the capacity supplied and the capacity used, to help the managers to review unused capacity or to discover where there is not enough capacity to satisfy customer requirements (McGowan 2009; Telma et al., 2019).

One of the basic objectives of TDABC system is to help managers to get accurate information about cost and profitability to set priorities for process improvements and price customer orders. The accurate information arises from its ability to detention the resource demands from diverse operations by adding more terms to the departmental time equation (Kaplan & Anderson 2007; Tran, U. T., & Tran, H. T. 2022).

To deal with the cost pressures and provide library services at a lower cost, management needs to understand the relevant cost drivers. TDABC provides the managers with better understanding of the cost drivers that help them to minimize the cost of acquisition process; also it helps them in improving their decisions (Stouthuysen, et al., 2010; Neringa, et al., 2020).
2.5. Advantages and disadvantages of TDABC model

TDABC model succeeded to overcome the difficulties and drawbacks from traditional ABC model, Kaplan and Anderson (2007) summarized these advantages as the following:

1. Easier and faster to build an accurate model.
2. Drives costs to transactions and order using specific characteristics of orders and customers.
3. Can be run monthly to capture the economics of the most recent operations.
4. Forecasts resources demands, allowing companies to budget for resource capacity based on predicted order quantities and complexity.
5. Enables fast and inexpensive model maintenance.
6. Provides visibility to process efficiencies and capacity utilization.

On the other hand, there are some disadvantages have been identified for TDABC model, the biggest problems are related to calculation of the capacity cost rate and estimation of the required capacity. The major weaknesses are summarized by (Namazi 2009; Irem K., & Veyis N. 2023) is that Identifying activities’ initial steps, Problems associated with determining practical capacity costs rates, and Applying a uniform capacity costs rate. To avoid the previous problems, TDABC concentrates on all operations of the department based upon the resource activity (time) that is required.

2.6. Lean philosophy approach and Lean manufacturing

There are more definition of lean philosophy, for instance, Shah and Ward (2003) define it as “a philosophy that focuses on avoiding seven cardinal wastes and on respecting customers, employees and suppliers”. These “seven cardinal wastes” are: overproduction, waiting, transportation, processing, inventory, mention and defects (Grasso 2005; MOHSIN, et al., 2021). Moreover, there are two views to define lean manufacturing, the first one considers lean as a way of “thinking” or more of philosophy and defines what lean manufacturing in concept is. The second views lean as a “tool box” and concerned with defining the practices that help in sustaining a lean manufacturing system (Pettersen 2009, Gamal 2011; Almusawi, et al., 2019).

While, Kennedy and Brewer (2006) defined lean manufacturing is a systematic method for waste elimination within a manufacturing system. Lean also considers waste created through overburden and waste created through unevenness in workloads. Working from the perspective of the client who consumes a product or service, "value" is any action or process that a customer would be willing to pay for. So, lean is centered on making obvious what adds value by reducing everything else.
Lean manufacturing is a management philosophy derived mostly from the Toyota production system (TPS) (hence the term Toyota is also prevalent) and identified as "lean" only in the 1990s. TPS is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved.

The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this success. There are some popular ways to begin implementing Lean Manufacturing include creating a “value stream map” (VSM) and focusing your initial efforts on a critical area of your company. This can be followed by sequentially addressing the elements in the VSM according to priority and greatest “bang-for-the-buck” opportunities (Kennedy & Brewer 2006; Neringa et al., 2020).

Theory of constraints (TOC) is another framework used to help companies begin their Lean Implementation. Although TOC is a different approach than lean, it is not wholly incompatible with lean principles. In many ways the main “Constraint” of a company, as well as many of its “Bottlenecks”, will be among the very highest priorities when lean manufacturing efforts are begun, and throughout the entire lean implementation process (Shah & Ward 2003; Al-Halabi N. B., & Shaqqour, O. F. 2018).

In truth, there are unlimited ways to begin and facilitate the implementation of your lean manufacturing program. Although we encourage companies to start their Lean efforts with something that will make a major, even bottom-line difference, it is more important to start getting Lean, than to talk about getting lean year after year as some companies do.

