

# **Important Characteristics and Critical Dimensions of an Effective Manufacturing Performance Manufacturing System**

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## **Abstract**

Measures are important to organizational effectiveness and the topic of manufacturing performance measurement (MPM) has recently attracted considerable interest, however, there is little research on what constitutes an effective performance measurement (PM) system. Therefore, the main objective of this paper is to identify the important characteristics of performance measures as a first step to design an effective MPM system. The second objective is to identify the critical dimensions of performance measures. The third objective is to validate the identified set of characteristics and dimensions by carrying out two cases under study at two different manufacturing companies.

## **Keywords**

Characteristics; Dimensions; Performance Measures, Effective MPM

## **1. Introduction**

In order to cope with the pressures of international competition, manufacturing companies must be capable of manufacturing high quality products at low cost and with increasing variety over short lead times and also delivering them to customers at the right time [1, 2]. In order to respond to these competitive demands and achieve these objectives, many manufacturing companies have implemented advanced manufacturing technologies (AMTs) and innovative managerial practices (IMPs), and emphasized quality, delivery, innovation, and flexibility to meet customer needs in their corporate objectives. These new manufacturing methods rely on increased worker involvement in the control of all phases of manufacturing and in identification of opportunities for process innovations and manufacturing performance improvement [3]. One approach to addressing these changes is to revise the information captured by performance measurement [4-5].

The subject of performance measurement is increasingly generating interest in both the academic and managerial ambits. Also, the business performance measurement has always been one of the management's objectives. This, for the most part, is due to the boarding spectrum of performance required by today's competitive environment and the new production paradigm known as lean production or world-class manufacturing. In addition there is a need to support and verify the performance improvement programs such as Just-In-Time (JIT), Total Quality Management (TQM), concurrent engineering, etc. [6].

A performance measurement system may be defined as set of metrics used for quantifying both the efficiency and effectiveness of actions [7]. As applied to manufacturing systems, the effectiveness of a manufacturing system describes the extent to which the system performs the customer requirements, whereas efficiency describes how economically (in terms of resources utilization) these requirements are performed. There are seven main reasons why so many people have become so interested in business performance measurement recently. These reasons are as follows: the changing nature of work; increasing competition; specific improving initiatives; national and international awards; changing organizational roles; changing external demands; and the power of information technology (IT) [8].

There are two steps to design a comprehensive and effective manufacturing performance measurement system. The first step consists of three phases: identify the critical dimensions in a performance measurement system (what to measure?); identify the important characteristics of the measures (how to measure?); and evaluate the existing system against the identified set of dimensions and characteristics. The second step is to suggest improvement of the existing performance measurement systems. Therefore, this paper presents an answer to the first two-phases of the first step of designing a comprehensive and effective MPM system.

The paper was developed in six sections. In the second section, the literature review related to the study is presented. The next section provides the characteristics of performance measures and followed by identifying the important characteristics of performance measures. In the fourth section, the dimensions of performance are described and followed by identifying the critical dimensions. Later, a case study are presented to validate the identified set of important characteristics and critical dimensions of performance measures. Finally, the conclusion of this paper is given.

## **2. Literature Review**

Throughout a survey of accounting, manufacturing, and managerial literature different characteristics were found on a consistent basis. Globerson [9] suggests that the following guidelines can be used to select a preferred set of performance criteria: be derived from strategy; provide timely and accurate feedback; relate to specific, stretching, but achievable goals (targets); be based on quantities that can be influenced, or controlled, by the user alone or the user in collaboration with others; be clearly defined; be part of a closed management loop; have an explicit purpose; be based on an explicitly defined formula and source of data; employ ratios rather than absolute numbers; and use data which are automatically collected as part of a process whenever possible.

Similarly, Maskell [10] offers seven principles of performance measurement system design: they are directly related to the manufacturing strategy; they primarily use non-financial measures; they vary between locations; they change over time as needs change; they are simple and easy to use; they provide fast feedback to operators and managers; and they are indented to foster improvement rather than just monitor. Crawford and Fox [11] suggest that measures of performance should be transparent; simple to understand; have visual impact; focus on improvement rather than variance; and be visible to all. Fortuin [12] adopts a similar stance, but also suggests that measures should provide fast feedback; provide information; be precise – be exact about what is being measured; and be objective – not based on opinion.

