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An Examination of MPCS and Their Relationship to Competitive Advantage

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Abstract

Manufacturing organizations are renovating their factories to become increasingly competitive in global markets. With this renovation they are focusing their attention on innovative programs. Since managerial time is limited, the increase in attention to these programs means less emphasis on traditional manufacturing planning and control systems. The research question asked by this study is: How effective are traditional manufacturing planning and control systems for increasing factory competitiveness?

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Management

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AN EXAMINATION OF MPCS AND THEIR RELATIONSHIP TO COMPETITIVE ADVANTAGE

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ABSTRACT

Manufacturing organizations are renovating their factories to become increasingly competitive in global markets. With this renovation they are focusing their attention on innovative programs. Since managerial time is limited, the increase in attention to these programs means less emphasis on traditional manufacturing planning and control systems. The research question asked by this study is: How effective are traditional manufacturing planning and control systems for increasing factory competitiveness?

INTRODUCTION

Manufacturing planning and control systems (MPCS) traditionally are considered the most important element for manufacturing competitiveness. These systems are designed to plan and control materials, labor, and equipment through developing feasible time-phased plans and monitoring their progress (Vollman, Berry and Whybark, 1992). Yet, over the last fifteen years, there are many new innovative programs being introduced into the productions/operations academic field derived from practitioners' experience. With the intense focus on these innovative programs, traditional manufacturing planning and control programs are being de-emphasized in the academic and manufacturing worlds. Although ideally, both traditional and innovative programs are integrated into a consistent strategy, it seems rather unlikely that both programs receive the same amount of managerial attention since managerial time is limited. Time limitations cause trade-offs between traditional and innovative programs. Although there are numerous studies that evaluate current innovative programs, few evaluate the effectiveness of traditional manufacturing planning and control (Ahire, Landeros and Golhar, 1995). Consequently, there is a need to evaluate the relative effectiveness of traditional MPCS to determine their effectiveness in improving manufacturing competitiveness.

The basic issue of MPCS' effectiveness is: What are the elements of MPCS and how are they related to manufacturing goals and competitiveness? There are three issues that need to be resolved before beginning this investigation: 1) What is meant by manufacturing competitiveness and its relationship to competitive goals? 2) What is meant by MPCS and what are its elements? and 3) What is the relationship of MPCS' elements to competitive goals?

AN OVERVIEW OF THE MODEL TESTED

Besides the MPCS elements, there are external and internal contingency factors that should be controlled for between factory comparisons. These factors are not part of formal MPCS but are important for its performance since they control for between-factory differences in the environment that MPCS performs. Figure 1 is an overview of the model tested. The first column of boxes is the external and internal contingency factors included in this study.

The first contingency factor is forecast error, which is considered external since it cannot be manipulated by the manufacturing plant. Forecast error represents the degree to which an organization must replan since the larger the forecast error, the more likely the factory will have to replan and thereby decrease manufacturing performance. All other contingency elements are grouped into major factors that are controlled inside the factory and do not change with forecast and planning. In this study, these factors are: 1) planning period factors, 2) production policy factors, and 3) data integrity factors. Planning period factors include the planning horizon (how many months into the future the MPCS plans), the size of the planning period (daily, weekly, monthly) and the freezing of the master production schedule. Traditionally, the production horizon is used to plan the seasonal cycles and is expected to give better performance with long production horizons. Smaller time buckets are used to add precision to planning; therefore, the smaller the time bucket is, the better the MPCS performance. Freezing the production schedule adds stability to the factory by not allowing the master schedule to change after production has begun and is expected to increase system performance. The second major internal contingency factor, production policies, are engineering change's percent and incoming material reject percent. These elements are called production policy variables since engineering changes and material reject percent can be controlled by production policy. Engineering changes after production begins have been shown to decrease productivity (Hayes and Clark 1986, Schmenner 1991). Since incoming rejects are likely to cause missed schedules, etc. (Schmenner 1991), it is expected to decrease MPCS performance. The third internal contingency factor, data integrity, includes elements that are prerequisites to ensure that MPCS has accurate data. The data integrity elements are inventory accuracy, BOM accuracy, routing accuracy, and time standard accuracy. The formal MPCS needs data integrity to perform effectively.

