مجلة التجارة والتمويل

https://caf.journals.ekb.eg/

كلية التجارة – جامعة طنطا

العدد : الثانى

يونيو ٢٠٢٣

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

Ass. Pro. Bassam Baroma [1]

Mostafa I. Elfeky [2]

[1] Faculty of Commerce, Tanta University, Tanta, Egypt

[2] Department of Accounting, Faculty of Commerce, Mansoura University, Mansoura, Egypt

Abstract

Customer needs must be accounted for in all evolving business practices in order to establish significant competitive advantages in the current global market. Moreover, in regard to lean manufacturing systems, conventional costing methods currently in use are obsolete. This research establishes a framework for the integration of Time-Driven Activity-Based Costing (TDABC) within a lean environment, assuming the presence of shared resources. The purpose of this research is to accurately calculate the cost per unit of a product in order to bolster the competitive position of the lean manufacturing system. This case study is implemented at an Egyptian facility of a multinational manufacturing corporation that has recently adopted lean manufacturing. In order to obtain a more precise product unit cost for one of the factory products, the TDABC method is recommended.

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 & 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 & 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 & anderson introduced the time-driven activity-based costing in 2004 to recognize the unused time capacity & solve the ABC problems in determining accurate product unit cost. TDABC is an efficient tool that considers activities performed for each product & 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 & 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 & TDABC on the accuracy of determining product cost per unit & 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)

Kaplan introduced the ABC model in the 1980s as a means of associating costs with the commodities & services produced by an organization. The ABC model is an accounting technique that identifies the activities performed by a company & subsequently allocates indirect costs to its products. By acknowledging the correlation between costs, activities, & products, the ABC system allocates indirect costs to products in a more rational manner compared to conventional approaches (BARRET 2005). Attributing indirect costs, such as salaries for office & management personnel, to a specific product manufactured can be challenging at times.

ABC is primarily utilized in the manufacturing sector because it improves the dependability of cost data, resulting in costs that are closer to reality & enable a more accurate classification of expenses incurred by the business during production. However, it failed to ascertain the unit cost of the product with absolute precision.

The standard procedure for ABC system estimation consists of two stages. After identifying & collecting the cost of resources that perform a variety of tasks, employees are then requested to estimate the proportion of time they spend or anticipate spending on the primary activities. The second approach allocates the cost of activities to cost objects using the activity cost drivers rates, which are determined by the transaction drivers (specifically, the number of orders executed for each object) (Kaplan & 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).

According to a study by Ayvaz & Pehlivanl (2011), firms favored the ABC model for a variety of reasons. For instance, the ABC model assists managers in more accurately analyzing activities, incorporating pertinent cost information into budgets, & estimating customer & product profitability.

Furthermore, the primary obstacles encountered by numerous firms & organizations in implementing the activity-based costing (ABC) system were the substantial expenses & time required to conduct interviews & surveys for the initial activity-based costing (ABC) model (Ayvaz & Pehlivanl 2011). Additionally, the ABC system proved challenging to maintain & update due to factors such as evolving processes & resource allocations, heightened complexity & diversity of individual orders, & a trade-related issue. Additionally, when heterogeneity is introduced within an activity through the addition of new activities to the model, the cost that should be ascribed to the new activity must be recalculated.

Kaplan & anderson (2007) Showed that implementing ABC model encountered the following pitfalls:

*time-consuming & costly related to the interviewing & surveying process to collect data requiring significant resources commitments.

*Subjectively data from ABC model & the difficulty to validate it

*The data for ABC model were expensive to store, process & report, subjective, & 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 & 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 & incorrect costing & timing results (Ayvaz & Pehlivanl 2011).

2.2. Time-driven activity-based costing (TDABC)

Kaplan & anderson (2003) introduced the time-driven activity-based costing (TDABC), a revised version of activity-based costing (ABC), to decrease the drawbacks & overcoming some of the downsides of traditional allocation system (ABC), allows for more heterogeneity in activities, orders, & customer behavior. Another reason helped (Kaplan & anderson 2003) to propose this model is that ABC model failed to offer a cost-effective & sustainable cost management solution(allocation resource costs into activity cost pools) (Ratnatunga, Michael et al. 2012).

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).

Kaplan & anderson (2003) found that TDABC model can be used by organizations to help them in understanding cost & profitability of delivering their products & services with lower costs & short time, & TDABC identifies which customers are profitable & 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 & speed up the whole process, & 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, Michael 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 and anderson 2007, Pernot, Roodhooft et al. 2007, Ayvaz and Pehlivanl 2011).

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, Bruggeman et al. 2008).

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, Witkowski et al. 2014):

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 and anderson 2007).

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 and anderson, 2004)

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, Michael et al. 2012).

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).

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 and anderson 2007).

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, Swiggers et al. 2010).

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) 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).

