Research Journal of Finance and Accounting
ISSN 2222-1697 (Paper) ISSN 2222-2847 (Online)
Vol.4, No.6, 2013

Product Costing in Lean Manufacturing Organizations

Wafaa Salah[1*] Hanafi Zaki[2]
1. M.Sc., Faculty of Commerce, Cairo University, Egypt
2. Professor of Cost Accounting, Faculty of Commerce, Cairo University, Egypt
* E-mail of the corresponding author: wsalah@gmail.com

Abstract
Lean manufacturing has been widely adopted by many organizations since the early 1990s. At the same time, the traditional accounting methods are almost obsolete with respect to Lean Manufacturing system. It fails to properly assess the operational improvements and therefore new cost management methods are needed to support the newly implemented lean manufacturing system. This paper discusses the drawbacks of traditional accounting methods used in companies that adopt Lean Manufacturing and presents two costing methods compatible with lean manufacturing organizations, Value Stream Costing (VSC) and features & characteristics costing which intended to cast light on the operational improvements achieved in organizations adopting lean manufacturing. Value Stream Costing appears to provide a bridge between operational views and financial views of lean, which enhances the transfer of information from shop level to management level.
Keywords: lean manufacturing, lean accounting, Activity-Based Costing, Value Stream Costing

1. Introduction

Traditional accounting methods are not compatible with lean organizations that have a wide range of low volume products, since it almost certainly leads to distorted cost information. Modern costing methods aim not only to accurately allocate overhead costs, but also to identify areas of waste. To address the industry needs, (Thomas Johnson, 1987) introduced Activity Based Costing (ABC), which objectively assigns costs by identifying cause and effect relationships based on historical data. Once costs of the activities have been identified, the cost of each activity is attributed to each product to the extent that the product uses the activity. In this way, ABC often identifies areas of high overhead costs per unit and so directs attention to finding ways to reduce the costs or to charge more for costly products. ABC has gained the reputation of being more accurate for cost estimation and calculations. However, ABC requirements for redesigning data collection, data manipulation, and reporting have resulted in ABC not being widely adopted by industry (Hughes, 2003).This is due to the great amount of effort and cost to accurately account for each activity and its failure to immediately recognize changes in the manufacturing process (Xueping Li, 2012). (Benjamin S. J., 2009) argued that ABC is simply an extension of traditional accounting, as they stated that ABC simply allocates the overhead into several bases instead of one, as is the case in traditional accounting. For this reason, (Ward, 2004) proposed VSC, the process of allocating all the costs to the product or value stream, rather than a department (Stenzel, 2007).

One of the essential principles of lean thinking is the value stream. Value streams are formed for the products in lean organizations in advanced stage of lean transformation. Manufacturing cells within value streams are structured to make a family of products or parts that require the same manufacturing sequence. The structure for developing a cost methodology that provides decision makers and managers throughout an organization with the accurate and relevant cost information they need to do their jobs effectively is provided by VSC. It is a simpler cost collection method unlike ABC that identifies all cost at each activity. This system is considered the best alternative for lean organizations because it simplifies management and provides visibility for managing continuous improvement (Xueping Li, 2012). This paper discusses the shortcomings of traditional accounting methods and the implementation of VSC, one of Lean Accounting tools as a preferred cost measurement methodology. Also it introduces Features & Characteristics Costing Method for more accurate cost measurement for a specific product.

2. The Obsolescence of the Traditional Accounting Methods in Lean Environment

The intense global competition in 1984 forced organizations to improve their manufacturing system and adopting lean principles. Attention to the quality of products and processes, the level of inventories, and the improvement of work-force policies has made manufacturing once again a key element in the strategies of Organizations intending to be world-class competitors. Such organizations, anticipating difficulty with growth, must adopt cost reduction strategies if they wish to maintain and increase profits. One strategy that can yield returns in competitiveness is Lean Manufacturing, with its relentless concentration on eliminating waste and producing high-quality goods at the lowest possible price. Lean Manufacturing improves the production figures

by eliminating waste in producing a product for cost reduction purposes. However, there remains a major obstacle to the lasting success of this revolution in the organization and technology of manufacturing operations. Most organizations are still using the traditional accounting methods that were developed decades ago for mass production.

Poorly designed or outdated accounting and control systems can distort the manufacturing performance. Traditional accounting methods cannot be allowed to exist in isolation from organization's manufacturing environment if the organization wishes to succeed as a world-class competitor. Lean team leaders state that traditional accounting methods fail to properly assess their operational improvements and therefore ask for new cost management methods. Organizations adopt Lean Manufacturing strategies find that lean practices lead to operational improvements but they do not "hit the bottom-line" because there are neither short-term financial benefits nor product cost reductions. This fact can act as a disincentive to change the production system (Ahlstrom, 1996). In consequence, (Goldratt, 1993) stated that cost accounting is the number one enemy of productivity. The problem with traditional accounting methods fall under five major headings (MASKELL, 2009):

2.1. Lack of Relevance

Traditional accounting reports are not directly related to the organization's strategy. It is, by its nature, primarily financial in the way they collect and report information. But the goals of lean organizations are primarily established nonfinancial. Strategic goals will often make reference to financial objectives and these goals can generally be reported through the financial accounting system but most of the goals are nonfinancial. These include issues such as Products, Markets, Customer value, Quality, Reliability, Flexibility and others. None of these issues is addressed by traditional accounting methods and so it is irrelevant (MASKELL, 2009). The application of cost accounting to pricing is dangerous. Management accounting analysis has become less significant to pricing decisions in recent years because worldwide competition has made product pricing market-driven and not cost-driven. Indeed, the starting point of lean thinking is customer value. Pricing is based on the value created for the customer, and there is no direct relationship between price and cost. The requirement is to set the price according to the needs of the market to give the organization a competitive edge. This doesn't mean that tracking costs is no longer important. Lean organizations are very concerned about costs but they need to use much better methods than standard product costs and variances (Bargerstock, 2012).

