CHAPTER – 2
LITERATURE REVIEW

In this chapter, different ways of performance measures are explored. The chapter begins with emphasizing some common questions a measurement practitioner must deal with. Performance measurement definition and scope are reviewed, and then various types of performance measures are discussed with their limitations. Finally, a review of conceptual performance measurement framework is presented.

2.1. INTRODUCTION

Lord Kelvin once said “When you can measure what you are speaking about, and express it in numbers, you will know something about it... [Otherwise] your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in thought advanced to the stage of science”. Unfortunately, this is easier said than done when it comes to measure the performance of a business or an activity in a company. There are, for example, numerous of performance measures to select from and it is often not clear what performance actually should considered to be in an operation.

The traditional way to measure performance is to use financial performance measures, such as return on investment, profit and cash flow. However, these types of measures have been found to have a number of limitations and it is argued that a performance measurement system cannot solely rely on financial performance measures, since they do not properly reflect the requirements that a company must fulfill in today’s competitive business environment. Consequently, the interest in performance measurement as a research topic has grown significantly in the last two decades, where much effort has especially been made on the development of new performance measurement systems that can cope with the common problems associated with the use of financial performance measures.

According to White (1996), there are two basic questions that must be answered in any measurement situation:

• What will be measured?
• How will it be measured?
Considering the question of what will be measured, wide range of available performance measures make it essential to understand that the performance measures to be used depend on the scope of interest. Different performance measures are to be used in different cases. It is also most likely that several performance measures must be combined to get a useful result out of the measurements. When deciding what to measure, it must first be considered if it is possible to measure it at all (White, 1996).

Considering the question of how it will be measured, an important issue is whether the data to be measured is tangible or intangible. Tangible data, i.e., objective data within manufacturing usually have units such as:

- Quantity (e.g. number of products, workers, work hours or defects)
- Time (e.g. lead time, process time or mean time between failures)
- Money (e.g. labor cost, manufacturing cost or material cost)

While tangible data is relatively easy to obtain, intangible data, i.e., subjective data with high accuracy will often be almost impossible to capture. Nevertheless, intangible measures can be ‘measured’ by making an individual estimation or using a ranking scale, for example, evaluating customer satisfaction on a scale from 1 to 5. Several other questions that need to be answered will also appear when deciding how to measure, such as:

- Who will perform the measurement?
- How frequently are the measurements to be made?
- Who acts on the data of the measures?
- When should the measures be revisited?

2.2. DEFINING PERFORMANCE MEASUREMENT

Performance measurement is a subject that is often discussed but rarely defined. Moreover, the language used in the field of performance measurement is confusing. Different authors use different terms to describe the same concepts. Some talk about performance measures, some about performance measurement, some about critical success factors and some about key performance indicators. The phrase adopted is often context dependent and although different phrases may be used to describe the
same thing, the words companies choose often carry an important message. Reckitt & Colman, one of the world’s largest pharmaceuticals and household products companies, for example, has decided to use the phrase “development measures” rather than “performance measures”, because it emphasizes that the role of measurement is to help the organization develop, rather than to allow an individual’s performance to be assessed. The distinction is subtle but useful, in that the phrase development measures eliminate some of the perceived threats of performance measurement.

Neely et al. (1995) described performance measurement as the process of quantifying action, where measurement is the process of quantification and action correlates with performance. They also proposed that performance should be defined as the efficiency and effectiveness of action, which leads to the following definitions:

- Performance measurement is defined as the process of quantifying the efficiency and effectiveness of action.
- A performance measure is defined as a metric used to quantify the efficiency and/or effectiveness of an action.
- Performance Measurement System (PMS) is defined as the set of metrics used to quantify the efficiency and effectiveness of action.

Above definitions are precise, but their very precision means that they do not convey what is now being labelled in the literature and in practice as ‘performance measurement’ (Neely et al., 1995). The concept of performance measurement should be used in a bigger perspective as given below (Bourne et al., 2003):

- Performance measurement (as promoted in the literature and practised in leading companies) refers to the use of a multidimensional set of performance measures. The set of measures is multidimensional as it includes both financial and non-financial measures, both internal and external measures of performance and it often includes both measures that quantify what has been achieved as well as measures that are used to help predict the future.
- Performance measurement can be done in isolation. Performance measurement is only relevant within the reference framework against which the efficiency and effectiveness of action can be judged. In the past, performance measurement has
been criticized for judging performance against the wrong frame of reference and now there is widespread support for the belief that performance measures should be developed from strategy.

- Performance measurement has an impact on the environment in which it operates. Starting to measure, deciding what to measure, how to measure and what the targets will be, are all acts, which influence individuals and groups within the organization. Once a measurement has started, the performance review will have consequences as will the actions agreed upon as a result of that review. Performance measurement is, therefore, an integral part of the management planning and control systems of the organization being measured.

- Performance measurement is now being used to assess the impact of actions on the stakeholders of the organization whose performance is being measured. Although this can be considered ‘as quantifying the efficiency and effectiveness of action’, in the case of measuring the impact of the organization’s performance on customer satisfaction, it is not as obvious in the cases of measuring the impact of organization’s actions and performance on employee satisfaction or local community satisfaction.

2.3. CLASSIFICATION OF PERFORMANCE MEASURES

The literature concerning performance measurement has had two main phases. The first phase began in the late 1880s and went through the 1980s. In this phase the emphasis was on traditional measures such as profit, return on investment and low cost production to quality, flexibility, short lead time and dependable delivery. It also implemented new technologies and philosophies of manufacturing management such as Computer Integrated Manufacturing (CIM), Flexible Manufacturing System (FMS), Just in Time (JIT), Total Quality Management (TQM), Total Productive Maintenance (TPM) etc. The implementation of these changes revealed that traditional performance measures have many limitations and the development of new performance measurement techniques is required for success. So, researchers developed non-traditional performance measures. The characteristics of non-traditional performance measures – measures related to manufacturing strategy and primarily non-financial measures (i.e. operational) - can provide managers,
supervisors, and operators with information required for daily decision-making. Performance measures, thus, can be broadly divided into traditional and non-traditional performance measures.

2.3.1. Traditional Performance Measures

The traditional way to measure performance is to use financial performance measures, such as return on investment, profit, cash flow, return on sales, price variances, sales per employee, productivity etc. Of these performance measures, productivity has been considered the primary indicator of performance. Following sub-sections discuss few traditional performance measures in brief.

2.3.1.1. Productivity

Based on the previous research, Ghalayini and Noble (1996) discussed the three issues concerning the importance of measuring productivity – strategic, i.e., comparison with competitors or related firms; tactical, i.e., management control of the performance of the firm; planning, i.e., comparison of the relative benefits from the use of different productivity. The second phase started in the late 1980s as a result of changes in the world market. Companies began to lose market share to overseas competitors who were able to provide higher quality products with lower costs and more variety. To regain a competitive edge, companies not only shifted their strategic priorities from inputs; and internal management, i.e., collective bargaining with trade unions. Three traditional types of productivity measures (Edosomwan, 1985; Sumanth, 1994) are:

- Partial productivity measures - ratios of output to one source of input, such as labour, capital, material or energy.

