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A Comparative Analysis of Management Accounting Systems on Lean Implementation

Karuppuchamy Ramasamy
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Karuppuchamy Ramasamy entitled "A Comparative Analysis of Management Accounting Systems on Lean Implementation." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

Rupy Sawhney, Major Professor

We have read this thesis and recommend its acceptance:

Dukwon Kim, Myong-Kee Jeong

Accepted for the Council:
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Vice Provost and Dean of the Graduate School

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of
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on
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A Thesis
Presented for the
Master of Science Degree
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Karuppuchamy Ramasamy
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My parents have always encouraged and guided me to achieve higher levels in my life and I am grateful to them.

Abstract

The adoption of lean principles and practices has become widespread in many industries since the early 1990's. Companies are now beginning to realize that traditional costing and accounting methods may conflict with lean initiatives they are implementing. Consequently, important research questions are being raised. Which cost management and accounting approach required for companies that adopt lean principles and practices? The primary objective of this research is to asses the impact of different management accounting systems on lean manufacturing as measured by performance metrics and to investigate the development of management accounting strategy which will support lean operations and will help to monitor the lean progress. Three management accounting alternatives investigated in this study are traditional management accounting, activity based costing and value stream costing. This study evaluates the overhead principles associated with management accounting alternatives to identify real product cost that will drive many business decisions. The financial measures commonly used are short-term and long-term profitability.

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Chapter I

Introduction

This introductory chapter begins with role of management accounting systems in manufacturing firms. It then proceeds to state the problem statement that outlines the objective of this research. Further this chapter provides a brief description on different costing methods, which is widely used to enrich decision-making processes. It talks about the need for improved performance measurers that will help to transfer the shop floor movements to the management level. The chapter concludes with a bird's eye view of the organization of this thesis in the subsequent chapters.

1.1 Introduction

Increasing global competitiveness worldwide has forced manufacturing organizations to produce high-quality products more quickly and at a competitive cost. In order to reach these goals, today's manufacturing organizations are required to compete with modern manufacturing paradigms such as lean manufacturing, six-sigma and supply chain management. It is not realistic to obtain all the advantages of theses new production paradigms such as automation, flexibility, quality and throughput without management accounting systems that supports and sustain the new production paradigm.

In the new manufacturing environment, companies attempt to become customer focused and concentrate on quality products at competitive prices. The recent article study states that the most manufacturers at their facilities are not structured to meet customer demands, and there are many roadblocks that make the transition difficult [8]. One of the most important but least understood of these roadblocks is current management systems. These management accounting systems do not provide adequate information to companies to manage a production transition. Under these circumstances, many firms are interested in determining and designing management accounting systems that assist to align the customer demands with manufacturing based improvements.

Various management accounting cost systems are used to provide an increased accuracy about product costs, overhead allocation, product-mix and pricing and other investment decision-makings. Johnson and Kaplan, who introduced the ABC-accounting, have highlighted the fact that management accounting systems are used for three main purposes: external reporting, operational control and product costing. Accounting is generally classified into Financial Accounting and Management Accounting. The Financial Accounting helps to prepare external reporting and management accounting plays an important role in operational control and product costing. Management accounting information systems should collect data related to performance metrics, classifies the data, and report information to managers for the purposes of planning, control and evaluation of production activities [16]. Planning is basically the process of deciding about the goals of an organization as well as the means to attain those goals [32]. Control refers to the process of influencing the behavior of people to increase the probability that people will behave in ways that lead to the attainment of organizational objectives [21]. It includes pricing, budgeting, performance measurement, integration with financial accounts and investment analysis. It consists of all the information that is officially gathered to assess the performance of the company and to guide future actions [1].

1.2 Problem Statement

The most important contribution is to show the impact of management accounting on lean implementation to regain the competitive advantages of firm's short term as well as long-term performance. Poor accounting systems by themselves will not lead to organizational failure. Nor will excellent management accountings assure success. However, management accounting systems must be viewed as an integral part of implementing lean [52]. The result of this study will help the managers to identify an appropriate management accounting alternative to sustain lean manufacturing.

The purpose of this study is to compare various management accounting systems in terms of the alignment of each system to the implementation of lean concepts. This study will compare three different management accountings, which are traditional standard costing; Activity-based costing and Value stream-costing under lean manufacturing environment.

- Assess the impact of different management accounting systems under lean manufacturing environment.
- Investigate the overhead cost allocation of different management accountings under lean environment on a product.
- Check whether the management accounting alternatives has significant contribution.
- Identify the management accounting, which will support lean operations and will help to monitor the lean progress.

Most researchers agree that activity based costing provides more accurate product cost information than any other management accounting system. Most accounting managers assume that this accurate product costs will help to make quality decisions on various issues. This assumption is made with out examining the other non-financial operational parameters like small batch size, resource utilization, on-time delivery, and inventory turn over. Moreover manufacturing environments will also play an important role in many decision making process. According to traditional accounting, the inventory is an asset for the company and it will encourage maximizing the inventory. In contrast modern management accounting says building an inventory is a non-value added activity.

1.3 Background

In traditionally, the costs of direct labor and materials, the most important production factors, could be traced easily to individual products. Relatively little attention is given to reporting and controlling overhead cost and material cost. The major portion of the product cost is overhead cost. Traditional costing computes the product cost based on direct labor, direct material and overhead allocation. This overhead allocation is based on the percentage of direct labor usage for each product. In activity based costing, this overhead cost allocation is traced based on activity level and resource usage of each activity. On the other hand, value stream costing traces the overhead cost based on product family that consumes the resources in the whole value stream.

The survey conducted by the researcher shows that majority of firms operating in an advanced manufacturing environment still recover overheads on a direct labor basis [2]. Consequently, management attention is directed to reducing direct labor by trivial amounts. To reduce their allocated costs, managers are motivated to reduce direct labor, since this is the basis by which all other costs are attached to cost centers and their products. This process overstates the importance of direct labor and directs attention away from controlling escalating overhead costs. A distortion from allocating the relatively small amount of factory and corporate overhead by burden rates on direct labor was minor. Some experiences reveal that the distortion in reported product costs and, in turn, product pricing could be reduced by using activity-based costing (ABC). In traditional cost accounting methods, most companies have produced a narrow range of products. Applying the same methods for a wide range of products with low volume products will lead to distorted cost information. Accurate cost information; such as the production costs and other value-added activities are very important since they are used as a decision base for management and control purposes, from production to marketing. Modern costing methods aim not only to allocate overhead costs accurately, but also identify the areas of waste. It considers that purchasing, receiving, setting up and running a machine consume resources, and products consume activities. These activities trigger the consumption of resources that are recorded as costs in the accounts. Cost management is not confined to cost reduction, but covers enterprise wide activities across different departments aimed at improving overall profitability performance. This involves target costing, capital investment planning, cost maintenance and cost improvement (kaizen costing). The new ways of thinking at Toyota that originated in the production operation

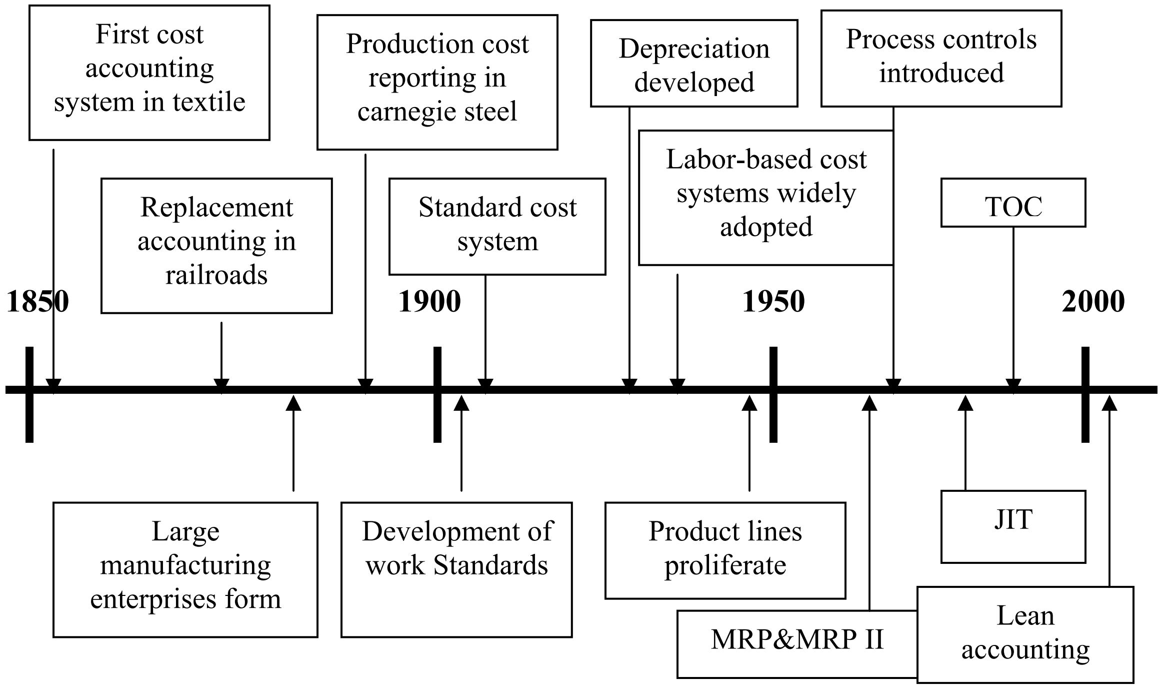


Figure 1 Revolution of management accounting

Source: Adopted from "the complete guide to Activity-Based Costing" O'Guin, M.C.,1991, Prentice Hall.

ended up having implications for capital planning, performance metrics, and many other aspects of the enterprise. For most of this century, traditional costing has been the most popular cost accounting technique for establishing and measuring the various elemental costs within a function or department [62]. One of the major differences among three management accounting systems (TA, ABC, and VSC) is overhead allocation.

The figure 1 illustrates the inceptions of various management accounting systems over many decades. Each accounting system follows different allocation or tracing the various costs that incurred during the different manufacturing stages. Table 1.1 compares the three different management accounting from research point of view. The typical management accounting can be evaluated based on the following criteria.

- Rapid feedback, sensitivity to profit contribution of various activities and products.
- Flexible and migratory measurement systems.

Table 1.1 Comparison of management accounting systems [62]

Characteristics	Traditional costing	Activity-based costing	Value stream costing
Time of introduction.	1900s	1970s	2000s
Type of production	Mass production that has volume related overhead	Any type of production	Mixed model production
Variety of products	Homogeneous and limited variety	Homogeneous and heterogeneous	Heterogeneous and high variety
Automation/Technology usage	Low and limited	Low to high	High
Overhead Allocation	Usually volume related	Based on activity usage	Based on Value stream
Costs included in product cost computation (the difference between cost and selling price is the profit used in product mix algorithm)	Direct material Direct labor Factory overhead (both variable and fixed) The purpose of report is to show how much the budgeted overhead has been allocated as a result of the actual production within the plant.	Direct material Direct labor Factory overhead (both variable and fixed) sales, general and administration Overhead costs charged to cost objects and identifies capacity wastage	Direct material Total value stream labor Value stream overhead (both variable and fixed) sales, general and administration Overhead directly charged to product family and it creates capacity to introduce new products

- Holistic product costing and control measures
- Identification, measurement and elimination of non-value added costs
- Focus on variance reduction in critical areas
- Reclassification of costs based on assignability and value adding characteristics
- Enhanced traceability of costs to specific products and processes to decrease allocations and their distortions.

1.4 Problems with Traditional Costing and Accounting Methods

Adopting a lean approach promises significant improvements in productivity, quality and delivery, resulting ultimately in substantial cost savings. However, although many companies across a range of industrial sectors have introduced lean working practices, lean initiatives are often not underpinned by appropriate and rigorous cost management and accounting methods. Many authors have identified the limitations of traditional costing and accounting methods. The more common criticisms of standard cost include: too much focus on direct labor efficiency; concentrations on cost rather than other competitive factors such as quality or delivery; variances too aggregate and often too late to provide meaningful information; failure to encourage short-term expenditures on such factors as product quality or process flexibility that have a long-term return; and distortion of product costs [67] [52] [37] [35] [45] [8]. Despite these criticisms, standard cost systems continue to be the most common accounting system used today [34].

Kaplan [52] argues that cost systems have been designed primarily to satisfy the financial accounting requirements for inventory valuation and as a result, are not appropriate for performance measurement, operational control or product costing purposes. In addition he states that a good product cost system should produce product cost estimates that incorporate expenses incurred in relation to that product across the organization's entire value chain. He claims that standard product costs usually bear no relation to the total resources consumed by a product. This is due to the fact overheads are allocated, often on the basis of direct labor hours, and as a result can cause distortions to product costs. As overheads need not be casually related to the demands of individual products to satisfy financial accounting requirements, many companies continue to use direct labor as a basis for allocating overheads even though it may account for less than 10% of total manufacturing costs. Cooper [26] and maskell [68] also argue that distortion of product costs, as result of inappropriate allocation of overheads, can lead managers to choose a losing competitive strategy by de-emphasizing and over-pricing products that are highly profitable and by expanding commitments to complex, unprofitable lines.

In addition to product costing, standard costing has also been used for internal decision-making process and operational control purposes. This costing emphasizes maximum utilization for resources (machine, human) in order to minimize the total cost of the product and this encourage the non-lean behaviors. These non-lean behaviors include the manufacture of over production, large batch sizes and holding huge inventory levels to show the balance sheets. Kaplan [25] supports this view and also suggests that cost accounting calculations such as the allocation of overheads or variance analysis should no form part of the company's operational control system because they obscure the information that cost center managers need to operate effectively. As a result, traditional costing and accounting approaches are believed to be a major impediment to lean manufacturing [69] [1]. However, accounting is an integral part of all manufacturing operations and control system and should be able to provide adequate information to make managerial decisions. In order to support the above mentioned, it should include non-financial operational metrics. Consequently, there are calls for a new costing and accounting approach to support lean manufacturing [8] [99]. There is, no clear consensus as to what constitutes appropriate costing and accounting methods for lean manufacturers.

Activity-based Costing (ABC) was developed as a direct response to the problems that can arise as a result of the allocation of overhead on the basis of direct labor. Its main objective is to provide improved product cost information, using appropriate cost drivers as the basis for overhead allocation [25] [26]. However, some advocates of lean manufacturing do not accept that ABC provides the solution to the problems caused by standard costing, believing that "in reality it's just another method of allocating overhead" [99]. The researcher wrote, " After 15 years of studying productivity problems in dozens of companies, I have concluded that in most companies at any given moment, employees are working on the wrong task… the real problem is that workers think that they are working on the right task… traditional measures create this problem." Performance measures are the key element in determining whether or not an improvement effort will succeed. The reason is simple: the actions of individuals in manufacturing are driven by the measures used to evaluate performance. If traditional performance measures conflict with improvement ideas and them often do the measures inevitably will inhibit improvement?

According to a survey conducted by national association of accountants (NAA) and computer-aided manufacturing-International (CAM-I), 60 percent of all the executives polled expressed dissatisfaction with their firms' performance measurement systems, while 80 percent of the executives in the electronic industry were dissatisfied.
A traditional cost-based performance measures have numerous shortcomings. Among the shortcomings, measures [76].

- Do not adequately trace costs of products, processes, activities, etc
- Do not adequate isolate non-value activities
- Do not penalize over-production
- Do not adequately identify the cost of quality
- Do not adequately evaluate the importance of non-financial measures based on quality, customer service, flexibility and throughput etc.
- Do not support the justification for investment in the program to improve non-financial measures.
- Focus on controlling processes in isolation rather than as a whole system and often conflict with strategic goals and objectives.

Making decisions based solely upon resource usage (ABC) is also problematic because there is no guarantee that the spending to supply resources will be aligned with the new levels of resources demanded in the near future. Consequently, before making decisions based on an ABC model, managers should analyze the resource supply implications of such decisions.

Fry [35], who ran a study in an automotive supplier plant that was working on reducing its operating inventories, further supported this argument. He wrote: Despite some of the more publicized success stories such as Harley Davidson, there are an equal or greater number of companies who have been unable to reduce their operating inventories. The reasons for these failures are numerous. In particular, many U.S. manufacturers have failed to successfully reduce inventories due to lack of an appropriate performance measurement system. Many U.S. manufacturers are plagued by an overemphasis on traditional cost-based performance measurement systems that stress the maximization of resource utilizations, in particular, direct labor utilization. Given that many U.S. companies employ a standard cost-accounting system, production managers often focus their attention on controlling standard costs, often at the expense of customer delivery and product quality. In addition, given that standard cost systems normally rely on direct labor as the basis for allocating overhead expenses, operations managers are acutely aware of direct labor efficiencies and direct labor variances [35].

1.5 Manufacturing Control System

Manufacturing control system plays an important role in maximizing the performance of an enterprise. Productivity is a composite measure of everyone’s work in the production facility. Traditional and lean manufacturing environments account this productivity in different ways. A rigid mass production system leads to a highly structured, centralized and inflexible command and control management system. There is a substantial difference between traditional and lean manufacturing systems in employee management, plant layout, material and information flow systems and production scheduling/control methods. These differences make it difficult for organizations that have historically relied on traditional manufacturing methods to predict the magnitude of the benefits to be achieved by implementing lean principles in their unique circumstances. For example in a traditional manufacturing environment work orders serve as the primary documentary for driving production schedules and tracking costs. Costs attach at various workstations and processes as products move through the factory. But work orders are not needed in a lean environment because production takes place in a department or workstation only if the units produced are required by the next workstation. Small lot sizes make it impractical to attach work orders to individual. There is no clear understanding of which costing method supports lean operations. Different manufacturers have implemented various cost accounting systems including back-flush costing, process costing, ABC, standard costing and value stream costing.

1.6 Operational Control – Performance Measures

Performance measures in the mass production environment primarily reflect departmental and individual outputs, not process performance. Traditional measures generally focused on outputs, not inputs or throughputs. On the other hand, Lean manufacturing is an organizational philosophy, which helps to identify and eliminate non-value added activities in manufacturing as well as non-manufacturing environments in order to maximize organizational performance. Lean performance measurement begins with deploying lean business policies and strategies, identify the process owners, complete lean value-added process analysis by utilizing lean standardize/do/check/act (SDCA), and then plan/do/check/act (PDCA) of continual improvement. This could be achievable by identifying improved performance measures. Performance measures provide the critical link between strategy and execution by providing a mechanism to evaluate and communicate performance against expected results. Management accounting system should convert this performance measures into cost information, which allows the managers to quantify the cost of the resources consumed in executing organizations strategies. The case study of Harris [41] on companies that were moving toward JIT, observed that the companies modified their product costing system to meet the JIT environment. Other authors, such as Holbrook [43], and Maskell [67] also argued that the traditional cost accounting measures, especially the ones used to gauge shop floor performance, may lead to decisions that are conflicting to the goal of JIT. Johnson [51] assert that traditional cost accounting tends to impair JIT implementation. This is because the features of cost accounting measures rely on standards, emphasize on variances and efficiencies and preoccupy with direct labor. They further added, In a JIT environment, any system for measuring performance must be designed to reflect the new production philosophy. Such a system should be capable of measuring and reporting progress toward total quality control, reducing inventory levels, faster setup times, reduced lead time and new product launch times. Equally important would be measures indicating improvement in on-time deliveries, floor space utilization and quality yield… such a system may require the elimination of some traditional short-term financial measures and include some new, more relevant non-financial measures of performance. [51].

