

The integration of strategic measures of performance and cause and effect relationships in manufacturing planning and control system models

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Abstract

In recent years it has become generally accepted that the performance of organisations, and the strategies used by organisations to improve overall performance, must be defined in terms of the factors considered important by customers. This performance can be defined in relation to the overall competitive priorities of quality, cost, delivery (speed and reliability) and flexibility (QCDF). In order to gain a meaningful understanding of the performance of an organisation it is necessary to measure the performance against these competitive priorities.

This paper discusses the relationships between performance measures and variables at all levels of the organisation, and highlights the importance of monitoring and being aware of cause and effect relationships in order to improve and gain greater control over performance. The paper highlights how low level variables within the organisation are linked to top level competitive priorities and performance criteria through the manufacturing planning and control (MPC) system, identifying variables that can be manipulated in order to achieve desired performance levels. This is incorporated into a framework that will allow understanding of conflicts between performance criteria and the side effects of actions.

Keywords

Manufacturing planning and control systems; performance measurement; cause and effect relationships.

1 INTRODUCTION

Recent years have witnessed a very high level of interest in 'world class' manufacturing. Much literature has been written in this area and many companies are striving to achieve the much coveted world class manufacturing status. A world class manufacturing organisation must

simultaneously achieve 'outstanding' levels of performance in terms of the quality, cost, delivery and flexibility parameters (Kochhar et al, 1994). The interpretation of outstanding levels of performance will vary between organisations and will also vary within an organisation over time as customer and competitive requirements change. Thus companies are faced with the problem that they must simultaneously achieve high levels of performance in each of these key areas whilst balancing the trade-offs that will inevitably exist between them (Maylor 1995).

In many organisations there is a lack of knowledge of the cause and effect relationships regarding the competitive priorities of QCDF and the decisions taken to improve these objectives. Decision making without a full understanding of these relationships can lead to long term problems. It should be possible to overcome some of these problems by establishing a framework which shows the relationships between the top level performance criteria and low level variables. This should enable operational managers to make informed decisions, identifying the variables that can be manipulated in order to improve performance and achieve the associated benchmark targets, while taking account of the impact on other performance measures which may be affected.

2 PERFORMANCE MEASUREMENT

Traditional financial measures do little to support improvement in operational areas and thus are inadequate as the sole criterion for assessing the performance of a company (Johnson and Kaplan, 1987; Maskell, 1991). Performance measurement in terms of the QCDF parameters ensures greater focus on the satisfaction of customer requirements. In order to achieve the competitive priorities, it is necessary to use a combination of strategically based measures focused around QCDF. Such measures should be devolved to all levels of the organisation in order to communicate desired strategic objectives and devolve ownership of their achievement. These measures must be balanced so that no one measure is overemphasised at the expense of others (Newing 1995). Furthermore, the setting and manipulation of performance measures must be integrated with the business planning and strategic decision making process to ensure that the desired combination of performance measures is maintained to satisfy the customers' requirements.

3 MANUFACTURING PLANNING AND CONTROL SYSTEMS

Manufacturing planning and control (MPC) systems have a significant and wide ranging impact on the overall performance of manufacturing organisations. These systems are implemented to support overall organisational objectives and satisfy the customer requirements by ensuring that manufacturing activities are undertaken as required (Vollmann et al, 1992). As a result MPC systems have a very significant impact on the achievement of all desired top level performance indicators. MPC systems can, therefore, be critical to the performance of the whole organisation and can be a source of competitive advantage to organisations (Vollmann et al, 1992).

There are several ways in which a manufacturing planning and control system can be interpreted and described, depending on the type of system that is used. The model described in this paper does not relate to any particular manufacturing system, but is intended to be generic. This model, illustrated in figure 1, shows the flow of information to and from each core process.

Structured analysis has been used to develop the model further and disaggregate the manufacturing planning and control system into constituent elements to carry out more detailed analysis. These smaller elements are referred to as modules. The overall model, the individual modules and the relationships between each of the modules have been developed, defining the

overall boundary which specifically excludes the areas of quality control and product design. This generic model has been used for the development of cause and effect relationships between the top level QCDF parameters and lower level parameters. For each module of the model, generic objectives and key activities are defined. For example the objective of the master production scheduling module is to produce an agreed, realistic and achievable master production schedule. The key activities include obtaining consensus and commitment of the key stakeholders; consideration of existing schedules and finished goods on receipt of orders; and production of a schedule to achieve due date compliance and efficient allocation of resources. The majority of activities within individual modules exist within all manufacturing organisations though the functional organisation and ownership of the activities is often not easy to identify.