Widely adopted throughout the world, and gaining ground in less industrialized nations, Lean Manufacturing has become a global standard or set of practices which virtually all companies must adopt to be competitive in a global economy. Beyond the “need” to compete globally, lean manufacturing principles and processes (even the lean mindset) empowers and motivates employees to engage in the betterment of their respective companies.

Newly, a lot of firms achieved a lot of benefits by changing their production systems moving to lean manufacturing system. These benefits containing creating a better understanding of the business processes for labor workers, improving workers’ productivity skills and decreasing production cycle time and better matching customers delivery dates (Shah & Ward 2003; Akanmu, et al., 2022).
Although more firms changed their production systems to lean manufacturing, other firms rejected the moving process to lean system because they do not see more financial benefits out of the changing (Fullerton, et al. 2014; Almusawi, et al., 2019).

However, this paper uses value stream costing (VSC) as a tool to help lean firms to improve their competitive by providing accurate information about the cost of production to take a correct decision. Maskell, Baggaley et al. (2011) defined Value Stream Costing (VSC) as; “VSC is used to eliminate most of the wasteful transactions associated with production control, materials, and product costing, VSC eliminates the need for standard costing and overhead allocations and creates a simple and effective cost accounting method”. Through using VSC, all costs shall be treated as direct costs that are easily traced to the value stream. While, Kennedy and Brewer (2006) defined VSC as: “value stream represents all activities and resources consumed from the time a customer order is received until the product is delivered to the customer”.

On the other hand, there are some conditions are suggested to apply an effective implementation of VSC; it requires eliminating both sharing of resources and the overlap of people (Maskell, et al., 2011; Binoy, et al., 2023). The firms need full support from top management, perfectly trained and empowered workers are requires to help them to adopted the lean accounting practices (Fullerton, et al., 2014; Almusawi, et al., 2019).

3. Research methodology
It is previously mentioned that the conditions needed for VSC to be implemented effectively seek perfect conditions of a lean manufacturing system. Therefore, a condition in which the products is included in each value stream and passes by the same production process consuming take the same processing time. This is in addition to eliminate any shared resources between the identified value streams as well. So, products in one value stream passes by the same process, the need for overhead cost allocation (allocating costs over the value streams) is eliminated which is the target of those two conditions in order to show that the products in one value stream consume different resources. This resulted in reducing the dependency on costing characteristics to avoid the accuracy related issues. According to the difficulty of applying those two conditions, some producers draw back for applying or for moving to a lean manufacturing system, a more accurate allocation method may be required instead of considering a barrier of shared resources status to implement VSC or to move to lean manufacturing system.
This idea is expanded in the study proposed framework shown in Figure 1, it shows that a condition of no sharing resources is needed to obtain reliable product unit costs using VSC method.
The Lean Accounting Proposed Value Stream Costing (VSC) Method

**Fig 1: study framework: integration TDABC in a lean Environment**

- **First stage**
  - Resources Supplied
    - V.S Time consuming by activity 1
    - V.S Time consuming by activity 2
    - V.S Time consuming by activity 3
  - Estimated to provide accurate product unit cost

- **Conditions for Effective Implementation**
  - An environment

- **The Lean Accounting Proposed Value Stream Costing (VSC) Method**
  - Value Stream I
    - Equipment and machines cost, facilities and maintenance plus all other VS costs
  - Value Stream II
    - Equipment and machines cost, facilities and maintenance plus all other VS costs
  - Production labor, materials and production and operation support costs

- **Reliable Average Cost/unit=Total VSC÷ No. Of units shipped**

- **The Lean Manufacturing System**
  - Specify customer Value
  - Identify Value Streams
  - Keep Process Flow
  - The Pull Principle
  - The Perfection Principle

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*Figures and data presented are for illustrative purposes only.*
At the point when such condition is not achieved a situation of shared resources is initiated which may require the use of a true overhead allocation method like the TDABC system. This is to determine any issues that may happen due to the obliging conditions to executing VSC with respect to product costing. This has the goal of developing more accurate product unit costs that encourage the organization's accounting system to better reflect a user-oriented operating system as lean manufacturing and inevitably help improve the organization's competitive position.