- Total factor productivity measures - ratios of net output (total output minus intermediate goods and services purchased) to the sum of associated labour and capital input. This type of productivity is also referred to as value added productivity or multi-factor productivity.

- Total productivity measures - ratios of total output to the sum of all input factors.

Each type of these measures has its own strengths and weaknesses. According to Grossman (1993), none of these measures should be considered better than the other,
instead they should be used for different purposes. However, it is not entirely clear how these measures should be used and combined to obtain a complete picture of a company's productivity.

**Partial Productivity Measures**

The advantage of partial productivity measures is that they are simple to understand and measure in reality. The needed data is usually easy to obtain and partial productivity indices are not difficult to calculate (Sumanth, 1994). It is also easy to pinpoint a specific partial productivity measure for an important smaller area, function or department in a company. This means that partial measures can detect improvements. The most common partial productivity measure is, without any doubt, labour productivity, e.g., output per working hour or output per employee. However, much criticism has been aimed at this way of calculating productivity. Suh (1990), for example, argues that terms like labour productivity are becoming un-useful measures in modern manufacturing operations, since the total direct labour cost is becoming a smaller fraction of the total manufacturing cost. Similarly, Hayes and Clark (1986) states that preoccupation with labour costs, particularly direct labour costs, is still common today even though direct labour usually accounts for less than 15% of total costs in most manufacturing companies. Much focus has traditionally been on efficiency of factory workers. This has caused negative associations with the term productivity. Increased labour productivity can in many cases only be achieved at the expense of other resource areas, such as materials. For example, improving labour productivity can actually hurt the overall profitability by increasing costs in inventory. Nevertheless, labour productivity can be an appropriate measure if the work force is a dominating production factor. It can also be very useful in feedback of performance to the workers, since these data are easy to understand and workers want to know how they are doing (Bemolak, 1997). Perhaps the major objection to partial productivity is that it only considers one production factor, which in turn is often decided upon in interplay with the use of the other production factors, e.g. capital, energy and primary products. One example of this problem is called capital-labour substitution, which means that the labour productivity can be improved at the cost of capital, resulting in decrease in the total productivity, for example, when automatic equipment is installed. In this way partial productivity measures tend to overstate an increase in productivity.
(Grossman, 1992). Partial measures do not have the ability to explain overall cost increase, and can be very misleading if they are used alone (Sumanth, 1994). An appropriate set of partial measures may, however, be useful in a manufacturing company, especially on the shop floor. Nevertheless, it is important to be aware of its limitations. It should also be mentioned that measuring output might not always be as easy as it seems, especially on an aggregated level. Today, products often come in numerous variants wherein it can be misleading to consider total output as the sum of its parts.

**Total Factor Productivity Measures**

Total Factor Productivity (TFP) provides a comparably good picture of the overall productivity of a process or a company. A major advantage of TFP is that it accounts for capital-labour substitution. Another advantage is that can be used to compare different companies. Many companies consider raw material as the fruit of someone else’s labour and therefore not be taken into account in productivity calculations (Taylor and Davis, 1997). The disadvantages are that the TFP is more difficult to understand and to measure (Grossman, 1993). Due to the difficulties in calculating such measures in practice, they are not always accurate. The TFP measures are based on a number of more or less carefully supported assumptions and can produce different results because of many different ways to weight the production factors. It is also more difficult to track activities that improve productivity with TFP measures. Another weakness lies in that the needed data to calculate the measure becomes more difficult to retrieve. The TFP does not capture the impact of materials and energy inputs, which means that it is not suitable when a larger portion of production costs is due to material or energy. The value-added output approach can also be difficult to understand (Sumanth, 1994).

**Total Productivity Measures**

Total productivity measures are very similar to measures of TFP, but they also include intermediate goods such as purchased materials and energy, which make them the most accurate measures. However, dealing with all sorts of inputs in the same measure is a difficult task, since each input has a different unit and must be appropriately weighted. Even though total productivity is conceptually more accurate measure than TFP to use at the top level of an organization, TFP is often as acceptable
as total productivity in practice. Input of material and energy has usually a minor influence on the total productivity and can therefore be neglected (Sumanth, 1994). It has also been argued that total productivity measures are actually too aggregate and make interpretations of productivity changes both difficult and vulnerable. It should as well be emphasized that they are not commonly used and are often misunderstood (Gold, 1980).

2.3.1.2. Cost

Irrespective of whatsoever the business or manufacturing activity one is involved with, in today's materialistic world it costs to do anything and, hence, knowledge of cost is very important. Because cost tends to go up and profit margins are always under squeeze due to the increasing competition, one must know how to cut the cost of manufacturing while producing the products of acceptable quality at the lowest cost so as to render them more competitive in the market. Profit depends on the cost of manufacturing, volume of sales and the selling price. In a competitive market, manufacturing usually does not have complete control over the volume of sales and selling prices where as it is possible to cut or at least control the cost of manufacturing to increase the profit. To survive in the market, one must have thorough knowledge of different costs associated with manufacturing. There are three main elements of the cost: materials, labour and overheads. Overheads are allocated in proportion to the amount of direct labour required to make a product.

Cost of producing a part can also be classified as fixed cost and variable cost (Gold, 1980). Fixed cost is the cost required to set up the facilities to produce a product. Fixed cost does not depend on the quantity of the product produced; rather it tends to be fixed for a given period of time and for a given level of installed capacity. It is related more to the period rather than the number of parts produced. Examples of fixed costs are: land, building, machinery, salaries and wages of permanent employees, rent, etc. Variable cost varies with the quantity or number of parts produced. If more quantity is produced, we incur more variable cost and vice versa. Examples of variable costs are: cost of raw materials, power, fuel etc.

2.3.1.3 Profit

As mentioned earlier, the success of a manufacturing system or company has traditionally been evaluated by the use of financial measures such as monetary value
of sales and profit. Nevertheless, one should keep in mind that these types of performance measures have significant limitations and that several problems have been connected to their use. There is, for instance, no completely unambiguous way of knowing when a company is profitable, since many business opportunities involve sacrificing current profits (Ross et al., 1993). But as described earlier, productivity and profitability often come hand in hand, and profitability ratios can therefore be used as indicators of productivity changes. Although financial measures can appear in several different forms, the following sections explain the most commonly used profitability ratios.