The second column of boxes in Figure 1 represents planning activities beginning with aggregate forecasting, which is disaggregated into specific business forecasts. These business forecasts are used for production planning that determines the specific time periods for production levels. Although some computer software packages may simultaneously derive the material and capacity plan typically the material requirements plan, along with routing and time standards are used to derive the capacity requirements plan for time-phased labor requirements. However, from a technical definition perspective, capacity requirements planning includes equipment requirements (APICS Dictionary, Cox et al., 1991). This study uses the formal definition of capacity requirements planning to include equipment (machine) requirements planning as well as labor requirements planning.

The last column of boxes in Figure 1 represents control activities, which monitor deviations from the plan to ensure the plan is executed. Control activity begins with monitoring the business forecast to determine if there are significant differences between the actual sales and the forecast for specific products or product families. The next activity is purchasing and material controls which indicate the degree that the material requirements plan effectively delivers the specific materials at the proper time, at the right place, and quantity. Deviations from the material requirements plan are indicated by stock-outs and shortages from poor vendor performance, etc. Control of the capacity requirements' plan is called the production activity control (shop floor control) and is indicated by labor and/or equipment shortages. The dispatch rules and controls method are conceptually the most detailed methods of control, so it is treated as a separate variable (Vollman et al. 1992).

RESEARCH METHOD

The Global Manufacturing Research Group (GMRG) collected the data used in this study. The questionnaires were translated and back-translated for all countries. The breadth of the countries studied provides cross sectional validity and therefore increases the generality of the findings.

The investigation of the relationship of MPCS elements to the self-assessed and objective goal measures requires four types of estimates. First, an estimate of the relationship between objective measures and self-assessed competitive goals is necessary to determine the degree of relationship between self-assessed to objective measures. Second, there is a need to determine how internally consistent the APICS definitions of the MPCS elements are. The third type of estimate determines the overall relative importance of each major factor on the self-assessed and objective goal measures. These major factors (the grouped elements) are: external factor (forecast error), planning period factor (planning horizon, time bucket, schedule freezing), production policy factor (material inspection policy, engineering change order policy), data integrity factor (inventory accuracy, BOM accuracy, time standard accuracy and routing accuracy), planning procedure factor (forecasting, business forecasting, demand management, production planning, MRP, CRP), and control procedure factor (forecast control, purchasing control, production activity control, dispatch rules). Hierarchical regression is performed to test the relative importance of each major factor of the MPCS overview. After these estimates are performed, the individual estimates of all elements on each self-assessed and objective manufacturing goal is estimated using regression to determine each elements relative importance.

STATISTICAL RESULTS

The statistical relationships between the self-assessed competitive goals and their objective measures are presented in Table 1. The strongest statistical relationships between the self-assessed goals and their objective measures are the delivery goals (delivery speed and on time delivery) and their objective measures. The relationship between self-assessed delivery speed and delivery promise time is highly significant ($p < 0.01$). Also, the self-assessed on time delivery and on time delivery percentage, and average days late are both very highly significant ($p < 0.0001$). For the relationship between self-assessed cost competitiveness with factory utilization, product cost percentage and productivity change, both product cost and productivity are significantly related to the self-assessed cost goal. On the other hand, factory utilization is not related to the cost goal. One reason for this relationship may be that as factory utilization increases there may be a decreasing marginal product (as suggested in the microeconomics literature). There is no statistical relationship between self-assessed quality competitiveness and customer reject percentage. One interpretation of this estimate may be that managers perceive quality to be more than customer rejects since customer's return may be the customer's "last resort". Unfortunately, the objective product variety measures are not significantly related to the self-assessed product variety goal (no relationships significant at the ($p < 0.10$) level). This result is very disappointing since there is not a readily available objective product variety measure that reflects the system's adaptability to satisfy customer product variety needs. The volume flexibility measure has a close relationship to change in product volume during the last year ($p < 0.001$). The self-assessed new product design competitiveness is related statistically to both the measurement of design time and the change in new product design time at the ($p < 0.05$) level. In sum, the statistical relationships between the self-assessed goal competitiveness measures and the objective goal measurements are statistically significant for all goals except the quality and product variety goals.