An example of how the functional organisation may confuse the way in which the activities of this model are undertaken can be seen by looking at the planning of material requirements and purchasing. Examples of the activities of each module are:

Planning of material requirements

- Coordinate and generate purchase orders;
- Consider purchasing and manufacturing lead times;
- Manage inventory;
- Consider current stock levels.

Purchasing

- Agree prices, specifications and supply conditions with suppliers;
- Source goods and services;
- Issue purchase orders to suppliers;
- Evaluate and act on supplier performance.

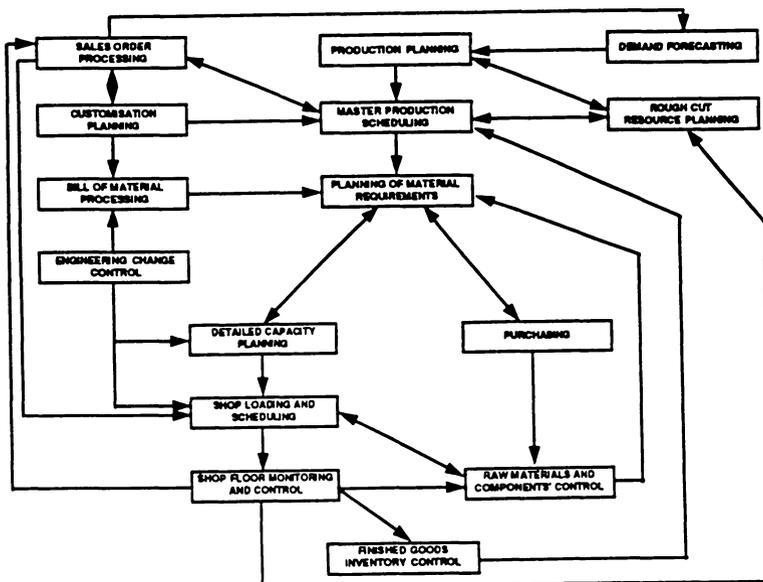


Figure 1 Model of manufacturing planning and control activities.

However, in practice it may be the case that the evaluation of supplier performance and issuing of purchase orders is done by material controllers working on the shop floor, based on the material requirements generated. In other circumstances the management of inventory may be undertaken by purchasing or production control personnel. This illustrates that, though the organisation may differ, most of the activities are relevant to all organisations.

Measures of the effectiveness and efficiency of each module have been developed. 'Effectiveness refers to the extent to which customer requirements are met, while efficiency is a measure of how economically the firm's resources are utilised when providing a given level of customer satisfaction' (Neely et al 1995). For example, for the activities identified above, a measure of the effectiveness of purchasing is supplier performance measured in terms of supplier due date compliance, supplier quality compliance or reduction in supplier lead time. A measure of efficiency is the lead time to issue a purchase order once the requirements for materials have been generated.

These measures identify how well the objective is satisfied, how well the activities are undertaken and the effect of the selected measures of performance on the overall performance of the organisation in terms of QCDF. This approach makes it possible to directly link the manufacturing planning and control activities with performance measurement systems.

4 CAUSE AND EFFECT RELATIONSHIPS

Decisions within organisations are often made without having a full understanding of their impact on the desired measures of performance. The consequences of this can be sub-optimisation of performance in key areas, conflicting actions and the potential to improve performance in one area whilst deteriorating performance in other areas. Such consequences are detrimental to the overall improvement of performance and thus there is a need to fully understand the implications of actions so that the long term effects can be assessed and informed decisions made.

An understanding of the impact of all of the variables affecting measures of performance should allow proper management of the conflicts that may act as barriers to the achievement of overall goals. These conflicts often relate to the top level competitive priorities (QCDF) and how they affect a business process. Furthermore conflicts in functional objectives can lead to sub optimisation and possible conflicts in overall competitive priorities. Similarly incompatible performance measures at various levels of the organisation and conflicting personal objectives can lead to inconsistent actions.