2.2. Cost Distortion

Traditional accounting methods is concerned with cost elements, but the pattern of cost elements has changed in recent years, and this detailed analysis is less important. Back when cost accounting was developed, the breakdown of costs into cost elements was quite straightforward. Total cost is determined by adding up material, labor and overhead costs for each level of the bill of material until the final product cost is determined. Obviously, there are some inaccuracies built into the traditional accounting methods. They present serious problems when applied to Lean as direct labor rates are too high for lean. Not many years ago, direct labor was a large part of the cost of a product as much as 30 to 60 percent of total cost. Material costs were low, and overhead was much lower. Today, a high-tech manufacturer may experience direct labor costs as low as 2% to 5% of the cost of product, and overhead of 40% to 60% of cost of product. Using the traditional accounting methods in a Lean environment, overhead costs normally can't be traced directly to the product. As a result, a major portion of product cost in Lean Manufacturing is not traceable and therefore not controllable (Stickler, 2009).

(Hyer, 2002) argued that when traditional accounting methods is applied to Lean, unnecessary activities can't be isolated as costs. The traditional system doesn't concern itself much with eliminating waste. While it does chase the cost of direct labor to four decimal places, it overlooks cost-added activities like storing inventory, inspection and material handling, because it does not recognize these as costs. (Cooper R. B., 2008) stated that there was a clear distinction between direct and indirect costs in traditional accounting methods and the same are true of fixed and variable costs. Today, this is no longer the case, and the ideas associated with direct and indirect costs do not apply. Lean organizations emphasize teamwork, continuous improvement, and employee empowerment. These approaches require the previously direct employee to become involved in many activities that were previously done only by indirect people, including scheduling, process improvement, problem solving, interaction with customers and suppliers, and sometimes hiring and firing. Similarly, employees previously considered indirect are in fact actively involved in creating the products and providing services to the customers. These changes blur the traditional distinction between direct and indirect employees and render the concept unhelpful in analyzing and understanding *costs.* VSC includes anyone working in the value-stream to be "direct" and almost everyone in the organization works in one value-stream or another.

Lean organizations do not have much need for calculating costs. Traditional organizations put great emphasis on the costs of individual products, and these costs are used for all kind of decision making, including pricing,

margin analysis, make sourcing decisions, valuing inventory, and so forth. Lean organizations do not require individual product costs for these kinds of decisions. The use of standard costs (or other full absorption accounting methods) is a weapon of mass production, and it is very harmful to a lean organization. Lean organizations do not need to address the cost of individual products, but instead considers the impact of a decision on the entire value-stream costs and profitability, without regard to the cost of individual product.

2.3. Inflexibility

Traditional accounting reports do not vary from plant to plant within an organization. Similarly, they do not change over time as the business needs change. The reports are consistent across the organization, the divisions, and the entire corporation. A single set of numbers controls the whole organization. This does not make sense for a lean organization. An important aspect in the implementation of lean is that each plant is different. They have different products, different processes, different strengths and weaknesses, different problems and different people. For the management reporting to be of value, it must take account of these differences. Similarly, plants change over time, and their management reporting must also change with them. Continuous improvement creates rapid and widespread change throughout an organization. Far greater flexibility and understanding are required. The traditional accounting reports used by senior managers to judge success may show that a plant is performing poorly when, in fact, the plant is doing well and the reports are wrong: they are measuring the wrong items, and this lack of flexibility can become a serious problem when the local managers are working hard to bring their plants up to world-class status (MASKELL, 2009).

According to (J. Bicheno, 2009), traditional accounting methods were essentially backward looking, i.e. not only reporting on past performance, but giving few real pointers how to improve in the future and are not able to reflect accurately the improvements made through lean. Traditional accounting reports are frequently received too late to be of value. Lean organization needs information on time. The timeliness of information will vary according to the need, but it must be up to date and accurate. Traditional accounting methods are usually driven by the financial accounting calendar, and the reports come out monthly. This is not timely and is not useful. In reality, no one in the organization really uses these reports to control the business; they are available too late to be useful.

2.4. Incompatibility with Lean Principle

One of the essential principles of lean thinking is the value stream. Value streams are formed for the products in lean organizations. Manufacturing cells within value streams are structured to make a family of products or parts that require the same manufacturing sequence. Lean organizations make money by maximizing flow on the pull from the customer, not by maximizing resource utilization. Traditional accounting system gives mixed messages that operational improvements are not working or resources are underutilized even performances are improved. The enormous changes in a Lean Organization force to change the traditional accounting practices, especially standard costing system. Standard costing system may not work well in a lean environment; in fact it is against Lean Manufacturing (Jochen G. Schunter, 2007). Lean Manufacturing violates all the assumptions of mass production. Whereas mass production is based on achieving economies of scale through long production runs, lean focuses on making products one at a time. It is no wonder, then, that these accounting methods lead people to do the wrong things, such as out-source items that should be in-sourced. In addition, the methods are complex and confusing to generate, they provide a misleading understanding of cost, and they lead to wrong management decisions on important issues, such as make/buy, profitability of sales orders, rationalization of products or customers, and so forth ((Haskin, 2010), (Hyer, 2002) and (Brian H. Maskell, 2004)).

Traditional accounting methods carefully measure machine and labor efficiency and utilization rates which encourages the production of large batch quantities. This is very harmful to Lean Manufacturing because it encourages people to produce more than they need which violate lean principles. It is better to have low labor efficiency than to build inventory for keeping machines busy or people occupied. Traditional accounting methods require much detailed data that is costly to obtain. The cost of obtaining the information required by traditional accounting methods is enormous and unmeasured. Included in the costly and irrelevant areas of cost tracking following activities:

- Reporting of labor hours
- Tracking of job-step completion on the shop floor
- Reporting of materials issued to production jobs
- Tracking of work-in-process (WIP) inventory
- The whole work-order process
- Reporting production completions

There is an incorrect theory that in order to control the business, everything must be tracked and checked in details. But in recent years it was discovered that the opposite was true. A lean organization creates control

within its organization by bringing its processes under control. Excellence and proactive control do not come from checking and tracking everything; they come from studying and perfecting every process in the organization by eliminating the root causes of the chaos (MASKELL, 2009).

2.5. Inappropriate Links to the Financial Accounts

Traditional accounting methods must provide support to business operations, not merely background for external financial reporting. This applies to such issues as inventory valuation, overhead absorption and accounting periods. A traditional organization had long production cycle times and large inventories and, therefore, it required detailed systems to support the valuation of inventory, raw materials, work in process, and finished goods. In contrast a lean organization strives to make cycle times very short and inventory very low. Therefore, there is no need to keep detailed track of materials and certainly the inventory value in detail. The traditional idea of posting inventory value across to the balance sheet at standard or actual cost is no longer significant. Inventory values can be posted in macro terms based on receipt costs minus stock. There are several ways of handling these issues that don't require integrating the financial accounts and the management accounts.