OVERALL RELATIONSHIP BETWEEN MPCS AND MANUFACTURING COMPETITIVENESS

The purpose of this section is to suggest overall relative importance of MPCS elements. Table 4 presents the results of the estimates to interpret the overall implications. Table 4 has the major competitive goals across the top and the specific procedures on the left side. These results are summarized from each of the competitive goals in Table 3. There are no simple statistical techniques to readily identify the relative importance of MPCS. Consequently, this study will perform a casual empirical method for simplifying the results. This method uses the number of significant estimates (at the $\alpha = 0.10$ level) for each major category of factors and for each element. Because there is more than one estimate for each manufacturing goal and each major factor, the percentage of significant estimates is used. For example, for the total effect of the external factor (forecast error) on quality, there are two estimates and neither is significant. Therefore, the percentage is 0/2 or 0%. For the planning period factors and the quality goal, there are six estimates and only one is significant. Therefore, the percentage is 1/6 or 16.67%. The last four columns are put into two sets of two: one set for the major factors and one set with the individual elements. The first set of two columns (on the far right) gives the average percentage across all goals and the rank relative to other major factors. The last two columns give the average percentage across all goals for each specific element. The purpose of the first set of estimates is to determine which major factors are most important for overall manufacturing competitiveness. Similarly, for each specific element, these results show their relative importance compared to specific MPCS elements and contingency factors.

CONCLUSIONS ON MANUFACTURING GOALS

One managerial conclusion on manufacturing goals competitiveness concerns the quantitative measurement of manufacturing goals. The empirical estimates suggest that the objective and self-assessed measures of manufacturing goals may give mixed indications as to the importance of individual MPCS elements. These mixed relationships indicate that careful selection of which competitive objective or self-assessed measures must be decided before improving elements in MPCS since different measures give different MPCS importances. Therefore, manufacturing firms cannot expect all measures of manufacturing performance to be related to all MPCS elements but rather they must select which competitive goal measures are related to their business strategy.

A second general conclusion comes from DeMeyer and Ferdows (1990) who suggest a hierarchy of manufacturing goals due to their ease of achievement. The order they suggest is: quality, delivery, flexibility, and cost. Based on a theoretical analysis, Wacker (1996) suggests a different goal sequence: quality, delivery, cost, and flexibility. By examining the bottom two rows of Table 4, an interesting conclusion may be drawn. The delivery, volume flexibility, and cost goals seem to be more closely related to the MPCS system, while quality and product variety and new product design flexibility goals have a weaker relationship. Consequently, this result implies that the higher level goals (quality and flexibility) are less closely related to MPCS than the lower level goals of cost, volume flexibility, and delivery. In short, the results suggest that there appears to be a hierarchy due to each goals relationship to MPCS. This result lends empirical support to the "sand cone" arguments of DeMeyer and Ferdows (1990) and Wacker (1996).

This study began with asking some straightforward questions concerning manufacturing planning and control systems. It first defined the elements of manufacturing planning and control using a traditional framework and the APICS dictionary. It next used these definitions to define measures and constructs that are important elements of manufacturing planning and control systems. Next, it defined manufacturing goals and their traditional self-assessed and objective measures. Then it empirically tested the relationship of the manufacturing planning and control system factors to customer-oriented manufacturing goals. The statistical results presented some important overall conclusions. First, it found that all elements of manufacturing planning and control are not equally important for manufacturing performance. Primarily, manufacturing planning followed by manufacturing control, manufacturing policies, and production policies are the most important statistical factors used for improving goal competitiveness. At the other extreme, the factors that are less important are quite noteworthy. For example, forecast error, which usually causes replanning, is not a major factor for manufacturing performance. Another unimportant factor is inventory measurement since it was insignificant in all estimates. In short, all areas of MPCS are not equally important for manufacturing competitiveness.

This study was written to evaluate the relative importance of MPCS for achieving manufacturing competitiveness. Its most basic conclusion is that manufacturing goals are affected by how MPCS performs. Although there are numerous shortcomings of this study, the most serious limitations are derived from the conceptual APICS definitions of the elements of MPCS. It is hoped that this study provides a conceptual beginning point for further refining these definitions so that future researchers can measure the underlying theoretical concepts.

References, tables and figures available from the authors.