Lummus and Duclos [2] go a step farther by arguing that a company should not claim itself a complete JIT company if it continues to use traditional methods of measuring efficiency and productivity. "Companies may claim to be practicing JIT but continue to use employee efficiency measures as indicators of performance. If these are the measurements reported, then the firm has not completely converted to the JIT philosophy."[2].

Some articles suggest specific performance measures to support individual elements of JIT. Dhavale [30] suggests performance measures for cellular manufacturing and focused factory system convey (1994) a performance measurement system in cross-functional teams. On the other hand, Hendricks [42] and Mc Nair [71] suggested a new performance measures that support a whole JIT system. In general, these authors suggest the performance measures be linked to a company's critical success factors, strategies, objectives and corporate mission. Hendricks [42] also offered the hierarchical performance measure attributes that are different at every level of the organizational hierarchy. At lower levels of the organization hierarchy, performance should be measured

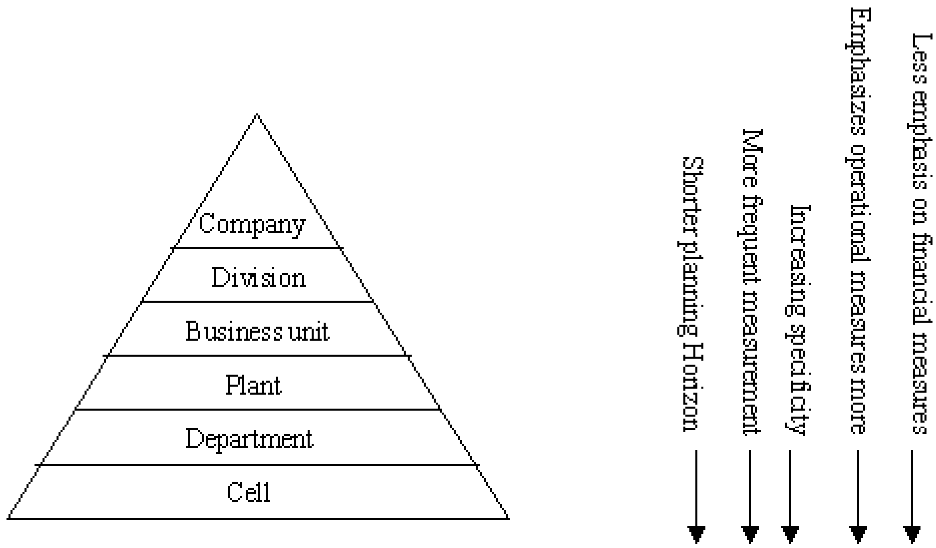


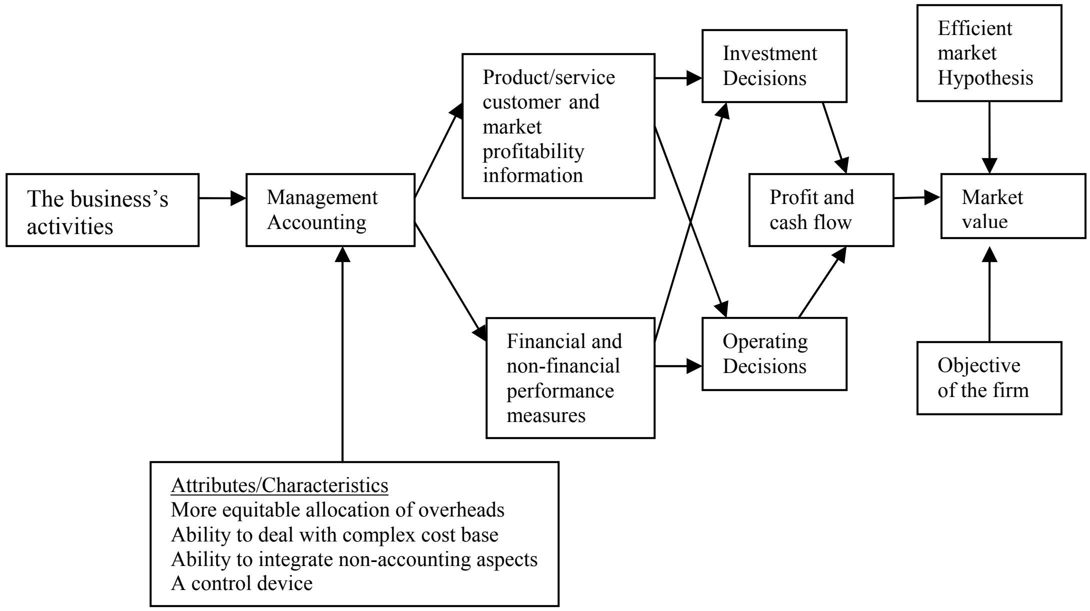
Figure 2 Performance measures of JIT [42]

more frequently, and specifically with more emphasis placed on operational measures and less emphasis on financial measures.

The figure 2 illustrates the importance of performance measure from manufacturing cell level to company in a lean manufacturing environment. The performance measures play a vital role in deciding bench mark and future state map. Further, good performance measure will drive for continuous improvement to achieve the desired state.

1.7 Scope and Anticipated Results

This study is an initial effort to evaluate the impact of management accounting alternatives, product flow, overhead allocation in lean manufacturing principles on shop floor performance under a given experiment setup. The management accounting performance is calculated based on the net income produced by a given product mix. This net income varies based on the selected lean principle. Further analysis of the results identifies the suitable management accounting for lean manufacturing. Although it provides number of interesting results, it is important to recognize that this study considers only limited variety of product routing and demand forecasting in a constrained capacity lean environment, so the results are not readily generalizable. It is also well known that the results of simulation study are only descriptive and should be interpreted with caution. However, the use of simulation modeling makes it possible to predict the behavior of different variable and it may provide insight and directions for future research. As mentioned earlier, only a limited variety of variables taken into consideration while assigning overhead cost to different products based on management accounting principles in order to avoid more complications. For example it has not considered the product complexity and structure for different bill of materials, work in process inventory is considered to be very low because of pull system setup. This overall experiment results are more suitable for high overhead content with low direct labor. Different industries may have different cost structures or centers to capture the real overhead cost that may have different impact on performance measures and selection of management accounting alternatives. For example this study may not be suitable for service industries because it has high labor content and less overhead cost. Further the experiments should be conducted for a wide variety of manufacturing environments. Many industries may not implement lean manufacturing principles and focused factory arrangements, so the research has to be conducted on other manufacturing environments. Another limitation of this study is that it assumes that all defective parts or poor quality parts do not have to be reworked and will be considered as scrap. In the real manufacturing environment, parts may be reworked and converted to good products at lower cost than producing new product to equalize the delivery quantity. There is a possibility that in real manufacturing environments, some unexpected delay may increase the cycle time or lead time, all of which cannot be captured using simulation model but it considers variation in processing time, changeover time, material handling variability and machine down time variability. However, the model does not consider the manufacturing cell which stops because of quality problem and other unknown downtimes.



The link between Management Accounting and Market value
Adapted from Ward and Patel (1990)

Figure 3 The link between management accounting and market value

1.8 Aligning Cost Management and Accounting Methods with Lean Thinking

The figure 3 indicates the importance of management accounting system in any business environment. This management accounting should provide the flexibility to deal with complex overhead cost base; include market profitability information and other non-financial performance measures in order to supply adequate information to make business decisions.

1.9 A Management Accounting Profile that Supports Manufacturing Excellence

Maskell [69] [68] and Jenson have made considerable contribution to align the costing strategy with manufacturing excellence. Case study research across a number of industrial sectors has enabled researchers to develop a profile of companies that successfully align accounting systems with lean principles. Jenson found that management accounting systems should be adapted to support manufacturing excellence to demonstrate the following characteristics: [69]

- Integrate the business and manufacturing cultures
- Recognize lean manufacturing and its effect on management accounting measurements
- Emphasize continuous accounting improvement
- Strive to eliminate accounting waste
- Encourage a pro-active management accounting culture.

1.10 Organization of the Thesis

This chapter briefly introduces the role of management accounting systems in lean implementation. It then proceeds to state the objective of this research. Further this chapter addresses the problems associated with each management accounting systems in lean environment, scope of this study and anticipated results. The first part of second chapter compares the difference between traditional manufacturing principles with lean manufacturing principles. It then proceeds to state the different overhead principles associated with different management accounting systems. In addition, it discuses the literature review. The third chapter begins with the research methodology. It consists of sections on experimental setup, process simulation, management accounting systems and performance measurement. Experimental setup lists the experiment variable and background variables used in this study. Process simulation explains the construction of simulation model and assumptions associated with that system. Management accounting system illustrates the overhead cost allocation under each accounting and calculates the product cost. The product cost is used to identify the individual contribution margin of products and will thus drive product-mix decisions under each management accounting system. The performance measure module captures the simulation output based on given product-mix for each management accounting system. The fourth chapter discusses the results of each management accounting system performance for different input variables.

It then checks the statistical significance of net income and compares the overall view across the experimental variables, and finally, ranks the accounting system using statistical test and benefit cost ratio. The fifth chapter summarizes the result, compares with previous study results and future research direction.

Chapter II
Literature Review

In recent years, the remarkable success stories of Japanese understanding of production planning and control systems introduced a new paradigm to production research literature. The so-called just in time (JIT) system organizes the production such that materials arrive just as they are needed in relatively small batches through an attached ‘Kanban’, which identifies a standard quantity of transfer batch or size of a container. JIT has been widely accepted and gained remarkable attention among researchers as well as practitioners [10] [47]. Further, they suggest the contribution margin per unit for the bottleneck capacity should be calculated for every product to determine the optimal production schedule for utilizing bottleneck capacity. The management cost accounting should provide adequate information in order to achieve the above-mentioned goals. Adopting a Lean manufacturing system has a significant effect on the nature of cost management accounting system. This system affects the traceability of costs, enhances product-costing accuracy, diminishes the need for allocation of service-center costs, changes the behavior and relative importance of direct labor costs, impacts job-order and process costing systems, decrease the reliance on standards and variance analysis, and decreases the importance of inventory tracking systems [40].

2.1 Manufacturing Environment

The organization culture plays a major role in lean manufacturing environment. The following table compares the different features and functions between traditional manufacturing and lean manufacturing environment. The major features that changes organizations are process and facilities, planning and control, product development and financial control. Mass production systems incorporate management decision and information support processes that operate within departmental boundaries, not as cross-functional and cross-enterprise processes across departmental and company boundaries. This cross-functional requiring lean improvement in most mass production environments include total quality management, maintenance, new product introduction and other engineering activities. These cross-functional and cross-enterprise processes are a key to sustain lean implementation [19]. The table 2.1 illustrates the difference between mass production and lean manufacturing. Each face of the organization has changed in lean environment for example; the process and facilities in traditional environment operate with high inventory in warehouse or distribution center to manage the market fluctuations. The manufacturing process seems less flexible to handle the demand variation is the primary reason for the above mentioned problem. But lean environment handles this situation by addressing the root cause of the problem. The manufacturing process should include flexible work centers with quick changeover and mixed model production scheduling in order to handle the demand variation. The changes in the basic process centers will lead to reduction in work in process inventory and warehouse space. Financially, this improvement will have a major reduction in working capital for the company. In addition, the manufacturing environment is updated but the management accounting system has followed the traditional way. Many lean implementation team has least understood that management accounting system needs improvement along with manufacturing environment. This management accounting system acts as a bridge in terms of transferring lean improvements from shop floor to higher level. The problems with traditional management accounting system are already discussed in chapter I.

2.2 Lean Manufacturing and Management Accounting Systems

Lean manufacturing has its roots in the automotive industry [99]. A global study of the performance of automotive assembly plants during the 1980's resulted in the widespread adoption of lean practices in a variety of industries [99] [42]. The application of lean ideas to a range of industrial sectors enabled Womack and Jones [99] to derive five generic, over-arching lean principles. These principles are:

- *Precisely specify customer value by product or family*: A key principle of lean manufacturing is that the customer defines value. Value is viewed "in terms of

Table 2.1 Features and functions comparison between traditional environment and lean manufacturing [71]

Features& functions	Manufacturing Environment –Traditional	Manufacturing Environment- Lean
Process & Facilities	▪ Many discrete machines ▪ Multiple setups ▪ Large warehouses ▪ Large WIP areas	▪ Flexible machine centers ▪ Zero setup ▪ No warehouses ▪ Drastic decline in space required
Planning and control	▪ Constant demand fluctuation ▪ Infinite rescheduling of requirements ▪ Constant engineering change ▪ Weekly planning ▪ Long lead times ▪ Large lot sizes ▪ Vendor difficulties	▪ Demand stabilization ▪ Minimum rescheduling ▪ Zero change ▪ Hourly planning ▪ Zero lead times ▪ Lot size of 1 ▪ Vendor synergies
Product design	▪ Life cycle declining ▪ Constant engineering change ▪ Many complex components ▪ Quality improvement over cycle ▪ Infinite options	▪ Life cycle much shorter ▪ Little or no engineering change ▪ Few complex components ▪ 100% quality at first time ▪ Limited options
Financial control	▪ Labor efficiency ▪ Little emphasis on investment ▪ Shop orientation ▪ Focus on variable cost ▪ Overhead spreading ▪ Cost measurement	▪ Product profitability full stream ▪ Investment intensive ▪ Product cost as incurred ▪ Minimum variable cost beyond material ▪ Zero direct labor ▪ Cost, flexibility, dependability and quality measures
Organization	▪ Functional interfaces ▪ Long lead times ▪ Hierarchical	▪ Product teams ▪ Flexible and rapid decision making ▪ Fewer levels

specific products with specific capabilities offered at specific prices through a dialogue with specific customers" [99]

- *Identify the value stream for each product:* The value stream is defined as " the set of all specific actions required to bring a specific product through the three critical management tasks of any business: the problem-solving task running from concept through detailed design and engineering to production launch, the information management task running from order-taking through detailed scheduling to delivery, and the physical transformation task proceeding from raw materials to a finished product in the hands of the customer" [99].
- *Make value flow without interruption:* Once any obviously wasteful steps are eliminated, the remaining value-creating steps need to be organized in such a way that they flow. This involves a move away from the traditional functional or departmental organization towards a holistic, customer-focused organization, laid out along value stream-lines. Lean manufacturers usually adopt cellular manufacturing, where each cell contains all the resources required to produce a specific product or where a series of cell is organized to produce a specific product. In order to enable products to flow smoothly through the factory to customer, batch production is rejected in favor of singly-piece or continuous flow. The emphasis moves away from the efficiency of individual machines and people to the effectiveness of the whole value stream.
- *Let customer pull value from process owner:* When the value-creating steps are organized to flow, the customer can pull the value through the system. Traditional production methods tend to push products through the system in the hope that a customer will buy them once produced. In a pull environment, no work is completed until required by the next downstream process.
- *Pursue perfection:* As companies widely adopt lean practices, it becomes clear that improvement is on-going process. Initiatives to reduce effort, time, space and cost can be conducted continuously. As a result, lean manufacturers adopt a continuous improvement philosophy.

The lean transformational principles presented here are an adaptation of those presented by Womack and Jones in the follow-up to "The Machine That Changed the World", the 1996 publication Lean Thinking: Banish Waste and Create in your corporation (Simon & Schuster, New York, pp 15-26).

Many of the companies that attempt to implement lean experience difficulties and/or are not able to achieve the anticipated benefits. One of the barriers to successful implementation is management accounting system. The company fails to improve performance measures in financial statements. By not communicating in the same language as management, the department or function implementing lean doesn't get the support needed to continue the efforts. However, the traditional management accounting system does not translate the lean improvements from shop floor level to management level. A review of the current literature on the inadequacies of the traditional MAS reveals that several aspects of the new manufacturing environment have the most far-reaching implications for its change [71].

- The relationships between "direct" and "variable" costs as well as "indirect" and "fixed" costs are becoming blurred.
- The focus has turned from a preoccupation with variance and standard costs to source of costs (eg.. drivers).
- Increased recognition of the interdependence between cost and performance among organizational subunits has negated the traditional focus on organization cost control.
- Change in manufacturing process has shifted a significant portion of product cost from traditional direct cost to indirect, resulting in high burden rates with distort true product costs.
- New information gathering devices and techniques have made cost traceability possible on a more detailed level.
- Compression of the life cycle has shortened the period available for recovery of development costs, necessitating efficient and effective production techniques from inception.

- Recognition of the cost of inventory is placing new emphasis on measuring and reducing cycle time.

Focus on eliminating waste is leading to increased demand for value added measurements of performance. Many cost accounting systems divide the overhead apportionment calculations into fixed and variable elements and allocate a little of the fixed costs to each production job and allocate the variable costs in the traditional manner. The key issue is that overheads are such a large amount of the total product cost that it is important to analyze these overhead costs and develop for applying them as direct costs.

2.3 Management Accounting System Strategies

2.3.1 Traditional Cost Accounting

Traditional cost accounting system has been widely used by many industries to measure the organization performance internally as well as report the financial accounting to management and shareholders. This costing computes the product cost based on direct labor, direct material and overhead allocation. This overhead allocation is based on the percentage of direct labor usage. The figure 4 illustrates traditional cost allocations stages in graphically. The traditional costing is summarized as follows.

- Assigning all manufacturing overheads to production and service cost centers / departments.
- Reallocating the costs assigned to service cost centers to production cost centers / departments.
- Computing separate overhead rates for each production cost centre/department.
- Assigning cost centre overheads to products or other chosen cost objects.

Traditional Costing is still favourite because of the following reason:

- Simplicity of traditional costing over the complexity of modern costing (ABC)
- Internal organisational problems such as resistance
- Problems associated with implementation such as finding out cost drivers, identify activities and lack of resources.
- Lack of top management support for ABC.