The general research question to test the suppositions of the study framework presented is "Can the Integration of Time-Driven Activity-Based Costing (TDABC) in a lean manufacturing system help improve the product unit cost accuracy?" To answer this research question, three sub-questions should be examined through this empirical study.

1) What is the impact of applying VSC on product unit cost computed for a lean company given a condition of shared resources?
2) Does the integration of TDABC system in a lean manufacturing system result in more accurate product unit cost?
3) Does the integration of TDABC in a lean manufacturing system help in improving the competitive position of the company?

To test the suppositions of the study framework, a case study is applied on company X that is operating in Egypt. This company works in supplying electrical power components and chosen because it is the only one that applies lean manufacturing and value stream processing approach. This company X has three major competitors in the Egyptian market; the three competitors are referred to as companies A, B, and C. To develop realistic figures of product unit cost prior and then afterward applying TDABC, a case study is chosen.

Data is collected from several interviews with the company’s head manager and the head of accounting controllers’ team to understand the costs for the company X and how it computes the unit cost. Two types of analysis are processed: manufacturing data analysis and costing data analysis. Also, a market analysis is used to determine the company’s position among its rivals.

4. Results and Analysis
4.1 Manufacturing data analysis:
In this stage the company’s manufacturing information are investigated to expound how the shared resources condition is created because of current manufacturing status. The VSC map for company X transformers factory was illustrated in Figure 2. Manufacturing process begins at accepting customer orders by sales and marketing department. The engineering, planning, and purchasing department develops the order design, sets its quotation, and
requests materials needed from suppliers. All materials shall be inspected before starting the production process.

The production process includes the production of the transformer’s main component parts and the production of transformers tanks. Production process for the transformer’s main components includes core slitting, core cutting, core stacking, low voltage winding, high voltage winding, active part assembly and connections. At the same time the transformers tanks production process shall be running. Such process includes folding, welding, final assembly, and leakage testing. Finally, both the transformers’ components and the tanks go through a painting and drying process before they go through their final testing process. Then the order is shipped to customers after being completely tested for any defects. All the power transformers from 50 Y to 5000 Y go through the same production process.

That is why - from the company’s head viewpoint – the factory executives did not need to identify various value streams. They only identified one value stream for all the transformers. At the same time the different power and size of the transformers produced entail that they actually take different processing time in each production process (Gamal 2011; Dieste, et al., 2020).

Consequently, such identification of the value stream creates a condition of shared resources. In such condition, all types of transformers are supervised with the same production supervisors, inspected with the same quality controllers and are being processed through the same machines. However, they are in fact using different processing time in most of the value stream processes. This means that the different types of transformers produced use resources differently and as a result they cannot be assigned the same production cost per unit.
4.2 Costing data analysis:

This phase is concerned with the analysis of how the company costs its transformer products in such condition of shared resources. Table (1) shows the total costs for Company X for Transformers as of December 31st, 2021.

The factory produces all types of transformers throughout the year, but due to confidentiality of most of the Egyptian Companies costing data, the data supplied by the Company’s accounting and finance department included the calculations for the per unit costs for both the 500 Y and the 1000 Y transformers only during year 2021. The chief accountant controller reports that since the application of lean manufacturing there were many years in which the demand and consequently the factory production was in the ratio of forty percent of the 500 Y transformers and sixty percent of the 1000 Y transformers. During 2021, one thousand eight hundred transformers were produced. Consequently due to the restrictions on the data supplied for two transformers only, the same demand and production percentages are assumed for year 2021.