Moreover, there are two definitions of lean manufacturing: the first defines lean manufacturing in concept and views it as a means of "thinking" or a philosophy. The second perspective characterizes lean as a "toolbox" and is focused on delineating the procedures that contribute to the maintenance of a lean manufacturing system.

Kennedy and Brewer (2006) provided the definition of lean manufacturing as a methodical approach to eliminating waste from a manufacturing system. Furthermore, Lean methodology takes into account waste resulting from workload inequities and overburdening. When considering a product or service from the client's vantage point, "value" refers to any action or process that a consumer is willing to expend money for. Therefore, lean is predicated on identifying what contributes value while eliminating everything else.

The management philosophy known as "lean manufacturing" originated primarily from the Toyota production system (TPS), hence the common usage of the phrase "Toyotas." The term "lean" was not officially coined until the 1990s. Although TPS is widely recognized for its emphasis on minimizing the initial seven wastes in order to enhance overall customer value, differing viewpoints exist regarding the most effective approach to accomplish this.

Toyota's ascent from a modest organization to the preeminent global automaker has prompted considerable interest in the secrets behind its success. Popular approaches to initiating the implementation of Lean Manufacturing encompass the development of a "value stream map" (VSM) and the concentration of initial endeavors on a critical sector within the organization. Following this, the elements in the VSM can be addressed sequentially in order of priority and greatest "bang for the buck" opportunities (Kennedy and Brewer 2006).

The theory of constraints (TOC) is an additional framework that assists organizations in starting their lean implementation. While TOC represents a distinct methodology from lean, it does not completely contradict the tenets of lean. The primary "Constraint" and several "Bottlenecks" of an organization will, in many respects, be regarded as critical concerns from the outset of lean manufacturing initiatives and throughout the lean implementation lifecycle (Shah and Ward 2003).

Indeed, the potential for initiating and facilitating the execution of a lean manufacturing program is boundless. Although we advise businesses to begin their Lean initiatives with something that will have a significant, even financial, impact, it is more crucial to begin achieving Lean than to continue talking about it year after year, as some businesses do.

Lean Manufacturing, which is gaining traction in less industrialized countries and has become a worldwide standard or set of practices that virtually all businesses must implement in order to remain competitive in the global economy, has been adopted on a global scale. Lean manufacturing principles and processes, including the lean mindset, inspire and empower employees to actively contribute to the improvement of their respective organizations, going beyond the mere necessity of global competitiveness.

Recently, numerous businesses have reaped numerous benefits by implementing lean manufacturing systems in place of their traditional production methods. The advantages encompass enhancing labor workers' comprehension of business processes, boosting their productivity abilities, reducing production cycle time, and facilitating more accurate adherence to customer delivery dates (Shah and Ward 2003).

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, Kennedy et al. 2014).

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”.

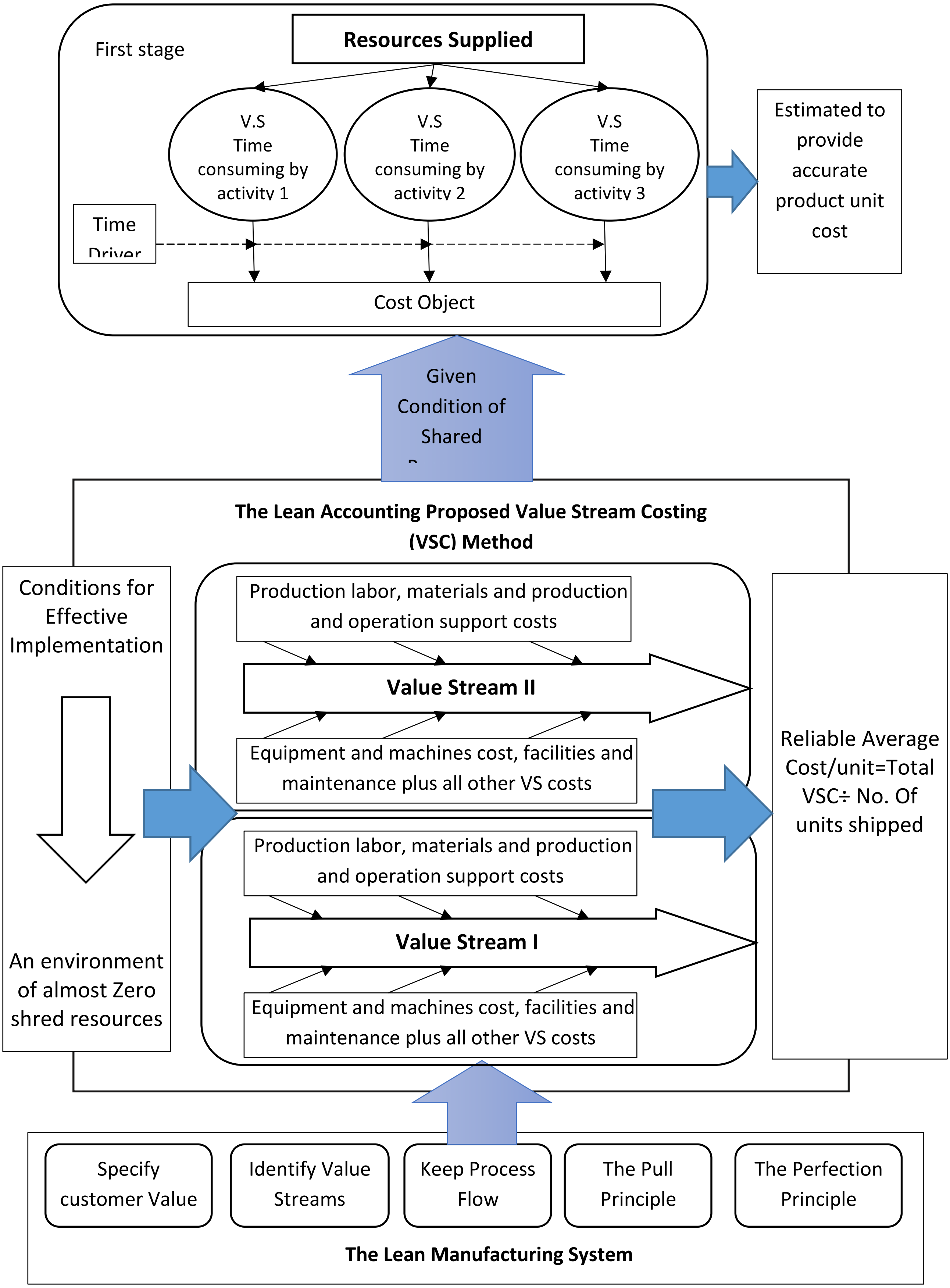
On the other hand, there are some conditions are suggested to apply an effective implementation of VSC; it requires eliminating both sharing of resources and the overlap of people (Maskell, Baggaley et al. 2011). The firms need full support from top management, perfectly trained and empowered workers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