2.6. Expensive to Maintain

Traditional accounting methods also create a detailed system of accounting for recording each and every transaction to trace the flow of processes through different stages of production. In a single-product environment, standard costing will be easy to maintain and can produce meaningful reports for control. In a multiproduct, Lean Manufacturing environment, where each process can produce a variety of products, maintaining detailed product accounts is considered as wasteful. The use of standard costing in such an environment may produce volumes of variance reports that may not only be difficult to analyze but may also not provide any meaningful information to exercise control (Solomon, 2007).

2.7. Divert the Accountant's Attention from More Important Matters

Talking about the roles of an accountant, it is reported that the average accountant in manufacturing organization spends up to 75% of his time on bookkeeping activities and less than 10% on analysis and process improvement (MASKELL, 2009). The job has been reduced to a backward looking, reactive recording and dissemination of data that, if it could be done by a machine, would make the accountant entirely unnecessary. There is a need to move accountants away from detailed bookkeeping, tracking, and checking and to give them the tools to help create excellence in the lean organization's operations.

2.8. Failure to Link Strategy to Product Cost

There is general agreement that traditional accounting methods are appropriate in manufacturing environments that exhibit a high degree of standardized processes, similar and limited product lines, mature product lines, and a high percentage of direct costs. This stands in contrast to most advanced manufacturing facilities today, where overheads typically represent the single largest percentage of total production costs and direct labor comprises the smallest share at 10% or less. The allocation of overheads by means of direct labor content under traditional accounting system has led manufacturing managers to focus attention on direct labor variances not to control direct labor costs, but, rather, to control the allocation of overhead costs to each product. The increased magnitude of the manufacturing overhead burden and the corresponding decrease of direct labor components in advanced manufacturing facilities have led practitioners and researchers alike to search for a more relevant cost management system to reflect the fundamental changes in manufacturing.

ABC quickly became a popular focus for consultants and researchers in the early 1990s. ABC is not radically different from the more prevalent traditional accounting methods it replaces. ABC simply accumulates overheads into activity pools and then allocates them to products by specific cost drivers instead of what may be a single generic, and often irrelevant, driver such as direct labor hours. ABC attempts to better model the relationships between the final product and the resources used at all stages in its manufacture, thus tying the activity costs to the appropriate activity driver (HUTCHINSON, 2007). ABC theoretically provides a more accurate and consistent method for calculating manufacturing costs, which may better highlight the constraints driving costs on the manufacturing floor. Although conceptually easy to understand, ABC has proven problematic for those firms that have attempted to implement it. Many ABC systems introduced in recent years have been regarded as failures. In most cases, the effort required in identifying and modeling the individual cost-driving activities within a manufacturing process from beginning to end does not justify the cost. Accuracy is often determined by the willingness of employees in manufacturing support functions to report their true time allocations, and—as one might expect—rarely does this add up to anything other than 100%.

It is not that traditional accounting methods is wrong. Standard costing was created in times when organizations operated in a stable environment and used mass production techniques such as large batch sizes. The most important cost was direct labor and therefore other costs were allocated as a percentage of labor cost. The principles of Lean Manufacturing are quite different since they are oriented to competitive and changing

environments, where suppliers must quickly adapt to their clients, without costly inventories that could soon become obsolete and therefore unsalable, thus using one-piece-flow plant layouts. Besides, labor cost is currently a small percentage of the total cost. Therefore, it can conclude that traditional accounting methods need renovation and hence, a few solutions to the shortcoming encounter in traditional accounting methods need to be proposed. A lean organization cannot neglect the legally mandatory set of financial statements but may look for an accounting system that is capable of measuring operational improvements and allows the organization to keep operational and financial control of the business. Consequently, there are calls for a new costing and accounting approach to support Lean Manufacturing (Maskell and Baggaley, 2002; deFilippo, 1996; Womack and Jones, 1996). However, there is no clear consensus as to what constitutes appropriate costing and accounting methods for lean manufacturers.

3. Value Stream Costing

VSC is the process of assigning the actual expenses of an enterprise to value streams, rather than to products, services, or departments. At the early stage of implementing Lean Manufacturing, back-flushing is used to calculate the product cost without the need to track the costs while the product is being produced. This process can gradually be eliminated and replaced with VSC since it provides the appropriate information for decision making and it is easy to understand and simple to implement. Lean Manufacturing and lean thinking violate mass production assumptions. Overhead costs are related to the value stream as a whole and not to production labor time. Maximum profitability comes from creating the maximum flow of product through the value stream at the pull of the customer. The cost of any particular product is primarily dependent upon how quickly it flows through the value stream, particularly at the bottleneck operations within the value stream. Value stream managers are much more interested in the rate of flow through the value stream than with the utilization of resources, people's individual efficiency, or overhead allocations (Baggaley & Maskell, 2003). VSC fulfills the needs of lean organizations with little or no monuments.

Monuments are machines or departments shared by more than one value stream. The lean goal is to minimize monuments, but when monuments exist it is necessary to allocate their costs across the affected value streams. The best allocation method is a simple one based on the activities of the monument. It is important to avoid tracking usage of the monument to create the allocation basis. Use a simple analysis at the beginning of the year to establish the allocation rates and adjust the rates annually (Stenzel, 2007). Value-stream costing is one of the cornerstones of accounting in lean organizations. Costs aren't collected by departments, or products, or individual production jobs. Instead, costs are collected by value-stream. There are several reasons for this (MASKELL, 2009):

- Value-stream cost and revenue information can be gathered quickly and simply. When an organization has a well-defined value stream organization, gathering the costs of the value-stream each week is simple and straightforward.
- The cost information is direct cost, with few allocations. This means that the cost information is immediately understandable to the people who need to use it. In contrast, an income statement developed using traditional standard costing or activity-based costing shows the costs based on complex methods of overhead allocation that render the information meaningless and reports provide very little meaningful information for the people who have to use them.
- Allocation of costs leads to meaningless information. In contrast, financial information provided is direct and clear, this means providing meaningful information that people can use with confidence.
- The financial information is timely—typically, weekly. This means that value-stream managers can use this information to control and reduce their costs. The information on the reports reflects recent events. The more frequently information is reported, the better it can be controlled.
- Value-stream cost information is relevant to and actionable by the value-stream managers. The value-stream managers are responsible for the revenues, costs, and profits of the value-stream, and the information on the report is directly relevant to doing their jobs.
- Value-stream costing gives better information for routine decision making such as quoting, make/buy, capital acquisition, sourcing, etc. The reason for this is that the information provided is real. In contrast when decisions are made using standard costs (or any other absorption-based product costing method), the information is not real because it includes a lot of allocation assumptions. Value-stream costing only collects the real costs that have occurred within the value-stream.
- Value-stream costing focuses attention on the value-streams. Managing by value-stream is one of the five key principles of lean thinking. Value-stream costing provides the information for the financial management of the value-streams.