In Table (1) the highlighted items represent the overhead costs for the factory. The “basis” column shows the criteria by which each cost is allocated to a transformer unit. From the “basis” column in Table (1) it can be concluded that almost all the overhead costs are allocated more or less on basis of the time equation.
### Table 1: Total Costs for Company X Transformers Plant for Year 2021

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Basis</th>
<th>Total Cost in EGP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1. Direct material costs</td>
<td></td>
<td>154872426</td>
</tr>
<tr>
<td>1.2. Material overhead</td>
<td>% of DM costs</td>
<td>1471289</td>
</tr>
<tr>
<td><strong>Total material costs</strong></td>
<td></td>
<td>156343715</td>
</tr>
<tr>
<td>2. Direct manufacturing costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1. Manufacturing process cost (MPC)</td>
<td>No. of production units</td>
<td>4875099</td>
</tr>
<tr>
<td><strong>Total direct manufacturing costs</strong></td>
<td></td>
<td>4875099</td>
</tr>
<tr>
<td>3. Manufacturing overheads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1. Engineering and design</td>
<td>% of MPC</td>
<td>902870</td>
</tr>
<tr>
<td>3.2. Quality cost</td>
<td>% of MPC</td>
<td>497069</td>
</tr>
<tr>
<td>3.3. Maintenance</td>
<td>% of MPC</td>
<td>1247060</td>
</tr>
<tr>
<td>3.4. Other production OH</td>
<td>% of MPC</td>
<td>4704956</td>
</tr>
<tr>
<td><strong>Total manufacturing overhead costs</strong></td>
<td></td>
<td>7261955</td>
</tr>
<tr>
<td><strong>Total manufacturing costs (TMC)</strong></td>
<td></td>
<td>168480769</td>
</tr>
<tr>
<td>4. Technology and product development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1. Product / system development</td>
<td>% of TMC</td>
<td>5896827</td>
</tr>
<tr>
<td><strong>Total technology and product development costs</strong></td>
<td></td>
<td>5896827</td>
</tr>
<tr>
<td>5. Other special direct costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1. Provision for warranties</td>
<td>% of total material costs</td>
<td>781715</td>
</tr>
<tr>
<td>5.2. Financing costs;</td>
<td>% of TMC</td>
<td>1684807</td>
</tr>
<tr>
<td>* Calculated interest</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total special direct costs</strong></td>
<td></td>
<td>2466522</td>
</tr>
<tr>
<td>6. Contingencies and provisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1. Contingency for material increase</td>
<td>% of TMC</td>
<td>3369615</td>
</tr>
<tr>
<td>6.2. Provision for currency risk</td>
<td>% of TMC</td>
<td>1684807</td>
</tr>
<tr>
<td><strong>Total contingencies and provisions</strong></td>
<td></td>
<td>5054422</td>
</tr>
<tr>
<td><strong>Total production costs (TPC)</strong></td>
<td>TMC+4+5+6</td>
<td>181898540</td>
</tr>
<tr>
<td>7. Sales and administration costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1. Sales and marketing costs</td>
<td>% of TPC</td>
<td>3637980</td>
</tr>
<tr>
<td>7.2. General and administration costs</td>
<td>% of TPC</td>
<td>9367767</td>
</tr>
<tr>
<td><strong>Total sales and administration costs</strong></td>
<td></td>
<td>13065747</td>
</tr>
<tr>
<td><strong>Full costs</strong></td>
<td>(production + sales and administration costs)</td>
<td>194904287</td>
</tr>
</tbody>
</table>
This is because, the main manufacturing process cost (MPC in Table 1) is computed on basis of the output units produced and the remaining overhead costs are allocated to individual transformer units as a percentage of this manufacturing process cost. Consequently, Company X Transformer factory uses the ABC costing method of overhead allocation. The case study focuses on the unit cost of the 500 Y transformers as the data collected in terms of costs and mainly time of cost drivers – for implementing the TDABC framework – are for the 500 Y transformers. Under the ABC overhead allocation method currently used by company X the cost of one 500 Y transformer during 2021 totals L.E.87, 100 per unit. Company X Transformers factory requires a profit margin of 15%. Accordingly during 2014 the selling price for the 500 Y transformer totals L.E. 102,470.59 per unit.