3. Research methodology

As stated earlier, the ideal conditions for the successful implementation of VSC are those that pertain to a lean manufacturing system. Consequently, if a product is included in each value stream and undergoes the identical production process that it consumes, the processing time will be identical. Furthermore, this will ensure that no resources that are shared among the identified value streams are eliminated. By ensuring that all products in a given value stream undergo the same process, overhead cost allocation, which involves distributing costs across all value streams, is obviated. These two conditions serve to demonstrate that the products in a given value stream utilize distinct resources. As a consequence, the reliance on costing characteristics was diminished in order to circumvent issues associated with precision. In lieu of considering the status of shared resources as a barrier to implementing VSC or transitioning to a lean manufacturing system, a more precise allocation method might be necessary in light of the difficulty of applying those two conditions, which discourages some producers from applying or transitioning to a lean manufacturing system.

Expanding on this notion, the framework proposed for the study (illustrated in Figure 1) demonstrates that in order to obtain dependable product unit costs using the VSC method, there must be no resource sharing.

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



When this condition is not met, a shared resources scenario ensues, which may necessitate the implementation of an actual overhead allocation method such as the TDABC system. This is to identify any complications that may arise as a result of the obligatory conditions for implementing VSC in regards to product pricing. Developing more precise product unit costs will incentivize the accounting system of the organization to more accurately reflect a user-centric operating system, such as lean manufacturing, which will inevitably contribute to an enhancement of the organization's competitive standing. 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