**Profit Margin**

Profit margins (also known as return on sales) measure how much a company earns relative to its sales. These measures determine the company’s ability to withstand competition and adverse rising costs, falling prices or declining sales in the future (Ross et al., 1993). There are two types of profit margins: gross profit margin and net profit margin. Gross profit margin measures the income before interest and taxes, and is calculated as:

\[
PM_G = \frac{I}{S}
\]

Where:

- \(PM_G\) = Gross profit margin [%]
- \(I\) = Income before interest and taxes [money]
- \(S\) = Sales [money]

Net profit margin measures income after taxes and is calculated as:

\[
PM_N = \frac{I_T}{S}
\]

Where:

- \(PM_N\) = Net profit margin [%]
- \(I_T\) = Income after taxes [money]
- \(S\) = Sales [money]

While it seems as if they measure the same attribute, their results can be dramatically different due to the impact of interest and tax expenses.
Return on Assets

Return on assets (ROA), a measure developed by DuPont in 1919 (see Figure 2.1), is one of the most widely used financial models for performance measurements (Zairi, 1994). ROA determines the company’s ability to utilise its assets. However, it should be noted that ROA does not tell how well a company is performing for the stockholders. A very similar measure to ROA is the return on investment (ROI), which is calculated in almost the same way but is used on a minor level. ROA is calculated as:

\[ \text{ROA} = \frac{I_T}{A_{\text{tot}}} \]

Where:

- \( \text{ROA} \) = Return on assets [%]
- \( I_T \) = Income after taxes [money]
- \( A_{\text{tot}} \) = Average total assets [money]

ROA can also be expressed in terms of the profit margin and assets turnover (i.e. Sales / Average total assets)

\[ \text{ROA} = P_M \times A_{ir} \]

Where:

- \( \text{ROA} \) = Return on assets [%]
- \( P_M \) = Profit margin [%]
- \( A_{ir} \) = Assets turnover [%]

Return on Equity

Return on equity (ROE) measures how well the company is doing for the investor (i.e. stockholders), since it tells how much income the investors are getting for their investments. It is calculated as:

\[ \text{ROE} = \frac{I_T}{E} \]

Where:

- \( \text{ROE} \) = Return on equity [%]
- \( I_T \) = Income after taxes [money]
- \( E \) = Equity [money]
2.3.1.4 Limitations of traditional performance measures

The traditional performance measures have many limitations that can be classified into two categories: general limitations due to the overall characteristics and limitations specific to certain traditional performance measures such as productivity or cost. These limitations make traditional performance measures less applicable in today’s competitive market.

General limitations

Traditional management accounting systems - The most significant limitation of traditional performance measures is that they are based on traditional management accounting systems that were initially developed for the purpose of attributing the
total costs of operating products, department and activities. During that period labour was the major cost driver that management accounting systems emphasized and other costs were de-emphasized by putting them together in one overhead category. However, today the average labour cost component rarely exceeds 12 percent while overhead is usually 50-55 percent of the manufacturing cost. Since in this case overhead is allocated based on the minor cost element of direct labour this allocation approach is not valid (Ghalayini and Noble, 1996).

**Lagging metrics** - Financial reports are usually closed monthly. Therefore, they are lagging metrics that are a result of past decisions. As a result, operators, supervisors, operational managers consider financial reports too old to be useful for operational performance assessment.

**Relevance to practice** - Traditional performance measures try to quantify performance and other improvement efforts in financial terms. Yet, most of the continuous improvement efforts are difficult to quantify in monetary scale (i.e. lead time reduction, adherence to delivery schedule, customer satisfaction and product quality). In addition, operators find typical financial reports difficult to understand which leads to frustration and dissatisfaction. As a result, traditional performance measures are often ignored in practice at factory shop-floor level.

**Inflexible** - Traditional financial reports are inflexible in that they have a predetermined format which is used across all departments. However, even departments within same company have their own characteristics and priorities. Thus, performance measures that are used in one department may not be relevant for others.

**Expensive** - The preparation of traditional financial reports requires an extensive amount of data, which is usually expensive to obtain.

**Continuous improvement** – Sahay et al., (2000) have advocated that setting standards for performance measures were in general conflict with continuous improvement. If standards were not carefully set, they would have the effect of setting norms rather than motivating improvement. Workers may hesitate to perform to their maximum potential if they realize that the standard for upcoming periods may be revised upwards by current results.
**Customer requirements and management techniques** - Traditional performance measures are no longer useful in order to meet customer requirements of higher-quality products, shorter lead time and lower cost. Management has given shop-floor operators more responsibility and authority in their work. Consequently, traditional financial reports used by middle managers do not reflect a more autonomous management approach (Ghalayini and Noble, 1996).

**Specific limitations**

*Productivity* - The limitations of productivity can be classified into three main categories: partial productivity, aggregate productivity and productivity paradox. Edosomwan (1985) stated that the actual danger of partial productivity was that it overemphasized one input and neglected others. Whereas aggregate productivity measures attempt to account for all or most of the system inputs and since inputs are not homogeneous and some are intangible, representing them is a difficult task. In addition, the consideration of all inputs requires significant amounts of data that is time consuming and costly to obtain.

Skinner (1986) argued that concentrating on improving productivity has its disadvantages. Productivity is mostly concerned with direct labour, which is no longer a significant portion of cost. Thus, decreasing the cost of direct labour and/or increasing direct labour efficiency do not contribute significantly to the overall performance of the company. Moreover, focusing excessively on the efficiency of factory workers and departments detracts attention from improving the production system itself.

*Cost* - Reducing cost has always been considered an effective weapon to achieve competitive advantage. However, customer demands have changed. Low cost is no longer the most important factor for competing in most markets. Factors like quality, reliable delivery, short lead times, customer service, rapid product introduction, flexible capacity and efficient capital deployment have assumed predominance in defining the competitiveness (Skinner, 1986). Reducing costs at the expense of any of these factors will be more harmful than helpful.

*Profit* - It is important to realize that when a company is making a profit, this does not necessarily imply that its operations, management and control systems are efficient.
Therefore, profit as a performance measure can only reveal that there is a problem, but it provides little information about the nature and reasons for that problem. Kaplan (1990) argued that the claim, profi- or rate of return can be considered as a composite indicator of the organizational success, is not valid, because such an indicator does not help in identifying specific areas that need improvement. Finally, considering the amount of profit alone as the basis of achievement for different plants can be misleading since each plant has its own circumstances even when the plants are producing identical products. Kaplan (1990) stated that "traditional summary measures of local performance – purchase price variances, direct labour and machine efficiencies, ratios of indirect to direct labour, absorption, and volume variances – are harmful and should be eliminated, since they conflict with attempts to improve quality, reduce inventories and increase flexibility. Direct measurement is needed for quality, process time, delivery performance, and any other operating performance criterion that needs to be improved". Kaplan (1990) further stated that a performance measurement system of an organization should include: a set of well-defined and measurable criteria; standards of performance for each criteria; routines to measure each criteria; procedures to compare actual performance to standards; and procedures for dealing with discrepancies between actual and desired performance.