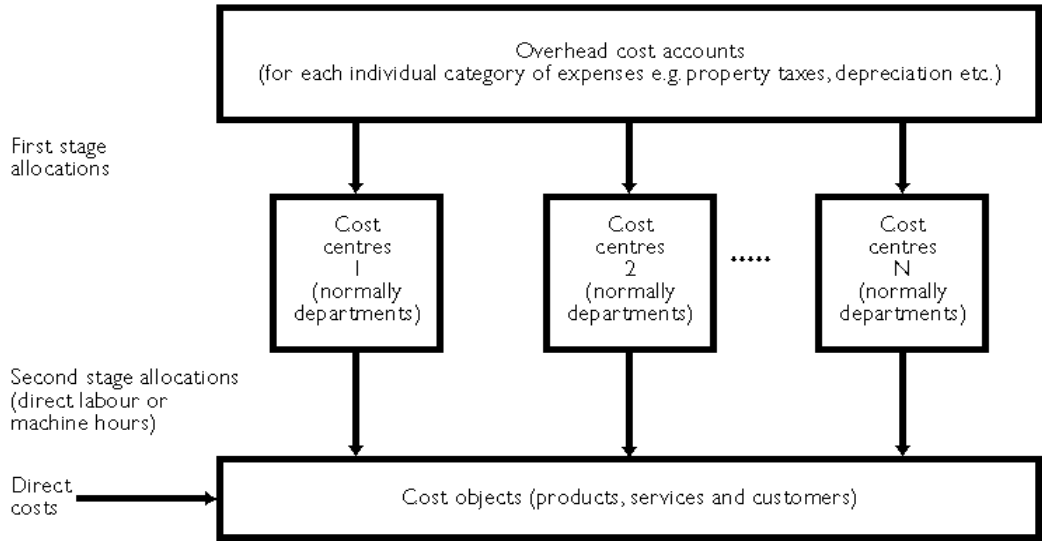


Figure 4 Traditional standard costing

2.3.2 Activity-Based Costing

Activity-based costing is a measure of cost drivers based on resource usage by each activity. It comprises a different, more logical approach to determine the product costs. It emphasizes the need to obtain a better understanding of cost behavior and it divides overhead costs into various process activities. A process could be described as logical series of activities, which can be linked together to produce reasonably homogeneous output. The figure 5 shows the link between cost drivers and activity drivers to trace the overhead costs associated with the resource and work station.

- *Cost drivers* are the casual factors that cause costs of an activity to change
- *Resource driver* describes the relationship between cost element and the activity
- *Cost elements* are traced to activities through the resource driver.

The steps behind Activity based costing is as follows:

- Identify the major activities that take place in an organization:
- Assigning costs to activity cost centre
- Selecting appropriate cost drivers (ex. Transaction drivers, duration drivers)

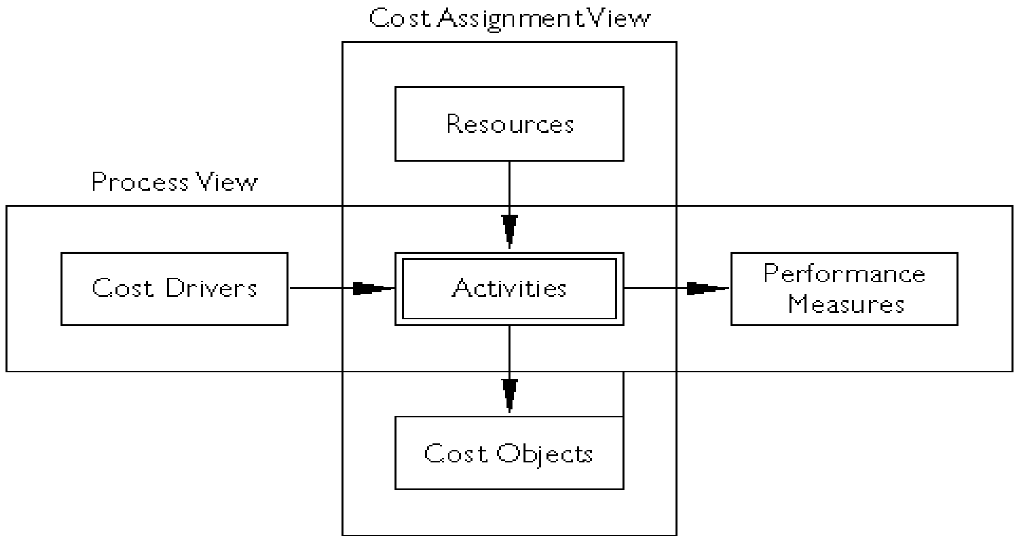


Figure 5 Activity-based costing.

- Assigning the cost of the activities to products:
- The cost driver measure must be capable of association with specific products.
- Cost driver rate must be predetermined based on estimated level of activity cost and cost driver volumes for the current period.
- Activity based costing system maintains and processes financial and operating data on a firm's resources, activities, cost objects, cost drivers and activity performance measures.

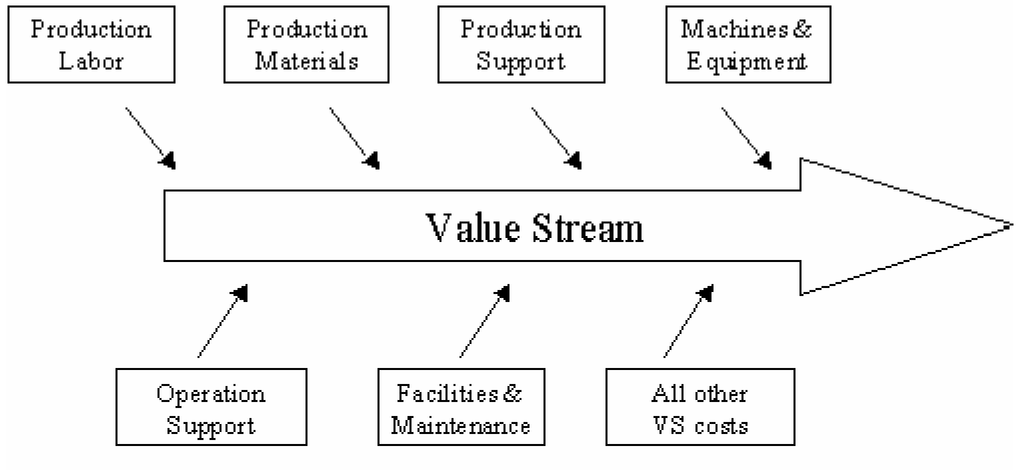
Although Activity based costing has many advantages over traditional standard costing. By comparing the success rate and failure rate of ABC, the success rate for ABC implementation is low. Research survey (2003) conducted by Narcyz Roztoci and Sally M. Schultz [75] showed that ABC had been "implemented" by only about 21% of responding organization. The project success rate is low because of the following reasons.

- The project was launched from finance, not pulled through from operations.
- Cost accounting is outside most everyone's comfort zones.

- It competes with the official regulatory accounting system as a parallel and off-line information system.
- There is an underestimated degree of employee resistance to change and of corporate disbelief with the new costs.
- Sales and marketing personnel do not know how to react to the new profit winners and losers.
- ABC/ABM does not provide all the information needed to make customer and product decisions.
- ABC/ABM competes with other improvement programs without integration.
- Acting on the data involves pain-refocused strategies usually require some different people and equipment, implying job eliminations and write-offs.
- The project loses initial management buy-in by not maintaining a brisk pace and momentum.
- There is no true profit-and-loss responsibility at the pilot site.
- There is minimal end-product diversity, resulting in little change in individual net costs.
- ABC/ABM's reputation is maligned as too costly to maintain or as a wrong tool.
- Training was inadequate or poorly timed and failed to include the right level of people.
- Activities are incongruently related with cost drivers, many of which are not the cause of cost.
- Scope is restricted to operations cost, not total integrated value-chain cost.

2.3.3 Value Stream Costing

A value stream is a group of products that belongs to one product family and follows same production routing. Value stream not only consider production steps but also it takes into account of each activity that adds value to customer from order placement to shipping of products. Simply, It creates value to the customer along the



Source: Adopted from "Practical Lean Accounting" by Brain H.Maskell

Figure 6 Value stream costing

whole stream. Value stream costing allocates all the costs incurred for this stream as direct cost. Typically, the costs include product labor, direct materials, equipment usages and other support functions. The figure 6 shows the typical overall costs associated with particular value stream for one or multiple product family of products.

Lean value stream costing is entirely different from traditional approach. Because standard costing assumes that all overheads need to be assigned to the product and that these overheads relate to the amount of direct labor required to make the product. This costing violates the above assumption and calculates the total cost required to run the whole value stream. It typically calculated biweekly or monthly. Production labor cost includes all the labors who works or supports in the value stream. The total raw material purchased for the whole value stream is considered production material. The other activities that supports value stream will be converted in terms of cost and included in this value stream total cost calculation. Space occupied by the value stream is allocated based on square footage cost of the facility. Value stream costing is simple because the detailed actual costs are not collected by production job or product. Value stream cost reduces the overhead allocation process, which improves cost calculation and profit

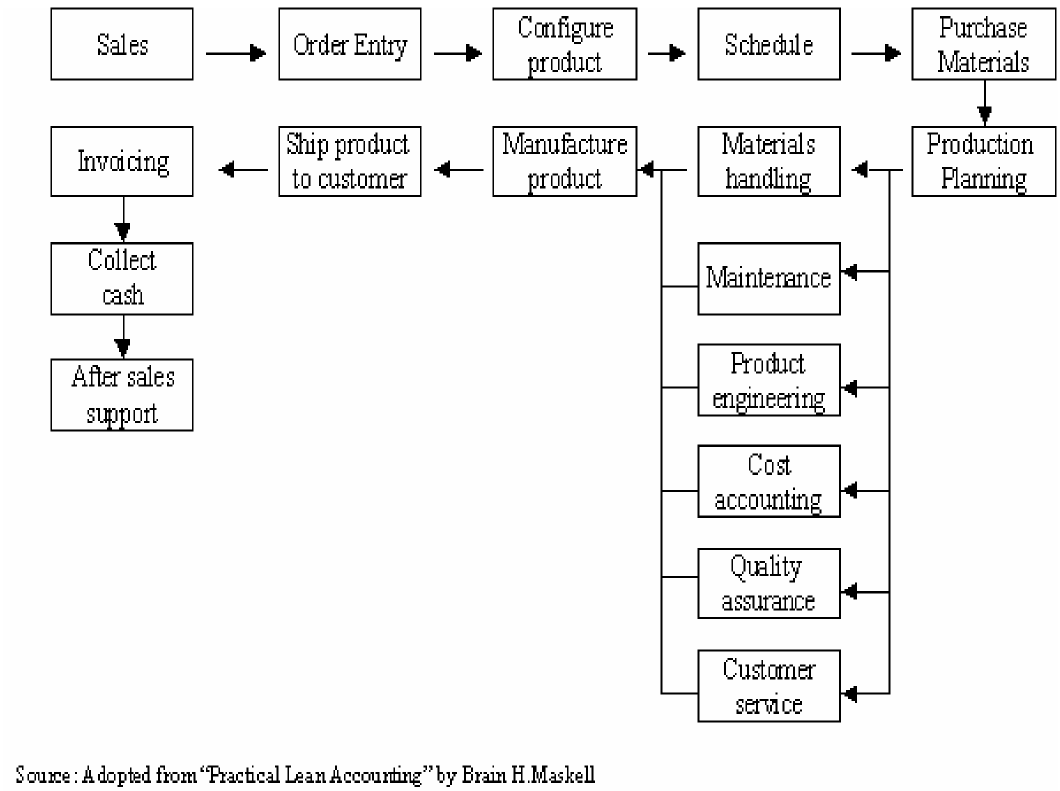


Figure 7 The information and material flow in a typical value stream

information. The non-value stream costs are inevitably small because most of the work of organization will be associated with value streams [70]. The value stream is far more than just manufacturing processes. From figure 7, manufacturing is just one step in the whole processes of serving the customer and creating value.

2.4 Literature Research

Many researchers have proposed theoretically that traditional management accounting may undercoat the low volume complex products and may overcoat the high volume simple products because overhead cost is allocated on direct labor hours or some other measure of volume [51][76][20] when both types of products are manufactured. And further it distorts the cost information. On the other hand, Activity-based costing has gained the recognition of a more accurate cost estimation and calculation method. It traces cost to products based on volume-related factors, such as unit-batch-, and product-level cost drivers as well as non-volume-related cost drivers, such as product diversity, complexity, and quality. Surveys and interviews with managers using ABC indicate it is used to support a wide range of economic activities, such as product mix, pricing, and outsourcing decisions [23]. However, evidence of enhanced "financial performance resulting from firms adopting ABC is somewhat limited". Low [65] and Spoede et al. [90], using numerical examples, illustrate that the TOC leads to a more profitable product mix than ABC. Low [65] noted that the `activity-based cost allocation procedure was a great deal more complex than traditional costing procedures, but it was not particularly helpful in a strategic sense. Kee [55], using a similar example, illustrates that an ABC model integrating the cost and capacity of production activities outperforms the TOC. The complementary nature of the TOC and ABC has been examined by various researchers [9] [68][44]. They suggest that the TOC is appropriate for the short run, while ABC is appropriate for longer-term decisions. However, as noted by Bakke and Hellberg ([9], there is no clear-cut demarcation between short-term and long-term decisions and short-term decisions may have longer-term economic consequences. Time is a surrogate in these studies for other factors in the firm operations that determine when the TOC and ABC lead to optimal resource allocation decisions. However, the nature and impact of these factors on ABC and the TOC were not addressed.

The primary focus of the TOC is managing bottleneck activities that restrict the firm's performance. As noted by Goldratt [37] any system must have at least one constraint. The TOC consists of a set of focusing procedures for identifying a bottleneck and managing the production system with respect to this constraint, while resources are expended to relieve this limitation on the system. When a bottleneck is relieved, the firm moves to a higher level of goal attainment and one or more new bottlenecks will be encountered. The cycle of managing the firm with respect to the new bottleneck(s) is repeated, leading to successive improvements in the firm's operations and performance. Goldratt indicates that many of the assumptions underlying traditional cost-based accounting systems, as well as ABC, are no longer valid and that these systems are leading any companies to disaster. Consequently, he proposes using an alternative measurement system to evaluate the impact of production-related decisions.

Kaplan [53] notes that ABC is not a system for allocating cost to products more accurately. Rather, it attempts to identify factors underlying the production process that cause activities to consume resources and, thereby, incur cost. The use of volume-related cost drivers and non-volume cost drivers, such as product complexity, diversity, and quality, enable ABC to provide a powerful and rich model of the relationship between why costs are incurred in the production process and the products produced. Advocates of the TOC assert that labor and overhead are a committed cost; therefore, tracing the cost of these activities to products is irrelevant for decision-making. In the literature, many researchers agree [25] [15] that activity based costing can measure product complexity better than traditional management accounting or throughput accounting
John Miller summarizes this idea as follows:

A Cost Management System by itself produces no increase in productivity, no reduction in cost, no improvement in quality, no reduction in cycle time, and no increase in customer satisfaction. Its true benefit can be measured only in the light of management's actions initiated based on information provided by the new CMS. Those actions should be directed toward continuously improving the organization's activities and business processes through better decision making [62].

Much of the research in the area lean/JIT has focused on the impact the techniques on operation performance levels. In these studies, the control variables used most often are organizational size, and hierarchical layers of the organization [2]. Further, the authors reported the results of a distribution of respondents to their survey by Standard Industrial Classification code, but did not analyze (or did not have enough data to analyze) their results controlling for this variable [2].

Kennedy and Affleck-Graves [56] examines the link between implementation of an activity-based costing system and the Shareholder Value Analysis (SVA). Given the SVA framework of analyzing how business decisions affect "economic value" through the identification of the key value drivers [98], ABC can provide information crucial to an understanding of how a firms' competitive advantage is generated. Shank and Govindarajan [85] highlight such an approach by asking two questions: is the activity necessary, and is the activity performed efficiently? They label this approach as "value engineering the cost structure." By more accurately attributing cost to products, services, and customers, ABC can play an important role in providing relevant information for management operating decisions, which, in turn, should impact on profitability and, ultimately, shareholder value. Ward and Patel [97] also suggest that ABC provides a sound foundation for future cash flow projections. They argue that this leads to investment in value-added activities that support products, services, customers, and market segments, thereby increasing shareholder value. The concept has been further developed by the application of Activity Based Budgeting [74], Activity Based Management [18], Activity Based Computing [12], Activity Based Cost Management [22], and its full infusion into the business process re-engineering framework.

Bih-Ru Lea and Lawrence D.Fredendall [62] have examined the different types of accounting systems on product mix interact with short term and long term that affect the manufacturing performance of the firm. They considered two different product structures (flat and deep) for this study. Further this study found that no single shop setting is best for all performance measures. The performance measure is not constant over different manufacturing environments. The research is conducted by developing different hypothesis on firm performance by varying product structure and product mix algorithm. This study suggests that ABC is more sensitive to environmental uncertainty than traditional costing. However this study also suggests that in an uncertain environment, given an appropriate overhead allocation rate and updated information from an integrated information system, traditional costing is not as outdated and irrelevant as some researchers have suggested [25][26][62][51].

Bakke and Hellberg [9] analyzed the potential gains of the OPT- and ABC-models in terms of short and long term production scheduling point of view. The ABC-philosophy constitutes a necessary basis for long term decisions about product-mix as complete cost-structures are revealed. However the information derived from ABC-analyzes unfortunately is not satisfactory for making short-term decisions in general. They concluded that neither OPT (optimized production technology) nor ABC has a relevance to all product-mix decisions and it depends on time horizon and manufacturing environment.

Ahlstrom and Karlson [1] analyzed the role of the management accounting system in the adoption process of implementing lean production system. That is, the focus is on the changes takes place in the production system and the role of the management accounting system in these changes and not the management accounting system itself. Researchers had created hypotheses for further investigation as well as systematic experience for practitioners to learn from. Their research concludes that the management accounting system indeed has very important role to play in modern manufacturing environments. Further they concluded that

- The management accounting system can create impetus for changes in the direction of lean production, but not until traditional performance measures have reached a certain threshold. Therefore, an important managerial task will be to influence the location of this threshold, by making it easier to reach.
- Another important way to create impetus for change is to raise the level of the unit of analysis in the management accounting system. First, there is a need to shift the focus from single machines and/or operators to the whole production flow. Second, there is a need to shift the focus from the operating level to the whole production system.
- When making these changes it is important to take into consideration that the management accounting system affects the adoption process in three concurrent ways: technically, through its design; formally, through its role in the organization

and cognitively, through the way in which actors think about and use the management accounting system.