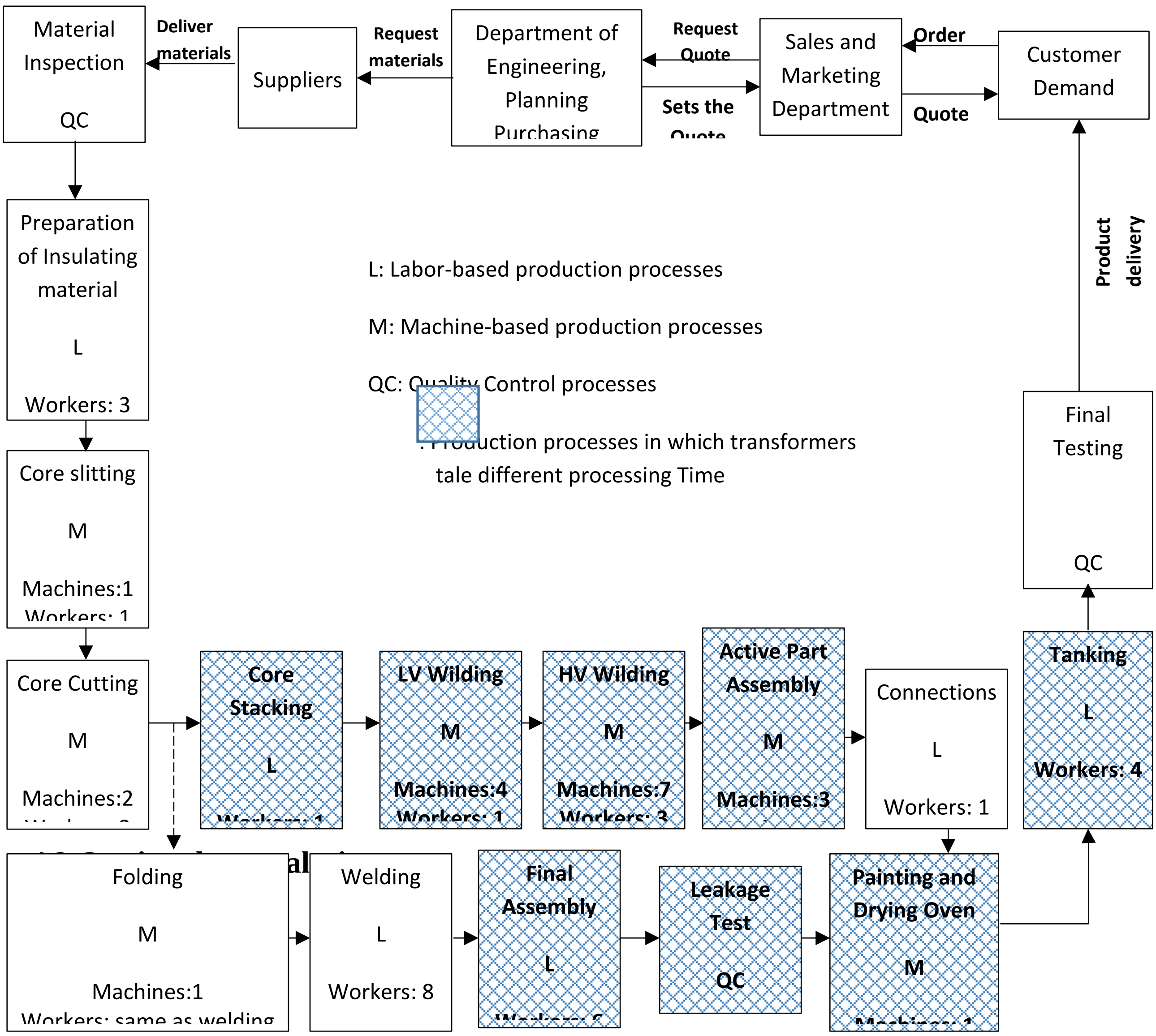
4.1 Manufacturing data analysis:

The manufacturing process of a company involves examining its manufacturing information to determine the condition of shared resources. The process begins with customer orders being received by the sales and marketing department, followed by the purchasing, engineering, and planning department formulating the order design, establishing the quotation, and soliciting materials from suppliers. A thorough examination of all materials is required before production begins.

The manufacturing process involves fabricating primary component sections of the transformer and tanks, including core slitting, cutting, layering, low voltage winding, high voltage winding, assembly, and connections of active parts. The fabrication process for transformer containers must be ongoing, including folding, welding, final assembly, and leakage testing.

In the final phase, both containers and transformer components are dried and painted before undergoing final testing. The order is dispatched to consumers after a comprehensive defect inspection. Every power transformer between 50 Y and 5000 Y is manufactured using the same procedure, resulting in a shared environment where resources are shared. All transformers are subject to identical production supervisors, inspection by identical quality controllers, and processing using identical machinery. However, various processing times are used for most value stream processes, resulting in different production costs per unit.

.Figure 2: VSC map for company X transformers plan



This stage entails the evaluation of the manner in which the organization charges for its transformer products under the shared resource conditions. The total expenses incurred by Company X for transformers as of December 31st, 2021 are detailed in Table 1.

The factory manufactures various types of transformers on an annual basis. However, as a result of the confidentiality regulations imposed on costing data by the majority of Egyptian companies, the information provided by the accounting and finance department of the company only encompassed the per unit costs for the 500 Y and 1000 Y transformers for the year 2021. According to the chief accountant controller, there were several years following the implementation of lean manufacturing during which the factory produced 60% of 1000 Y transformers and 40% of 500 Y transformers in response to demand. One thousand eight hundred transformers were manufactured in 2021. As a result of the limitations imposed on the provided data, which is limited to two transformers, the demand and production percentages for the year 2021 are presumed to be the same.

The highlighted elements in Table (1) correspond to the overhead expenses incurred by the factory. The "basis" column specifies the parameters through which each expense is assigned to a transformer unit. Based on the information provided in the "basis" column of Table 1, it can be deduced that the time equation governs the allocation of nearly all administrative expenses.