2.3.2. Non-traditional Performance Measures

The characteristics of non-traditional performance measures have been discussed recently in the literature (Hayes and Wheelwright, 1984; Dixon et al. 1990, Kaplan, 1990; Maskell, 1991; Ghalayini and Noble, 1996; White, 1996; Bourne et al., 2000; Neely et al., 2001) The characteristics that have been mentioned include: measures related to manufacturing strategy; primarily non-financial measures (i.e. operational) so that they can provide managers, supervisors, and operators with the information required for daily decision making; simple measures so that shopfloor operators can easily use and understand them; measures that foster improvement and measures that change as is required by a dynamic marketplace. Utzig (1988) has suggested a list of operating measures for advanced manufacturing: lead time, total value-added versus non value-added time and cost. Following sub-sections are focused on cost and time based performance measures.
2.3.2.1. Cost based performance measures

The traditional methods of product costing are fundamentally flawed. The basis of this concern is that standard methods of accounting, which allocate overhead in proportion to the amount of direct labour required to make a product, are no longer valid. Increasing automation has meant that the proportion of finished product cost attributable to direct labour can now be as low as 5-10%, whereas attributable to overhead can be as high as 50-55%. Thus allocating overhead on the basis of labour can result in wildly erroneous product cost and a gross misunderstanding of the organization’s cost base. Activity based costing and throughput accounting take account of these concerns by focusing on activities and seeking to identify where in the manufacturing process cost is really incurred.

Activity Based Costing

To cope with the demands from today’s business environment, a new approach to cost accounting, known as activity-based costing (ABC), was developed by Kaplan and Johnson (1987) in the late 1980’s as an attempt to remove some of the fundamental inadequacies of traditional cost accounting (Tangen, 2003). Activity based costing is concerned with the cost of activities within a company and their relationships to the manufacture of specific products rather than on functional base (Hill, 1988). The basic technique of ABC is to analyze the indirect costs within a company and to discover the activities that cause those costs. Such activities are called cost-drivers and can be used to apply overheads to specific products. In this way, it is believed that ABC results in a more accurate identification of costs than traditional cost allocation. According to Maskell (1991), several practical cases indicate that ABC can be of practical value for product pricing, production decision-making, overhead cost reduction and continuous improvement. But on the other hand, there are also researchers who concur that the claim that ABC provides more accurate product costs has never been proven (Neely et al, 1997).

Throughput Accounting

Throughput accounting adopts a radically different basis for the determination of cost and concentrates on the bottleneck or capacity constrained resource. Advocates of throughput accounting base their arguments on Eli Goldratt’s (1990) belief that the
critical resource in any manufacturing facility is the capacity-constrained resource or bottleneck (Neely, 1998). In Goldratt’s view, a bottleneck constrains the output of a manufacturing system and hence an hour lost at the bottleneck is an hour lost for the system as a whole. Imagine, for example, a production process with three stages, the first machine can produce at a rate of 250 units per hour, the second at a rate of 450 units per hour and third at a rate of 20 units per hour. If all units have to be processed by all three machines, then the maximum output from this process would be 20 units per hour. As this is the rate at which the bottleneck (third machine) can process products. The implication is that an hour lost at either of the first two machines is unimportant; it costs the organization nothing in terms of lost output. An hour lost at the third machine, however cost the organization the market value of 20 units, assuming that everything produced can be sold. This is because an hour lost at a bottleneck can never be replaced as the bottleneck, by definition, is fully utilized and therefore has no spare production capacity.

Applying this argument to product costing, the critical issue becomes not how much direct labour input the product requires, but how much the bottleneck time the product requires. Consider, for example, two products, which have the same overall direct labour content. Product A takes twice as much time at the bottleneck machine so it can manufacture only half as fast as product B. Thus for every two units of product B only one unit of product A can be manufactured. Traditional cost accounting would attribute the same level of overhead to both these products, yet product B cost the organization far less to produce than product A as it does not require as much time at the bottleneck machine. Advocates of throughput accounting argue that unless organizations consider this when pricing products, they are deluding themselves about the margins they are actually generating and more importantly, not realizing the margins they could be generating.

Critics of ABC and throughput accounting method of costing highlight their complexity to implement and question whether the product costs that result are any more valid than those generated by traditional methods of cost accounting. There are difficulties in identifying and assigning cost to the real cost drivers, and bottlenecks are rarely static in manufacturing firms, shifting as the product and volume mix changes. Nevertheless, both methods are widely accepted as alternative ways of
product costing which can be used in parallel with more traditional approaches to provide additional insight into the financial health of the business.

2.3.2.2. Time based performance measures

Examining the current literature of business strategy and performance measurement reveals that time has been proposed as the new strategic metric in the world market. The importance of time can be realized from the following argument: measuring, controlling and compressing time will increase quality, reduce costs, improve responsiveness to customer orders, enhance delivery, increase productivity, reduce risks since reliance on forecasts is reduced, increase market share and increase profits (Stalk, 1988; Schmenner, 1991; Maskell, 1991; Azzone et al., 1991; Bockerstette and Shell, 1993; Hum and Sim, 1996; White, 1996; Neely et al., 2001).

Bockerstette and Shell (1993) argued that reducing cycle time reduces costs and improves customer satisfaction, which in turn increases revenue. Azzone et al. (1991) argued that time is a more important metric than cost and quality since it can be used to drive improvements in both of them and it has a common definition throughout the manufacturing system. Quality does not have such a common definition and cost is a lagging metric. Furthermore, cost reduction is not always beneficial. In contrast, time is not a lagging metric and it is always beneficial to reduce time. Moreover, reducing time will decrease costs by eliminating the activities that add no value to products. Quality will also increase since eliminating non value-added activities will decrease the chance of error introduction. Hum and Sim (1996) argued that the variability of time is an important metric that should be used to assess manufacturing system performance. They stated that reducing the variability of an activity through decreasing rate of scrap and rework, reducing machine breakdowns, reducing batch sizes, eliminating material shortage and increasing the accuracy of the bill-of-materials will drive improvements in quality and costs. Time-based performance measurement systems have been developed to help companies control and improve their operations. Stalk (1988) stated that time-based companies should go beyond measures like lead time, on-time delivery and response time to time-based metrics which could be used as diagnostic tools throughout the organization. They summarized the main time-based metrics that companies could use into four
different areas - new product development, decision-making, processing and production, and customer service. New product development includes: time from idea to market; rate of new-product introduction; and percentage first competitor to market. Decision-making includes: decision cycle time and time lost waiting for decisions. Processing and production includes: value added as percentage of total elapsed time; uptime yield; inventory turnover; and cycle time (per major phase of main sequence). Customer service includes: response time; quoted lead time; percentage deliveries on time; and time from customer’s recognition of need to delivery. Azzone et al. (1991) presented a framework of performance measures for time-based companies. This model contains three main areas in which time measures should be applied: research and development (R&D), operations, and sales and marketing. Hum and Sim (1996) provided a time-based performance measurement system that is based on the concept of positive and negative value-adding measurements. Improvement efforts have been directed to reduce negative value-adding components and decrease system throughput time.

**Operating profit through time and investment management**

Sullivan (1986) discussed Operating Profit through Time and Investment Management (OPTIM) as a way to model business activities. The OPTIM is an inventory flow model (cost-time profile) that graphically represents an activity and illustrates where to look for problems. The main principle of OPTIM is to measure how business cost builds over time. The OPTIM cost-time profile has two elements, - first element represents material, labour, and factory expenses, while the other element represents cycle time for the operation.