Neely et al. [13] suggest useful recommendations for both the design of the performance measures (22 requirements to define a measure) and the performance measurement process (through a practical “record sheet”). Tesoro and Tootson [14] suggest that the performance measurement system should meet the following criteria to have credibility and functionality: validity, accuracy and precision, completeness or collective exhaustiveness, uniqueness or mutual exclusiveness, reliability, comprehensibility, ability to be quantitative, controllability, ownership, flexibility, cost effectiveness, adaptability, and maintainability.

Skinner [15] originally linked manufacturing strategy and performance measurement together. He suggests that manufacturing controls focus on cost, quality, flows, inventory, and time, and that results be measured in terms of productivity, service, quality and return on investment. Skinner [16] then argues that to be competitive, concentration on quality, reliable delivery, short lead times, customer service, rapid product introduction, flexible capacity and efficient capital deployment is required. Wheelwright [17] suggested that performance measures be tied to the organization’s strategy as reflected by its “competitive priorities”. Leong et al. [18] claim that it is widely accepted that the manufacturing task, and hence the key dimensions of manufacturing’s performance, can be defined in terms of quality, delivery speed, delivery reliability, price (cost), and flexibility.

Maskell [19] identified six factors of a manufacturing strategy that should be measured: quality, cost, delivery reliability, lead-time, flexibility, and employee relationships. Each factor, he identifies measures commonly used by world class companies. Allen [20] further developed this list to 19 critical success factors. Lynch and Cross [21] considered that qualitative and non-financial manufacturing performance measures can help organizations to link operations to strategic goals on all hierarchical levels, since they are easier to derive from the qualifying and order-winning criteria and easier to put into effect, but it is still necessary to link corporate, business and manufacturing strategies. Vickery et al. [22] presented a list with 31 items according to a survey. They argued that manufacturing

does not have primary responsibility for all 31 items. On the other hand, White [23] has suggested that the items for which manufacturing have at least 50 percent of the responsibility are quality (conformance to specifications, reliability, and durability), cost, flexibility (volume and process), delivery dependability, and speed (delivery speed and lead time).

### **3. Important Characteristics**

The characteristics of the performance measures can be grouped into four attributes: configuration, style, actionability, and information. The PM system can achieve configuration along many characteristics. One of the prime objectives of a performance measurement system is to provide direction to the organization. That direction is a function of the competitive priorities of the operation. The PM system should focus all business activities on internal and external customer requirements [21]. It should focus on measures to which the customer can relate [4]. Measures should be directly tied to manufacturing strategy to assess progress toward goals constantly. The style of a performance measurement system should be simple to understand and use, relevant and easy to maintain, consistent, and precise. Actionability addresses how directly the performance measurement system employs measures and data. It is important that a PMS identify what kind of measures and data are needed. The PMS plays a key role in promoting continuous improvement and providing fast feedback. Also, the PMS should use trends over either time or point differences to assess changes in performance. Plotting specific trends over time allows operators and managers to associate experiences with PM levels.

The sets of guidelines for design performance measures would lead to good performance in today's highly turbulent and competitive business environment. However, a review of these sets revealed that many of the characteristics are duplicated or are not deemed to be desirable. The removal of duplication and a focus on important characteristics proposed the following set: performance measures should be derived from strategy, should be clearly defined with an explicit purpose, should be relevant and easy to maintain, should be simple to understand and use, should provide fast and accurate feedback, should stimulate continuous improvement, should link operations to strategic goals, and should employ ratios and non-financial measures. These important characteristics appear to have been most widely accepted in the manufacturing performance measurement literature. Those set of characteristics can be seen to cover all aspects of selecting the appropriate performance measures. The criteria for selecting the important characteristics are as follows: the literature, opinion of the authors, and real case studies from the literature.