Possible conflicts and trade-offs that exist should be communicated to all parties and reference should be made to objectives to ensure that actions are consistent with company objectives. This requires formal communication of objectives at all levels of the organisation based on the top level competitive priorities of the organisation.

Over time it is important to constantly challenge assumed conflicts and trade-offs in order to assess whether they are still valid, in the same way as measures of performance must be monitored and reviewed. Both will change as strategy and competitive priorities change.

The framework highlighted in the figure 2 links top level strategic objectives to the objectives of the lower level activities of the MPC system. The achievement of the overall objectives can be assessed through the use of measures at the lower level for which the variables affecting performance are identified. The framework also involves an assessment of the impact of the variables on the performance of other activities, which form part of the MPC system, and hence other top level objectives. The effect of manipulating an identified variable on other variables may be favourable or adverse. The overall framework, once defined, should allow the manipulation

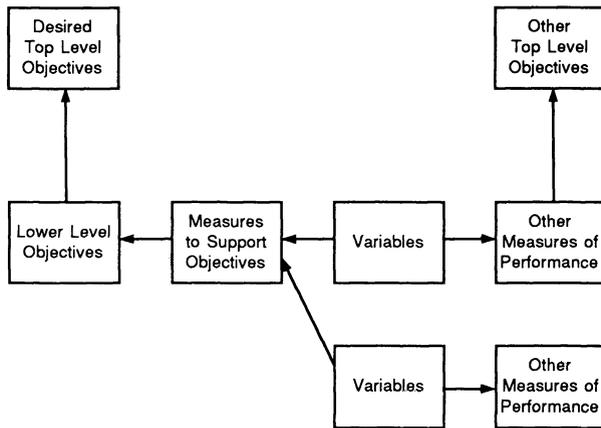


Figure 2 Framework for linking competitive priorities, lower level performance measures and the variables affecting them.

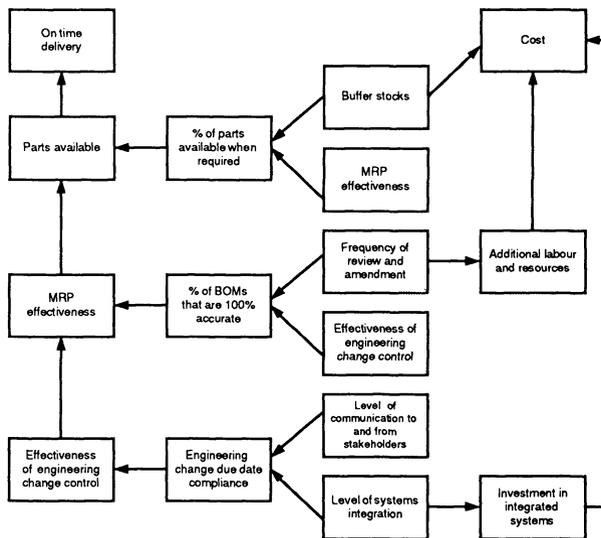


Figure 3 Example application of the framework.

of the identified variables to achieve the desired level of performance whilst considering the side effects and conflicts as indicated earlier. By being aware of the existence and strengths of the relationships between measures and the variables that affect them, more informed decisions can be made. This framework links objectives and measures at MPC system level to strategic objectives and ensures that actions are geared towards the achievement of the desired combination of top level competitive priorities. All of the performance measures used within an organisation should relate to overall strategic objectives, there is little purpose measuring those that do not.

The framework cascades measures of performance based on the strategic objectives to all levels of the organisation. This should provide for vertical and horizontal communication and integration of objectives and measures. Effective implementation of the framework, including an education and training process, should ensure that all employees have a thorough understanding of the implications of the measures and what they are required to do to improve performance. This should lead to improved organisational performance by improving the congruence of goals and priorities (company wide, giving consideration to trade-offs); giving ownership and accountability for performance and actions; and allowing the movement of decision making to lower levels of the organisation in order to speed up decision making, improve flexibility and responsiveness and free managers to consider more strategic issues.

While the overall competitive priorities will vary from company to company, it is possible to create a framework which shows the relationships between a defined competitive priority, the performance measures for associated MPC activities, and the significant variables which affect them. The strength of the relationships between individual variables and the associated measures of performance can vary from one type of organisation to another. This has been confirmed by a considerable amount of field work that has been carried out.