Table 1: Total Costs for Company X Transformers Plant for Year 2021

Cost Item	Basis	Total Cost in EGP
1. Material		
1.1. Direct material costs		154872426
1.2. Material overhead	% of DM costs	1471289
Total material costs		***156343715***
2. Direct manufacturing costs		
2.1. Manufacturing process cost (MPC)	No. of production units	4875099
Total direct manufacturing costs		***4875099***
3. Manufacturing overheads		

3.1. Engineering and design 3.2. Quality cost 3.3. Maintenance 3.4. Other production OH	% of MPC % of MPC % of MPC % of MPC	902870 407069 1247060 4704956
Total manufacturing overhead costs		***7261955***
Total manufacturing costs (TMC) 1+2+3		***168480769***
4. Technology and product development 4.1. Product / system development	% of TMC	5896827
Total technology and product development costs		***5896827***
5. Other special direct costs 5.1. Provision for warrantees 5.2. Financing costs: • Calculated interest	% of total material costs % of TMC	781715 1684807
Total special direct costs		***2466522***
6. Contingencies and provisions 6.1. Contingency for material increase 6.2. Provision for currency risk	% of TMC % of TMC	3369615 1684807
Total contingencies and provisions		***5054422***
Total production costs (TPC) TMC+4+5+6		***181898540***
7. Sales and administration costs 7.1. Sales and marketing costs	% of TPC	3637980

7.2. General and administration costs	% of TPC	9367767
Total sales and administration costs		***13005747***
Full costs (production + sales and administration costs)		***194904287***

This is due to the fact that the main manufacturing process cost (referred to as MPC in Table 1) is calculated based on the quantity of output units manufactured, while the residual overhead costs are distributed to specific transformer units in proportion to this MPC. As a result, Company X's Transformer factory allocates administrative expenses using the ABC costing method. As the collected data regarding costs, and primarily time of cost drivers, for implementing the TDABC framework pertain to the 500 Y transformers, the case study concentrates on their unit cost. The ABC overhead allocation method, which is presently employed by company X, will incur a total cost of L.E.87,100 per unit for one 500 Y transformer in 2021. The transformer factory of Company X demands a 15% profit margin. As a result, the 500 Y transformer sold for a total of L.E. 102,470.59 per unit in 2014.

In order to develop an answer to the first research inquiry designed to examine the impact of implementing VSC on the product unit costs calculated within a lean organization, under the assumption of shared resources. Prior to proceeding, the cost of a single 500 Y transformer is determined utilizing the VSC method. In 2021, the factory of Company X Transformers was entrusted with a cumulative count of 600 orders, equivalent to 2,400 transformers. As previously stated, 1,400 of the 1,800 transformers manufactured were delivered to customers. Considering the factory's exclusive reliance on a single value stream for all transformers manufactured, the utilization of VSC to calculate product unit cost yields an average cost per unit of L.E. 139217.35 (L.E. 194904287 divided by 1400 units). Irrespective of the varying resource utilization of the company and the factory by each transformer type (SDT, MDT, or LDT), this average unit cost shall be uniformly applied to all products.

By 52,117.35 L.E., the cost calculated using VSC significantly surpasses the cost calculated by the Transformers factory of Company X using the ABC overhead allocation method. That is a nearly 60% increase in the unit cost of the transformer. Table 2 presents a comparative analysis of the selling prices of a 500 Y transformer determined by the VSC method, the conventional overhead allocation method, and the unit selling prices established by the three competitors of the company for the identical product.

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

Selling prices for One 500 Y Transformer during 2021					
Company Name	**Company X Transformers Factory**		**Company A**	**Company B**	**Company C**
	ABC costing	**VSC**			
Selling price/unit in EGP	102470.59	163785.12	103200	102000	104100

When a comparable profit margin requested by the manufacturer is applied to the unit cost of a standard item as recorded under VSC, the resulting selling price is L.E. 163785.12. By comparing this selling price to the selling price established by competitors of Organization X Transformers industrial facility for the 500 Y, it becomes evident that there is a significant deviation from the competing selling price. This suggests that the item unit cost may be manipulated. Furthermore, it would be both illogical and fiscally incorrect to establish a uniform product unit cost for all transformers supplied, even though they employ the organization's resources in an unforeseen manner. Despite the assurances of the organization's accounting and back-office managers and the plant manager that the manner in which their various transformer types utilize resources acts as an impediment to the implementation of a costing method that calculates a uniform unit cost for all transformers, this remains the case.

Therefore, it can be deduced that the utilization of VSC by the production line of Organization X Transformers to calculate a standard item unit cost that is applicable to all items results in the processing of off-base item unit costs. The inaccuracy in the unit cost of the item could potentially affect its cost and, consequently, the processing plant's competitive standing.

However, for the time being, the manufacturing facility of Organization X Transformers continues to base its neighborhood valuation on the cost per unit of product and shipped items, which account for 30% of the total units produced.