Ozbayrak and Akgun [77] have estimated the manufacturing and product costs in an advanced manufacturing system either MRP or JIT by using Activity-based costing principles. Further they analyzed the potential effects of manufacturing planning and control strategies implemented on financial structure of the production environment. Their model assumes many non-traceable costs as indirect cost and used the proportion of these cost while calculating the product cost. For example determining direct labor contribution to product cost is very difficult and many times these contributions are negligible. So, all labor costs are pooled as indirect labor cost. In this study, the indirect resources are distributed to the main activity centers according to the utilization levels obtained from the system simulation. Therefore, for each activity center, two cost pools are formed as direct and indirect cost pools. The direct pool consists of raw materials, direct energy consumed, cutting tools, fixtures, etc. The indirect cost pool consists of externally provided service costs, indirect labor cost and other indirect cost associated with it. They conclude that ABC is a valuable information tool, which provides management with an unrivalled insight into the workings of the manufacturing system. In addition, they identified buffer capacity and lead-time is to be most important cost drivers in terms of their effect on WIP and throughput in both push- and pull-based production environments.

Jong-min Choe [21] has studied the relationship among management accounting information, organizational learning and production performance. His research shows a positive correlation between management accounting information and advanced manufacturing technology. The various researchers asserted that when advanced manufacturing technology is utilized, some types of information produced by management accounting information systems could improve production performance through organizational learning. Further, he identified the type of information produced by management accounting information system and suggested that when advanced manufacturing technology is used, large amount management accounting information improves the production performance.

Durden and Upton [31] have analyzed the cost accounting methods and performance measurement in a Just-in-Time production environment. The purpose of this paper is to examine whether management accounting system change is positively associated with performance for JIT firms. Researchers conducted a survey from different manufacturing organizations both JIT and Non JIT firms to support their conclusions. Respondents completed a brief questionnaire about their cost accounting modification, use of non-financial performance indicators and organizational performance. Their results indicate that JIT companies have not modified their cost accounting system to match the production management system. Therefore, the production system appears to have a moderating influence on the cost accounting modification. Further, evidence from survey shows that non-financial performance measures are used to significantly greater extent in companies operating JIT production systems as well as non-JIT production systems. Their result supports Foster and Horngren statements that conventional cost accounting systems are likely to be sub optimal in a JIT environment.

L.H. Boyd and J.F. Cox [14] have compared the different cost accounting systems (traditional cost accounting, direct costing, Activity based costing and throughput accounting) in a resource-constrained production environment in order to make two categories of decision based on cost accounting information. The survey was conducted to measure the importance of different decisions made based on cost accounting information. The hypothetical financial company produces 5 different products based on the product-mix decision of different management accounting result. The performance of each accounting is discussed based simulation model results. Their result shows that throughput accounting model outperforms the other three management accounting system. Activity-based costing, traditional cost accounting, and direct costing in some cases reached the same decision as theory of constraints but resulted in suboptimal decisions in majority of cases. Further, they concluded that cost accounting system should aware of production constraints and not use allocated costs in order to provide information for optimal decisions. This implies that only marginal costs should be considered to make better decisions. Management accountant refers marginal cost is the difference between selling price and the variable cost of the product. This marginal cost does not include overhead cost in the product cost calculations.

2.5 Conclusion for Literature Review

In a nutshell topics such as various management accounting systems under a given manufacturing environment were discussed. Then the techniques in analyzing a system from accounting standpoint were studied and academic research work in the area of management accounting was reviewed. When investigating the literature regarding the management accounting, it is apparent that many authors address the shortcomings of traditional cost accounting. However, few authors have investigated the impact of using different management accounting alternatives in various manufacturing environments. These authors were analyzed behavior of management accounting system for different product structure and planning horizon in a lean manufacturing environment. But they have not focused on different components of lead time. It is one of the main lean principles that create more flexibility in processes to match the demand variations. The performance of management accounting systems are not directly tested under different lean manufacturing principles like lot size, quick changeover and material handling. In addition, there has been no direct comparison between lean accounting and other accounting principles in lean manufacturing environment. However, there is no evidence of using this concept to analyze the lean system to identify management accounting strategy, which illustrates the research findings of this thesis.

Chapter III

Research Methodology

Chapter 3 discuses the research methodology involved in developing a Lean management accounting system model (LMAS). The chapter analyzes the individual components that make the model and charts out how these components are interpolated in the model. The objective of this chapter is to describe the development of an experimental design that uses simulation modeling to examine the impact on operational and strategic decisions of using different management accounting alternatives under lean manufacturing environment with various scenarios.

3.1 Conceptual Design

A conceptual framework of the LMAS model has four distinct phases of which are: experiment setup, management accounting system, process simulation, and output performance analysis for each set of experimental conditions and overall performance across management accounting systems. The figure 8 shows graphically how each phase is linked with successive modules to find out the performance measure of each management accounting systems.

3.2 Experimental Setup

Experimental setup identifies the appropriate experimental variables and background variables to be considered in this study. The experimental variables closely address the variability associated with different components of lead time. Lead time consists of wait time, setup time, move time and processing time. All these components are considered as non value added activity expect processing time. Further, the user input determines the background variables, process information depending upon the lean manufacturing principle and workstation capability.

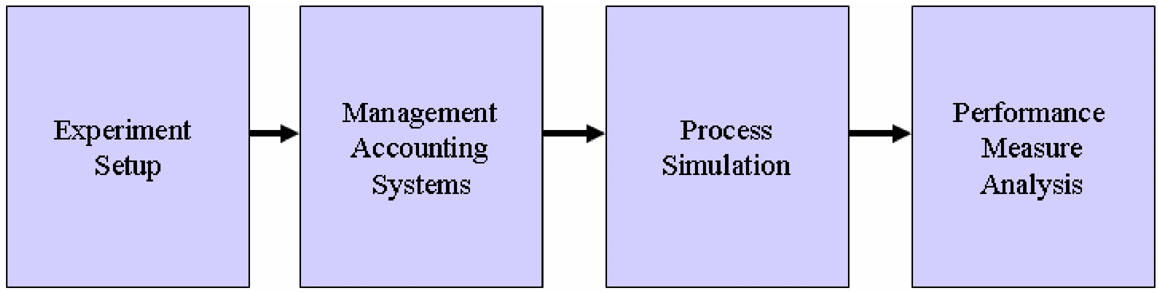


Figure 8 Research approach

Management accounting system module analyzes the overhead cost principle associated with each system to identify the product cost and contribution margin for a constrained capacity environment. This contribution margin will lead to find the optimal product mix for each management accounting system. The product mix will drive the process simulation module.

Process simulation comprises a simulation shop floor which runs under pull based system and it includes the experimental variables and background variables. The experimental variables are lot size flexibility, changeover time and material handling. The background variables are capacity and demand, equipment downtime, process time of work stations and product quality. The observed results from the model are net income for a given product-mix. This output measure is mainly depends on the experimental variables. The background variables are constant throughout the experiment.

This performance measure module analyze the net income across various set of experimental variables to identify the most aligned management accounting system for a given lean manufacturing setup. This analyzes phase uses statistical hypothesis tests to evaluate the mean net income for different experimental conditions. Finally it compares overall net income across management accounting systems and ranks based on Tukey test and benefit cost ratio.

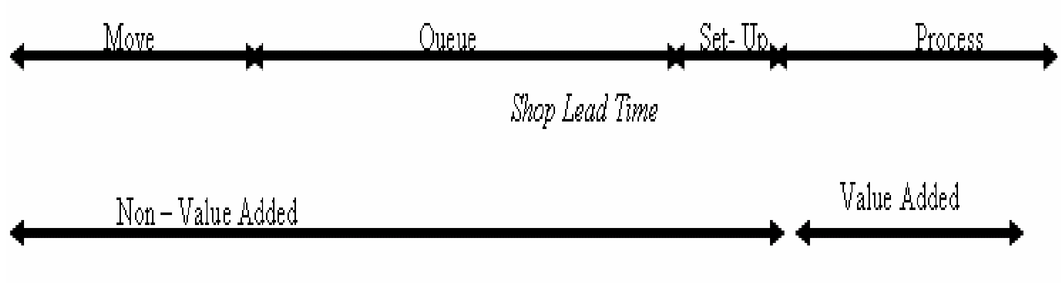


Figure 9 Components of lead time

3.3 Experimental Variables & Methodology

To minimize cycle time, one must reduce inventory or increase capacity, according to Little's Law. Kingman's formula shows that a reduction of variability can also affect cycle time and reduce inventory. A balanced production line is one where, given a fixed input and output schedule, the mean WIP does not increase over time due to randomness of tool failures and repairs. In this study, variability's of three different lean production principles are tested to check the performance of three different management accounting alternatives. The figure 9 shows different components of lead time and the classification of each component according to lean as value added and non-value added activities. The following lean production principles are considered in this study:

- Small lot size
- Single minute exchange of die (SMED)
- Material handling

Lean manufacturing focuses to reduce the lead time or cycle time of the products which produced by a given manufacturing setup. This lead time comprises of processing time, material movement, setup time and waiting time (queue). All the components except process time are considered as non value added activity in lean culture. Our experimental factors are closely related to all these components. The lot size reduction will have an impact on wait time, setup time reduction will impact more flexibility and

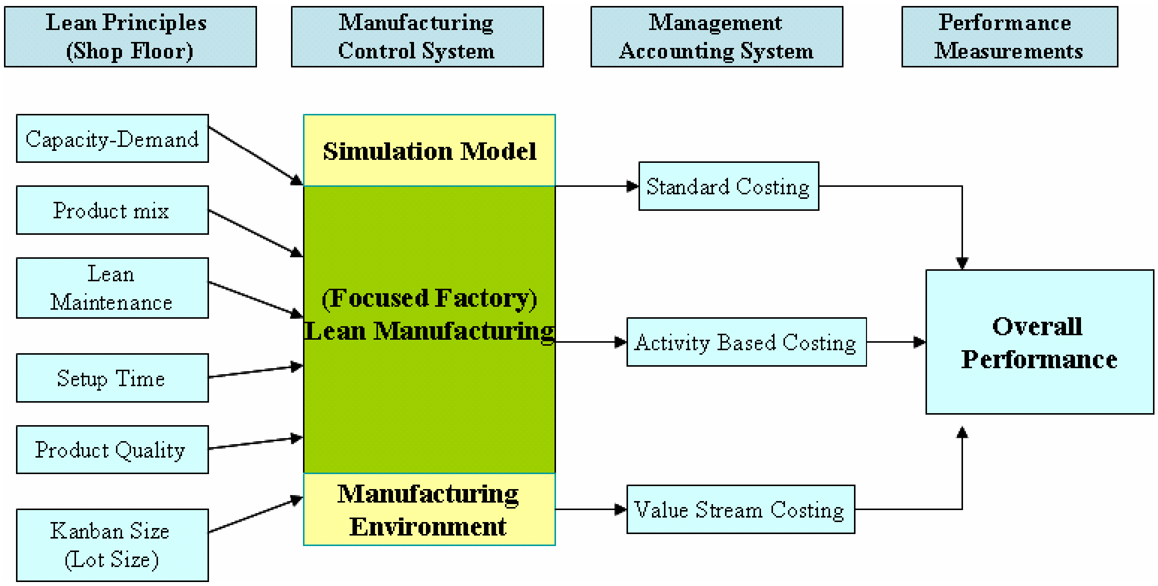


Figure 10 Experimental setup

quick response, less material handling will reduce the move time. This experimental study considers 4 levels of lot size, 3 level of setup time and 2 levels of material handling along with 3 different management accounting systems to check the performance of net income benefit. The experimental design will result in a total of 432(4x3x2x3x6) simulation runs.

3.4 Experimental Factors

Figure 10 explains the different experimental factors and background variables considered for this study and replicate the whole experimental setup. The research methodology consists of four different layers, which are lean principles, manufacturing control systems, management accounting system and performance measurements. The lean principle layer will be constantly changed for each scenario. These changes will make the simulation model to run different replications to get average output performance measurements. Manufacturing control system layer is a prototype of shop floor, which runs under lean manufacturing environments. This discrete event simulation model plays a vital role in this research to collect the output parameters. The management accounting system layer will calculate the different cost parameters based on simulation output and corresponding changes in the lean principle layer. For example this layer gets machine processing time for each operation and cycle time to allocate the indirect overhead cost. The overhead cost allocation differs when changing the costing methodology. The net income benefit for each management accounting systems will be the output of this layer.

The following discussion describes how lean manufacturing factors, different management accounting alternatives and production environments are setup for this experiment study.

One of the key lean manufacturing principles is defining customer value. This is viewed to analyze the capacity and demand for each product at specific price. This experiment considers capacity and demand of as the main factor to calculate product-mix. The experiment has tested under a constraint capacity environment which runs based on product mix decision based on each management accounting alternatives. For this study, one product family of products which consists of four different parts is examined to check the output performance of each management accounting alternatives. It is not uncommon for a firm's product line to contain some high, medium, and low volume products. Generally high volume products have constant demand, cause little overhead and use maximum standard tools and fixtures and generate lower profit margins. On the other hand, low volume products or stochastic demand products cause higher overhead and use minimum standard parts and generate high profit margins. Support system plays important role to create a uniform production flow in the shop floor. Engineering, maintenance and office support are the three major support systems. In this experimental study, preventive maintenance is scheduled for all the resources in order to reflect the real environment.

Another major hurdle to increase flexibility in the production floor is changeover time. This changeover time is considered as non-value added activity in lean environment. Changeover time mainly depends on the product complexity and how often changeover takes place. In traditional mass production, even though it takes longer time but it has not been viewed from the resource constraint point of view. Because of less frequency of setup changes in the shop floor. On the other hand, lean manufacturing requires producing small batches of each product on daily and making frequent deliveries to customer. This leads to reduce changeover time in order to achieve more flexible and minimize non-value added activity. Experiment consider setup time as one of the major factor in the simulation modeling to check the behavior of performance measures under different management accounting alternatives. In lean environment, WIP does not add any value to customer but it may be helpful to manage the market fluctuations. However WIP has to be minimized in order to reduce lead-time. In today's competitive environment, Customers are looking for best price with minimum lead-time. Lot size plays a major role to reduce WIP. This experiment incorporates lot size flexibility to check the performance measures behavior.

3.5 Manufacturing Control System (Lean Manufacturing)

Forecast demand and inventory level for all manufacturing products are calculated monthly. Master production schedule releases the production planning and material requirement based on this information. Material requirement planning is used to determine the planned order releases of end items and intermediate items. In this study, all monthly demands have the same due dates which are earliest of next month [62]. The manufacturing order quantity is calculated using EOQ equation and each batch is further divided based on experimental factor (lot size), which has been sent to respective workstations. This study compares operational similarity products, which is grouped into one product family runs under one value stream and also considered as focused factory. So, it does not have complicate routing and product structure. Material requirements will be ordered in the regular interval in order to avoid material shortage. But the material requirement order release has been sent to bottleneck operation only. This peacemaker process will not only drive the upstream and downstream work centers but also vendor management process and raw material supplier. The master production schedule (MPS) will be frozen for four weeks. No rescheduling will be made during this period. The research study [91] indicated that increasing the frozen period does not result in major impact on customer satisfaction level. Various researchers in the literature study the same frozen period. This experiment incorporates pull system setup, which is one of the key lean principles to achieve lean enterprise level. Further this experiment assumes one focused factory is nothing but cellular manufacturing, has been dedicated to one product family. Order released to work centers based on production kanban as result of withdrawal of inventory by a consecutive work centers. First-Come-First-Serve (FCFS) option will be used as the shop floor dispatching rule as commonly used in other literature [60].

Practically, to achieve single piece flow in all manufacturing environment is very difficult. Experiment setup allows the user to specify the lot size for each product in the product family. The lot size will be as minimum as possible to handle minimum WIP. The changeover time and product priority can be specified in the program to test various output performance measures for different changeover time and product sequence under each management accounting alternatives. Materials are directly sent to the first work center of the cell from the raw material supplier. There is no material handling and receiving station which shown in the experimental setup figure. The safety buffer will be pre-assigned to each workstation based on the processing time and flow criticality.

3.6 Management Accounting Alternatives

3.6.1. Cost Structure

In earlier chapters, the cost structure associated with different parts of manufacturing activities has been discussed and each management accounting alternative

Table 3.1 Life cycle costs of product and cumulative percentage

Life-cycle phase	Cost Contribution to total cost	Cumulater costs	Type Non-recurring / recurring
Concept & definition	2%	2%	Non recurring costs
Design & development	6%	8%	
Manufacturing	21%	29%	
Commissioning/installation	8%	37%	
Operation & maintenance	60%	97%	Recurring costs
Reconstruction/disposal	3%	100%	Non recurring costs

has follows different approach to capture the cost incurred to produce the products. Table 3.1 shows the life cycle cost associated with the products and classified these costs as recurred cost and non-recurring cost. Many researchers [76][45] reported that direct labor might comprise less than 10% of the total product cost in heavily automated manufacturing firms. In this automated factory environment, overhead cost plays very important role in assigning the cost objects to various products and it contributes major portion of total product cost. In advanced manufacturing environment more than 70% of non-material costs tend to be indirect or overhead costs. This study follows the trend and gives more importance to overhead content and indirect costs. In this experiment study, the average percentage of each type of cost used is as follows: the labor cost is 5% to 12%, raw material cost is 20% to 35%, and overhead cost is 53% to 75%, the same cost structure has been followed. Overhead costs are accumulated in one or more cost pools. This cost pool may include both fixed and variable overhead costs, which is fully depends on management decision. Fixed overhead includes costs such as production management salaries and space rental.

3.7 Cost Associated with Manufacturing Activities

The total manufacturing cost can be assigned by four different ways, which are direct tracing, indirect, driver tracing and allocation. Direct tracing gives more accurate product cost compare to others. Traditional and lean environment follows different procedure to calculate various portions of manufacturing cost. The following table explains the differences and shows which method is used to calculate the product cost.

From the earlier discussion, all the manufacturing activities, direct labor usage, raw material procurement and direct manufacturing costs are likely to vary based on production volume and are often classified as variable costs. Other costs include support system in terms of production (facility cost) and administration will be considered as fixed cost or semi variable cost. The table 3.2 compares the overhead allocation across different management accounting alternatives.

Table 3.2 Overhead allocation methods for traditional and lean environment

Manufacturing cost	Traditional Environment	Lean Environment
Direct labor	Direct tracing	Direct tracing
Direct materials	Direct tracing	Direct tracing
Material handling	Indirect	Direct tracing
Maintenance	Driver tracing	Direct tracing
Utilities & supplies	Indirect	Direct tracing
Marketing	Indirect	Direct tracing
Supervision (dept.)	Indirect	Direct tracing
Insurance and taxes	Indirect	Allocation
Plant depreciation	Allocation	Allocation
Equipment depreciation	Indirect	Direct tracing
Engineering support	Indirect	Direct tracing
Custodial services	Indirect	Driver tracing

Each management accounting alternatives consider these costs in different manner either directly to assign products or period cost to allocate various products to calculate the total product cost. The following table listed the fixed cost, variable cost and other support costs. The variable cost is collected from the simulation modeling. These activities are consistent with activities studied in the literature [65] [15] [76] [62].