- Value-stream costing fosters and supports value-stream teamwork. The purpose of developing value-stream teams is to create a mini-entrepreneurial organization within the organization that is focused on growing the business for the products manufactured within the value-stream. Weekly value-stream income statements assist in this team-based endeavor.
- The cost and revenue information can be collected using very few transactions. The financial information is a summary of the direct costs of the value-stream for a week. There is no need for detailed and complicated, transaction-based systems common in traditional manufacturing organizations.

VSC can only be effective if the following is in place (Debra Smith, 2005):

- Reporting needs to be by value stream, not by departments.
- The people in the organization must be assigned to value streams with little or no overlap.
- There should be few (or no) shared services departments and few monuments.
- Production processes must be reasonably under control and low variability.
- There must be thorough tracking of "out-of-control" situations and of exceptions like scrap, rework, etc.
- Inventory must be reasonably under control, relatively low, and consistent.

In the early stages of Lean Manufacturing, these criteria may not all be in place. There is usually a transition period when the costs are reported by value stream, but the information is derived from the old-style methods. For example, the organization may be organized in departments, and the people within the value streams are matrixes into the value stream, while still reporting organizationally to a department. The cost information is reported by department. When this occurs the labor costs are calculated for the value stream based upon the number of people working in the value stream. Often organizations use an average cost per head for different categories of people, rather than go to the complexity of tracking each specific person's costs. In the early stages some people are still working in more than one value stream, it is common for the labor costs to be calculated using equivalent heads. This is based upon a simple estimate of the amount of time spent in each value stream. Monuments are dealt with in a similar way. The cost of the monuments is allocated using a simple percentage for each value stream using the monument. Over time the monuments will be eliminated, but this can take a long time. To make VSC work, the value stream processes must be reasonably under control. Performance measurements are a key to understanding if these processes are under control. Performance measurements must be in place and working at the cells, non-production processes, and for the value streams. These will show that the processes are under control and indicate quickly when and where the processes are going wrong. This is why the cell level measures are reported by the hour and by the day. Out-of-control situations can be corrected quickly.

3.1. Costs Included in Value Stream Costing

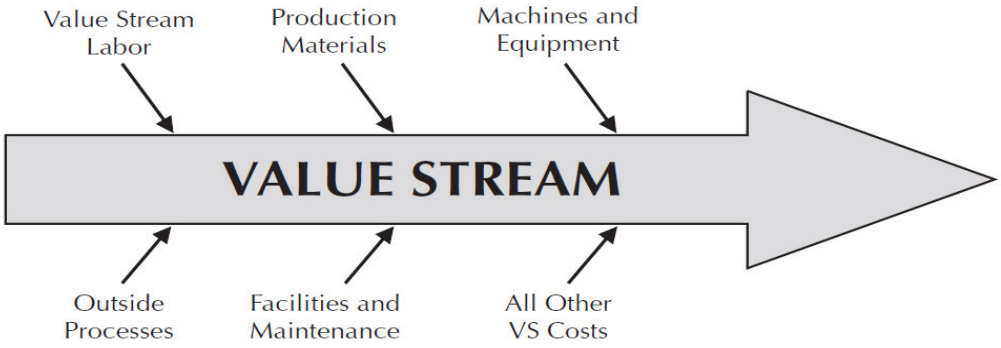
The VSC process begins with a value stream map. The value stream mapping process generates the necessary information on material flow and resource allocation that can then be applied to VSC. The material flow defines which products flow through any particular value stream. The mapping process determines how people, equipment, and space are used by each value stream. From this information, actual value stream costs can be calculated. All costs within the value stream are considered direct costs to the value stream. No effort is made to allocate costs excluded from the value stream into the value stream. Figure 1 illustrates typical value stream costs. Value-stream costs are collected as the direct costs of the value stream for the week or month. The direct costs of the value-stream include Labor costs, Material costs, Machine costs, outside process costs, Facilities costs and other costs.

3.1.1. Value stream labor costs come from an organization’s payroll, based on the actual people who work in the value stream as defined in the value stream map. There is no distinction between “direct” and “indirect” labor in VSC, nor is there a distinction between the work activities of specific employees. Whenever possible, people are assigned directly within a single value stream irrespective of whether they are traditionally “direct” employees or people who support the processes (Stenzel, 2007). Labor hours are not tracked through the production process. Rather, costs are allocated as direct costs at the value stream level. This saves a great deal of unnecessary paperwork (Maynard, 2007).

3.1.2. Value stream material costs are calculated based on the actual material used by the value stream. The actual material used by the value stream can be based on actual material purchased or actual material issued to the value stream from raw material inventory. The decision to use actual purchases or actual issues is a function of an organization’s raw material inventory. If raw material inventories are low (30 days or less, for example) and under control then actual material purchased can be charged to the value stream. This amount can be calculated from cash disbursements made through accounts payable. If raw material inventory is high, then value stream material cost is calculated based on raw material issued to the value stream. This figure can be calculated

from bills of material of product issued to production or from calculating the month-end inventory plus purchases less the previous month-end inventory (Stenzel, 2007).

Figure1: Costs Included in Value Stream Costing (Stenzel, 2007).