Furthermore, although the facility employs a draw generation method, it still applies item unit costs for certain closure stock valuation objectives. This is because the production line receives a significant volume of requests that necessitate a generation execution period that can extend up to one year. Consequently, processing an accurate item unit cost is critical to the operations of the industrial facility and to ensure accurate item estimating decisions. Therefore, considering the aforementioned circumstances for the industrial facility of Organization X Transformers, implementing a TDABC system for item unit cost registration could facilitate more accurate costing of units and address any costing complications that may arise from utilizing a single value stream for the three fundamental types of transformers.

Assigning overhead expenses to a single unit of the 500 Y transformer via the TDABC system yields a unit cost of L.E. 86211.4 for the year 2014. A comparison between the product unit cost calculated by the company and the one calculated using the VSC method is presented in Table 3. The results of calculating the unit cost for a single 500 Y transformer using the TDABC system are presented in Table 3. When compared to the ABC costing overhead allocation method, the latter yields a higher unit cost for the product. Although the L.E. 888.6 per unit reduction may appear insignificant, the implementation of TDABC offers greater insight into the temporal factors that influence the costs incurred by the organization.

The aforementioned results address the second research inquiry that casts doubt on TDABC's capability to furnish precise product unit costs within a lean setting. In fact, it has been discovered that the ABC method of overhead allocation establishes a causal connection between the organization's expenditures and the time drivers that generate those expenses. This is accomplished by employing precise cost factors that delineate the manner in which the organization's resources are being utilized.

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

	ABC Costing	VSC	TDABC Costing	TDABC-ABC	TDABC-VSC
Cost per unit	L.E 87100	L.E 139217.35	L.E 86211.4	L.E -888.6	L.E -53005.95

Furthermore, when the product unit cost is calculated using the proposed TDABC, any costing distortions that may arise from employing the VSC method with shared resources are reinforced. The substantial disparity in unit costs calculated for the 500 Y transformers using the TDABC and VSC, amounting to L.E. 53005.95 per unit, demonstrates this. This perspective aligns with the findings of the study and the viewpoints expressed by factory executives regarding the impracticality of applying a single average product unit cost to all manufactured transformers, given that the three primary transformer types produced utilize distinct company resources and require varying processing times. As a result, TDABC's product unit cost calculations are more precise than those of Company X's ABC costing system and the lean accounting VSC method.

To address the third research inquiry regarding the potential of TDABC to improve the competitive standing of a lean organization, the selling price of a 500 Y transformer is determined by utilizing the product unit cost calculated by the TDABC system.

Table 4 illustrates a comparison between the selling price specified here and the prices calculated by the Company X Transformers factory, the VSC method, and the three competitors of the company that offer the identical product. The inaccurate product unit cost calculated using VSC is reflected in Company X Transformers' factory attaining the maximum selling price, which is significantly higher than that of its competitors.

Table 4: Comparison of Selling Prices set by Company X Transformers Factory and Its Competitors for one 500 Y Transformer during 2021.

Selling prices for One 500 Y Transformer during 2021						
Company Name	**Company X Transformers Factory**			**Company A**	**Company B**	**Company C**
	ABC	**VSC**	**TDABC**			
Selling price/unit in EGP	102470.59	163785.12	101425.18	103200	102000	104100

The substantial discrepancy between the 500 Y unit cost calculated via VSC and the suggested framework by TDABC has implications for the company's pricing strategies, consequently impacting its competitive standing. Additionally, Table (5) demonstrates that in light of this shared resource condition, the utilization of the TDABC method for allocating overhead can aid in the implementation of lean manufacturing principles. In fact, it has been discovered that the utilization of the majority of the time cost variables mentioned earlier encourages lean behaviors and waste elimination.

The lean manufacturing pull principle is supported by the estimation of engineering costs, sales and marketing costs, and general and administrative costs based on the time of sales orders. Allocating these overhead expenses in accordance with the timing of sales orders encourages sales rather than overproduction, since increased sales result in reduced overhead rates. In order to increase sales in a lean environment, it is necessary to have a deeper comprehension of the activities that add value for the customer and to satisfy their quality and delivery time demands more effectively.

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

Cost activity	Time driver	Supported lean principle
Sales and marketing Engineering, planning and purchasing General and administrative	Time of sales orders	Value and pull principles
Labour-based production activities	Labour hours	Waste elimination Continuous improvement
Machine-based production activities	Machine hours	Waste elimination Continuous improvement
Maintenance and insurance costs	Machine hours	Flow principle

Testing and quality control	Time for units inspected	Value principle

The lean manufacturing value principle is further motivated by the cost-driving effect of time spent inspecting units for quality control activities. This is because attaining low quality cost rates may suggest that a greater number of products are undergoing inspection, which demonstrates the factory's sincere commitment to ensuring optimal product quality that satisfies customer requirements.