5 APPLICATION OF THE FRAMEWORK

In order to illustrate the framework an example of the relationships affecting one of the top level measures of performance is examined. This example is illustrated in figure 3. The strategic competitive priority of on time delivery of finished products is used to illustrate the factors that affect its achievement, the measures within the manufacturing planning and control system that contribute to it and the trade-offs that exist with other competitive priorities.

On time delivery of finished products can be measured by a due date compliance measure that assesses the percentage of products delivered on the date or time agreed with the customer. A large number of variables affect the ability of a company to deliver its products on time as it is affected in some way by each of the modules of the MPC system. These variables will include the availability of parts, which can be measured by the percentage of parts that are available for use when required. This measure will be directly affected by the planning of material requirements, purchasing and raw material and component inventory control modules.

It is possible to ensure parts availability by maintaining buffer stocks. Whilst this will contribute to the objective of improving customer due date compliance it will have a detrimental effect on stock levels and the costs of holding stock. This is a key trade-off that can only be resolved with reference to overall objectives. If due date compliance is the overriding objective then it may be desirable to hold safety stock of certain significant parts. This should be done in conjunction with other activities designed to improve parts availability without holding safety stock.

If cost reduction is a higher priority than due date compliance it may be desirable to eliminate safety stock at the risk of not having parts available when required. These choices can only be made taking into account the environment within which the particular organisation works and the overall strategic objectives, and must be done with full knowledge of the effects of the actions that are taken.

Clearly the objective should be to ensure parts availability without the need to hold safety stock. A variable that has a significant impact on parts availability is the effectiveness of the planning of material requirements. There is a need to take the cause and effect relationship to the next level of detail in order to understand how the planning of material requirements can be made more effective. Measures that contribute towards the effectiveness of the planning of material requirements, whether or not this is done by a computerised MRP system, will include the accuracy of the planning data on which the plan is based. These will include BOM accuracy, the accuracy of supplier lead time information and inventory record accuracy.

The accuracy of the bills of material will have a significant impact and that will be controlled within the BOM processing module. The percentage of the bills of material that are accurate can be improved by applying procedures to review and update the bills of material. Whilst this will improve the effectiveness of the planning of material requirements, parts availability and customer due date compliance, this may well require additional resources as the auditing of bills of material will be time consuming. There is a need to assess the importance of improving the accuracy of the bills of material by weighing up the problems caused by inaccurate bills of material against the cost of auditing and updating them.

In addition to auditing bills of material it should be possible to improve the accuracy of the bills of material by improving the effectiveness of the engineering change control process. The associated measures of performance would include due date compliance of implementing changes. Variables affecting the effectiveness of engineering change control will include such things as the level of communication of changes to stakeholders and the level of systems integration. Hence it should be possible to manipulate any of these variables to improve the effectiveness of engineering change control, which should then have the knock on effect of improving the performance of the other measures that have been highlighted including the strategic objective of customer due date compliance.

The example clearly shows how measures of performance within the MPC system can be integrated into the proposed framework and how they contribute to the achievement of overall strategic objectives. It also shows that the achievement of a specific top level objective is affected by a number of the modules of the MPC system demonstrating that to improve overall performance it is necessary to improve all elements of the MPC system. It would be undesirable to concentrate on one module in isolation. It is important that all employees have a good understanding of the impact of the variables which affect the performance of all of the activities undertaken in the company. This should increase cooperation and result in improved performance.

There are clearly very complex and wide ranging relationships between the variables that affect the performance of any of the measures of performance and hence the competitive priorities. The example shows the complexity of the problem and how it may be overcome by the framework developed.

6 CONCLUSION

The need for companies to compete on a variety of conflicting competitive priorities and the complexity of the factors affecting their achievement give rise to the need to integrate measures of performance which will effectively monitor the existence of trade-offs and the incorporation of these factors into decision making. Decision making can be made more effective through the use of a framework for analysing such cause and effect relationships and determining the effect of manipulating one variable on other variables and measures. The framework discussed in this paper allows the assessment of the relationships between variables and measures of performance at all levels of the organisation. This framework should be a useful tool for operational managers

for determining the effects of actions prior to their implementation. The use of strategically devolved measures reinforces the need to be aware of the trade-offs and should reinforce the company's strategic objectives in terms of QCDF.

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