3.1.3. Value stream machine cost is the depreciation expense of the machines, in addition to costs such as spare parts, repairs, and supplies. Depreciation expense can be calculated from an organization's detailed fixed asset and depreciation system. Generally, no depreciation is charged to a value stream for fully depreciated assets. However, some organizations determine that they would like to impose a "replacement value" charge on value streams for fully depreciated machines. This is acceptable, provided that replacement value is simple calculation. Other costs of running machines, such as spare parts, repairs, and supplies can be charged to the value stream as part of machine costs if these costs are readily identifiable by value stream in the general ledger. In some cases, these machine costs cannot be easily identified by specific machine or by value stream in the general ledger. An example of such an expense would be fuel or spare parts that are used on many machines. In such cases, these costs can be considered a monument and assigned to the value stream using a simple allocation process.

3.1.4. Outside process costs are tracked visually. Many organizations have the problem that the invoices for the outside processes come too late to provide valid cost reporting on the value-stream income statement. Lean organizations handle these issues visually. A visual board is placed at the shipping dock where the items are shipped to the outside process organizations. Every outside process supplier has a long-term contract with the organization defining the jobs they do, together with the technical information, lead-times, pricing, terms and so forth. When a job is shipped out, the authorizing document is a kanban, and a copy of the kanban is posted on the visual board to show that the job has been shipped out. When a job is received back into the plant the kanban relating to it on the board is turned over: often, the back of the kanban is a different color. At the end of the week, the person in the value-stream responsible for the control of outside processes can easily count how many jobs have been completed this week and calculate their cost. In addition to this, there may be a transaction when the outside process job is received that posts the cost of the job to the value-stream and vouchers the accounts payable account for the supplier. This would maintain a good record of the outside process costs, and it eliminates the need for the contractor to provide an invoice. Payments are made based on the subcontract jobs received, and an invoice is unnecessary.

3.1.5. Value stream facility costs consist of the actual costs such as rent or lease (interest expense if owned), repairs and maintenance, and utilities. Facility costs are allocated to value streams on the basis of square footage of the value stream. The total facilities costs are divided by the total square footage of the building to get the cost per square foot. The square footage of the value stream is multiplied by the cost per square foot. This is the only allocation used regularly within VSC, specifically for the purpose of motivating the value stream to reduce the amount of floor space used by the value stream. The only difference from traditional facilities allocation is that value-stream manager is charged only for the space he or she uses. There will be a good deal of space within the organization that is not charged to any value-stream and is assigned to support cost category. This avoids the problem where the value stream uses less space only to find that the cost per foot has increased and the organization is no better off.

Utility costs can be for both general facilities and/or specific machines. Typically utility costs can be assigned to specific machines and general facilities if the machines are metered and utility bills are broken down by meters. In other cases, certain machines are obviously the primary consumers of utilities and facility utilities are a small portion of the entire bill, in which case the entire utility bill could be charged to the specific value stream. What

is important to remember when dealing with such issues is to keep any methodology both simple and apply it in a consistent manner (Stenzel, 2007).

3.1.6. Other costs of the value-stream include spare parts, supplies, consumable tools, travel, and so forth. It is common for someone in the value stream to be responsible for buying these items. They are mostly purchased from suppliers that have long-term contracts and are paid for by credit card (or purchase card). The responsible person keeps track of what he has spent and reports it weekly (MASKELL, 2009).

3.2. Calculating Value Stream Costing

Traditional standard costing methods are based on the premise that if an organization predetermines what it will cost to make one unit by detailing material, machine and labor time, and support resources (overhead allocation), and if employees can actually make the unit relatively close to that estimate, then the organization is operating efficiently and will meet its profit goals. Accountants then calculate variances on all of the resource categories to help managers spot where they may be falling short. The calculation and use of overhead rates is an integral part of this process and represents a substantial portion of overall unit product cost. Total overhead are divided by the number of units produced (or other volume-related base, such as labor or machine hours) to calculate an overhead rate per unit. Inherent in this calculation are the effects of changes in production volume. As more units are produced, the rate decreases, resulting in a lower product cost; fewer units produced means a higher product cost (Frances A Kennedy, 2005).

Lean Manufacturing is based on a "pull" system, whereby actual product costing motivates producing only to order, and completing shipments from existing finished goods inventory when possible. Standard costing, on the other hand, provides incentives to produce more inventory than may be needed. Product costs are used in pricing and profit planning, outside sourcing decisions, and special order decisions. Standard costs are typically used for all of these purposes and the results of these decisions are only as good as the standard. Most standard costs are determined on an annual basis at the beginning of the year when budgets are approved and overhead rates for the year are set. Many organizations make these critical decisions using product margin reports as the key information. As the year progresses, the standard costs become increasingly inaccurate as the business environment and the internal processes change. Important decisions are based on outdated costing information (Frances A Kennedy, 2005). The overall premise to determine product costs within a value stream is that of an input/output model. It is necessary to first collect and add all of the value stream inputs together including labor, conversion, fixed, and material costs (Table 1). To determine an average unit cost, total value stream costs are divided by the total value stream outputs in units.

$$Average\ Product\ Cost\ Per\ Unit = \frac{Total\ Value\ Stream\ Inputs\ (Costs)}{Units\ Produced}$$

The greater the similarity of products in the value stream, the easier the costing process. As product variety increases, additional steps will be required to account for the various product features and benefits. One major objective in VSC is to minimize the amount of allocated costs in any given value stream. Each value stream in a value stream organization will contain its own engineering, purchasing, planning, sales, and service teams. If the value stream truly acts like a "mini-business" unit, support functions such as human resources, information technology, and finance also may be included. All of these expenses linked to the value stream are charged as direct costs of the value stream. One of the major differences of VSC is that all costs are directly expensed to the value stream on an actual cost basis. This is in contrast to a standard cost system, whereby costs flow into inventory on a standard cost basis, and upon shipment, are relieved from inventory at the same standard cost basis. All actual cost versus standard cost differences are aggregated on month-end financial statements in the form of variances (Solomon, 2007).