The allocation of costs for labor-intensive and machine-intensive operations to transformer units according to the number of actual machine hours operated and labor hours worked, respectively, aids in the segregation of dormant capacity costs from the actual costs incurred in the production of transformers. This isolation underscores the expenses associated with squandered resources, which may be recouped via ongoing enhancement initiatives or redirected towards the production of alternative in-demand goods. Using machine hours as the cost driver for insurance and maintenance expenses also contributes to the support of the lean manufacturing flow principle.

Additionally, the applied case study indicates that most value stream activities at the transformer factory of Company X are value adding activities, as each stage contributes something of value to the customer, beginning with the receipt of sales orders and concluding with product delivery. On the contrary, should the factory be able to implement a draw purchasing system that effectively engages suppliers in facilitating the production process's flow. Much of the material inspection expenses that contribute to the overall cost of testing and quality control operations can be eliminated by the company. It may also result in a reduction in warranty provision costs, as the implementation of a draw purchasing system is anticipated to reduce the production of defective units.

Lastly, by associating costs with their origins via precise time of cost variables, TDABC enables the computed overhead rates to function as performance indicators for the factory. This implies that the implementation of TDABC may generate performance indicators that, in conjunction with the performance measures recommended by lean accounting, can be utilized to more effectively assess the factory's performance. This can additionally enhance the factory's competitive standing by facilitating the creation of additional performance metrics that encourage ongoing efforts at improvement.

The allocation of costs for labor-intensive and machine-intensive operations to transformer units according to the number of actual machine hours operated and labor hours worked, respectively, aids in the segregation of dormant capacity costs from the actual costs incurred in the production of transformers. This isolation underscores the expenses associated with squandered resources, which may be recouped via ongoing enhancement initiatives or redirected towards the production of alternative in-demand goods. Using machine hours as a time driver for insurance and maintenance expenses also contributes to the support of the lean manufacturing flow principle. A reduced rate of machine maintenance expenses could potentially signify a malfunctioning machine condition, in which case corrective measures can be implemented to enhance the efficiency of the process flow. This suggests that the manner in which TDABC cost factors facilitate the implementation of lean manufacturing principles could ultimately assist the factory of Company X Transformers in attaining a competitive market position and effectively satisfying customer demands.

Additionally, the applied case study indicates that the majority of value stream activities at the transformer factory of Company X are value adding activities, as each stage contributes something of value to the customer, beginning with the receipt of sales orders and concluding with product delivery. On the contrary, should the factory be able to implement a draw purchasing system that effectively engages suppliers in facilitating the production process's flow. Much of the material inspection expenses that contribute to the overall cost of testing and quality control operations can be eliminated by the company. It may also result in a reduction in warranty provision costs, as the implementation of a draw purchasing system is anticipated to reduce the production of defective units.

In fact, employing the quantity of faulty units as the cost driver for warranty expenses can demonstrate the impact of implementing a pull purchasing system and suggest a time when the allowance for warranty costs should be reduced. In certain circumstances, the quantity of faulty units may also serve as an indicator that materials inspection is not a value-adding endeavor. This distinction between value-adding and non-value-adding activities is consistent with the lean manufacturing methodology for reducing waste. This results in enhanced process flow optimization, improved customer demand fulfillment, and ultimately a strengthened competitive position.

Lastly, by associating costs with their corresponding causes via precise cost time factors, TDABC enables the calculated overhead rates to function as performance indicators for the factory. This implies that the implementation of TDABC may generate performance indicators that, in conjunction with the performance measures recommended by lean accounting, can be utilized to assess the factory’s performance more effectively. This can additionally enhance the factory's competitive standing by facilitating the creation of additional performance metrics that encourage ongoing efforts at improvement.

5. Summary and Conclusion

The objective of this study was to examine the effects of incorporating the TDABC allocation method into a lean environment on the competitive standing of lean organizations operating under shared resource conditions. It is possible to conclude from this case study that the utilization of the VSC approach for product costing in lean organizations is not erroneous. As a result of an ineffectual value stream definition at the factory under study, the integration of TDABC under shared resource conditions yields an accurate product unit cost. The precision of this costing method surpasses that of the conventional overhead allocation method. Moreover, its precision surpasses that which was calculated utilizing the ABC method.

A cause-and-effect relationship is established by TDABC between costs and their time-consuming resources. Additionally, it aids the examined factory in distinguishing between value-adding and non-value-adding activities and in developing time-related cost variables that can serve as performance indicators for lean accounting metrics. This suggests that the factory managers who were analyzed can rely more heavily on the product costing data in order to strengthen the competitive position of the organization. This also suggests that managers may become more convinced to continue implementing lean standards and become more proficient with lean change. By integrating the operating system (Lean manufacturing) and the costing method (TDABC), the organization can foster a more steadfast commitment to its objectives.

6. Future Research

The findings of this research ought to be duly considered due to their applicability to a single empirical case study. In addition, the application of Value Stream Costing to the pricing of product units was evaluated in this study. However, additional research is required to compare the profitability and decision-making benefits of utilizing Value Stream Costing in conjunction with TDABC for product costing under shared resource conditions.