### **4. Critical Dimensions**

A review of existing literature on performance measurement in accounting, manufacturing, and managerial was performed in order to identify the performance dimensions by focusing on the competitive strategy. Different dimensions of a manufacturing performance measurement system were obtained. In summary, quality, flexibility, time, delivery, and cost are commonly cited as the main operational dimensions which should be measured. Finance, in various different forms, is also considered to be a critical dimension of performance. In addition, customer satisfaction is repeatedly cited as a critical measurement area.

The competitive priorities (quality, flexibility, time, delivery, cost, finance, and customer satisfaction) appear to have been most widely accepted in the manufacturing strategy literature [24]. These seven critical dimensions appear to cover all aspects of business: the financial results, the operating performance (through the dimensions of quality, flexibility, time, delivery, and cost), and the way the company is perceived externally (through its customers). Also, those dimensions provide the first level for classifying manufacturing performance measures. It is, however, important to note that these dimensions are not prescriptive. Instead, they are intended to encourage the holistic consideration of these areas when developing measures to support the company strategy.

A variety of criteria can be used to select appropriate performance dimensions. The establishment of criteria can assist in identifying and achieving consensus of the measurement goals. These criteria address some important characteristics of the data, measurement, and measurement system. Data criteria include simplicity, preciseness, relevancy, consistency, source of data and others. For example: Are the data currently available in a simple format? Are the data sufficiently precise? Are the enough data for providing feedback? Are there sufficient resources available for data collection? Measurement criteria include validity and uniqueness of the performance dimensions and measures. For example: Does the dimension or measure address non-financial results? Does the dimension clearly reflect changes in the system? Does the information conveyed by one dimension or measure duplicate information provided by another? Measurement system criteria address strategy, goals, and objectives of the

management. For example: Are the dimensions and measures of the performance derived from strategy? Does the dimension or measure related to goals? Are dimensions and measures linking operations to strategic goals?

## 5. Case Study

Two cases under study were carried out at two manufacturing companies to collect data in order to help in selecting the important characteristics and critical dimensions of performance measures for both companies. They are considered as small to medium-sized companies. In general, the reasons for choosing small to medium-sized companies are as follows: they are expected to react to changes more quickly than their larger counterparts, the existing tools for performance measurement are mainly focused on large firms, most of them operate with a poor forecasting and planning system, they are the backbone of any modern economy, knowledge about performance measurement is often quite limited, they are susceptible to business failures primarily due to poor risk management associated with inadequately informed decision-making, and a comprehensive performance measurement system can deliver vital information to support the decision-making and ascertain the continuity of the organization. This study was conducted by visiting the companies, interviewing engineers and managers, and doing a survey to collect data.

The answers given by the companies surveyed to the question of “what is the preferred percentage for each characteristic?” is given in Table 1. This percentage represents the importance of each characteristic can be met by their performance measures. This table shows that the performance measures derived from strategy are not very important for small-sized company, because the owner is the only person who knows what the strategies are. Also, it shows that both companies totally agree with the important characteristics of performance measures that are identified previously, but they disagree with the last characteristic which is “performance measures should employ ratios and non-financial measures”.

There were no non-financial measures in use. In addition, they agree that the following characteristics should be achieved by their performance measures. These characteristics are as follows: performance measures should be based on quantities that can be influenced, or controlled, by the user alone or the user in co-operation with others; performance measures should be based on an explicitly defined formula and source of data; performance measures should use data which are automatically collected as part of a process whenever possible; and performance measures should be objective – not based on opinion.

The answers given by the companies surveyed to the question of “what is the importance of each dimension (competitive priority)?” is given in Table 2. This percentage represents the opinion of the company representatives about the weight for each dimension he/she would like to use to achieve their strategy by using an effective performance measurement system. This table shows that small-sized company does not use the terms flexibility and time in its performance measurement as competitive priorities, but it is very flexible and try to deliver its products on time. On the other hand, medium-sized company uses both terms but with very limited measures. Also, it shows that both companies totally agree with the dimensions of performance measurement system that are identified before, but they disagree about the time and flexibility. Both companies agree about customer satisfaction as a competitive priority, but it seems to be specified mainly through delivery reliability and quality of the products. In addition, they agree to use productivity as a very important factor in their performance measurement system.