The variable cost center values are collected based on the production quantity, raw material consumption and machine center utilization. Table 3.3 shows different manufacturing cost centers and allocation rules for each management accounting system. The pilot run of individual products simulation model is used to calculate the variable cost. If the total processing time of products is identical then this function does not have significant difference when the management accounting changes. In practically this may not be true and this study considers different processing time for individual products. On the other hand, fixed cost allocation has major differences across management accountings. Traditional standard costing allocates the major portion of overhead to products based on volume and machine utilization or labor percentage usage. Activity based costing traces all the overhead cost to products based on activity level and resource consumption. Value stream costing traces the overhead cost to product family not individual products for particular value stream. The different overhead cost methods have been discussed earlier in this chapter.

3.8 Product Costing with Activity-Based Costing

Activity based costing identifies different manufacturing activities and group the possible activities into single activity. It is very difficult to model all the activities in that takes place in the real world. Therefore depending on the resource consumption, some of the resource centers will be described as activity centers. Activities used within the department to support the primary activities are secondary activities [15]. The cost of Figure 11 shows graphically how the cost drivers calculated from different resource centers.

Table 3.3 Management activities and type of cost allocation [62]

Manufacturing Activities	Amount	Type of Cost (Allocation department and rates)		
Variable cost		**Traditional Costing**	**ABC**	**Value Stream Costing**
Raw Material Cost	Varied by product type	Product	Product	Product
Direct Labor		Product	Product	Value Stream
Direct Manufacturing cost(machine depriciation)		P(Manufacturing)	Product	Value Stream
Overhead Costs				
Product supervision	6400	P(Manufacturing)	P(time on products A:B:C:D =.15:.2:.4:.25)	Value Stream
Indirect labor(setup, material handling and inspection)	7200	P(Manufacturing)	P(parts handled)	Value Stream
Depriciation-facility & others	12000	P(Corporation)	P(space occupancy A:B:C:D =.2:.25:.35:.1)	Value Stream
Production Engineering	4800	P(Manufacturing)	P(total processing time ratio by products)	Value Stream
Maintenance	2000	P(Manufacturing)	P(total processing time ratio by products)	Value Stream
Supplies & Expendable tools	5000	P(Manufacturing)	P(total processing time ratio by products)	Value Stream
Prod&Inventory control	5040	SG&A(Administration)	P(time on products A:B:C:D =.15:.25:.35:.2)	Value Stream
Utilities	6000	P(Manufacturing)	P(space occupancy on A:B:C:D =.248:.20:.31:.248)	Value Stream
General Administration	10640	SG&A(Administration)	P(total processing time ratio by products)	Value Stream
Engineering	5760	SG&A(Administration)	P(time on products A:B:C:D =.2:.35:.15:.3)	Value Stream
Sales & Marketing	9200	Marketing	P(time on products A:B:C:D =.15:.3:.35:.2)	Value Stream
Miscellaneous cost	5400	P(Corporation)	P(equal ratio by products A:B:C:D = .25:.25:.25:.25)	Value Stream

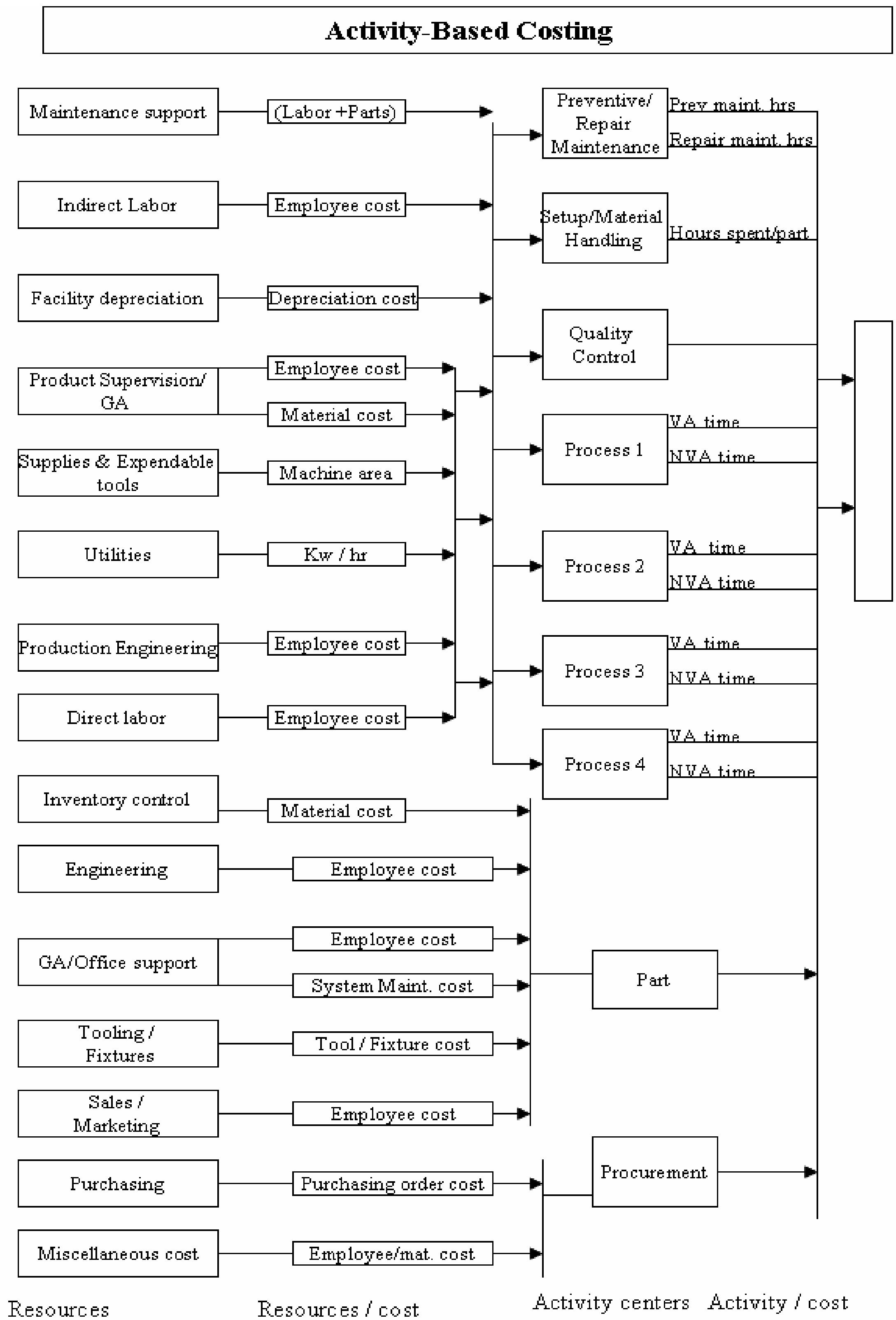


Figure 11 Activity-based overhead cost tracing [81]

secondary activities are normally allocated to the primary activities [65] and then the costs of primary activities are allocated to products. In this experimental study, the following activity centers are described based on these operation centers and these activity centers will consume certain level of resources. The resource consumption is calculated based on the utilization levels. The overhead cost centers are

- Product supervision
- Indirect labor (setup, material handling and inspection)
- Depreciation of facility and other costs
- Production engineering
- Maintenance support
- Supplies and expendable tools
- Production and inventory control
- Utilities
- General administration
- Engineering and development
- Sales and marketing
- Miscellaneous cost

The two major goals of activity based costing are to calculate the activity cost and product cost. The total product cost is summation of various activity costs incurred in the manufacturing facility. Every activity cost includes direct cost and indirect cost associated with the assigned resources. Support system resources are considered as indirect resources in this study and it will be assigned to main activity centers based on the utilization levels obtained from the system simulation output. Identified resources, activity centers and various activity costs are listed in the following flow chart. The economic life of all major equipment in this system is assumed to be 15 years or 108,000 hours and hourly depreciation cost of equipment can be calculated. The accumulated total product cost is calculated using the following mathematical equations. The following equations can be used to calculate the different activity level costs and resource consumption rates for a given product. The same standard cost centers are used across different management accounting alternatives in order to avoid complication of the process. Table 3.4 shows the overhead cost allocation of ABC for different products on each cost centers.

Procurement cost [81]

$PCi = (OPC \times NOi) + (RMCi \times NBi)$

PCi = per unit procurement cost for part type i.

OPC = Order processing cost per order

NOi = Number of orders for part i.

RMCj = Repair Maintenance Cost per hour for machine j.

NBij = Number of batches of part i processed on machine j

Material handling cost for part type

$MHCi = \sum (TMHi \times CRLi)$

TMHi = Total time required to move the materials between work stations

MHCi = per unit material handling cost for part type i.

CRLj = Cost of labor for machine j per production hour.

Inspection/Quality control cost for part type

$QCi = \sum (CRLi \times TQ_i) + (CQCj \times NUi)$

QCi = per unit quality cost for part type i.

CRLj = Cost of labor for machine j per production hour

TQ_{ij} =Total time required for quality and inspection of part types i processed on machine j.

CQCj = Inspection cost rate following machine j

NUij = Number of units of part i produced in machine j.

Table 3.4 Overhead allocation using ABC

Overhead Allocation Using Activity Based Costing	A	B	C	D
Machining (A:77 hrs; B:92 hrs, C:129 hrs, D:54 hrs) x $28.125	2165.6	2587.5	3768.75	1518.75
Material Handling (A:266 parts; B:553 parts, C:366 parts, D:362 parts) x $4.26	1133.16	2355.78	1559.16	1542.12
Product Supervision (time on products A:B:C:D = .15:.2:.4:.25)	960	1280	2560	1600
Marketing Expense(time on products A:B:C:D = .15:.3:.35:.2)	1380	2760	3220	1840
Depriciation-Facility & others(space occupancy A:B:C:D = .2:.25:.35:.2)	1200	1500	2100	1200
Maintenance support(Total processing time ratio by products)	375	300	950	375
Prod& Inventory Control (time on products A:B:C:D = .15:.25:.35:.25)	756	1260	1764	1260
Production Engineering (total processing time ratio by products)	450	950	2200	1000
Supplies and Expendable tools(total processing time ratio by products)	500	1000	2600	900
Utilities (space occupancy and process time on A:B:C:D = .248:.20:.31:.248)	744	600	930	744
Engineering(time on products A:B:C:D = .2:.35:.15:.3)	1152	864	2016	1728
General Administration(total processing time ratio by products)	2638.7	2128	3298.4	2638.7
Miscellaneous cost (A:B:C:D = .25:.25:.25:.25)	1350	1350	1350	1350
Total Overhead Cost / month	$14,804.46	$18,935.28	$28,316.31	$17,696.57
Unit Overhead cost(A:B:C:D)	55.65	34.24	77.36	48.88

Maintenance cost for part type i / unit

$MCi = (1/ NAi) \sum (PMCi \times TM_i) + (RMCj \times TRi)$

MCi = per unit maintenance cost for part type i.

NAi = Number of part type i to enter processing.

PMCj = Preventive Maintenance Cost per hour for machine j.

TM_i = Preventive maintenance time for machine j

RMCj = Repair Maintenance Cost per hour for machine j.

TRj = Repair Maintenance Cost per hour for machine j

The unit production cost for part type i on machine j

$MPCi = (1/ NAi) \sum [(GACRj + SCRj + CDPj + OCj + CRSj) \times TP_{ij} +(CRLj \times TL_{ij})+(CRSj + CRLSj + CDSj) \times TS_{ij}]$

MPCi = per unit production cost for part type i on machine j.

NAi = Number of part type i to enter processing.

GACRj = General Administrative cost rate for machine j

SCRj = Space occupied rate for machine j.

CDPj = Cost of depreciation for machine j per production hour

OCj = Operating cost rate per hour for machine j CRSj = Consumable supplies rate for machine j.

TP_{ij} =Total machine processing time for production of part types i processed on machinej

CRLj = Cost of labor for machine j per production hour.

TL_{ij} = Total Labor time for production of part types i processed on machine j.

CRLSj = Setup cost of labor for machine j per hour.

TS_{ij} = Total time for batch setup of part types i processed on machine j

CDSj = Cost of depreciation for machine j per setup hour

Inventory handling cost of part i /unit

$$WIP_i = \frac{NQj \times IOHj}{\sum NAi}$$

NQj = Maximum number of parts waiting in the machine j queue

IOHj = Inventory overhead rate per part.

NAi = Number of part type i to enter processing.

Product development cost of part i / unit

$$DCi = \frac{1}{\sum_{i} NEi} (TCi + ECi)$$

DCi = per unit development cost for part type i.

TCi = Tooling cost per unit for part type i.

ECi = Total Engineering cost for part type i.

NEi = Number of estimated part type to be produced over product life cycle i.

Accumulation of all costs to provide the per unit cost for part type i

$$UCi = DCi + PCi + MHCi + QCi + MCi + \sum_{J} (MPCi + WIPi)$$

UCi = per unit cost for part type i.

DCi = per unit development cost for part type i.

MHCi = per unit material handling cost for part type i.

PCi = per unit procurement cost for part type i.

QCi = per unit quality cost for part type i.

MCi = per unit maintenance cost for part type i.

MPCi = per unit production cost for part type I on machine j

WIPi = per unit inventory overhead cost for part type i.

3.9 Traditional Costing System

Traditional costing is used in this study to represent traditional management accounting. The reason behind selection of this management costing system because it is widely used by accountants in practice [25] [26][85] and more than 60% of industries surveyed by [42]. This product costing systems rely on simplistic methods to allocate overheads to products. According to literature, four cost centers represented by four departments are used in this study. Traditional management accounting frequently accumulates various activity costs by department [15] [42]. Figure 12 shows the overhead costing principle associated with traditional costing and table 3.5 lists the cost accumulated with different departments in order to identify the indirect product cost and in direct operation cost for overhead allocation. The respective departments are purchasing, manufacturing, administration and marketing. All the activities pooled into these departments and overhead is allocated to each product in the respective departments. In common, this allocation is based on labor usage or machine hour rate. Non-manufacturing overheads are recorded as period costs and are disposed exactly same as manufacturing overheads.

Normal costing is used in this study to evaluate overhead cost. Further, predetermined overhead cost allocation rate used based on machine hour usage of each product and the amount of direct labor cost is very small that will be contribute less than 10% of product cost in many advanced manufacturing environment. From the literature, many overhead costs including tools and fixture cost, utilities and machine depreciation, engineering, supervision and property taxes are more likely related to usage of machine hours than direct labor hours [42]. Using machine-based overhead rates instead of labor-based rates should produce more accurate product costing in advanced manufacturing environments which means high overhead based manufacturing industry [76].

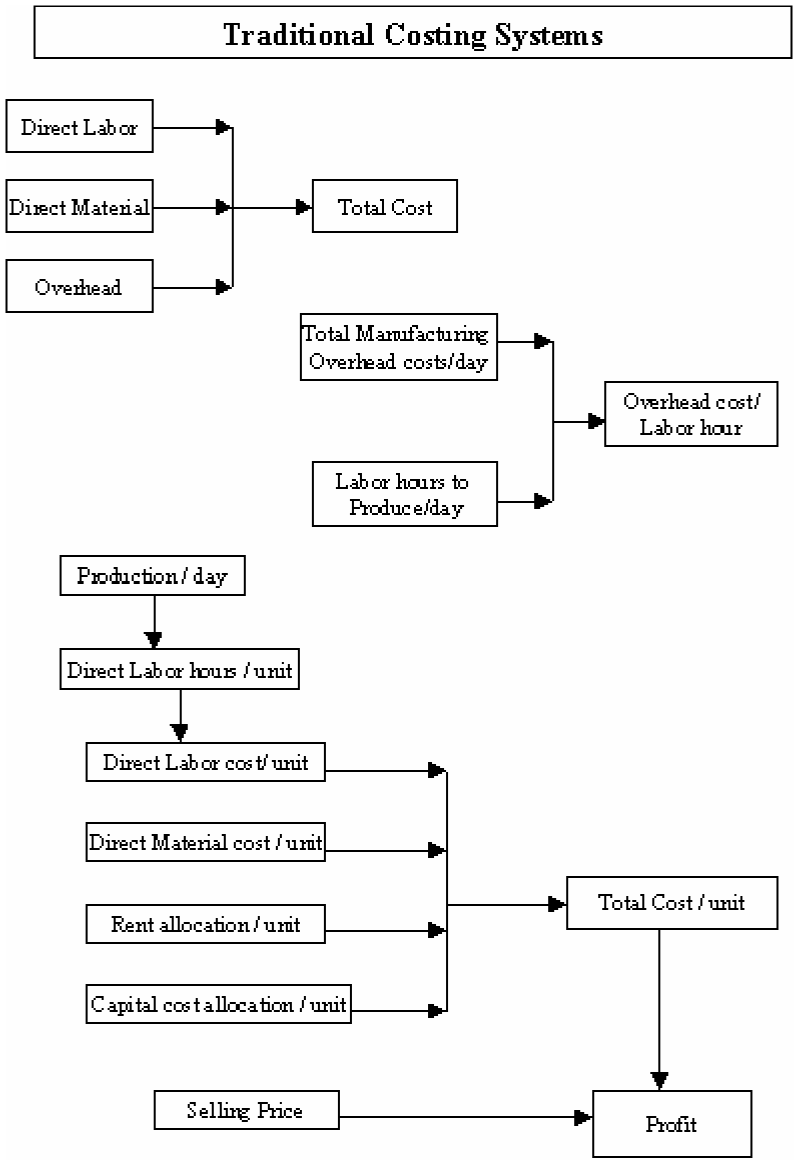


Figure 12 Overhead cost allocation based on traditional costing

Table 3.5 Overhead cost centers for traditional management accounting

Products	Finished Units	Machining (hrs)	Production	Marketing	SG&A	Corporation
R	100	29	31400	9200	21440	17400
S	200	32.2				
T	100	35.5				
U	200	29				
Total dollars			Indirect Product cost (48440), Indirect Operating cost (31000)			

Overhead rate:($48440)/320 hours

R (29hrs x 151.375)/100 units =$43.89 + 15.89 = 63.93/unit

S (32.2hrs x 151.375)/200 units =$24.37 + 15.89 = 44.41/unit

T (35.5hrs x 151.375)/100 units =$53.73 + 15.89 = 73.77/unit

U (29hrs x 151.25)/200 units =$21.93 + 15.89 = 41.97/unit

3.10 Lean Accounting (Value Stream Costing)

Lean accounting concepts are designed to reflect the changes or improvements of the shop floor which run under flow line value stream. It accounts the cost based on value stream for one product family not by individual products, and includes non financial performance measures in management accounting statements. A typical value stream includes everything done to create value for a customer that can reasonably be associated with a product or product line. Among the costs in value stream would be the expenses of a company incurs to design, engineer, manufacture, sell, market and ship a product as well as costs related to servicing the customer, purchasing materials and collecting payments on product sales[70]. It considers all labor works in the particular value stream as direct labor irrespective of his work whether he produces or supports value stream. This leads to direct tracing of indirect labor into one product family instead of allocation. This chapter already discussed the different overhead methods and advantages. Further it takes all other cost as direct cost except facility depreciation cost. This cost will be allocated based on the plant floor square foot usage. This costing tracks the cost on a product line level not by individual activity level. The product cost varies based on product mix and volume. Value stream costing will consider all the manufacturing costs and support costs except raw material as value stream overhead. This overhead is assigned to one product family not by individual products. This accounting principle computes maximum profitability based on creating the maximum the flow of product through the value stream. Non financial performance measure plays an important role across product families in the stream line. Lead time 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. The rate of flow through the value stream is more important than utilization of resources, people’s individual efficiency, or overhead allocations [101]. The above statement is clearly support the lean manufacturing principle and it drives based on customer demand. Figure 13 shows the overhead cost allocation for a product family of value stream.