**In order to develop an answer to the first research question** that intended to test the effect of applying VSC on product unit costs computed in a lean company, given a condition of shared resources. The cost of one 500 Y transformer is first computed using the VSC method. During 2021, Company X Transformers factory received a total of 600 orders which constitutes 2,400 transformers. As mentioned earlier, 1,800 transformers were produced of which 1,400 units were shipped to customers. Given that the factory defines only one value stream for all its transformers produced, the application of VSC to compute product unit cost results in an average cost per unit of L.E. 139217.35 (L.E. 194904287/1400 units). This average unit cost shall apply for all products regardless to the fact that each transformer type (SDT, MDT or LDT) use the Company’s and the factory’s resources differently. The cost computed using VSC far exceeds the one computed by Company X Transformers factory using the ABC overhead allocation method by L.E. 52,117.35. That’s almost 60% increase in the transformer’s unit cost. Table (2) shows a comparison between the selling price of a 500 Y transformer applying the VSC method and the selling price of the same transformer using the traditional overhead allocation method as well as the unit selling price set for the same product by the company’s three competitors.

**Table 2:** Comparison of Selling Prices set by Company X Transformers Factory and Its Competitors for one 500 Y Transformer during 2021.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Company X Transformers Factory</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Selling price/unit in EGP</strong></td>
<td>102470.59</td>
<td>163785.12</td>
<td>103200</td>
<td>104100</td>
</tr>
</tbody>
</table>

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Applying a similar profit margin asked for by the factory to the normal item unit cost registered under VSC gives a selling price of L.E. 163785.12. Contrasting this selling price with the selling price set by the industrial facility's rivals for the 500 Y, demonstrates that it leaves a lot from the selling price set by the contenders of Organization X Transformers industrial facility, which demonstrates that the item unit cost might be twisted. Additionally it will be illogic and fiscally erroneous to set a similar product unit cost for a wide range of transformers delivered despite the fact that they utilize the Organization's assets in an unexpected way. This is not withstanding the confirmation of the Organization's bookkeeping and back controllers and the plant head that the way their distinctive transformer sorts utilize assets goes about as a hindrance to the utilization of any costing strategy that processes a similar production unit cost for a wide range of transformers.

Thus, it can be reasoned that for Organization X Transformers production line utilizing VSC to figure a normal item unit cost that applies for all items brings about processing off base item unit costs. The mistake of item unit cost might have its impact on the item's cost what's more, therefore may contrarily influence the processing plant's aggressive position.

In the meantime, Organization X Transformers manufacturing plant still rely on upon product unit cost to value its neighbourhood and sent out items which incorporate 30% of its aggregate created units. Additionally even despite the fact that the plant utilizes a draw generation approach regardless it utilizes item unit costs for some closure stock valuation purposes. This is on account of the production line gets substantial requests that require a long generation execution period that may achieve one year. Therefore, processing an exact item unit cost is of much significance to the industrial facility's operations and to guarantee precise item estimating choices. Thus, given these conditions for Organization X Transformers industrial facility, a use of a TDABC system to register item unit cost may help process more exact item unit costs and may resolve any costing twists that come about because of distinguishing just one value stream for the three fundamental sorts of transformers.

Using the TDABC system to allocate overhead costs to one unit of the 500 Y transformer results in a unit cost of L.E. 86211.4 for year 2014. Table (3) shows a comparison between this product unit cost, the one computed by the company and the one computed using the VSC method. As shown in Table (3), computing the unit cost for one 500 Y transformer using the TDABC system results in a lower unit cost, compared to the product’s unit cost computed using the ABC costing overhead allocation method. This cost is lower by L.E. 888.6 per unit, such difference may seem trivial but in
concept the application of TDABC provides more insights on the time of cost drivers behind the company’s costs.

These findings answer the second research question which challenges the ability of TDABC to provide accurate product unit costs in a lean environment. Actually, the application of the ABC approach to overhead allocation is found to provide a cause-and-effect relationship between the company’s costs and their time drivers. This is achieved through the use of accurate cost drivers that explain how the resources of the company are being used.