**Value focused cycle time**

Noble and Lahay (1994) presented the value-focused cycle time (VFCT). The value-focused cycle time model is based on two performance metrics: time and value. Cost has been used in the model as a surrogate measure to quantify both value added and non-value added time. By using the concept of non-value added time, other metrics such as quality can be represented in the model, yet in dollar terms. Thus, the model directly connects cost, quality and time.
The overall equipment effectiveness

Another time-based measure is the Overall Equipment Effectiveness (OEE), which is used within the concept of Total Productive Maintenance (TPM) (Nakajima, 1988). The main goal of TPM is to increase equipment efficiency so that each piece of equipment can be operated to its full potential and maintained at that level (Chand and Shirvani, 2000). This goal is measured by using the OEE. The measure is based on three aspects of performance (Slack et al., 2001):

- The time that it is available to operate.
- The speed or throughput rate of the equipment.
- The quality of the product.

Furthermore, six major categories of equipment losses that reduce the OEE have been defined (Chand and Shirvani, 2000) as:

Downtime losses

- Failures - Downtime losses caused by unexpected breakdowns.
- Set-up and adjustments - Downtime losses due to set-up and adjustments such as exchanging dies in presses and plastic injection moulding machines.

Speed losses

- Idling and minor stoppages - Idling and minor stoppages caused by malfunction of sensors and blockages of work on chutes.
- Reduced speed - Losses caused by discrepancy between the designed speed and actual speed of equipment.

Defect losses

- Defects in process - Losses caused by defects and reworking of defects.
- Reduced yield - Reduced yield losses that occur between start-up and stable production.

These six major losses lead to the three generic elements of OEE: availability, performance efficiency and quality rate. Availability measures the effectiveness of maintaining tools in a condition of running products. Performance efficiency
measures how effectively equipment is utilized. Quality rate measures the effectiveness of the manufacturing process to eliminate scrap, rework and yield loss.

Together these three elements constitute the OEE ratio.

\[
\text{OEE} = A \times P_E \times Q_R
\]

Where:

- \( \text{OEE} \) = Overall equipment effectiveness [%]
- \( A \) = Availability [%]
- \( P_E \) = Performance efficiency [%]
- \( Q_R \) = Quality rate [%]

The three elements of OEE can be further broken down as:

- \( A = (t_{AV} - t_D) / t_{AV} \)
- \( P_E = t_{IC} \times N / t_{OP} \)
- \( Q_R = N - N_D / N \)

Where:

- \( A \) = Availability [%]
- \( t_{AV} \) = Available time [time]
- \( t_D \) = Downtime [time]
- \( t_{IC} \) = Ideal cycle time [time]
- \( t_{OP} \) = Available operative time [time]
- \( N \) = Number of processed products [units]
- \( Q_R \) = Quality Rate [%]
- \( N_D \) = Ideal cycle time [units]

Jonsson and Lesshammar (1999) stated that the greatest contribution of OEE is that it is a simple, but still comprehensive, measure of internal efficiency and it can work as an important indicator of the continuous improvement process. The OEE is also an effective way of analyzing the efficiency of a single machine or an integrated machinery system (Ljungberg, 1998). However, the application area of OEE is limited to the semi-automatic and automatic manufacturing processes. The OEE is not suitable for manual manufacturing processes since it does not consider the number of
workers working in a process and anticipates that there is a fixed ideal cycle time of each machine that controls the maximum processing rate (Ljungberg, 1998). It is important to point out that OEE measurement, alone, does not provide a tool to support improvement programs. The power of OEE is in the linkage of the OEE data to the identification of major equipment losses (Jonsson and Lesshammar, 1999). There are also several aspects that OEE does not consider such as planned downtime and disturbances from incoming material. Ljungberg (1998) argued that the six major losses must be further divided into sub-groups to make the OEE measurement more useful. He also stated that there are some problems when calculating speed losses due to an inappropriate definition of ideal cycle time. Furthermore, it is also not clear how the data of losses should be collected by the operators (Ljungberg, 1998). Moreover, Jonsson and Lesshammar (1999) found in a case study of three companies that the OEE systems did not measure strategy, flow orientation or external effectiveness to any great extent. Nevertheless, the most important objective of OEE is not to get an optimum measure, but to get a simple measure that tells the production personnel where to spend their improvement resources.

**Manual assembly efficiency**

Petersson (2000) developed a performance measure, similar to the OEE, called Manual Assembly Efficiency (MAE). While the application area of the OEE is limited to the automatic or semi-automatic area, the MAE is focused on fulfilling the specific needs that manual assembly operations require. A central difference between manual and automatic operations is that automatic operations have a relatively fixed pace, which is easy to determine when the equipment runs at a constant speed. The pace in manual operations, on the other hand, is highly dependent on the human beings that are part of the manufacturing system. The pace will therefore fluctuate, especially when many variants of a product are made in the same line. The MAE is calculated as:

\[
MAE = \frac{\sum_{i=1}^{N} (t_{IAi} - t_{RI})}{N_A \cdot (t_{TOT} - t_{PS} - t_{UN})} \cdot 100
\]
Where:

- \( \text{MAE} \) = Manual assembly efficiency [\%]
- \( N_a \) = Number of assembled units [units]
- \( t_{\text{iai}} \) = Ideal assembly time for unit \( i \) [time/unit]
- \( t_{\text{Ri}} \) = Rework for unit \( i \) after the assembly process [time/unit]
- \( N_A \) = Number of assemblers that are registered for work [number]
- \( t_{\text{TOT}} \) = All available time [time]
- \( t_{\text{PS}} \) = Total planned stop time [time]
- \( t_{\text{UN\_man}} \) = Total unused assembly time due to lack of order [time]

The MAE can be divided into three different components – availability, utilization and quality – which facilitate the identification of potential improvements.

One of the main strengths of MAE is that it can monitor processes in which many product variants with different ideal assembly times are made. It has proven to easily spot over-employment in a process (Peterson, 2000). Nevertheless, it also has some flaws. First, it does not distinguish between quality problems that can be related to the assembly process and the ones that are caused by external factors, such as defects in purchased parts. Second, MAE can theoretically be greater than 100% if there is no waste in the process and the assembly personnel work faster than ideal assembly time.

### 2.3.2.3 Limitations of non-traditional performance measures

Non-traditional performance measures are simple, easy to understand and use. The main disadvantage of these performance measures is that they solely concentrate on time and cost and neglect other operational performance measures such as quality, flexibility, delivery etc. (Kaplan and Norton, 1992; Ghalayini and Noble, 1996; Neely et al., 2001) Without controlling and improving these operational measures, companies will not be able to compress time and reduce cost.

It is argued that even an improved cost accounting system will not entirely solve the problem with financial measures. Other measures besides cost are needed to adequately gauge manufacturing performance relative to a competitive strategy (White, 1996). This is why many researchers have focused on developing conceptual
performance measurement frameworks during the last decade. Most of these frameworks propose that a performance measurement system should include both traditional and non-traditional performance measures; it is also argued that such an approach is more suitable for the business environment of today than the use of traditional performance measures.

In fact, the importance of performance measures was clearly emphasized by the Foundation of Manufacturing Committee of the National Academy of Engineering where one of the ten foundations of world-class practice states, “World-class manufacturers recognize the importance of metrics in helping to define the goals and performance expectations for the organization. They adopt or develop appropriate metrics to interpret and describe quantitatively the criteria used to measure the effectiveness of the manufacturing systems and its many interrelated components” (Ghalayini and Noble, 1996).

In the light of this, the next section deals with some of the most well-known conceptual performance measurement frameworks.

2.4. CONCEPTUAL PERFORMANCE MEASUREMENT FRAMEWORKS

Researchers have developed conceptual performance measurement frameworks in order to give an overall view of company performance and to guard against sub-optimization. These performance measurement frameworks are appropriate for a environmentally conscious manufacturing firm in many aspects. However, they have some limitations. The following sub-sections will discuss few such systems.

2.4.1 The PO-P System

Using the principles of modern business and system theory, and drawing upon the proven strength of the techniques of multiple attributes decision and goal programming, (Vrat P. et al., 1998) proposed a new methodology of productivity measurement termed as Performance Objective-Productivity (PO-P). The PO-P system is a multi-criteria productivity management technique, which lays stress on performance against the objectivated output. One of the primary and most important tasks of a productivity measurement technique is to provide comparative information, i.e., on the rise or decline in productivity along with the identification of opportunities for improvements. Productivity of a system should be an indicator of its efficiency
and effectiveness. However, external environment has an impact on productivity which can get altered without any change in the productive efforts of the organization. PO-P model meets these requirements.

The PO-P concept is the system productivity. The outputs are the performance of the system (and its sub-systems). These include the tangible as well as the intangible covering areas, such as goods produced, services rendered, organizational goals and values. Also included are performance objectives such as service to community, contribution to human habitat, participation in social welfare so as to provide a specified satisfaction to all members of society who have a stake in the organization. The performance so achieved (as output) is the result of acquisition, deployment and efficient use of resources in a rationally acceptable norm. Emphasis is on achievement of goals related to a system within the constraints of the resources available.

Productivity measurements by PO-P approach consists of the following steps:

- Identification of sub-systems.
- Identification of Key Performance Areas (KPAs) in each of the sub-systems.
- Setting of performance objectives.
- Ranking and weighting of sub-systems, KPAs and performance objectives.
- Determination of objectivated output.
- Calculation of productivity index and identification of sub-systems and KPAs with low performance.

Identification of sub-systems is the first step and a major exercise. It is suggested (Burns et al., 1997) that a system (or a sub-system) has five basic characteristics.

- A central objective and measure of performance.
- Its environment.
- Its resources.
- Its components.
- Its management.
An organization as a system can have functional sub-systems, such as a production sub-system, a marketing sub-system etc., as well as management sub-systems, such as production control sub-system, management information sub-system, personnel management sub-system etc. These sub-systems may also be embedded in other sub-systems.

The KPAs deal with positive performance and areas where the management is interested that results be the most performing. McConkey (1983) recommends that KPA (Key result areas as called by McConkey) can be in one or more of the following categories:

- Quantity, such as revenue/production levels.
- Quality, such as customer satisfaction, product quality.
- Timeliness, such as scheduling and customer demands.
- Cost, such as cost of services and manufacturing cost levels.

While identifying KPAs, two considerations are vital. First, identified KPAs should be those which are associated with the sub-systems effectively. There are bound to be overlaps and some areas would appear to be belonging to more than one sub-system. However, it is the sub-system that controls the development of inputs and has the responsibility of function/objectives that the KPAs should belong to. Second, KPA should have basis and relevance to organizational objectives. As organizational objectives can vary from one organization to another, so should the importance of each KPA vary. Business budgets, planning and product strategies of the sub-system have priority over the operational responsibilities of the KPA. A KPA must subordinate to the sub-system.

2.4.2. The Sink and Tuttle Framework

The Sink and Tuttle framework is a classical approach to design a performance measurement system (see Figure 2.2), which claims that the performance of an organization is a complex interrelationship between seven performance criteria (Sink and Tuttle, 1989):

i) Effectiveness, which involves doing the right things, at the right time, with the right quality. In practice, effectiveness is expressed as a ratio of actual output to expected output.
ii) Efficiency, defined as a ratio of resources expected to be consumed to resources actually consumed.

iii) Quality, where quality is an extremely wide concept. To make the term more tangible, quality is measured at several checkpoints.

iv) Productivity, which is defined as the traditional ratio of output to input.

v) Quality of work life, which is an essential contribution to a well performing system.

vi) Innovation, which is a key element in sustaining and improving performance.

vii) Profitability/budgetability, which represents the ultimate goal for any organization.

3. Quality

Figure 2.2: Sink and Tuttle Framework
Although much has changed in the industry since this model was first introduced, these seven performance criteria are still important. However, the model has limitations, for example, it does not consider the need for flexibility that has increased during the last two decades. The model is also limited by the fact that it does not consider the customer perspective and environmental, health and safety.

2.4.3. The TOPP Performance Model

The TOPP performance model considers performance as an integration of three dimensions – efficiency, effectiveness and adaptability (see Figure 2.3).

The first two dimensions in the TOPP performance model are the same as in the Sink and Tuttle model, while the third expresses the extent to which the company is prepared for future changes. The TOPP is a new performance measurement system, which was developed by SINTEF in Norway in partnership with Norwegian Institute of Technology (NIT) and Norwegian Federation Engineering Industries (TBL). TOPP is a questionnaire that is used to determine how an enterprise is performing in all the areas of manufacturing (Sahay et al., 2000).

![Figure 2.3: Performance Model from TOPP](image)

The answer to each question is qualitative (i.e. on a scale of 1 to 7, where 1 is poor and 7 is excellent). Enterprises are requested to answer each question for their status today and for their expected status two years hence. They are also requested to rate how important each question is to enterprise competitiveness on a three letter scale –
‘N’ (no importance), ‘M’ (medium importance) and ‘G’ (great importance). The TOPP system is very large and time consuming to fill. It is over 60 pages long and there are about 15-20 questions on each page. Each question also requires three ratings (status today, future status and relative importance). Therefore, in total about 3000 assessments need to be made to fill out one complete questionnaire.

The TOPP system is a generic questionnaire and, therefore, the performance measures in the TOPP questions are not directly related to the strategy or customer requirements of enterprises. The TOPP questionnaire is qualitative, based on the view of individuals and not on actual measurement. Therefore, answers can biased. The TOPP questionnaire is very thorough and makes enterprises think about areas of manufacturing they may not have thought important before. Anything that the enterprise measures, it will want to improve, especially performance areas that are marked with ‘G’.

2.4.4. The AMBITE System

The AMBITE (Advanced Manufacturing Business Implementation Tool for Europe) is a modern performance measurement system (Sahay et al., 2000). The objective of this framework is to develop a technique that senior management can use to assess the impact of strategic decisions made by their enterprise. The framework provides a means of translating the business plan of the enterprise (i.e. critical success factors) into set performance measures. The performance measures will be directly related to the strategy of the enterprise and will also be process oriented. The AMBITE framework uses the business model to describe a manufacturing enterprise. Each of the five macro-business processes (customer order fulfillment, vendor supply, design coordination, co-engineering and manufacturing) are mapped on to measures of performance (time, cost, quality, flexibility and the environment) This is done for the Make-To-Stock (MTS), Assemble-To-Order (ATO), Make-To-Order (MTO) and Engineer-To-Order (ETO) manufacturing environment.

The AMBITE method takes Critical Success Factors (CSFs) of an enterprise and maps them to the five macro measures of performance indicators (SPIs) for each manufacturing typology on AMBITE framework. The performance indicators can then be broken down into many lower-level performance indicators. The precise
breakdown of each performance indicator will be different for different enterprises, thus producing a unique set of customized performance indicators.

Figure 2.4: The AMBITE Performance Framework

The AMBITE performance measurement framework is complete in that, once an enterprise knows its CSFs, it should not be too difficult to develop a consistent set of performance indicators for that enterprise which are directly related to the CSFs. It is process-oriented, generic framework and therefore, it can be applied to almost any enterprise.

2.4.5. The Balanced Scorecard

One of the most well known conceptual performance measurement frameworks is the balanced scorecard developed and promoted by Kaplan and Norton (1992). The balanced scorecard proposes that a company should use a balanced set of measures that allows top managers to take a quick but comprehensive view of the business from four important perspectives (see Figure 2.5). In turn, these perspectives provide answers to four fundamental questions:
i How do we look to our shareholders (financial perspective)?
ii What must we excel at (internal business perspective)?
iii How do our customers see us (customer perspective)?
iv How can we continue to improve and create value (innovation and learning perspective)?

Evidently, the balanced scorecard includes financial performance measures giving the results of actions already taken. It also complements the financial performance measures with more operational non-financial performance measures, which are considered as drivers of future financial performance. Kaplan and Norton (1992) argue that giving information from four perspectives, the balanced scorecard minimizes information overload by limiting the number of measures used. It also forces managers to focus on the handful of measures that are most critical. Further, use of four perspectives guard against sub optimization by compelling managers to consider all measures and evaluate whether improvement in one area may have been achieved at the expense of another.

According to Ghalayini et al., (1997), the main weakness of this approach is that it is primarily designed to provide senior managers with an overall view of
performance. Thus, it is not intended for or applicable at the factory operations level. Further, they argued that the balanced scorecard is constructed as a monitoring and controlling tool rather than an improvement tool. Neely et al (2000) argue that although the balanced scorecard is a valuable framework suggesting important areas in which performance measures might be useful, it provides little guidance on how the appropriate measures can be identified, introduced and ultimately used to manage business. They also conclude that the balanced scorecard does not at all consider competitors.

There are other common faults which can be drawn from the literature (Ahmed, 2002), such as:

- The balanced scorecard framework is more complex than it looks and some companies in haste select inappropriate sets of measures and think they have built their measurement system on this basis.

- The “learning perspective” is still weak, with people factors being treated only superficially, in particular the corporate learning (i.e. knowledge management), which is entirely absent from the framework.

- A number of leading measures such as customer satisfaction are not clearly focused.

- Most seriously, there is no view on how the various measures interact and integrate with each other.

2.4.6. The EFQM Business Excellence Model

The European Foundation for Quality Management (EFQM) business excellence model developed in 1992 is shown in Figure 2.6. It originally emanated from the total quality movement and is heavily focused on continuous improvement. The ‘results’ aspect of the EFQM framework is similar to the balanced scorecard, though the EFQM has the advantage of considering the ‘enablers’ in organizational performance as well. A detailed set of scoring criteria is used to determine how the company identifies processes, shows leadership, sets policies, allocates resources, achieve people and customer satisfaction and has an impact on society. Ahmed (2002) stated
that the disadvantage of the EFQM framework is that it does not explicitly link business strategy and operations.

Figure 2.6: The EFQM Business Excellence Model

2.4.7. The Performance Measurement Matrix

Similar to the balance scorecard but not as an extensive framework is the performance measurement matrix which was proposed in the late 80’s by Keegan et al. (1989). Figure 2.7 shows the performance measurement matrix framework proposed by Keegan et al., (1989). This framework promotes PMS that integrates four different classes of business performance: cost and non-cost, internal and external.

Kennerley and Neely (2003) state that the performance measurement matrix is not as well packed and does not make explicit links between the different dimensions of business performance.

Figure 2.7: The Performance Measurement Matrix (Keegan et al., 1989)
2.4.8. The Performance Pyramid

An important requirement of a PMS is that there must be a clear link between the performance measures at the different hierarchical levels in the company, so that each function and department strives towards the same goals. One example of how this link can be achieved is through the performance pyramid (i.e. the SMART system), proposed by Cross and Lynch (1992) as shown in Figure 2.8. Such a PMS starts at the top of the pyramid with the company’s vision. The second level, business units, compromises the company’s key results, objectives and measures in two ways: reaching short-term targets of cash flow and profitability; and achieving long-term goals of growth and market position (market, financial). The business operating system bridges the gap between top-level and day-to-day operational measures (customer satisfaction, flexibility, productivity). Finally, four key performance measures (quality, delivery, cycle time and waste) are used at departments and work centers on a daily basis.

![Performance Pyramid Diagram](image)

**Figure 2.8: The Performance Pyramid (Cross and Lynch, 1992)**

As stated by Ghalayini *et al.* (1997), the main strength of the performance pyramid is its attempt to integrate corporate objectives with operational performance...
indicators. However, this approach neither provide any mechanism to identify key performance indicators nor does it explicitly integrate the concept of continuous improvement.

2.4.9. The Performance Measurement Questionnaire

Dixon et al. (1990) developed conceptual framework, that is often referred as the performance measurement questionnaire (PMQ), to help managers identify the improvement needs of their organizations to determine the extent to which existing performance measurer support improvements and to establish an agenda for performance measure improvements. The result of the PMQ is evaluated by four types of analyses – alignment, congruence, consensus and confusion. The PMQ has the advantage of providing a mechanism for identifying the improvement areas of the company and their associated performance measures. However, Ghalayini et al. (1997) argued that it cannot be considered as a comprehensive integrated measurement system and does not take into account continuous improvement.

2.4.10. Theory of Constraints

Many researchers have stated that there is a need to limit the number of used performance measures in the PMS to avoid information overflow (Jackson and Peterson, 1999). Goldratt (1990) has developed such an approach named as the Theory of Constraints (TOC). The TOC emerged in the mid 1980s as a process of ongoing improvement. The TOC researchers have focused on production planning and scheduling methods, and have also been involved in performance measurement. Within a system, a constraint is defined as anything that limits the system from achieving higher performance relative to its purpose. While the concept of TOC is simple, it is far from simplistic. To a large degree, the constraint/non-constraint distinction is almost totally ignored by most managerial techniques and practices (Moore and Scheinkopf, 1998).

The TOC offers a systematic and focused process that organizations use to successfully pursue ongoing improvement. The TOC’s “five steps of focusing” are conducted in the following way (Goldratt, 1990).

i. Identify the system’s constraints.
ii. Decide how to exploit the system’s constraints.

iii. Subordinate everything else to the above decisions.

iv. Elevate the system’s constraints.

v. When a constraint is broken go back to step one.

Within the TOC three global performance measures are used for assessing a business organizations ability to obtain the goal (i.e. making money). These global measures are net profit, ROI, and cash flow:

Net profit = T - OE

ROI = (T-OE)/ I

Where:

T = Throughput: the rate at which the system generates money through sales [monetary unit]

I = Inventory: all the money the system invests in purchasing things that the system intends to sell [monetary unit]

OE = Operating Expense: all the money the system spends in turning inventory into throughput [monetary unit]

These definitions can also be used to measure productivity as a ratio of throughput divided by operating expense.

Studies have shown that one of the strengths of TOC approach is that it provides focus in a world of information overload (Tangen, 2004). Another advantage is that the performance measures within TOC are both easy to access and easy to comprehend. However, the TOC is far from being a complete PMS. One could argue that TOC simplifies the reality a little too much, since TOC assumes that there always is a legible constraint in the system, which is not necessarily true. A system is all the time exposed to several of circumstances, which in turn can result in that the constraints are frequently created and eliminated. Furthermore, TOC does not consider other performances than financial and its relation to company strategy, as ‘making money’ is somewhat naive (Tangen, 2004).

2.4.11. The Performance Prism

The performance prism, one of the recently developed conceptual frameworks as shown in Figure 2.9, describes that a PMS should be organized around five distinct
but linked perspectives of performance (Neely et al, 2001). These five perspectives are:

i) Stakeholder satisfaction – Who are the stakeholders and what do they want and need?

ii) Strategies – What are the strategies we require to ensure the wants and needs of our stakeholders?

iii) Processes – What are the processes we have to put in place in order to allow our strategies to be delivered?

iv) Capabilities – What are the capabilities we require to operate the processes?

v) Stakeholder contributions – What is wanted and needed from stakeholders to maintain and develop these capabilities?

The performance prism has a much more comprehensive view of different stakeholders (e.g. investors, customers, employees, regulators and suppliers) than other frameworks. Neely et al. (2001) argues that the common belief that performance measures should be strictly derived from strategy is incorrect. It is the wants and needs from stakeholders that first must be considered. Then, the strategies can be formulated. Thus, it is not possible to form a proper strategy before the stakeholders have been clearly identified.

Figure 2.9: Performance Prism (Neely et al. 2001)
The strength of this conceptual framework is that it first questions the company’s existing strategy before the process of selecting measures is started. In this way, the framework ensures a strong foundation for the performance measures. The performance prism also considers new stakeholders (such as employees, suppliers, alliance partners or intermediaries) that are usually neglected when forming performance measures.

However, much attention has been placed on the process of finding the right strategies for the development of a PMS, but little concentration is given on the process of the actual design of a PMS. In other words, the performance prism extends beyond performance measurement, but tells little about how the performance measures are going to be realized. “The Neely Group” has previously published many useful tools in this area and should, if possible, create a better link between such tools and the performance prism.

2.4.12. Limitations of Existing Conceptual Performance Measurement Framework

From the above discussion, it is clear that some of these frameworks (e.g. Sink and Tuttle framework, performance measurement matrix, performance measurement pyramid) are very strict on performance measures to be included in the performance measurement system (PMS). Others emphasize that a company should have a unique PMS and guide the measurement practitioners to select and design performance measures. However, all conceptual frameworks have in common that they endorse a particular typology (or arrangement) that the performance measures in the PMS must be structured according to. They have paid little attention in the continuous updating of the performance measures. Another weakness of these frameworks is that little or no consideration is given for existing PMS that companies may have in place. However, companies rarely want to design PMS from scratch. Usually managers are interested in eliminating any weaknesses in their existing system (Neely et al, 1994, Tangen, 2003) rather than developing a new system.

From the literature review, it is observed that all conceptual frameworks have their relative benefits and limitations, with the most common limitation being that
little guidance is given for the actual selection and implementation of the performance measures.

2.5. NEED OF A NEW FRAMEWORK FOR ECM PERFORMANCE MEASUREMENT

In environmentally conscious manufacturing, the focus is on managerial practices, business process & technology. ECM includes proactive measures like product life cycle analysis and crosses organizational boundaries. Many organizations have begun to look ECM as a strategy to beat competition. However to determine whether the ECM will fit within the overall strategy and scope of the organization or whether ECM can improve performance of the organization to achieve its business goal, requires performance measures to assess the continuous improvement of the organization in the desired direction.

Traditional performance measurement systems are invalid for the measurement of environmentally conscious manufacturing practices as they are based on outdated traditional cost management systems, lagging metrics not related to corporate strategy, inflexible, expensive, contradict continuous improvement and not necessarily reflect the organizations core competency. The traditional notion of productivity, which has been considered a good indicator of the performance and progress of an organization, also has many limitations. The simple forms of productivity are misleading while the aggregate ones are complicated and neglected in practice.

In response to the need of new performance measurement, many researchers have argued that new strategic performance measures based on time and cost should be used to drive improvement. Yet, systems solely based on time-based performance measurement have the limitation of over-emphasizing the role of time and not considering the impact of other measures such as employee training & involvement, product & process designs, vendor selection, etc.

Some researchers developed conceptual performance measurement frameworks for ECM. Sarkis (1999) developed quality, recyclability, costs, waste reduce, waste pack and compliance as performance measures to evaluate ECM. Wee and Quazi (2005) established seven critical factors for environmental management –
top management commitment, total involvement of employees, training, green product/process design, supplier management, measurement and information management. According to Wee and Quazi (2005), there is a need to focus on environmental issues for improving the performance of organization. Sangwan (2006b) developed qualitative (customer loyalty, stimulated staff morale, enhanced market opportunity, durability and odor pollution) and quantitative measures (cost, material, energy and pollution/toxicity). Rao (2008) developed six measures for evaluating ECM programs – cost, quality, recyclablity, process waste reduction, packaging waste reduction and regulatory compliance.

The limited literature available on ECM performance measures indicates the need to develop performance measures capturing the entire domain of ECM like designing product & process for entire product life cycle, cost & benefit through life cycle in financial & non-financial terms, delivery of products through green logistics, purchasing materials from green vendors, etc. Also, performance measures thus developed need to be validated through statistical tools.