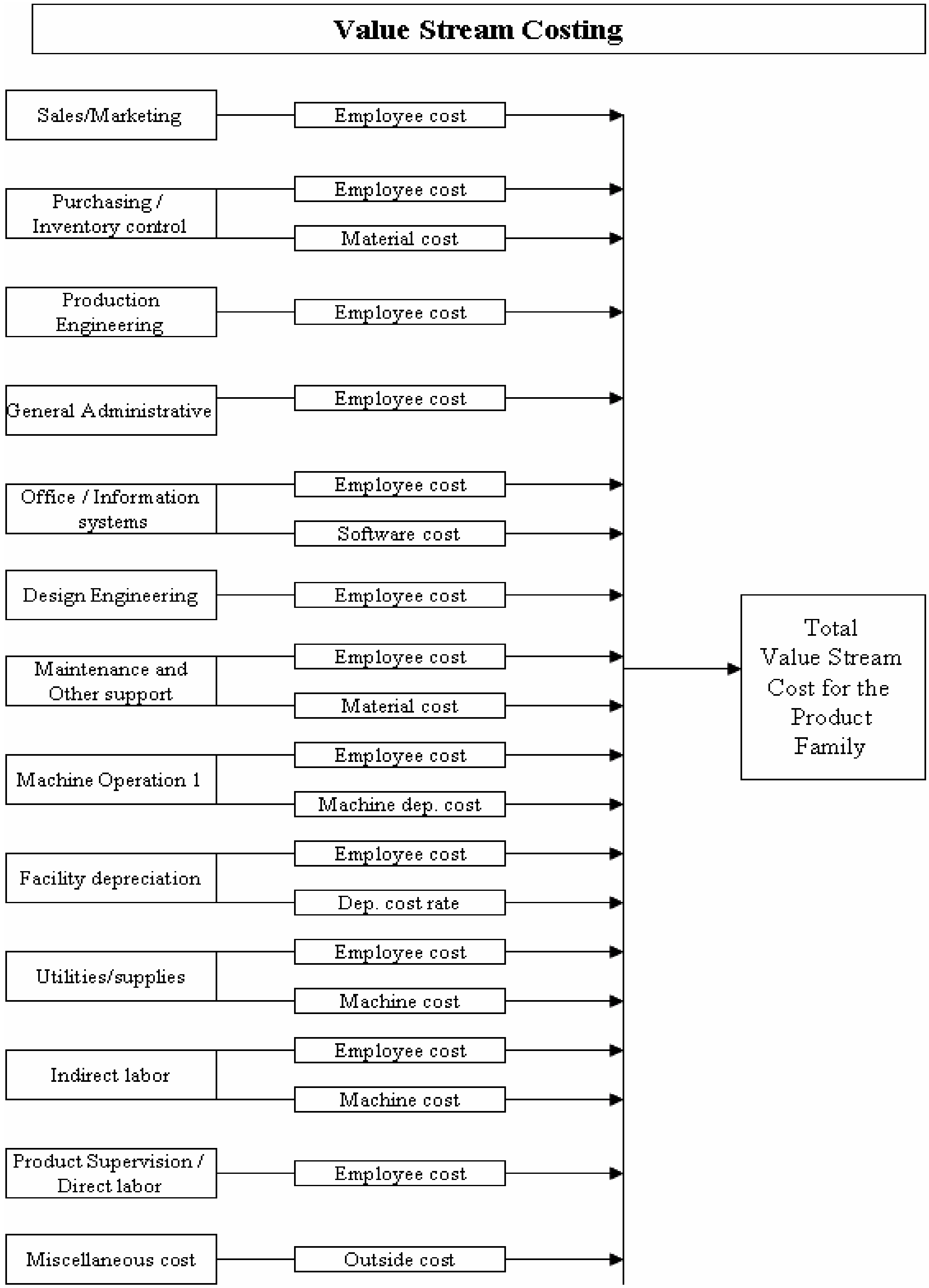


Figure 13 Overhead cost allocation based on value stream costing

Actual cost system uses actual costs for direct materials, direct labor, and overhead to determine unit cost. In practice, strict actual cost systems are rarely used because they cannot provide accurate unit cost information on a timely basis.

Normal costing systems that measure overhead costs on a predetermined basis and use actual costs for direct materials and direct labor. In practice, this cost system is used in many firms to calculate product cost. This experimental study follows normal costing system to achieve more realistic results.

Raw material costs: high volume purchase gets lower price quote on purchased materials than low volume material with frequent orders. But this variation can be adjusted by establishing long term contract with material suppliers. Direct Labor cost: Labor cost is included in the individual product cost for traditional accounting and activity based costing and value stream for lean accounting. The raw material cost and direct labor cost is calculated based on number of products produced in the given product mix and simulation program accounts for it. The raw material and labor cost per product is shown in table 3.6.

Selling price: Market is assumed to be perfectly competitive in this study. This selling price is decided by market based on the competition. The selling price for each product as follows and shown in table 3.7.

Contribution margin for individual products is calculated from the available selling price and product cost of each management accounting system. Linear program is constructed to find out the optimal product mix. This linear program includes the capacity constraints and demand constraints. Table 3.8 shows the forecast demand or customer order and different product mix under various management accounting alternatives.

Table 3.9 shows the total product cost calculated based on traditional standard costing principles. Table 3.10 indicates the product cost calculated based on activity-based costing principles. Table 3.11 shows the product cost calculated based on value stream costing principles.

Table 3.6 Raw material cost and direct labor cost

Raw Material & Direct Labor Cost

Product Id.	Raw Material Cost	Direct Labor Cost
Product R(LR 220)	$21	$9.09
Product S(LR 110)	$16	$4.80
Product T(LR 330)	$31	$10.7
Product U(LR 210)	$19	$19

Table 3.7 Selling price for individual products

Product Id.	Selling Price
Product R(LR 220)	$160
Product S(LR 110)	$110
Product T(LR 330)	$210
Product U(LR 210)	$125

Table 3.8 Forecast demand and product mix for different accountings

	R	S	T	U
Forecast	1200	750	600	1050
TA	595	524	368	1002
ABC	550	731	370	872
VSC	806	0	483	806

Table 3.9 Traditional standard costing-product cost

Products	RM Cost	Labor Cost	Overhead Cost	Total Cost
Product R(LR 220)	$21	$9.09	$63.93	$94.02
Product S(LR 110)	$16	$4.80	$44.41	$65.21
Product T(LR 330)	$31	$10.70	$73.77	$115.47
Product U(LR 210)	$19	$4.35	$41.97	$65.32

Table 3.10 Activity-based costing-product cost

Products	RM Cost	Labor Cost	Overhead Cost	Total Cost
Product R(LR 220)	$21	$9.09	$55.65	$85.74
Product S(LR 110)	$16	$4.80	$34.24	$55.04
Product T(LR 330)	$31	$10.70	$77.36	$119.06
Product U(LR 210)	$19	$4.35	$48.88	$72.23

Table 3.11 Lean Accounting (value stream costing)-product cost

Products	RM Cost	Conversion Cost	Total Cost
Product R(LR 220)	$21	$57.97	$78.97
Product S(LR 110)	$16	$57.97	$73.97
Product T(LR 330)	$31	$57.97	$88.97
Product U(LR 210)	$19	$57.97	$76.97

3.11 Process Simulation

The simulation model utilizes ARENA software package, and Microsoft Corporation's Visual Basic were used to develop the simulation model, to mimic the production shop floor environment and to collect various performance measurement statistics.

3.12 Simulation Experimental Setup

The simulation model assumes the following assumptions and these assumptions have already referring to the studies conducted by Ramasesh and Krawjewski [60], and Bih – Ru Lea [62].

- Pre-emption is not allowed after work starts.
- No alternate routings other than specified.
- Transit time between some workstations is assumed to be material handling time.
- Back orders are not allowed and once demand that cannot be filled is lost.
- All the work centers are driven by successive work station queue length to achieve minimal work in process inventory.
- Simulation model runs under make-to-order concept. So there is no finished goods inventory in the storage area.

Number of work centers used in production floor simulation model in the literature ranges from 4 to 50 and is commonly set to between 5 and 10 work centers[60]. By examining various test lean principles and manufacturing control systems, this study assumes 9 work stations in the floor and grouped as focused factory for dedicated product family of products.

- Nine workstations are used to process all the parts
- Production planning station will process the order and release the schedule to peacemaker process.
- All set-up activities take place when the work centre starts to process different product.

- Assembly work centre is used to assemble all sub and major components.
- An inspection and packing station is used to inspect and pack all the products.
- Different material handling equipments are used to transfer the material between various work stations.

The mean processing time was calculated to obtain an average utilization rate for bottleneck and desired utilization rates for all other work centers. Processing time variation is also considered in this study because processing time variation is unavoidable in many practical situations under any given manufacturing control system. This processing time variation may impact the product cost calculation in the different management accounting alternatives through machining cost center value. Figure 14 shows the schematic simulation model setup for the production shop floor and other manufacturing activities. Table 3.12 shows the processing time and distribution considered for each work station in this study.

3.13 Number of Replications

Simulation replication will be used to capture the variation of performance or response variable means. The number of replications can be estimated from the given formula by Pritsker [80] based on 90% confidence interval of sample means.

$$I = \left[\frac{t_{\alpha/2, I-1} S_x}{g} \right]^2$$

Where

I – number of independent replications

$t_{\alpha/2,I-1}$ – Student’s t value with I-1 degrees of freedom

S_x –sample standard deviations of response variable.

g-half-width of confidence interval for sample mean.

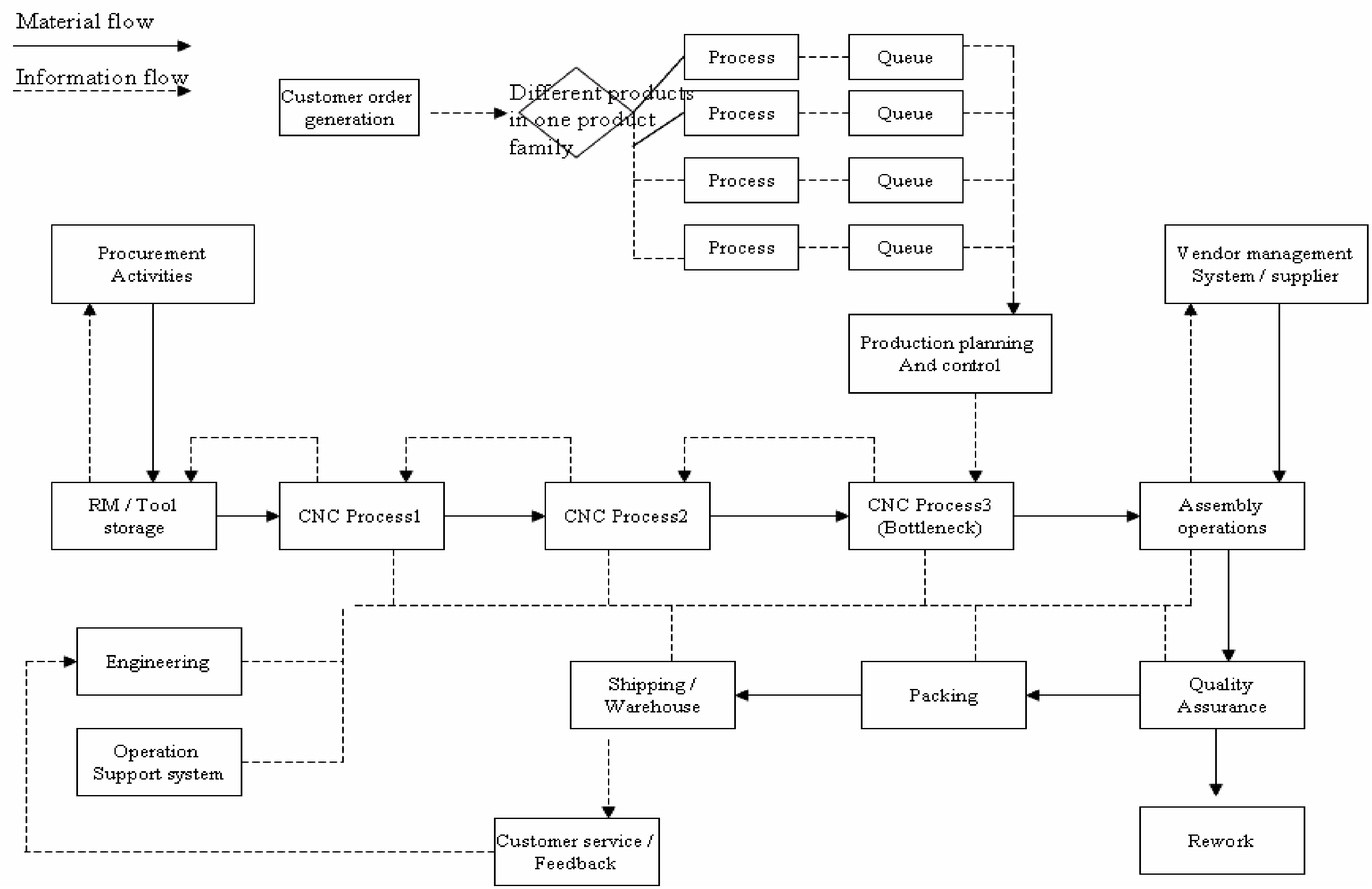


Figure 14 Schematic diagram of simulation model

Table 3.12 Process time and distribution used for various work stations

Work center(Resource)	Capacity	Product R	Product S	Product T	Product U
WC 1 (Process)	1	NORM(10,1)	NORM(4,0.5)	NORM(5,0.5)	NORM(3,0.5)
WC 2	1	NORM(3,0.5)	NORM(5,0.5)	NORM(4,0.5)	NORM(7,0.5)
WC 3	1	NORM(5,0.5)	NORM(2,0.5)	NORM(5,0.5)	NORM(5,0.5)
WC 4	1	NORM(0,0)	NORM(10,1)	NORM(8,0.7)	NORM(3,0.5)
WC 5	1	NORM(3,0.5)	NORM(3,0.5)	NORM(15,1.2)	NORM(4,0.5)
WC 6	1	NORM(2,0.5)	NORM(0,0)	NORM(3,0.5)	NORM(8,0.7)
WC 7	1	NORM(10,1)	NORM(2,0.5)	NORM(5,0.5)	NORM(3,0.5)
WC 8 (Inspection)	1	NORM(2,0.5)	NORM(2,0.5)	NORM(2,0.5)	NORM(2,0.5)
WC 9 (Packing)	1	NORM(2,0.5)	NORM(2,0.5)	NORM(2,0.5)	NORM(2,0.5)
WC 10 (FG Handling)	1	NORM(2,0.5)	NORM(2,0.5)	NORM(2,0.5)	NORM(2,0.5)

The g value can be specified in relative terms of σ_x, that is, let $g = v\ \sigma_x$ for $v>0$. In this case, we can compute without the knowledge of σ_x [80]. This study is also desired to have 90% confidence interval that μx is within (x_i-0.8σ_x, x_i+0.8σ_x). This equation requires approximate 6 replications to provide this level of statistical confidence.

3.14 Validation of Simulation Models

Verification is determining that a simulation computer program perform as intended [61]. Computer simulation program output is verified with numerical calculation and checked for validity. Further, the model run with very slow speed and carefully tracked the flow of entities during the simulation run mode. This study also applies several verification techniques proposed to ensure the simulation program performs as intended. Many researchers stated that animation is a powerful tool to check the validity of the program.

Validation determines whether the conceptual simulation model is an accurate representation of the system under study [61]. The advantages of using the simulation program is to capture the real variance in the manufacturing environment, it will be possible by more replications with same input data under a given mean processing time and standard deviation. The construct validity is achieved through reviewing literature to ensure that the treatment effect being measured is caused by the experimental factors. Further, statistical conclusion validity determines whether sample size is large enough to detect a treatment effect, and whether a desired alpha level is obtained. Based on these discussions, we can check the simulation program that it runs like a real manufacturing environment and captures all the variations exists.

Chapter IV

Results

The results of the experiment are summarized, and detailed analyses are presented in this chapter. The discussion of results is based on data generated by simulation model using Rockwell Simulation Software (ARENA). Details of how the simulation was set up are discussed in Chapter III. The first section of this chapter presents the raw data from simulation output for various management accounting systems. These data were then tested to check the statistical significance. ARENA 5.0 simulation model, JMP and MS Excel are the computer application softwares used to analyze the data. The second section discuses the performance measures of different accounting system. Mathematical means of the different performance measures are checked and ranked by the Univariate Analysis of Variance (ANOVA) and Tukey HSD test.

4.1 Presentation of Raw Data and Statistics

First, the product costs were determined using the simulation model run based on individual product processing time under a given lean manufacturing setup environment. Each management accounting requires different data to calculate product cost. For example standard absorption accounting needs machine processing time for each product in order to allocate the overhead cost. This costing allocates overhead based on labor hour or machine hour. In this case, our manufacturing environment is highly automated and requires less man hour to run the machines. Table 4.1 shows the net income for a given traditional standard costing product mix under different experimental condition. In this case, machine hour based overhead allocation is more suitable compare to labor hours. On the other hand, assembly related plants require high labor hour to assemble the parts in each station and it may be allocated based on labor hour usage. Based on the product cost data, the product mix for each management accounting alternatives were calculated using linear programming model which was constructed in LINGO software.