Table 3: Unit Cost for one 500 Y Transformer using Different Approaches to Product Costing computed for Company X Transformers Factory in 2021.

<table>
<thead>
<tr>
<th></th>
<th>ABC Costing</th>
<th>VSC</th>
<th>TDABC Costing</th>
<th>TDABC-ABC</th>
<th>TDABC-VSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per unit</td>
<td>L.E 8710</td>
<td>L.E 139217.35</td>
<td>L.E 86211.4</td>
<td>L.E -88.6</td>
<td>L.E -53005.95</td>
</tr>
</tbody>
</table>

Also, computing the product unit cost under the suggested TDABC reinforces any costing distortions that the use of the VSC method may initiate under such condition of shared resources. This is shown in the huge difference between per unit costs computed for the 500 Y transformers under the TDABC and VSC, a difference of L.E. 53005.95 per unit. This also coincides with the study and the factory executives’ opinion that in concept when the main three types of transformers produced actually take different processing time and use the company resources differently, computing an average product unit cost that applies for all products produced does not provide accurate computation of product unit cost. That is why TDABC computes more accurate product unit cost compared to the ABC costing system adopted by Company X and to the lean accounting VSC method.

In an attempt to develop an answer for the third research question on the ability of TDABC to enhance a lean company’s competitive position, the selling price of a 500 Y transformer is computed using the product unit cost computed using the TDABC system.

Table (4) presents a comparison between this selling price and the one computed by Company X Transformers factory as well as the one computed using the VSC method and the selling price set by the three competitors of the company for the same product. The inaccurate product unit cost computed using VSC is reflected in achieving the highest selling price for Company X Transformers factory that highly departs from its competitors.
Table 4: Comparison of Selling Prices set by Company X Transformers Factory and Its Competitors for one 500 Y Transformer during 2021.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Selling price/unit in EGP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company X Transformers Factory</td>
<td>103785.12</td>
</tr>
<tr>
<td>Company A</td>
<td>103200</td>
</tr>
<tr>
<td>Company B</td>
<td>102000</td>
</tr>
<tr>
<td>Company C</td>
<td>104100</td>
</tr>
</tbody>
</table>

This large difference between the 500 Y unit cost computed using VSC and using the TDABC suggested framework affects the company’s pricing decisions and thereby affects it’s the competitive position as well. Table (5) also shows that given this condition of shared resources, the application of the TDABC approach to overhead allocation can help support lean manufacturing principles. Actually, the use of most of the time cost drivers mentioned previously is found to support lean behaviours and motivate waste elimination.

The use of time of sales orders as a driver for sales and marketing costs, engineering costs as well as general and administrative costs supports the lean manufacturing pull principle. Allocating these overhead costs on basis of the time of sales orders promotes sales and not overproduction behaviours as lower overhead rates are achieved with more sales. Promoting sales in a lean environment requires a better understanding of the customer value adding activities and better meeting the customer demanded quality level and delivery times.

Table 5: Summary of Cost Activities and How their Cost Drivers can Support Various Lean Principles.

<table>
<thead>
<tr>
<th>Cost activity</th>
<th>Time driver</th>
<th>Supported lean principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales and marketing</td>
<td>Time of sales orders</td>
<td>Value and pull principles</td>
</tr>
<tr>
<td>Engineering, planning and purchasing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General and administrative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labour-based production activities</td>
<td>Labour hours</td>
<td>Waste elimination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous improvement</td>
</tr>
<tr>
<td>Machine-based production activities</td>
<td>Machine hours</td>
<td>Waste elimination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous improvement</td>
</tr>
<tr>
<td>Maintenance and insurance costs</td>
<td>Machine hours</td>
<td>Flow principle</td>
</tr>
<tr>
<td>Testing and quality control</td>
<td>Time for units inspected</td>
<td>Value principle</td>
</tr>
</tbody>
</table>
Also, the use of time for units inspected as a cost driver for quality control activities motivate the lean manufacturing value principle. This is because achieving low quality cost rates may indicate that more products are being inspected which signifies the factory’s due concern to maintain good quality products that meet the customer needs. 