Table 1: The costs for PCB value stream

PCB Oct. 04	Material	Sub-contract	People	Operating Costs	Other	Total
Design		L.E 4,000	L.E 6,000			L.E 10,000
Purchasing			L.E 2,000			L.E 2,000
SMT Machine	L.E 50,000		L.E 6,000	L.E 5,000		L.E 61,000
Manual Load	L.E 20,000		L.E 10,000	L.E 3,000		L.E 33,000
Test/Rework	L.E 15,000		L.E 5,000	L.E 7,000		L.E 27,000
Warehouse			L.E 2,000	L.E 1,500		L.E 3,500
Shipping			L.E 3,000	L.E 1,500		L.E 4,500
Quality Assurance		L.E 5,000	L.E 3,000	L.E 15,000	1,000	L.E 24,000
Accounting		L.E 1,000	L.E 8,000		1,000	L.E 10,000
Total	L.E 85,000	L.E 10,000	L.E 45,000	L.E 33,000	2,000	L.E 175,000

The total value stream cost for the week amounted to 175,000. During the week in question, the organization shipped 2,000 units of product. The average cost of the product is 87.5. The results of this simple approach to cost accounting are used to create a value stream P&L (Table 2). The P&L includes the revenue from sales of the value stream during the period less the materials and conversion costs expended during the same period. In Value Stream Management, there are some people in the plant or organization who do not work in the value streams. These are people who do tasks unrelated to the value streams (financial accounting for example) or their work crosses all value streams (ISO9000 or ISO14000 support, for example). The costs and expenses associated with these non-value stream tasks are not allocated to the value streams. They are treated as sustaining costs of the business. They are budgeted and controlled, but they are not allocated. There is no need for full absorption costing. The purpose of the VSC is to provide relevant, accurate, and understandable cost information to the people managing the value streams. To absorb into the value stream any costs that occur outside the value stream does not provide anything helpful for managing or improving the value stream processes. The non-value stream costs are inevitably small because most of the work of the organization will be associated with value streams. These costs will be reported on the plant or organization P&L as sustaining costs and people within these areas will be responsible for the elimination of these costs and improvement of the processes (Baggaley B. H., 2004).

Table 2: Value Stream Profit & Loss Statement

PCB Oct. 4		
Sales		L.E 205,000
Material		L.E 85,000
Conversion Cost		
Subcontract	L.E 10,000	
People	L.E 45,000	
Operating Cost	L.E 33,000	
Other	L.E 2,000	L.E 90,000
Total Expenses		L.E 175,000
Value Stream Profit		L.E 30,000

One of the major differences of VSC is that all costs are directly expensed to the value stream on an actual cost basis. This is in contrast to a standard cost system, whereby costs flow into inventory on a standard cost basis, and upon shipment, are relieved from inventory at the same standard cost basis. All actual cost versus standard cost differences are aggregated on month-end financial statements in the form of variances. The following concepts drive the methodological differences between standard costing and VSC (Solomon, 2007):

- In a Lean environment, transactions are considered wasteful activities and symptomatic of out-of-control processes, and are therefore minimized.
- It is preferable to have associates become familiar with the actual expenditures they are creating, even to the point of assigning them the responsibility of tracking their daily expenditures, where possible.
- A simple measurement system is much easier to understand and improve.
- Accuracy is improved as real-time data is utilized.
- In an ideal Lean environment, with single piece flow and instantaneous replenishment, there are few changes in inventory from one period to the next. This makes it possible to simplify the preparation of

financial statements by immediately expensing all *costs* to the value stream in the period in which they occur.

4. Calculating specific product cost for an individual product

If costs are collected and reported by value stream and the average product cost calculated then the cost of individual products is unknown. The question to ask is why is the product cost needed? Standard costs are typically used for some of the following reasons:

- Pricing decisions
- Profit margins on product lines and customer orders
- Performance measurement of the factory (using efficiency measures, utilization measurement, cost variance, and absorption)
- Encourage process improvement through analysis of the product costs and the variances
- Make/buy decisions
- Product and customer rationalization
- Inventory valuation
- Capital decisions

When using VSC it is not necessary to know the cost of specific products to make decisions on these issues. Pricing decisions for lean organizations are never made with reference to the cost of the product. Lean organizations focus on the value created for the customer or the market. It is customer value that determines the price. Customer value has no relationship to product cost. Stating that prices are market driven only lead to another question, "Are organizations making a profit on this product if they sell at this price?" Once again it is unhelpful to determine profitability by referencing the product cost. The right approach is to look at the potential order and work out the effect on the value stream profitability, taking account of any additional costs that will be associated with this new order (Maskell, 2006).

A decision relating to make/buy is again addressed with reference to the profitability of the value stream as a whole, not the individual product. Using a standard cost to determine the make/buy status of an item is very dangerous. The standard cost will almost certainly lead to the wrong decision. If the value stream has the capability of making an item and has capacity to make it, then there is no (financial) reason for making outside. The cost of doing it in-house is virtually nothing because the cost of the machines, the people, and the facility is already being paid for. Standard costs are not required for valuing inventory providing the inventory levels are low and under control. When Lean Manufacturing is introduced, the level of inventory falls substantially. If the inventory level is low then the valuation of the inventory is far less important than when inventory is high. If, for example, a value stream has three months of inventory then it is very important to value this inventory in a detailed way, such as the use of standard costs. If the inventory is less than five days then the materiality of the inventory value to the calculation of the organization's profits and financial position is low.

When inventory is low and under control there are several methods of valuing inventory. These run from the use of average costs, the use of direct material costs but adjusted for the labor and overhead required to bring the valuation up to full absorption, through to a simple calculation based upon the number of days of inventory and the estimation of a day's cost-of-sales amount. Lean Manufacturing creates low and consistent inventory. This in turn enables very simple approaches to inventory valuation. A standard cost is not required for inventory valuation. Indeed a perpetual inventory quantity for each item is no longer required (Maskell, 2006). In general, there is no need to calculate a product cost for an individual product. The idea of an individual product cost is quite misleading, and it leads to misunderstandings about cost and profitability and to poor decisions. In addition, a standard cost is usually calculated to four or five decimal places, giving an illusion of accuracy to something that is full of false assumptions. However there are some cases when a product cost is needed. For example, some organizations need product costs for the purpose of calculating transfer prices between organization locations in different countries because many organizations require costs to be shown on the import/export documents (MASKELL, 2009).