Table 4.1 Traditional standard costing

Lot Size (Qty)	Changeover (Hrs)	Material Handling time (mins)	Traditional Costing (Profit)
30	0.5	10	109481.62
		20	105620.7
	1	10	92361.71
		20	89974.51
	1.5	10	85778.13
		20	82523.55
40	0.5	10	106842.42
		20	103422.95
	1	10	101828.99
		20	100301.75
	1.5	10	92361.71
		20	89974.51
50	0.5	10	94579.73
		20	94174.18
	1	10	94295.8
		20	92727.38
	1.5	10	92212.62
		20	91198.65
60	0.5	10	95650.66
		20	94523.53
	1	10	90190.65
		20	88716.5
	1.5	10	86151.18
		20	84193.41

This optimal product mix was used to schedule the products to produce in the simulation model shop floor which runs under lean manufacturing principles. The total net income for each accounting is shown in the following table with other experimental factors.

4.2 Standard Absorption Costing

The performance measure is calculated based on the simulation output under each manufacturing setup which runs based on traditional standard costing. The series of different experiment setup shows considerable variation in the performance in total net income when it changes lot size, changeover and material handling. These independent factors play a major role in determining the lead time of any product which is manufactured in this focused factory environment. Focused factory arrangement has been widely accepted in modern manufacturing environment to effectively implement the ideas of just-in-time (JIT), small lot sizes, continuous improvement, and to enhance the total quality. Greater variety in product-line offers and smaller customer orders became a norm in many manufacturing environments coupled with the need to speed delivery to the marketplace by drastically reducing lead times. The net income collected in this study represented monthly income under different experimental settings. There is a significant difference in the net income for any particular lot size with various change-over time. From the table 4.2, one can observe that the net income increases when changeover time decreases. The above statement is true for all the management accounting alternatives.

Table 4.2 Hypothesis results for standard costing

Hypothesis	Approx. F	p-value
Ho: Lot Size = 0	358.3579	<.0001
Ho: Change Over = 0	1284.175	<.0001
Ho: Material Handling = 0	94.3029	<.0001
Ho: Lot Size * Change Over = 0	176.4305	<.0001
Ho: Lot Size * Mat Handl. = 0	5.6818	0.0346
Ho: Change Over * Mat Handl = 0	0.0834	0.9211

In summary, statistical tests have been conducted to check the impact of input variables on output performance measure. These tests found that all the input factors lot size, changeover and material handling do significantly affect the performance of net income. As shown in table, all main effects, two-way interactions expect changeover and material handling were significant under this manufacturing environment. Further Tukey-Kramer HSD test was conducted to check if there is any significant difference between each group of 4 levels of lot size and 3 levels of changeover time. Even though simulation output looks different across the 4 levels of lot size, the performance measure does not show a statistical significance of mean net income between 4 levels of lot size at alpha 0.05. On the other hand, changeover time has a major impact on performance measurement and it shows statistical significance across the different groups. This indicates that lot size has lesser impact on performance measure compared to changeover time for a given traditional product mix under a capacity constrained manufacturing facility. The figure 15 indicates the effect of individual factors on performance measure of total net income.

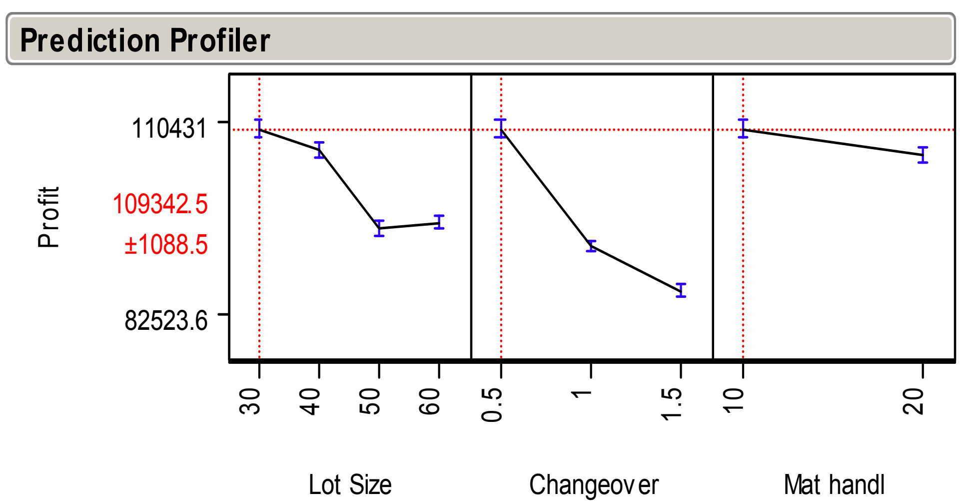


Figure 15 Profile graph for traditional standard costing

It can be seen that net income increases when the lot size approaches minimum but the magnitude of increase differs with lot size. For example, increase in net income is much higher when the lot size increases from 40 to 50 than when lot size increases from 50 to 60. This is consistent with earlier findings in literature. Hug [49] compared the functional layout and cellular layout for various lot size levels and concluded that lot size greater than 60 in cellular manufacturing environments does not show a significant impact on performance improvement compare to functional layout. This indicates that greater lot size products could be more suitable in functional layout. The changeover time also has major impact on total income. But material handling time has very less impact on total performance. In lean culture, all the three factors are considered as non value added and should be minimized through continuous improvement activities.

4.3 Activity-Based Costing

The table 4.3 shows the total net income for various experimental setups which runs based on activity based cost product mix. The output performance measure follows a trend similar to traditional management accounting but it is more sensitive to change in input variable. As discussed in chapter III, unlike traditional accounting as well as value stream costing, activity based costing calculates the product cost based on the activity level and resource consumption rate. It does not aggregate and allocate the overhead costs to products. It traces the cost from activity level to resource consumption level. Thus this costing assigns the real overhead cost and it replicates near accurate product cost for individual products. The different overhead cost allocation methods have been discussed in chapter III. Further it shows the comparison table of overhead allocation for mass production and lean production environment.

The statistical tests have been conducted to check the impact of input variables and the values are shown in table 4.4. The figure 16 predicts the profile behavior of activity-based costing product-mix products. The above table shows that main factors and some second order factors has major impact on output performance under

Table 4.3 Activity-based costing

Lot Size (Qty)	Changeover (Hrs)	Material Handling time (mins)	ABC Costing (Profit)
30	0.5	10	122,861.86
		20	119,959.46
	1	10	111,539.09
		20	108,638.72
	1.5	10	94,635.48
		20	92753.84
40	0.5	10	108667.25
		20	106339.01
	1	10	100,701.39
		20	97806.53
	1.5	10	96372.2
		20	94448.6
50	0.5	10	101943.4
		20	99672.4
	1	10	95670.65
		20	94670.31
	1.5	10	86072.53
		20	85193.17
60	0.5	10	98646.96
		20	96954.5
	1	10	96047.48
		20	95052.32
	1.5	10	91411.33
		20	90297.43

Table 4.4 Hypothesis results for activity-based costing

Hypothesis	Approx. F	p-value
Ho: Lot Size = 0	2023.157	<.0001
Ho: Change Over = 0	4162.509	<.0001
Ho: Material Handling = 0	190.2255	<.0001
Ho: Lot Size * Change Over = 0	358.1846	<.0001
Ho: Lot Size * Mat Handl = 0	3.857	0.075
Ho: Change Over * Mat Handl = 0	4.5587	0.0625

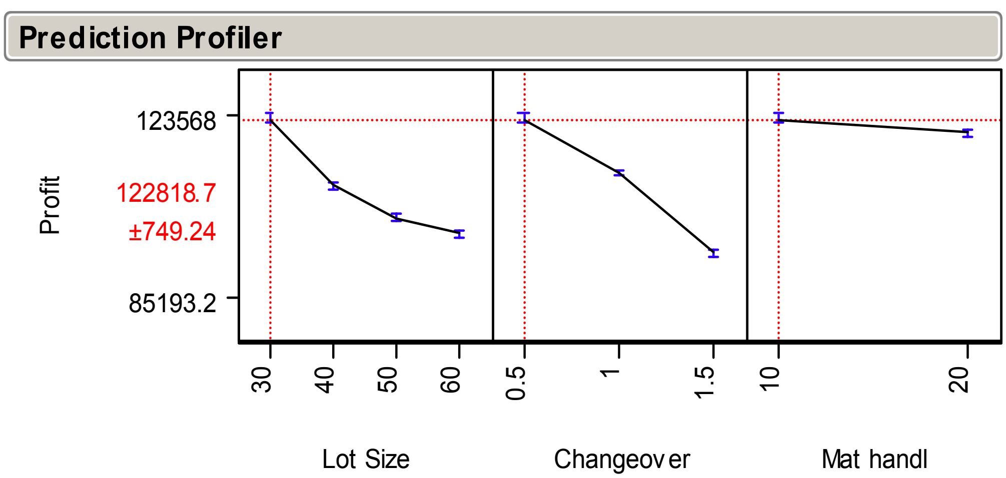


Figure 16 Profile graph for activity-based costing

a given experimental setup which runs based on activity based cost product mix. The effect of mean net income across various lot sizes is also statistically significant and the p value is less than 0.0001. Further, the above statement supports our earlier conclusion about the sensitivity and flexibility of changes for any given input variable. In addition, this cost model provides detailed view of cost information to support different types of decisions.

The profile graph indicates the effect of individual factors on performance measure of total net income. The activity based costing total profit gradually increases when the lot size decreases and as well as for different levels of changeover times. But this is not true for standard traditional costing and value stream costing. The effect of material handling on net income is very low. The principle behind activity based costing relies on the assumption of labor and overhead costs are relevant to resource allocation decisions. Under ABC, an activity's resources are disaggregated into either flexible or committed cost [26] [26]. Flexible cost represents the cost of resources acquired as demanded, while committed cost represents the cost of resources contracted for in advance of usage. Under ABC, an activity's flexible and committed or total costs are divided by its practical capacity to develop a cost driver rate that measures the cost of an activity's service. Under this procedure, an activity's committed cost is transformed into a flexible cost to reflect the cost of an activity's services. Using the quantity of an activity's service or activity cost driver consumed in a product's production, ABC traces the cost of an activity's resources to the products it is used to produce. As noted by Kaplan and Cooper [25], ABC reflects a long-term perspective of cost behavior. The benefits of operational ABC model are applicable to a wide range of production-related decisions. A product's activity-based cost, based on its flexible cost and bottleneck utilization, measures the incremental and opportunity costs of producing a product needed for short-run pricing, special order, and outsourcing decisions. A product's opportunity cost is the profit given up from using a unit of the bottleneck to manufacture the product relative to the profit that could be earned from producing the firm's most profitable product.

4.4 Value Stream Costing (Lean Accounting)

The table 4.6 shows the simulation output of total net income for a given experimental setup which runs based on value stream cost product mix. Value stream cost aggregates all the overhead cost, direct cost as well as indirect cost and assigns it to the whole value stream. All the costs are considered as direct cost and assigned to one group of products or product family. This value stream costing does not have the concept of allocating a portion of indirect, fixed costs as period costs. This period cost will be considered as period expenses which will be deducted from the overall company profit of that period. The overhead cost tracing is fairly simple when all the costs are considered as direct. Even though simulation output of value stream costing performance measure shows higher value for many experiments compared to other two management accounting principles, similar statistical tests have been conducted to check the impact of input variable.

Table 4.5 shows that main factors and interaction between lot size and changeover has considerable impact on output performance measure. The analysis of results shows that mean net income across the lot size does not have significant difference. This reflects the behavior of traditional standard costing. Because value stream costing does not trace overhead costs to individual products and this principle

Table 4.5 Hypothesis results for value stream costing

Hypothesis	Approx. F	p-value
Ho: Lot Size = 0	88.812	<.0001
Ho: Change Over = 0	1279.04	<.0001
Ho: Material Handling = 0	48.0039	0.0004
Ho: Lot Size * Change Over = 0	60.69	<.0001
Ho: Lot Size * Mat Handl = 0	1.4007	0.331
Ho: Change Over * Mat Handl = 0	0.1607	0.8551

Table 4.6 Lean accounting (value stream costing)

Lot Size (Qty)	Changeover (Hrs)	Material Handling time (mins)	Value Stream Costing
30	0.5	10	118910.75
		20	115400.14
	1	10	108732.17
		20	105674.53
	1.5	10	93781.64
		20	90426.62
40	0.5	10	120334.59
		20	118446.83
	1	10	106907.93
		20	103026.73
	1.5	10	91988.53
		20	90176.17
50	0.5	10	110114.46
		20	108133.71
	1	10	101605.67
		20	100155.95
	1.5	10	92150.59
		20	88994.12
60	0.5	10	104992.81
		20	103052.21
	1	10	99131.11
		20	98636.02
	1.5	10	95926.81
		20	94472.39

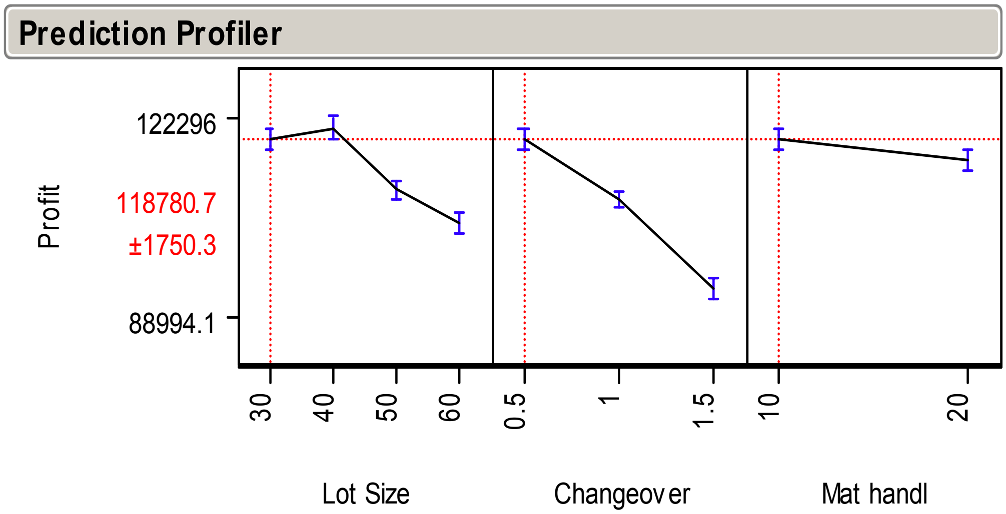


Figure 17 Profile graph for value stream costing

makes to aggregate the over head to total value stream or particular product family. This value stream overhead is divided equally to all the products that belong to the product family.

The figure 17 indicates the effect of individual factors on performance measure of total net income for value stream costing. The total profit gradually increases when the lot size decreases for three levels and as well as for different levels of changeover times. But performance behavior changes when the lot size decrease from 40 to 30. Unlike the other two management costings, value stream costing yields maximum net income for lot size 40 with minimum change-over time. Traditional standard costing and activity based costing achieves higher net income for minimum changeover and minimum lot size. However, our main focus is to find out the overall higher net income for all the experiment setup scenarios across different management accounting alternatives. The effect of material handling on net income is very low and it follows a similar trend like other management accountings.

4.5 Performance Comparison between Management Accountings

The total net income across traditional management accounting, activity based costing and value stream costing have been compared to identify the suitable management accounting for focused factory environment. An overall analysis of variance (ANOVA) showed that the total net income across different accounting and two of the three main effects has statistical significance on output performance. The following table 4.7 indicates the formulated null hypothesis and the results.

The resulting F and p value of this ANOVA test shows the impact of all the factors across the different management accounting. The p value for hypothesis Ho: MASi = 0 is less than 0.05. Therefore we can not accept the null hypothesis. It concludes that the overall mean net income of each management accounting shows significant difference. The interaction between lower lot sizes and changeover times of mean net income across various management accounting shows a statistical difference. Table 4.8 shows the mean net income for different management accounting system across various lot size and changeover. Figure 18 indicates the mean net income variation for different lot sizes and figure 19 shows the net income variation across different changeover for each management accounting system.

Table 4.7 Total net income across management accountings

Hypothesis	Approx. F	p-value
Ho: MASi = 0	8.9749	0.0043
Ho: Lot Size = 0	9.9955	<0.0001
Ho: Change Over = 0	52.625	<0.0001
Ho: Material Handling = 0	2.6178	0.1115
Ho: Lot Size * Change Over = 0	2.7389	0.0214

Table 4.8 Overall mean net incomes across different input factors

Input factors	Traditional standard costing	Activity based costing	Value stream costing
Lot Size 30	94290.04	108398.07	105487.64
Lot Size 40	99122.05	100722.49	105146.79
Lot Size 50	93198.06	93870.4	100192.4
Lot Size 60	89904.32	94735	99368.55
Changeover 0.5	100536.97	106880.6	112423.18
Changeover 1.0	93799.66	100015.8	102983.7
Changeover 1.5	88049.2	91398.07	92239.6

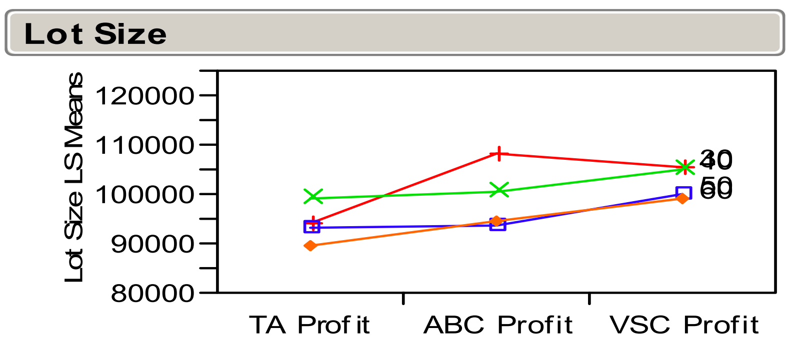


Figure 18 Mean net income of management accounting across lot size

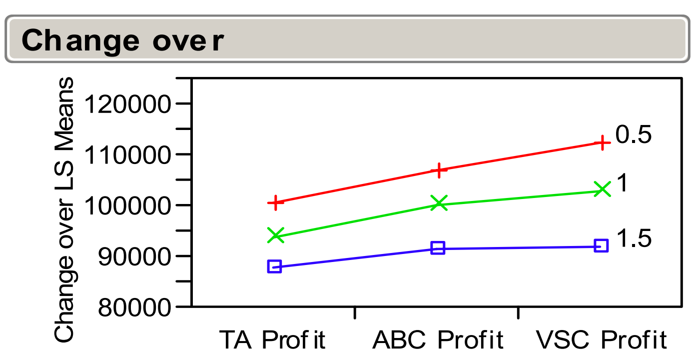


Figure 19 Mean net income of management accounting across changeover

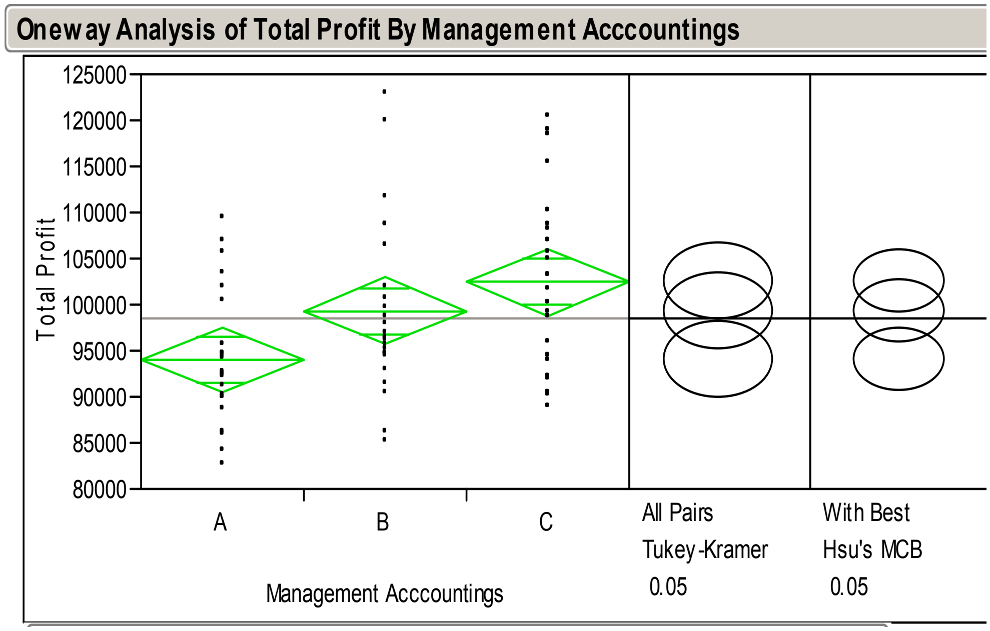


Figure 20 One way analysis of total profit by management accountings

The main factors across the different management accounting also make significant difference when it changes from lower lot size to higher lot size or change over time increases. The results discussed in total net profit are consistent across different management accounting alternatives. This finds consistent with literature [85] suggesting that short-term decisions should not conflict with long-term decisions.