## 6. Conclusions

A performance measurement system is a key factor in ensuring the successful implementation of a company’s strategy. It is very important to identify the important characteristics and critical dimensions of performance measures as a first step to design an effective manufacturing performance measurement system. The important characteristics are as follows: performance measures should be derived from strategy, should be clearly defined with an explicit purpose, should be relevant and easy to maintain, should be simple to understand and use, should provide fast and accurate feedback, should stimulate continuous improvement, should link operations to strategic goals, and should employ ratios and non-financial measures. The results from the case study show that both companies agreed about the identified set of characteristics and they would like to add two more: performance measures should be objective and performance measures should be based on an explicitly defined formula. Also, they disagreed about this characteristic: performance measures should employ ratios and non-financial measures. In addition to, they agreed that the performance measures should be derived from strategy is not important for small-sized company.

The critical dimensions are as follows: quality, flexibility, time, delivery, cost, finance, and customer satisfaction. They appear to be the most widely accepted in the manufacturing strategy literature. The results from the case study show that both companies agreed to add productivity to the critical dimensions. Also, they agreed about customer satisfaction as a competitive priority, but it seems to be specified mainly through delivery reliability and quality of the products.

Table 1: Weight percentage of the performance characteristics

| Characteristic  | %           |              |
|---|-------------|--------------|
|   | Small-sized | Medium-sized |
| Performance measures should be derived from strategy;   | 60          | 98           |
| Performance measures should be simple to understand;  | 90          | 85           |
| Performance measures should provide timely and accurate feedback;   | 90          | 95           |
| Performance measures should be based on quantities that can be influenced, or controlled, by the user alone or the user in co-operation with others;      | 100         | 90           |
| Performance measures should reflect the “the business process” – i.e. both the supplier and customer should be involved in the definition of the measure; | 50          | 100          |
| Performance measures should relate to specific goals (targets);   | 90          | 100          |
| Performance measures should be relevant;  | 100         | 100          |
| Performance measures should be part of a closed management loop;  | 60          | 100          |
| Performance measures should be clearly defined;   | 100         | 100          |
| Performance measures should have visual impact;   | 70          | 100          |
| Performance measures should focus on improvement;   | 80          | 100          |
| Performance measures should be consistent (in that they maintain their significance as time goes by);   | 40          | 100          |
| Performance measures should provide fast feedback;  | 90          | 100          |
| Performance measures should have an explicit purpose;   | 100         | 100          |
| Performance measures should be based on an explicitly defined formula and source of data;   | 100         | 90           |
| Performance measures should employ ratios rather than absolute numbers;   | 0           | 90           |
| Performance measures should use data which are automatically collected as part of a process whenever possible;  | 100         | 89           |
| Performance measures should be reported in a simple consistent format;  | 100         | 85           |
| Performance measures should be based on trends rather than snapshots;   | 40          | 95           |
| Performance measures should provide information;  | 20          | 100          |
| Performance measures should be precise – be exact about what is being measured;   | 100         | 100          |
| Performance measures should be objective – not based on opinion;  | 100         | 100          |
| Performance measures should using non-financial measures;   | 10          | 25           |
| Performance measures should link operations to strategic goals;   | 80          | 95           |

Table 2: Dimensions of the performance measurement system

| Dimension                        | %           |              |
|----------------------------------|-------------|--------------|
|                                  | Small-sized | Medium-sized |
| 1. Quality                       | 100         | 100          |
| 2. Flexibility                   | 40          | 85           |
| 3. Time                          | 50          | 100          |
| 4. Customer satisfaction         | 70          | 100          |
| 5. Productivity                  | 100         | 100          |
| 6. Delivery                      | 90          | 100          |
| 7. Cost                          | 90          | 85           |
| 8. Inventory                     | 70          | 100          |
| 9. Financial                     | 90          | 90           |
| 10. Speed                        | 70          | 60           |
| 11. Flows                        | 80          | 85           |
| 12. Rapid product introduction   | 50          | 95           |
| 13. Employee relationships       | 10          | 45           |
| 14. Efficient capital deployment | 70          | 100          |
| 15. Human resources              | 50          | 90           |

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