VSC represents the cost of an `average product' that has the average features and characteristics found in the other products. Therefore, the actual cost of any of the products is probably close, but not identical, to the average cost. The difference between the two costs depends on how much the two products are different in their features and characteristics. Therefore, to calculate the cost of a product more accurately, the features and characteristics that differentiate it from the `average product' should be identified and the cost generated from having them should be calculated (Khalil, 2008). When a product cost is required, it can be calculated quite simply by using features and characteristics costing (Figure 2) to calculate product costs when they are needed. Features and characteristics costing create a cost for individual products from an understanding of what truly

affects the cost of one product as it flows through the value stream. Features and characteristics costing recognize that value streams are designed based on the common processes used to make similar products. It is necessary only, therefore, to define how an individual product departs from the norm, and then to understand how significantly that differs from the average. Some products incur more work than others in the value stream so it is important to define the features and characteristics that cause cost and how to use the features and characteristics information to modify the average value stream costs.

In general, the products that require more time to be manufactured consume more cost; this means, the cost of a product is related to its production rate of flow, which in turn is determined by the flow at the bottleneck cell in the value stream. Therefore, all these issues should be considered when using the features and characteristics costing method for calculating the cost of a product. Not only can features and characteristics costing method can be used to calculate the cost of a product already being manufactured but it can also be used to calculate the cost of products that are still in the design stage (Khalil, 2008).

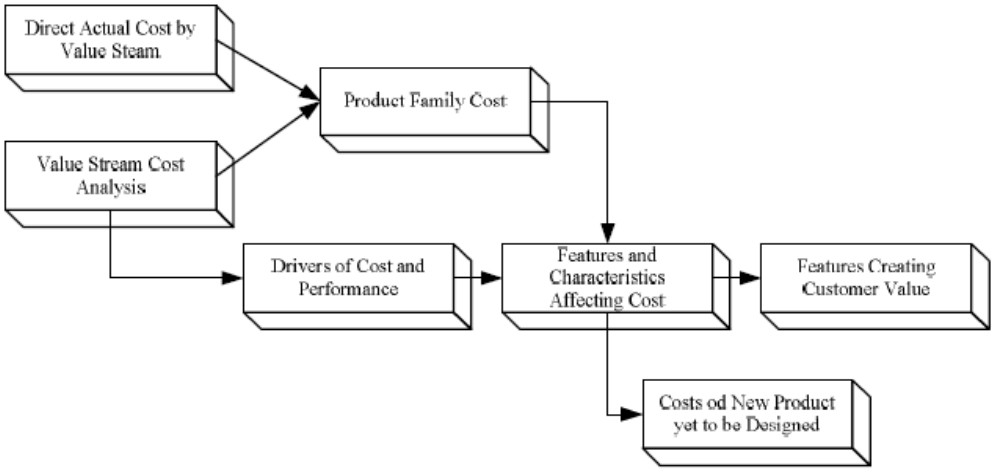


Figure 2: Feature and characteristic costing (STOJANOVIC, 2006)

4.1. What Drives Cost in a Lean Value Stream?

A lean value stream differs markedly from traditional manufacturing, as it is a defined set of processes through which similar products flow. In traditional manufacturing each product has its own unique routing. In lean, the products that have similar production flows are grouped together into a value stream. This grouping greatly simplifies the costing process, because instead of costing out each individual product through multiple routings, managers now have to worry only about the cost of the value stream as a whole. The primary driver of product cost through the value stream is the rate of flow of the individual product. A product manufactured at ten units per hour, for example, has twice the conversion cost of product running at twenty per hour through the value stream. Generally the rate of flow through the value stream is determined by the rate of flow of the product through the bottleneck operation within the value stream flow (Brian H. Maskell, 2004).

The average product cost is equal to the total cost of the value stream divided by the number of units shipped during the period. The number of units that can be shipped is limited to the number that can be processed through the bottleneck operation (Figure 3). The cost of a product is dependent upon the cycle time through the bottleneck operation. In figure 3, the bottleneck process is the drilling operation because the individual process cycle time takes twelve minutes to make a product. Thus, by dividing that cycle time into sixty, five products can be made in an hour (sixty minutes divided by twelve minutes per product). In general, the maximum number of units (Y) that can be processed by a cell (or value stream) during a given period of time (X), given that the bottleneck operation can produce at a rate of Z units per period of time (X), can be calculated using the formula: Y=X/Z. It does matter that other operations take less time to perform. The cell, or value stream, can only work as fast as the slowest (or bottleneck) operation. Now, if all products took exactly twelve minutes to go through the bottleneck, then the average time of twelve would be correct for each and every product. However, in most cases, products in a value stream do not have the same cycle times through the bottleneck operation. Depending on their features, products consume more or less of the bottleneck operation's time than the average. In the example, there may be some products that consume as few as nine minutes and some as many as fifteen minutes. A primary goal of features and characteristics costing is to understand how product features use the bottleneck resource differently (Baggaley B. H., 2004).

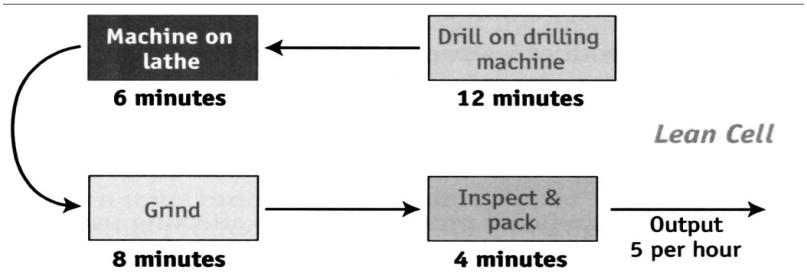


Figure 3: Cycle Times in the Value Stream (Baggaley B. H., 2004)

4.2. How to Use Features and Characteristics

The average value stream cost did not accurately reflect the fact that some of the components required more effort to manufacture than others. There are seven steps to developing features and characteristics products costs (Brian H. Maskell, 2004):

- Calculate the average product cost for the value stream.
- Analyze available capacity.
- Identify the primary bottleneck and pacemaker within the value stream.
- Identify how product features and characteristics affect use of the bottleneck.
- Calculate conversion costs using product features and characteristics' effects.
- Calculate material costs.
- Identify other significant product features affecting use of the bottleneck resource.