The fact that costs for labour-based and machine-based activities are assigned to transformer units on basis of the actual labour hours and actual machine hours worked help separate the idle capacity costs from the actual cost used by the transformers produced. Such isolation highlights the costs of wasted resources that can be either eliminated through continuous improvement efforts or can be used to produce other demanded products. Also, using machine hours as the cost driver for maintenance and insurance costs helps support the lean manufacturing flow principle.

Also, according to the applied case study most of the value stream activities for Company X Transformers factory are value adding activities as each step add a value to the customer starting from the receipt of sales orders till the delivery of products. However, if the factory succeeded to apply an effective pull purchasing system in which suppliers are involved in supporting the flow of the production process. The Company can eliminate a lot of the materials inspection costs which add up to the costs of testing and quality control activities. It may also lead to decreasing the provision for warranty costs since in such pull purchasing system less defective units are expected to be produced.

Finally, the way TDABC links costs to their causes through the use of accurate time of cost drivers helps the calculated overhead rates to act as indicators for the factory’s performance. This suggests that, the application of TDABC can initiate some performance indicators that can be used together with the lean accounting suggested performance measures to better evaluate the factory’s performance. This can also contribute to the factory’s competitive position through the development of more performance measures that promote continuous improvement efforts.

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A low maintenance cost rate may imply less machine hours worked which may indicate a condition of machines breakdown consequently corrective actions can be taken to improve the process flow. This implies that, the way TDABC cost drivers help support lean manufacturing principles can eventually help Company X Transformers factory to better meet customer demands and achieve a good competitive market stand.

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provision for warranty costs since in such pull purchasing system less defective units are expected to be produced. Actually using the number of defective units as the cost driver for warranty costs help show the effect of applying a pull purchasing system and can indicate when the provision for warranty costs shall decrease. The number of defective units can also indicate when materials inspection can be considered as a non-value adding activity. Such identification of value adding and non-value adding activities also support the lean manufacturing approach to waste elimination. This leads to optimizing the process flow, better meeting the customer demands and consequently achieving a better competitive position.

Finally, the way TDABC links costs to their causes through the use of accurate cost time drivers helps the calculated overhead rates to act as indicators for the factory’s performance. This suggests that, the application of TDABC can initiate some performance indicators that can be used together with the lean accounting suggested performance measures to better evaluate the factory’s performance. This can also contribute to the factory’s competitive position through the development of more performance measures that promote continuous improvement efforts.

5. Summary and Conclusion
This research aimed to test the impact of integrating the TDABC allocation method in a lean environment to improve the competitive position of lean firms in a condition of shared resources. After this case study it can be concluded that the application of VSC approach to cost products in lean firms is not incorrect. The integration of TDABC in a condition of shared resources initiated due to an ineffective value stream definition of the studied company’s factory provides an accurate product unit cost. This costing method is more accurate than the traditional overhead allocation method. It is also more accurate than the one computed using the ABC method. TDABC develops a cause and effect relationship that links costs to their time consuming resources. It also helps the studied factory identify value adding and non-value adding activities as well as develop a time related cost drivers that can act as indicators that can support lean accounting performance measures used. Subsequently, this recommends the studied factory managers can better depend on their product costing information to enhance the company's competitive position. This likewise proposes supervisors can turn out to be more persuaded to keep on applying lean standards and turn out to be more developed with lean change. So applying both the operating system (Lean manufacturing) and the costing method (TDABC) will work as an inseparable unit to inspire a superior focused remain for the organization.

6. Future Research
The results of this study should be taken into consideration because it relates to one empirical case study. Moreover, this study tested the use of Value Stream Costing to cost product units. Though further research examining the use of TDABC for product costing with the use of Value Stream Costing for profitability and decision-making purposes in conditions of shared resources.
Also, more studies can use analyze the cost of establishing of TDABC system compared to the benefits achieved from its usage in a lean environment. Finally, more studies are required on the effect of using other allocation method such as the Resource Consumption Accounting (RCA) to overhead allocation.
7. References:


