The changing basis of performance measurement

Alaa M. Ghalayini and James S. Noble
University of Missouri, Columbia, USA

Introduction

In order for companies to ensure achievement of their goals and objectives performance measures are used to evaluate, control and improve production processes. Performance measures are also used to compare the performance of different organizations, plants, departments, teams and individuals, and to assess employees. Heim and Compton[1, p. 43] quoted the following words of Lord Kelvin (1824-1907):

> When you can measure what you are speaking about and express it in numbers, you know something about it … (otherwise) your knowledge is a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in thought advanced to the stage of science.

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 system and its many interrelated components[1, p. 6].

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 financial measures such as profit, return on investment and 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 low-cost production to quality, flexibility, short lead time and dependable delivery, but also implemented new technologies and philosophies of production management (i.e. computer-integrated manufacturing (CIM), flexible manufacturing systems (FMS), just in time (JIT), optimized production technology (OPT) and total quality management (TQM)). The implementation of these changes revealed that traditional performance measures have many limitations and the development of new performance measurement systems is required for success.

This paper will address this changing basis of performance measurement in the following manner. First, the limitations of traditional performance measures will be discussed. Second, the characteristics of recently developed

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performance measures will be presented. In this the attempts to incorporate time-based issues and continuous improvement will be reviewed. Third, three integrated performance measurement systems that have been developed will be presented. Finally, the current state of performance measurement will be assessed and recommendations for future performance measurement systems will be proposed.

Traditional performance measures

Traditionally, performance measures have been primarily based on management accounting systems. This has resulted in most measures focusing on financial data (i.e. return on investment, return on sales, price variances, sales per employee, productivity and profit per unit production). Of these performance measures productivity has been considered the primary indicator of performance. Teague and Eilon[2] state the following four 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 inputs); and internal management (i.e. collective bargaining with trade unions).

Edosomwan[3] argues that there are three basic forms of productivity that have been accepted by most researchers and practitioners: partial productivity, total factory productivity and total productivity (other authors provided different classifications such as Teague and Eilon[2] and Mason[4]). Partial productivity is defined as "the ratio of total output to one class of input"[3, p. 3]" (i.e. output per labour hour). Total factor productivity is defined as "the ratio of total output to the sum of associated labour and capital (factors) inputs[3, p. 3]. Total productivity is defined as "the ratio of total output to all input factors"[3, p. 3]. Many models of total productivity have been developed. Craig and Harris[5] were the first to provide a total productivity model at the firm level. Gold[6] developed a network approach for measuring productivity (Figure 1). The network integrates labour, material and efficiency of fixed investment. The arcs of the network represent the ratio of material to labour, the ratio of labour input to effective fixed investment, and the ratio of the material volume input to the effective fixed investment. Riggs and Felix[7] developed the objective matrix format to measure the productivity of a team of employees. Edosomwan[3] provided the task-oriented total productivity model. It differs from other models in that it is based on all measurable output and input components.

The above and other 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. Both of these types of limitations make traditional performance measures less applicable in today's competitive market. The following discusses eight general limitations and three specific limitations.

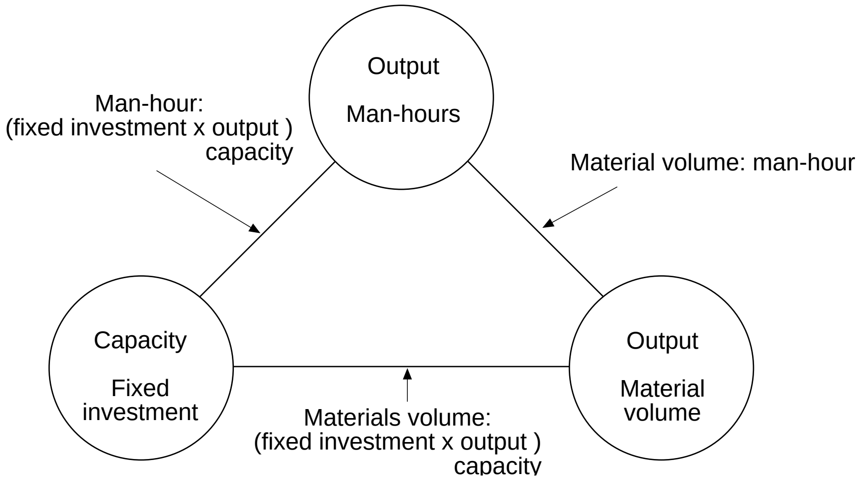


Figure 1. The network of productivity relationships

General limitations of traditional performance measures

The limitations of traditional performance measures and traditional management accounting system – which is the basis for traditional performance measures – have been discussed by many authors (e.g. [8-15]). The following will present the eight most commonly cited 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 textile mills, railroads, steel mills, and retail stores to specific products, department, and activities"[9, p. 135]. During this 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 per cent while overhead is usually 50-55 per cent of the manufacturing cost[16]. Since in this case overhead is allocated based on the minor cost element of direct labour this allocation approach is not valid.

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.

Corporate strategy. Traditional performance measures have not incorporated strategy. Rather the objectives have been to minimize costs, increase labour efficiency and machine utilization.

Relevance to practice. Traditional performance measures try to quantify performance and other improvement efforts in financial terms. Yet, most improvements efforts are difficult to quantify in dollars (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 the factory shopfloor level.

Inflexible. Traditional financial reports are inflexible in that they have a pre-determined format which is used across all departments. However, even departments within the 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. Fisher[14, p. 21] argues that setting standards for performance measures in general conflicts with continuous improvement. "If standards were not carefully set, they had the effect of setting norms rather than motivating improvement. Workers may hesitate to perform to their maximum if they realize that the standard for upcoming periods may be revised upward by current results."

Customer requirements and management techniques. Maskell[15] argues that traditional performance measures are no longer useful since in order to meet customer requirements of higher-quality products, shorter lead time and lower cost management have given shopfloor operators more responsibility and authority in their work. Consequently, traditional financial reports used by middle managers do not reflect a more autonomous management approach.

Limitations of specific traditional performance measures

Productivity. The limitations of productivity can be classified into three main categories: partial productivity, aggregate productivity and the productivity paradox. Edosomwan[3] states that the actual danger of partial productivity is that it overemphasizes one input and neglects 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 are time consuming and costly to obtain. Finally, in reference to aggregate productivity measurements Armitage and Atkinson[17, p. 94] found that managers refer to aggregate measures as "misdirected, irrelevant, or too complex to be understood and effective in motivating performance". The third category of limitations is what Skinner[18] called the "productivity paradox". Skinner argues 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, customers' demands have changed. Low cost is only one and no longer the most important factor for competing in most markets. Skinner[18] argues that to be competitive you should concentrate on quality, reliable delivery, short lead times, customer service, rapid product introduction, flexible capacity and efficient capital deployment. Skinner adds that these are not cost reductions *per se*, but are essential to success in the market. Reducing costs at the expense of any of these areas 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 provides little about the nature and the reasons for that problem. Globerson[19] argues that the claim that profit 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. It is obvious from the previous discussion that there is a need for new performance measures that can overcome the stated limitations. In fact, Kaplan[12, p. 35] states 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”. Globerson[19] has 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.

Emerging performance measures (non-traditional)

The characteristics of emerging performance measures have been discussed recently in the literature[9,15,20,21]. The characteristics that have been mentioned include: measures related to manufacturing strategy; primarily non-financial measures (i.e. operational) so they can provide managers, supervisors, and operators with information required for daily decision making; simple measures so that shopfloor operators can easily use and understand them; measures should foster improvement versus just monitor it; and measures should change as is required by a dynamic marketplace.

The differences between traditional and non-traditional performance measures are summarized in Table I.

Time: a strategic performance measure

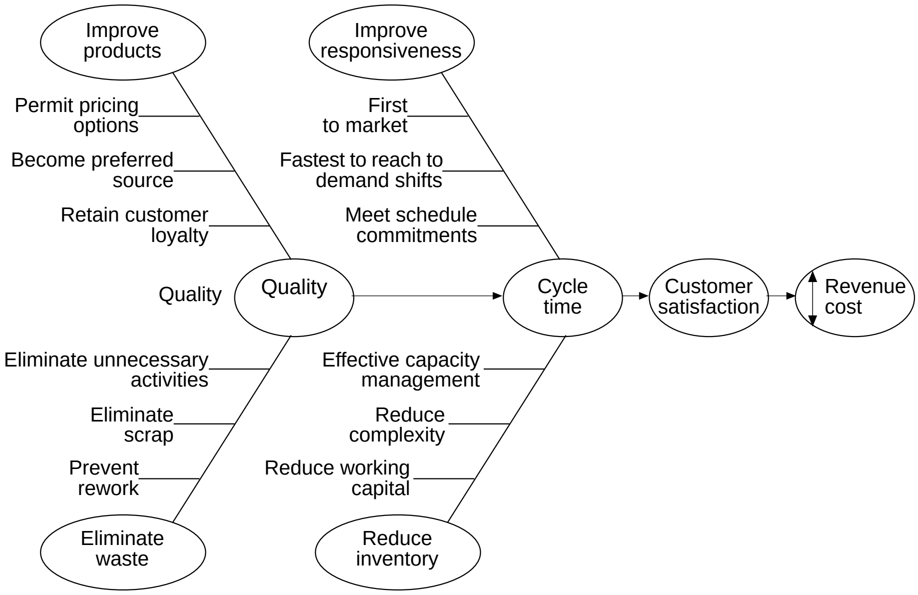
Examining the current literature of business strategy and performance measurement reveals that time is proposed as the new strategic metric that

Table I.
A comparison between traditional and non-traditional performance measures

Traditional performance measures	Non-traditional performance measures
Based on outdated traditional accounting system	Based on company strategy
Mainly financial measures	Mainly non-financial measures
Intended for middle and high managers	Intended for all employees
Lagging metrics (weekly or monthly)	On-time metrics (hourly, or daily)
Difficult, confusing and misleading	Simple, accurate and easy to use
Lead to employee frustration	Lead to employee satisfaction
Neglected at the shopfloor	Frequently used at the shopfloor
Have a fixed format	Have no fixed format (depends on needs)
Do not vary between locations	Vary between locations
Do not change over time	Change over time as the need change
Intended mainly for monitoring performance	Intended to improve performance
Not applicable for JIT, TQM, CIM, FMS, RPR, OPT, etc.	Applicable
Hinders continuous improvement	Help in achieving continuous improvement

companies should strive to measure and improve in order to be able to compete 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[22-28].

Bockerstette and Shell[28] illustrated how controlling cycle time will lead to overall business success (Figure 2). They argue that reducing cycle time reduces costs and improves customer satisfaction which in turn increases revenue. Krupka[26] argues 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. Krupka also argues that the variability of time is an important metric that should be used to assess manufacturing systems performance. He states that reducing the variability of an activity through decreasing rate of scrape 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.



Source: [29, p.13]

Figure 2.
The effect of cycle time on business success

Time-based performance measurement systems

Time-based performance measurement systems have been developed to help companies control and improve their operations. Stalk and Hout[24] state that time-based companies should go beyond measures like lead time, on-time delivery and response time to time-based metrics which could be use as diagnostic tools throughout the organization. They summarized the main time-based metrics that companies could use into four different areas: developing new products, decision making, processing and production, and customer service:

(1) New product development includes: time from idea to market; rate of new-product introduction; and percentage first competitor to market.

(2) Decision making includes: decision cycle time; and time lost waiting for decisions.

(3) 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).

(4) Customer service includes: response time; quoted lead time; percentage deliveries of time; and time from customer's recognition of need to delivery.

Azzone *et al.*[30] present a framework of performance measures for time-based companies. Their model contains three main areas in which time measures should be applied: research and development (R&D), operations and sales and marketing. "The columns represent the ways through which the company benefits from time to create a competitive advantage, while the rows represent the macro-activities which could be critical in developing such a competitive advantage"[30, p. 83].

Barker[31] provides a time-based performance measurement system that is based on the concept of positive and negative value-adding measurements. Improvement efforts are directed to reduce negative value-adding components and decrease system throughput time.

The advantage of the performance measures presented by Stalk and Hout[24], Azzone *et al.*[30], and Barker[31] is that they are simple and easy to understand and use. The main disadvantage of these performance measures is that they solely concentrate on time and neglect other operational performance measures such as quality, cost and delivery. Without controlling and improving these operational measures companies will not be able to compress time.

Realizing that time is critical for evaluating and improving manufacturing performance has led various researchers to develop different tools for cycle time modelling. The following section discusses the different cycle time models.

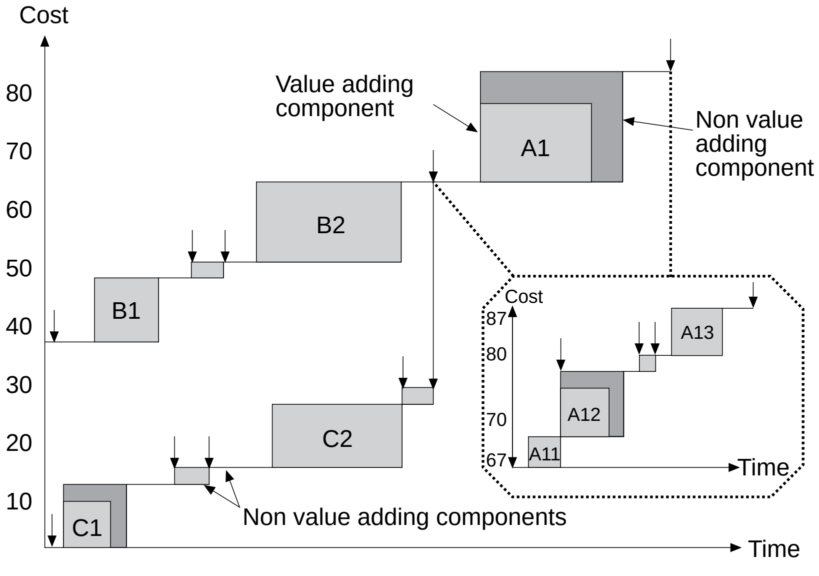
Cycle time modelling

Sullivan[32] discusses OPTIM (operating profit through time and investment management) as a way to model business activities. 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: The Y axis represents material, labour, and factory expense, while the X axis represents cycle time for the operation. The goal of quality improvement is to shrink the profile"[32, p. 53].

Noble and Lahay[33] presented the value-focused cycle time (VFCT) diagram to model the manufacturing systems in a simple way using the cycle time concept. 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. By using the concept of non added value, other metrics such as quality can be represented in the model, yet in dollar terms. Thus, the model directly connects cost, quality and time. Figure 3 is an example of a VFCT diagram and illustrates that the model can represent different levels of aggregation. The VFCT diagram provides the following as a tool for cycle time modelling and for improvement efforts: simple and easy to use which makes it an excellent tool for process improvement teams; guards against sub-optimization by allowing an overall view of the manufacturing process; allows different level of representation (i.e. an aggregate overall view of the process and a detailed view of the sub-process, process A1 in Figure 3).

Goal setting for continuous improvement

Companies use performance measurement systems to ensure that they are achieving continuous improvement in their operations in order to sustain a



Source: [33, p. 376]

Figure 3. Multi-level-focused cycle time diagram

competitive edge, increase market share and increase profits. To aid them in achieving continuous improvement managers need tools to help them in setting specific goals to be achieved during a predetermined time horizon. These goals need to be carefully set. If they are set too low the company will under-achieve relative to its ability. On the other hand, if the goals are set too high the company will under-perform relative to expectations. The following will discuss two methods that have been suggested for goal setting for continuous improvement.

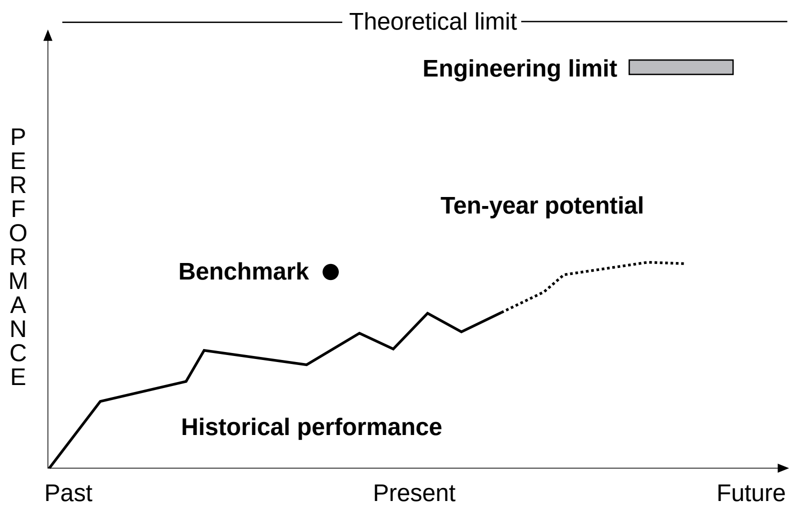
The half-life concept for continuous improvement

Schneiderman[29] argued that the half-life concept can be used as a goal setting tool for achieving continuous improvement. The concept is that any defect level that is subject to legitimate process improvement efforts will decrease over time. By plotting the defect levels on semi-log paper against time, the points will form a straight line, which is easy to characterize and extrapolate. Schneiderman refers to a "defect" in a general sense, "which includes errors, rework, yield loss, unnecessary reports, cycle times (manufacturing, design, administrative, etc.), unscheduled downtime, inventory, employee turnover, absenteeism, lateness, unrealized human potential, accidents, late deliveries, order lead time, setup time, cost of poor quality, and warranty costs. In fact, a defect can be any measurable quantity that is in need of improvement"[29, p. 53]. The concept is that for a specific period of time that is equal to the half-life, the defect level drops, on average, by 50 per cent. Thus, "the model has the appealing attribute that accommodates the notion of zero defects, yet guarantees that it is achievable only in infinite time"[29, p. 54].

Performance limits of continuous improvement through strategic analysis

The ALCOA group[34] developed an approach for strategy formulation in order to enhance the company's ability to compete in the market and increase its market share. The approach is based on four main principles[34, p. 225]: emphasis on using data for process understanding; development of forecasts for key processes, using the constraints of limits; systematic summarizing of forecasts and interpretation of issues and opportunities; and shared engagement in the analysis by key operating and technical staff and management.

Strategic analysis requires compilation of a set of data that facilitates a more comprehensive understanding of the key processes for the business (such as: factors that drive the overall demand for the company products, customer satisfaction criteria and performance against those criteria, the nature and strengths of competition, and the efficiency and effectiveness of the manufacturing systems). The analysis focuses on the most significant manufacturing features to develop forecasts of manufacturing process potential. A team from different disciplines in the company, such as engineering, operation, marketing and management, examine the potential of the manufacturing processes against historical data. The analysis has four main components: historical performance, theoretical limits, engineering limits and relevant benchmark information. Integrating these four components helps in developing three, five, ten years potentials for process performance. For each process what-if analysis can be conducted in order to improve the process and anticipate the effect of this improvements on the aggregate performance (Figure 4).



Source: [34, p. 227]

Figure 4.
ALCOA strategic analysis

Analysis of the half-life concept and the ALCOA strategic analysis

The half-life concept is a simple and practical approach that could be used for setting improvement goals. This concept does not require skill in data analysis and is easy to understand. The disadvantage of this approach is that it is mainly based on practical observation. Though it may work well for some processes there will be some for which it will not.

The strategic analysis approach differs from the half-life concept in that it requires careful analysis and understanding of the historical data, the capability of the process, and its physical and theoretical limits. Even more, it requires deep understanding of the market, and competitors and their future trends. The approach was mainly developed for long-term strategic analysis rather than for short-term process improvement planning. Thus, such a comprehensive understanding of all the variables is a must. The main advantage of the strategic analysis approach is that it requires a deep understanding of the process which makes the improvement process more fruitful. Another advantage is that this concept encourages the participants to go beyond the limits of benchmarking. A major disadvantage of the strategic analysis is that it is not designed for short-term improvement.

The half-life concept and the strategic analysis approach both have the disadvantage of being based on historical data that are supposed to be accurate and sufficient. The availability of such data in the appropriate form is not common in many companies. Consequently, the implementation of these concepts is not an easy task.

Finally, both the half-life concept and the strategic analysis motivate setting improvement objectives and the time frame to achieve them. However, the optimum improvement level to be achieved within a planning horizon is not addressed. Some researchers argue that setting standards conflicts with the continuous improvement philosophy. They state that when objectives are met improvement efforts will slow down. However, not setting objectives also contradicts the concept of continuous improvement. Companies need to know if they are improving their operations or not.

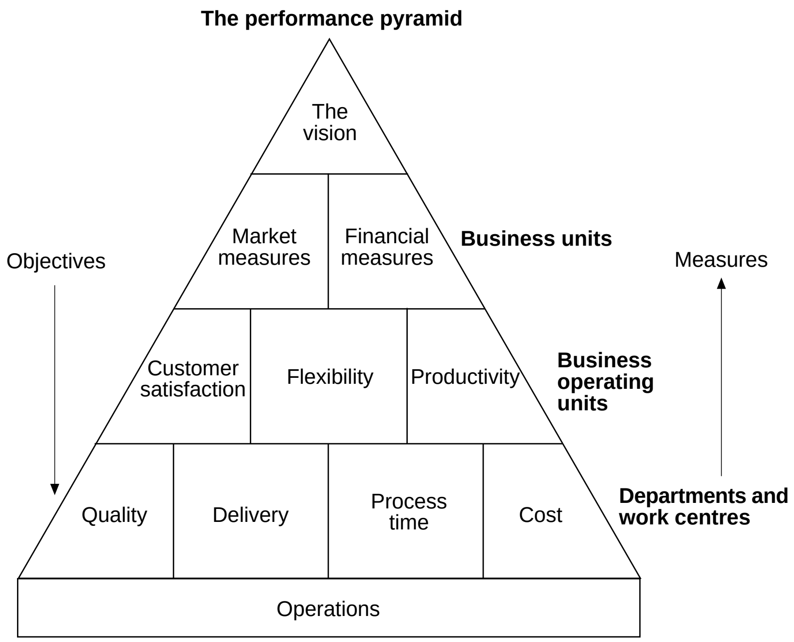
Integrated performance measurement systems

Researchers have developed integrated performance measurement systems in order to give an overall view of companies' performance and to guard against sub-optimization. These integrated systems are appropriate for a world-class manufacturing firm in many aspects. However, they have some limitations. The following sections will discuss three such systems.

The "SMART" system

The strategic measurement analysis and reporting technique (SMART) system was developed by Wang Laboratories, Inc. as a result of dissatisfaction with traditional performance measures such as utilization, efficiency, productivity and other financial variances[35]. The objective was to devise a management control system with performance indicators designed to define and sustain success.

The SMART system can be represented by a four-level pyramid of objectives and measures (Figure 5). At the top is the corporate vision or strategy. At this



Source: Adapted from [35, p. 25]

Figure 5.
The SMART way

level management assigns a corporate portfolio role to each business unit and allocates resources to support them. At the second level, objectives for each business unit are defined in market and financial terms. At the third level more tangible operating objectives and priorities can be defined for each business operating system (BOS) in terms of customer satisfaction, flexibility and productivity. At the fourth level, the department level, customer satisfaction, flexibility and productivity are represented by specific operational criteria: quality, delivery, process time and cost. As the foundation of the performance pyramid, these operational measures are the keys to achieve higher-level results and ensure successful implementation of the company strategy. For example, quality is defined as:

> translating the "voice of customer" into appropriate company requirements at each stage from product/service concept to delivery… For marketing and R&D this means innovative designs within price and reliability ranges expected by the customer. For production, quality is translated into reliability, aesthetics, and perceived quality[35, p. 28].

The performance measurement questionnaire (PMQ)

Dixon *et al.*[20] developed the PMQ to help managers identify the improvement needs of their organization, to determine the extent to which the existing performance measures support improvements and to establish an agenda for performance measure improvements.

The PMQ consists of four parts. The first part provides general data to be used to classify the respondents. Part two of the PMQ assesses the companies' competitive priorities and performance measurement system. It consists of items labelled as "improvement areas". They are placed in the centre of the questionnaire as shown in Table II. The respondent is asked to circle a number on each side of the table. The third part of the PMQ is similar to Part two except the focus is on performance factors (performance measures). The final part of the questionnaire asks the respondents to provide performance measures that best evaluate their own performance and any other general comments.

Long-run importance of improvement	Improvement areas	Effect of current performance measures on improvement
None >>>> Great		Inhibit >>>> Support
1 2 3 4 5 6 7	Quality	1 2 3 4 5 6 7
1 2 3 4 5 6 7	Labour efficiency	1 2 3 4 5 6 7
1 2 3 4 5 6 7	Machine efficiency	1 2 3 4 5 6 7

Source: [20, p. 68]

Table II. Section of Part two of PMQ

The results of the PMQ are evaluated in four ways: alignment, congruence, consensus and confusion. Alignment analysis is conducted to investigate in general terms how well a company's actions and measures complement its strategy. Congruence analysis is conducted to provide a detailed understanding of how well the measurement system supports an organization's actions and strategy. Consensus analysis is carried out by grouping the data by management level or by functional group. This analysis shows the effect of communication. The goal of the confusion analysis is to determine the extent of consensus (standard deviation) regarding each improvement area and performance measure.

The balanced scorecard

Kaplan and Norton[36] developed a framework for an integrated performance measurement system for strategic, operational and financial measures. The balanced scorecard provides answers to four basic questions[36, p. 72] (Figure 6): How do customers see us? (customer perspective); What must we excel at? (internal perspective); Can we continue to improve and create value? (innovation and learning perspective); and How do we look to shareholders? (financial perspective).

For each of the above perspectives goals are set by the managers. Similarly, specific measures are specified in order to achieve each goal. The balanced scorecard has two main strengths. First, it summarizes in one management report many of seemingly disparate elements of a company's competitive

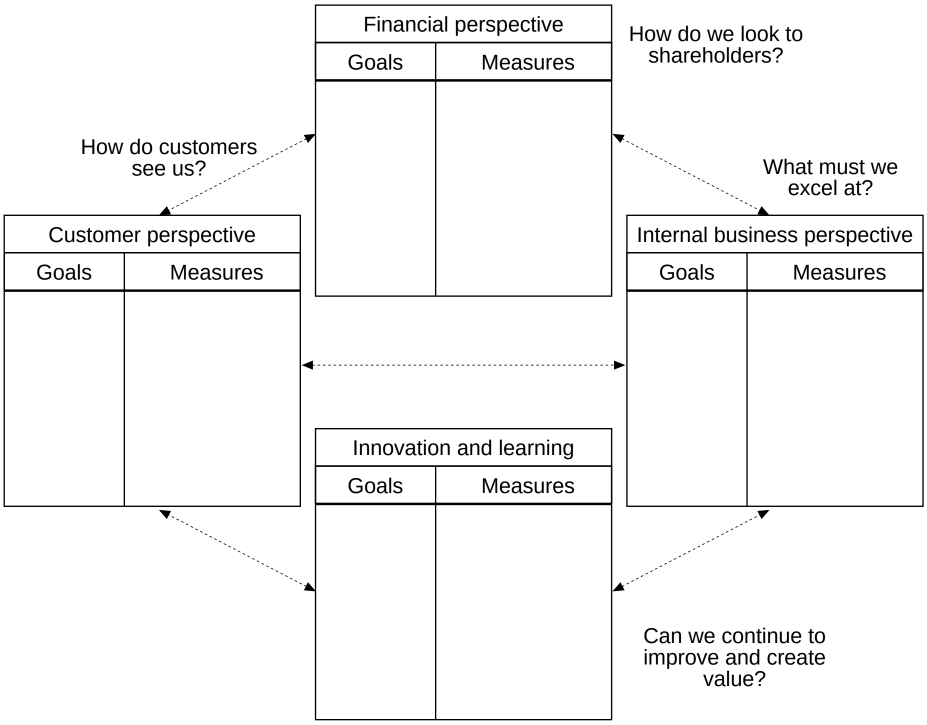


Figure 6.
The balanced scorecard

Source: [36, p.72]

agenda. Second, it prevents sub-optimization by forcing senior managers to consider all operational measures at the same time.

Analysis of the existing integrated performance measurement systems

The three integrated performance measurement systems discussed have some strengths and weaknesses relative to each other. The main strength of the SMART system is its attempt to integrate corporate objectives with operational performance indicators. However, one weakness of the SMART system is that it does not provide any mechanism to identify key performance indicators for quality, cycle time, cost and delivery. For example, what are the most appropriate measures for assessing quality? Also, the SMART system does not explicitly integrate the concept of continuous improvement.

The PMQ has the advantage of providing a mechanism to identify the improvement areas of the company and their associated performance measures. In addition, it tries to determine the extent to which the existing measurement system supports such improvement areas. The disadvantage of the PMQ is that it cannot be considered a comprehensive integrated measurement system. More work is required to link these areas of improvement and performance measures to the factory shopfloor. Another weakness of the PMQ, like SMART, is that it does not take into account the concept of continuous improvement.

The balanced scorecard attempts to integrate four important performance perspectives in one simple and easy-to-use management report. The main weakness of this approach is that it is primarily designed for senior managers to provide them with an overall view of performance. Thus, it is not intended for, nor applicable at, the factory level. Gregory[37, p. 296] stated that "Clearly, much work would need to go on below the level of the 'scorecard' to provide systems which could deliver these generally rather aggregated measures".

In fact, Gregory[37], in his analysis of the state-of-the-art integrated performance measurement systems, states:

> None of the current offerings appears to address the need for management process as distinct from a once-off method. A process approach would allow the management team to review its data systematically, decisions and outcomes over time, and could be linked to company-wide visualization and tailored to particular needs. The need for a "dynamic" approach to performance measurement is also not widely addressed. This might involve the use of a variety of short-term measures, proactively to change systems and behavior rather than simply as monitors or problem solving tools.

In summary, the integrated measurement systems have the following limitations:

- They are mainly constructed as monitoring and controlling tools rather than improvement tools. Thus, they do not explicitly consider the integration of continuous improvement.
- They do not provide any mechanism for specifying which objective should be met in a specific time horizon.
- They are not dynamic systems. They do not allow any systematic revision of critical areas, performance measures, historical data, decisions and outcomes.
- They do not look ahead to predicting, achieving and improving future performance. They are only concerned with present performance.
- Although some of them stress the importance of global optimization versus local optimization, they do not provide any mechanism to achieve this, especially at the operational level.
- Most of these systems do not stress the importance of time as a strategic performance measure.
- None of the models provides a specific tool that could be used to model, control, monitor and improve the activities at the factory shopfloor.

Summary and recommendations

Traditional performance measures have many limitations that make them less applicable in today's competitive market. They are based on outdated traditional cost management systems, lagging metrics, not related to corporate strategy, inflexible, expensive and contradict continuous improvement. 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 (i.e. partial productivity) are misleading while the aggregate ones are complicated and neglected in practice. As a result of the limitations of the traditional performance measures many researchers have suggested that a new set of operational performance measures should be used. These measures should provide managers, supervisors and operators with on-time information that is necessary for daily decision making. These measures should be flexible, primarily non-financial, and able to be changed as needed.

In response to the need for new performance measurement approaches many researchers have argued that time is the new strategic performance measure that 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 operational performance measures with respect to time. In order to improve time performance all operational performance measures should be measured, controlled and improved.

Finally, to overcome the previous limitations associated with performance measurement systems, various integrated performance measurement systems have been developed. However, they also suffer from a variety of limitations. Thus, there is still a need for an integrated dynamic performance measurement system that has the following characteristics: a clearly defined set of improvement areas and associated performance measures that are related to company strategy and objectives; stresses the role of time as a strategic performance measure; allows dynamic updating of the improvement areas, performance measures and performance measures standards; links the areas of improvement and performance measurement to the factory shopfloor; is used as an improvement tool rather than just a monitoring and controlling tool; considers process improvements efforts as a basic integrated part of the system; utilizes any improvements in performance (i.e. going beyond just achieving improvement and actively planning for the utilization of benefits from an overall company perspective); uses historical data of the company to set improvement objectives and to help achieve such objectives; guards against sub-optimization; and provides practical tools that could be used to achieve all of the above.

This paper has highlighted how the area of performance measurement has been traditionally considered and how it is currently changing. Based on these observations it is apparent that there is much work that still remains in the development of performance measurement systems.

References

1. Heim, J.A. and Compton, W.D. (Eds), *Manufacturing Systems: Foundations of World-Class Practice*, National Academy of Engineering, Washington, DC, 1992.
2. Teague, J. and Eilon, S., "Productivity measurement: a brief survey", *Applied Economics*, Vol. 5, 1973, pp. 133-45.

3. Edosomwan, J.A., *Integrating Productivity and Quality Management*, Marcel Dekker, New York, NY, 1985.
4. Mason, R.O., "A general system theory of productivity", *International Journal of General Systems,* Vol. 5, 1979, pp. 17-30.
5. Craig, C.E. and Harris, R.C., "Total productivity measurement at the firm level", *Sloan Management Review*, Vol. 14, Spring 1973, pp. 14-29.
6. Gold, B., "Practical productivity analysis for management accountants", *Management Accounting*, Vol. 62, May 1980, pp. 31-44.
7. Riggs, J.L. and Felix, G.H., *Productivity by Objectives: Results-Oriented Solutions to the Productivity Puzzle*, Prentice-Hall, Englewood Cliffs, NJ, 1983.
8. Kaplan, R.S., "Measuring manufacturing performance: a new challenge for managerial accounting research", *The Accounting Review*, Vol. 58 No. 4, 1983, pp. 686-705.
9. Hayes, R.H., Wheelwright, S.C. and Clark, K.B., *Dynamic Manufacturing: Creating the Learning Organization*, Free Press, New York, NY, 1988.
10. McNair, C.J., Mosconi, W. and Norris, T., *Beyond the Bottom Line: Measuring World Class Performance*, Dow Jones-Irwin, Homewood, IL, 1989.
11. Woods, M.D., "New manufacturing practices – new accounting practices", *Production and Inventory Management Journal*, Vol. 30, Fourth Quarter, 1989, pp. 7-11.
12. Kaplan, R.S., "Limitations of cost accounting in advanced manufacturing environments", in Kaplan, R.S. (Ed.), *Measures for Manufacturing Excellence,* Harvard Business School Press, Boston, MA, 1990, pp. 91-126.
13. Eccles, R.G., "The performance measurement manifesto", *Harvard Business Review*, Vol. 69, January-February 1991, pp. 131-7.
14 Fisher, J., "Use of non-financial performance measures", *Journal of Cost Management*, Vol. 6, Spring, 1992, pp. 31-8.
15. Maskell, B.H., *Performance Measurement for World Class Manufacturing: A Model for American Companies*, Productivity Press, Cambridge, MA, 1992.
16. *Business Week*, "The productivity paradox", Special Report, *Business Week*, 16 June 1988, pp. 100-8.
17. Armitage, H.M. and Atkinson, A.A., "The choice of productivity measured in organizations", in Kaplan, R.S. (Ed.), *Measures for Manufacturing Excellence,* Harvard Business School Press, Boston, MA, 1990, pp. 91-126.
18. Skinner, W., "The productivity paradox", *Harvard Business Review*, Vol. 64, July-August 1986, pp. 55-9.
19. Globerson, S., *Performance Criteria and Incentive Systems*, Elsevier, Amsterdam, 1985.
20. Dixon, J.R., Nanni, A.J. and Vollman, T.E., *The New Performance Challenge: Measuring Operations for World Class Competition*, Dow Jones-Irwin, Homewood, IL, 1990.
21. Sink, D.S. and Smith, G.L., "Performance linkages: understanding the role of planning, measurement and evaluation in large scale organizational change", in Sumanth, Edosomwan, Poupart, and Sink (Eds), *Productivity and Quality Management Frontiers-IV*, Institute of Industrial Engineering, 1993, pp. 500-11.
22. Stalk, G., "Time – the next source of competitive advantage", *Harvard Business Review*, Vol. 66, July-August 1988, pp. 41-51.
23. Schmenner, R.W., "The merit of making things fast", *Sloan Management Review*, Vol. 29, Fall 1988, pp. 11-17.
24. Stalk, G., and Hout, T.M., *Competing against Time – How Time-Based Competition Is Reshaping Global Markets*, Free Press, New York, NY, 1990.
25. Blackburn, J., *Time-Based Competition – The Next Battleground in American Manufacturing*, Business One Irwin, Homewood, IL, 1991.

26. Krupka, D.C., "Time as a primary system metric", in Heim, J.A. and Compton, W.D. (Eds), *Manufacturing Systems: Foundations of World-Class Practice,* National Academy of Engineering, Washington, DC, 1992, pp. 167-72.
27. Northey, P. and Southway, N., *Cycle Time Management – The Fast Track to Time-Based Productivity Improvement*, Productivity Press, Portland, OR, 1993.
28. Bockerstette, J.A. and Shell, R.L., *Time Based Manufacturing*, Institute of Industrial Engineers and McGraw-Hill, Norcross, GA, 1993.
29. Schneiderman, A.M., "Setting quality goals", *Quality Progress*, Vol. 21, April 1988, pp. 51-75.
30. Azzone, G., Masella, C. and Bertele, U., "Design of performance measures for time-based companies", *International Journal of Operations & Production Management*, Vol. 11 No. 3, 1991, pp. 77-85.
31. Barker, R.C., "Time-based performance measurement: a model to aid competitive restructuring", *Management Decision*, Vol. 31 No. 4, 1993, pp. 4-9.
32. Sullivan, E., "OPTIM: linking cost, time, and quality", *Quality Progress*, 19 April 1986, pp. 52-5.
33. Noble, J.S. and Lahay, C.W., "Cycle time modeling for process improvement teams", *Proceedings, 3rd Industrial Engineering Research Conference*, Atlanta, GA, May 1994, pp. 372-7.
34. Turnbull, G.K., Fisher, E.S., Peretic, E.M., John, R.H., Arnoldo, R.C. and Newborn, M., "Improving manufacturing competitiveness through strategic analysis", in Heim, J.A. and Compton, W.D. (Eds), *Manufacturing Systems: Foundations of World-Class Practice*, National Academy of Engineering, Washington, DC, 1992, pp. 224-32.
35. Cross, K.F. and Lynch, R.L., "The SMART way to define and sustain success", *National Productivity Review*, Vol. 8 No. 1, 1988-1989, pp. 23-33.
36. Kaplan, R.S. and Norton, D.P., "The balanced scorecard – measures that drive performance", *Harvard Business Review*, Vol. 70, January-February 1992, pp. 71-9.
37. Gregory, M.J., "Integrated performance measurement: a review of current practice and emerging trends", *International Journal of Production Economics*, Vols 30-31, 1993, pp. 281-96.