5. Conclusions

Traditional accounting methods have the potential to conflict with the implementation of lean manufacturing. Consequently, a new approach to costing and accounting is required to reflect the changes introduced by lean manufacturing. Due to the lack of consensus as to what type of costing and accounting systems are appropriate in a lean environment, this paper provides a valuable mechanism for identifying costing and accounting tools and techniques that may be of benefit to lean organizations for cost measurement. Lean organizations eliminate Standard Costing in favor of Value Stream Costing and Features & Characteristics Costing. This paper presents reorganizing the organization into value streams, the initial critical step in the progression to VSC. It focuses on the analysis and adoption of VSC in manufacturing, one of LA tools as the preferred cost measurement methodology and the precursor to developing "Plain English" profit-and-loss statements. In the early stages of Lean Manufacturing, when an organization is working just on local production cells, there is no need to change the costing system. However, once the move has been made to working by value streams, then VSC becomes the best way to collect the costs and report the value stream profitability assuming the case of few or no monuments. The primary collection and reporting of revenue and costs is the value stream, rather than the product. Income statements are reported for each value stream, usually weekly, and the value stream manager has P&L (profit and loss) responsibility for the products flowing through the value-stream. VSC represents the cost of an `average product' that has the average features and characteristics found in the other products. Therefore, the actual cost of any of the products is probably close, but not identical, to the average cost. The difference between the two costs depends on how much the two products are different in their features and characteristics. In general, there is no need to calculate a product cost for an individual product. The idea of an individual product cost is quite misleading, and it leads to misunderstandings about cost and profitability and to poor decisions. However there are some cases when a product cost is needed. For example, some organizations need product costs for the purpose of calculating transfer prices between organization locations in different countries because many organizations require costs to be shown on the import/export documents. Therefore, to calculate the cost of a product more accurately, the features and characteristics that differentiate it from the `average product' should be identified and the cost generated from having them should be calculated.

References

Ahlstrom, P. &. (1996). Change Processes towards Lean Production the role of the management accounting system. International Journal of Operations and Production Management, 16(11), 42-56.

Baggaley, B. H. (2004). Practical Lean Accounting: A Proven System for Measuring and Managing the Lean Enterprise. New York: Productivity Press.

Baggaley, B. M. (2003). VALUE STREAM MANAGEMENT FOR LEAN COMPANIES, PART I. Cost Management, 23-27.

Baggaley, B., & Maskell, B. (2003). Value stream management for lean companies, Part II. Cost Management, 24-30.

Bargerstock, M. H. (2012). Exploring the role of standard costing in lean manufacturing enterprises: a structuration theory approach. management accounting quarterly, 13(1), 47-60.

Benjamin S. J., M. S. (2009). An improved methodology for absorption costing: efficiency based absorption costing (EBAC). The Journal of Applied Business Research, 25(6), 87-104.

Brian H. Maskell, B. B. (2004). Practical Lean Accounting: A Proven System for Measuring and Managing the Lean Enterprise. New York: Productivity Press.

Cooper, R. (2000). Cost management: from Frederick Taylor to the present. Journal of Cost Management, 4-9.

Cooper, R. B. (2008). How to Manage Through Worse-Before-Better. MIT Sloan Management Review, Cambridge, MA, USA, 58–65.

Debra Smith, P. M. (2005). How Lean Accounting Works - Does it Solve the Measurement Nightmare.

Frances A Kennedy, J. H. (2005). LEAN ACCOUNTING: MEASURING AND MANAGING THE VALUE STREAM. Cost Management, 19(5), 31-38.

Goldratt, E. &. (1993). The Goal (second Edition ed.). Gower.

Haskin, D. (2010). Teaching special decisions in a lean accounting environment. American Journal of Business Education, 3(10), 91-96.

Hughes, S. a. (2003). Do different cost systems make a difference? Management Accounting Quarterly, 5(1), 22–30.

HUTCHINSON, R. (2007). Linking Manufacturing Strategy to Product Cost: Toward Time-Based Accounting. Management Accounting Quarterly, 9(1), 31-42.

Hyer, N. U. (2002). Reorganizing the factory: competing through cellular manufacturing. Portland: Productivity Press.

J. Bicheno, M. H. (2009). The Lean Toolbox (The Essential Guide to Lean Transformation, Buckingham, Production and Inventory Control). Systems and Industrial Engineering.

Jochen G. Schunter, B. Z. (2007). Vom Standard Costing zum Value Stream Costing. Germany: VDM Verlag Dr. Müller: Saarbrücken.

Kaplan, R. (1988). One Cost System isn't Enough. Harvard Business Review, 61-66.

Karlsson, P. Å. (1996). Change processes towards lean production: The role of the management accounting system. International Journal of Operations & Production Management, 16(11), 42 - 56.

Khalil, E. (2008, May). INTELLIGENT PLANNING AND CONTROL OF MULTI-ASSEMBLY SYSTEMS. South Yorkshire, England: Sheffield Hallam University.

Maskell, B. H. (2006). SOLVING THE STANDARD COST PROBLEM. Cost Management, 20(1), 27-35.

MASKELL, B. H. (2009). MAKING THE NUMBERS COUNT (SECOND ed.). LONDON: TAYLOR & FRANCIS GROUP.

Maynard, R. (2007). Count on Lean. BMA Inc, 28-33.

OSTRENGA, M. R. (1998). The Ernst & Young Guide to Total Cost Management.

Solomon, J. a. (2007). Accounting for World Class Operations: A Practical Guide for Management Accounting Change in Support of Lean Manufacturing. Fort Wayne: WCM Associates.

Stenzel, J. (2007). LEAN ACCOUNTING:BEST PRACTICES FOR SUSTAINABLE INTEGRATION. Hoboken, New Jersey: John Wiley & Sons, Inc.

Stickler, M. J. (2009). Achieving World Class Levels of Performance through Lean Manufacturing. Retrieved May 2013, from http://www.empoweredperformance.com/Portals/0/Articles/Achieving_World_Class_Levels_of_Performance_Through_Lean_Manufacturing.pdf

STOJANOVIC, D. &. (2006). ACCOUNTING CHARACTERISTISC IN LEANMANUFACTURING. INTERNATIONAL SCIENTIFIC DAYS, 1146-1151.

Thomas Johnson, R. S. (1987). Relevance Lost: The Rise and Fall of Management Accounting. Boston, MA: Harvard Business School Press.

Ward, Y. C. (2004). Costing for Competitiveness: Cost Management and Accounting for Lean Enterprises. Society of British Aerospace Organizations Publication.

Xueping Li, R. S. (2012). A comparative analysis of management accounting systems' impact on lean implementation. International Journal of Technology Management , 33-48.