The figure 20 compares the overall mean net income of each management accounting graphically to check the statistical significance. All the analysis has been conducted through (JMP) statistical analysis software which is widely used to evaluate the statistics or relationship between any given data. All pairs Tukey-Kramer and Best Hsu's MCB has shown the significance at alpha 0.05. The table 4.9 shows the overall mean output performance for each management accounting and rank classified based on statistical tests and other cost ratios. The figure 21 shows graphically how the profile of out put performance varies for different experimental variables.

Table 4.9 Comparison of overall mean and ranking

All Pairs Tukey-Kramer Mean

Management Accountings	Mean	Rank
Value Stream Costing	102548.85	A
Activity Based Costing	99431.5	B
Traditional Standard Costing	94128.62	C

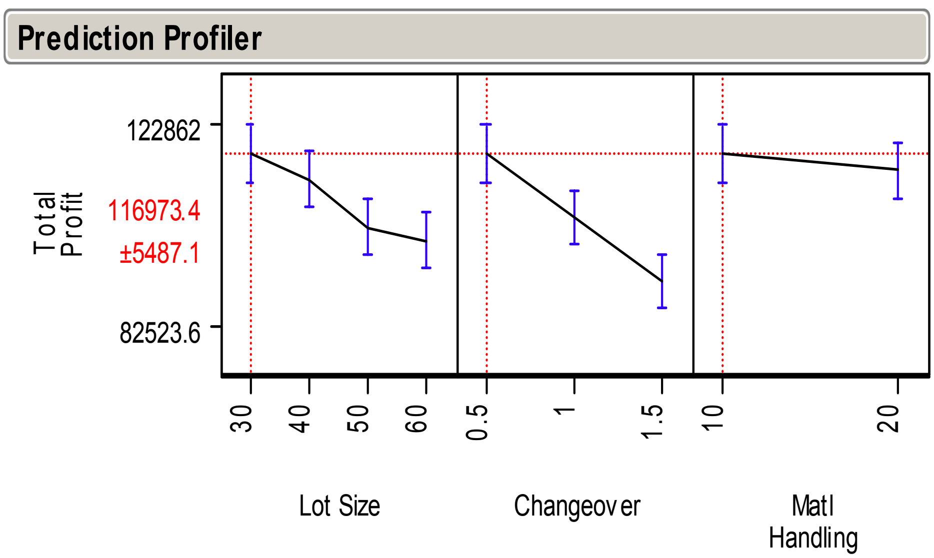


Figure 21 Profile graph for overall profit across all input variables

In addition, the following table shows rank for different management accounting alternatives. This rank is assigned based on above the test results and benefit cost ratio of each management accounting. Benefit cost ratio for value stream costing and standard traditional costing is higher compared to benefit cost ratio of activity based costing.

This profile graph shows the average variation of overall net profit income for any given lot size, changeover and material handling time. It clearly indicates that changeover time contributes major variation compared to lot size and material handling. Changeover time reduction is one of the main essential preconditions for a focused factory environment influenced by lean manufacturing philosophy. Traditional mass production environment is a function based layout, which operates on huge lot size with minimum changeovers. The frequency of changeover from one product to another product is comparably low and is of less significant in that environment. In contrast, for focused factory environment lean manufacturing, small lot size with high variety of products is a key principle. SMED is one of the lean tools available to reduce changeover time and this tool has to be studied in detail in order to effectively increase the total net income of any management accounting alternatives.

4.6 Pareto Chart of Overall Profit vs. Lot Size

The figure 22 indicates the average net income of all the management accounting alternatives across the different lot sizes. Traditional standard costing and activity based costing produces nearly same total net income for lot size 50 but this is not true for other lot sizes. Value stream costing generates higher net income compared to other two management accountings for all the lot sizes except lot size 30. Activity based costing out performs in lot size 30 but the difference between value stream costing and activity based costing net incomes are very low. The overall mean net income of traditional standard costing is lower for lot size 30 compare to lot size 40. This implies it may be more

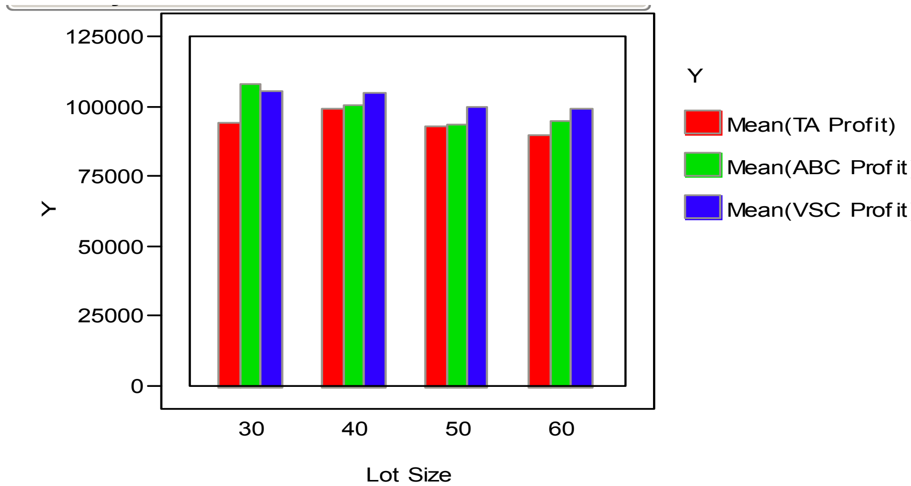


Figure 22 Pareto chart for lot size

suitable for higher lot sizes. The potential short comes of traditional standard costing over the modern management costing has been discussed in chapter I and II.

4.7 Pareto Chart of Overall Profit vs. Changeover

This figure 23 shows the mean net income for various management accounting alternatives under a given changeover time. When the changeover time is large, difference in net income for all the management accounting is comparably low. On the other hand, when the changeover time is less, difference in net income across the various accounting system is high. Further this graph implies that for a mass production environment, the different management accounting may not show the significant difference in performance measurement because the changeover frequency is less. But in lean environment, the frequency of changeover is higher and it leads to appropriate selection of management accounting in order to maximize the total net income. In addition, management accounting plays a major role by providing adequate information to select appropriate business decisions. This product cost based performance

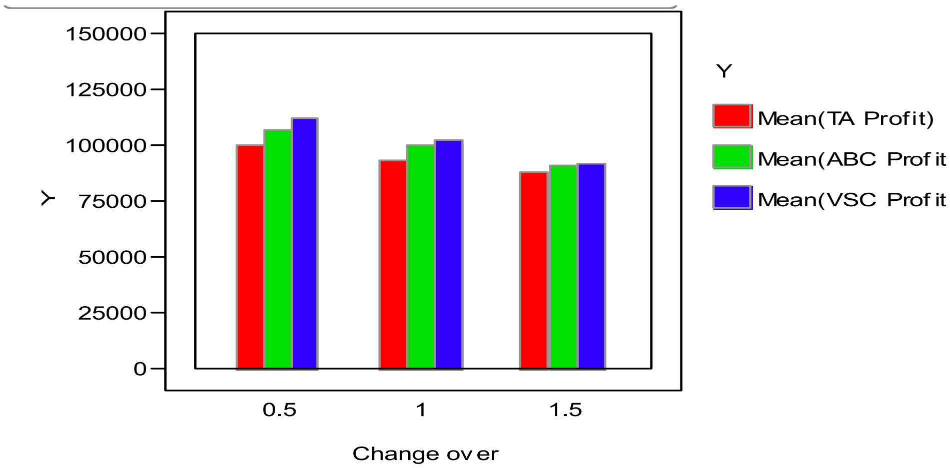


Figure 23 Pareto chart for changeover

measurement is widely used to direct and measure continuous improvement activities, mass customization, supply chain and other lean thinking initiatives. By comparing all the management accountings, value stream costing provides a bridge between operational views and financial views of lean. This communication vehicle is called *box score*. It presents the key operations and financial results, together with information on how the value stream resources are used. This will enhance and transfers the information from shop floor level to management level.

4.8 Management Accounting Strategy during Transition from Traditional to VSC

The natural evaluation of lean movement is toward streamlining and simplicity, and that accounting systems can and should become simple and even elegant. In addition to financial performance measure, non-financial performance measure plays a major role in today's competitive lean manufacturing environment. Lean manufacturing focuses to reduce the cycle time or lead time of any given product in the manufacturing facility. Therefore we need to integrate the non-financial measures with financial measures to capture the true benefits of lean manufacturing. This will be possible only through tracing overhead costs of products based of cycle time. This value stream costing insists to dedicate individual resources to each value stream or focused factory setup. In practical this may not possible during the transition period. Further it does not have any guidelines to share the resources among value streams. The following implementation steps will overcome the drawbacks and enhance the existing value stream costing.

- Performance measurement report needs to be based on value stream not by departments. This step assumes that the company already changed from traditional report to lean performance report.
- During the transition period, it is very difficult to allocate dedicated resources for each value stream. Therefore trace the shared resources across different value streams.
- Reduce the shared resources through continuous improvement or kaizen activities.
- Allocate the fixed direct cost to different value stream based on cycle time.
- The shared resource cost should be assigned based on cycle time of the value stream and this will lead to replicate the real overhead cost of the value stream.
- Total value stream overhead can be assigned to individual products based on product flow efficiency. Even though, all the products belong to one product family, cycle time between products will vary and mainly it depends on line balance of the products. This will help better understanding of individual contribution margin of products.
- Cycle time based overhead tracing will enhance the product mix decision for a constrained resource manufacturing environment (value stream).
- Identify the bottleneck operation inside the value stream and trace peace maker resource usage between individual products.
- Redesign the *box score* based on operational and financial performance measurement reports.
- This cycle time based tracing of overhead makes more reasonable and predicts the right business decisions which eventually drives the market share and future prosperous of the company.

Traditional overhead allocation

- Traditional standard costing assigns overhead based on machine processing time of the product and it gives less attention to work in process inventory.
- Activity based costing traces overhead cost based on each activity required and resource consumption rate. Even though this costing replicates the real product cost, it holds very complicatedly process and other reasons of implementation failures have been listed in literature review.

Chapter V
Conclusion

The purpose of this study was to evaluate the impact of management accounting alternatives on performance measures in lean manufacturing environment. In the preceding chapters, the problem statement was discussed, the literature was reviewed, the research methodology was described and simulation results were discussed. This chapter begins with research findings and recommendations and then limitations of this study. Finally, the future research directions are also discussed.

5.1 Summary of Research

This study analyzes the overhead cost distribution for three different accounting systems to calculate the product cost of individual parts that will lead to drive many business decisions like pricing, optimal product mix, make/buy decision and capacity investment analyzes. This product cost is used to identify the performance measure of accounting system in lean manufacturing environment. For that, this study uses simulation model to mimic the actual production shop floor to calculate the production quantity of every week or month based on the product mix supplied by different management accounting. The manufacturing environment was characterized by high overhead, low labor content. The effect of management accounting alternatives, lean production principles, performance measures (total net income) were examined through the impact of product mix decisions on generating maximum profitability. All the three management accounting system calculates product cost using different principle. The major portion of the product cost is overhead. This overhead allocation has to be linked with lean production principles. Any continuous improvement activity should lead to affect the overhead cost and eventually it changes the product cost. This overhead allocation in a focused factory environment which runs in one product family of products should be based on whole value stream overhead cost. One of the important Lean Principle is flow, how fast the product can move from initial work station to final work station. This flow includes not only machine process time but also all other value added activities performed to make final product. Further this study implies that portion of overhead cost can be allocated based on the cycle time of the product in the value stream. So, many lean principle implementations will lead to reduction of cycle time and it will eventually impact the product cost reduction. Moreover lean principle identifies waste in terms of lead time, focuses on 100% on-time delivery and high inventory turns. Through continuous improvement, we can reduce the total cycle time of the given product and this will lead to quick customer response, more flexibility and additional capacity creation to introduce new products in the assigned focus factory. The overhead cost is traced or assigned based on individual value stream of the product supports and sustain lean activities in the shop floor. In addition, reduction in cycle time creates more revenue which will reflect in the financial statements also. Value stream costing includes this non financial measure as one of the performance measure to show the lean improvements. On the other hand, standard absorption costing includes only financial measures to make any business decision and many situations this can't lead good business decisions.

This research identified that there is a significant difference between using Activity based costing and traditional costing to determine the product costs that were used to make product mix decisions when overall profitability as performance measure in the simulated shop. The other performance measures are not considered because the whole system drives based on pull system. Therefore work in process inventory is considered to be low at any given time and it is not be used as one of the performance measure to check the significant difference between various management accounting alternatives. When overall performance is considered, value stream costing led to higher profit and better benefit-cost ratio of understanding the system. Although activity based costing performs nearly close to value stream costing in mean net income, but the benefit cost ratio for value stream is higher than activity based costing. The results of this study suggest that short-term decision making across different accounting has significant impact when management accounting changes. As suggested by other literature, short-term controllable and non-controllable costs considered to determine product costs. As discussed in previous chapters, traditional costing takes some uncontrollable cost into consideration in determining product costs, and ABC costing takes all controllable and uncontrollable costs into consideration to determine product costs. Value stream costing follows the ABC method and it assigns all the cost to particular value stream to determine the product cost in the product family. The results of this research indicate that management accounting alternatives that considered controllable and uncontrollable costs resulted in decisions that led to better system performance. In addition, this study suggests that major portion of the overhead should be traced based on value stream of the product family to determine the product costs to capture the continuous improvement activities of the manufacturing environment which leads to sustain the system. A management accounting alternative that can properly represent all the manufacturing processes and activities will result in decisions that lead to better performance in the short term as well as in the long term. The management accounting should mimic the manufacturing process is one of the main implication from this study. The purpose of management accounting should provide adequate and relevant information to support business decisions.

5.2 Comparison to Previous Studies

In addition to the findings and results discussed in chapter 4, this research is noteworthy because it is the only management accounting alternative compares lean accounting (value stream costing) with other costing methods in the lean manufacturing environment to measure the overall performance of the system. Previous studies have not tested value stream costing, which allocates overhead cost based on value stream under a resource constraint environment to make product mix decision in a focused factory. Further, this research also incorporates small lot size and flexible changeover time to predict the practical shop floor characteristics. Many research studies have neglected these factors while comparing different accounting systems. The previous studies have analyzed the impact of different product structure and time horizon for when the management accounting system changes.

The results of this research also support Shank's argument [85] that short-term and long-term decision making should be consistent with each other. Bakke and Hellburg [9] reported that the effect of management accounting alternatives on product mix and profit is highly dependent on manufacturing environment. This study further breaks her statement into different steps, the product cost drives the product mix and this leads to measure the accounting performance. So, the product cost consists of raw material, direct labor and overhead. Raw material and direct labor is constant in any management accounting alternative and the only variable is overhead. This overhead is studied in detail and identified a suitable method to trace the major portion of overheads to different products. In addition, the results of this research support conclusions of] Shank [85] that short-term controllable costs and uncontrollable costs should be considered together to make better decisions. Shank [85] even suggested that ABC costing should be used to make short-term decisions as well as long-term decisions.

5.3 Limitations/Scope of Current Study and Future Research

The limitations of this study are already discussed in chapter I under scope and anticipated results. So, this study identifies many future research directions in order to make the results more generalizable. Although it provides number of interesting results, it can be tested under wide variety of products with different product routing. However, the use of simulation modeling makes it possible predict the behavior of different variable and it provides insight and directions of future research for stochastic demand and seasonal demands. As mentioned earlier, only a limited variety of variables taken into consideration while assigning overhead cost to different products based on management accounting principles in order to avoid more complications. This can be further extended for specific industrial applications. For example it can be tested for different product complexity and structure for different bill of materials. This overall experiment results are more suitable for high overhead content with low direct labor. Different industries may have different cost structures or centers to capture the real overhead cost that may have different impact on performance measures and selection of management accounting alternatives. For example this study can be extended to service industries. Further the experiments should be conducted for a wide variety of manufacturing environments like throughput and mass production. Many industries may not implement lean manufacturing principles and focused factory arrangements, so the research has to be conducted on other manufacturing environments. In addition, this may be tested with other management accounting principles like direct costing and throughput costing to measure the performance of manufacturing environments. The overhead cost tracing may be tested with other non-financial performance measures like inventory turns or include these measures while decision making on product mix, new product introduction to existing product family which runs in one value stream setup.

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VITA

Karuppuchamy Ramasamy was born in Chennai, India on April 15 1978. He graduated from M.S.P.S.M – High School in 1995. He received his Bachelor of Engineering degree with a major in "Mechanical Engineering" from Bharathiyar University, India in 1999. He worked 3 years as "Design and Development Engineer" in Genau Extrusions Ltd., India. Then, he obtained his Master of Science degree with major in Industrial Engineering from University of Tennessee, Knoxville in August 2005.