Additionally, further research can be conducted to compare the expenses associated with implementing the TDABC system to the advantages gained from its application in a streamlined setting. Lastly, additional research is necessary to determine the impact of resource consumption accounting (RCA) and other alternative allocation methods on overhead allocation.

References:

AbdAllah, & G., S. (2011). A Suggested Framework for the Integration of Activity-Based Costing (ABC) in a Lean Environment to Enhance Companies Competitive Position- A Case Study in Egypt. Rochester.

Ayvaz, E., & Pehlivanli, D. (2011). The Use of Time Driven Activity Based Costing and Analytic Hierarchy Process Method in the Balanced Scorecard Implementation. International Journal of Business and Management, 6(3), 146-158.

Barrett, R. (2005). Time-Driven Costing: The Bottom Line on the New ABC. Business Performance Management Magazine, 3(1), 35-35.

Everaert, P., & Bruggeman, W. (2007). TIME-DRIVEN ACTIVITY-BASED COSTING: EXPLORING THE UNDERLYING MODEL. Cost Management, 21, 16-20.

Everaert, P., Bruggeman, W., Sarens, G., Anderson, S. R., & Levant, Y. (2008). Cost modeling in logistics using time-driven ABC Experiences from a wholesaler. International Journal of Physical Distribution & Logistics Management, 38(3), 172-191.

Fullerton, R., & Kennedy, F. A. (2009). Modeling a Management Accounting System for Lean Manufacturing Firms .

Fullerton, R. R., et al. (2014). "Lean manufacturing and firm performance: The incremental contribution of lean management accounting practices." Journal of operations management **32**(7-8): 414-428.

Gamal, S. (2011). "A suggested framework for the integration of activity-based costing (ABC) in a lean environment to enhance companies competitive position-A case study in Egypt."

Grasso, L. (2005). Are ABC and RCA accounting systems compatible with lean management. Management Accounting Quarterly, 7(1), 12-27.

Horngren, C. T., Foster, G., Datar, S. M., Rajan, M. I., & Baldwin, A. A. (2010). Cost accounting: a managerial emphasis. Issues in Accounting Education, 25(4),789-790.

Kaplan, R. S., & Anderson, S. R. (2003). Time-driven activity-based costing.

Kaplan, R. S., & Anderson, S. R. (2004). Time-Driven Activity-Based Costing. Harvard Business Review, 82, 131-138.

Kaplan, R. S., & Anderson, S. R. (2007). THE INNOVATION OF TIME-DRIVEN ACTIVITY-BASED COSTING,Cost Management, 21, 5-15.

Kaplan, R. S., et al. (2014). "Using time-driven activity-based costing to identify value improvement opportunities in healthcare." Journal of Healthcare Management **59**(6): 399-412.

Kennedy, F. A., & Brewer, P. C. (2006). The lean enterprise and traditional accounting—Is the honeymoon over?, Journal of Corporate Accounting & Finance, 17(6), 63-74.

Kennedy, F. A., & Widener, S. K. (2008). A control framework: insights from evidence on lean accounting. Management Accounting Research, 19(4), 301-323.

Maskell, B. H., Grasso, L. P., Baggaley, B., & Grasso, L. (2011). Practical lean accounting: a proven system for measuring and managing the lean enterprise. CRC Press.

McGowan, C. (2009). Time-Driven Activity-Based Costing: A New Way To Drive profitability. Accountancy Ireland, 41(6), 60-61.

Namazi, M. (2009). PERFORMANCE-FOCUSED ABC: A THIRD GENERATION OF ACTIVITY-BASED COSTING SYSTEM. Cost Management, 23, 34-46.

Pernot, E., Roodhooft, F., & Van den Abbeele, A. (2007). Time-driven activity-based costing for inter-library services: a case study in a university. The Journal of Academic Librarianship, 33(5), 551-560.

Pettersen, J. (2009). Defining lean production: some conceptual and practical issues. The TQM Journal, 21(2), 127-142.

Ratnatunga, J., Tse, M. S., & Balachandran, K. R. (2012). Cost Management in Sri Lanka: A Case Study on Volume, Activity and Time as Cost Drivers. The International Journal of Accounting, 47(3), 281.

Reyhanoglu, M. (2004). Activity-Based Costing System Advantages and Disadvantages.

Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management, 21(2), 129-149.

Stout, D. E., & Propri, J. M. (2011). Implementing Time-Driven Activity-Based Costing at a Medium-Sized Electronics Company. Management Accounting Quarterly, 12(3), 1-11.

Stouthuysen, K., Swiggers, M., Reheul, A.-M., & Roodhooft, F. (2010, September 25). Time-Driven Activity-Based Costing for a Library Acquisition Process: A Case Study in a Belgian University. ELSEVIER, 83-91.