
Manufacturing Planning and Control

The manufacturing planning and control (MPC) system is concerned with planning and controlling all aspects of manufacturing, including managing materials, scheduling machines and people, and coordinating suppliers and key customers. Because these activities change over time and respond differently to different markets and company strategies, this chapter provides a model for evaluating responses to changes in the competitive environment. We believe that the development of an effective manufacturing planning and control system is key to the success of any goods producing company. Moreover, truly effective MPC systems coordinate supply chains—joint efforts across company boundaries. Finally, MPC systems design is not a one-time effort; MPC systems need to continuously adapt and respond to changes in the company environment, strategy, customer requirements, particular problems, and new supply chain opportunities. The critical question is not what one has accomplished; it is “What should the firm, together with its supply chain partners, do next?” To put these ideas in perspective, this chapter is organized around the following four managerial concerns:

- *The MPC system defined:* What are the typical tasks performed by the MPC system and how do these tasks affect company operations?
- *An MPC system framework:* What are the key MPC system components and how do they respond to a company’s needs?
- *Matching the MPC system with the needs of the firm:* How do supply-chain product, and process issues affect MPC system design?
- *Evolution of the MPC system:* What forces drive changes in the MPC system and how do companies respond to the forces?

The MPC System Defined

In this section we define what the MPC system does and some of the costs and benefits associated with effective MPC systems. The essential task of the MPC system is to manage efficiently the flow of material, to manage the utilization of people and equipment, and to

respond to customer requirements by utilizing the capacity of our suppliers, that of our internal facilities, and (in some cases) that of our customers to meet customer demand. Important ancillary activities involve the acquisition of information from customers on product needs and providing customers with information on delivery dates and product status. An important distinction here is that the MPC system provides the information upon which managers make effective decisions. The MPC system does not make decisions nor manage the operations—managers perform those activities. The MPC system provides the support for them to do so wisely.

Typical MPC Support Activities

The support activities of the MPC system can be broken roughly into three time horizons: long term, medium term, and short term. In the long term, the system is responsible for providing information to make decisions on the appropriate amount of capacity (including equipment, buildings, suppliers, and so forth) to meet the market demands of the future. This is particularly important in that these decisions set the parameters within which the firm responds to current demands and copes with short-term shifts in customer preferences. Moreover, long-term planning is necessary for the firm to provide the appropriate mix of human resource capabilities, technology, and geographical locations to meet the firm's future needs. In the case of supply chain planning, the long term has to include the same kind of capacity planning for the key suppliers. For companies that outsource their manufacturing to outside companies, the planning of supplier capacity can be more critical than internal capacity planning. Moreover, the choice of outsourcing partners has to consider their capabilities to ramp up and adjust capacities to the actual dictates of the marketplace.

In the intermediate term, the fundamental issue addressed by the MPC system is matching supply and demand in terms of both volume and product mix. Although this is also true in the longer term, in the intermediate term, the focus is more on providing the exact material and production capacity needed to meet customer needs. This means planning for the right quantities of material to arrive at the right time and place to support product production and distribution. It also means maintaining appropriate levels of raw material, work in process, and finished goods inventories in the correct locations to meet market needs. Another aspect of the intermediate-term tasks is providing customers with information on expected delivery times and communicating to suppliers the correct quantities and delivery times for the material they supply. Planning of capacity may require determining employment levels, overtime possibilities, subcontracting needs, and support requirements. It is often in the intermediate time frame that specific coordinated plans—including corporate budgets, sales plans and quotas, and output objectives—are set. The MPC system has an important role in meeting these objectives.

In the short term, detailed scheduling of resources is required to meet production requirements. This involves time, people, material, equipment, and facilities. Key to this activity is people working on the right things. As the day-to-day activities continue, the MPC system must track the use of resources and execution results to report on material consumption, labor utilization, equipment utilization, completion of customer orders, and other important measures of manufacturing performance. Moreover, as customers change their minds, things go wrong, and other changes occur, the MPC system must

provide the information to managers, customers, and suppliers on what happened, provide problem-solving support, and report on the resolution of the problems. Throughout this process, communication with customers on production status and changes in expectations must be maintained.

To effectively manage the manufacturing processes, a number of manufacturing performance indicators need to be compiled. Among these are output results; equipment utilization; and costs associated with different departments, products, labor utilization, and project completions. Also, measures of customer satisfaction such as late deliveries, product returns, quantity errors, and other mistakes are needed. The implications physically and financially of the activities on the manufacturing floor are collected, summarized, and reported through the MPC system.

The initial costs for a manufacturing planning and control system can be substantial. Moreover, the ongoing operational costs are also significant. An effective MPC system requires a large number of professionals and all their supporting resources, including computers, training, maintenance, and space. It's not uncommon to find the largest number of indirect employees at a manufacturing firm to be involved in the MPC area.

An MPC System Framework

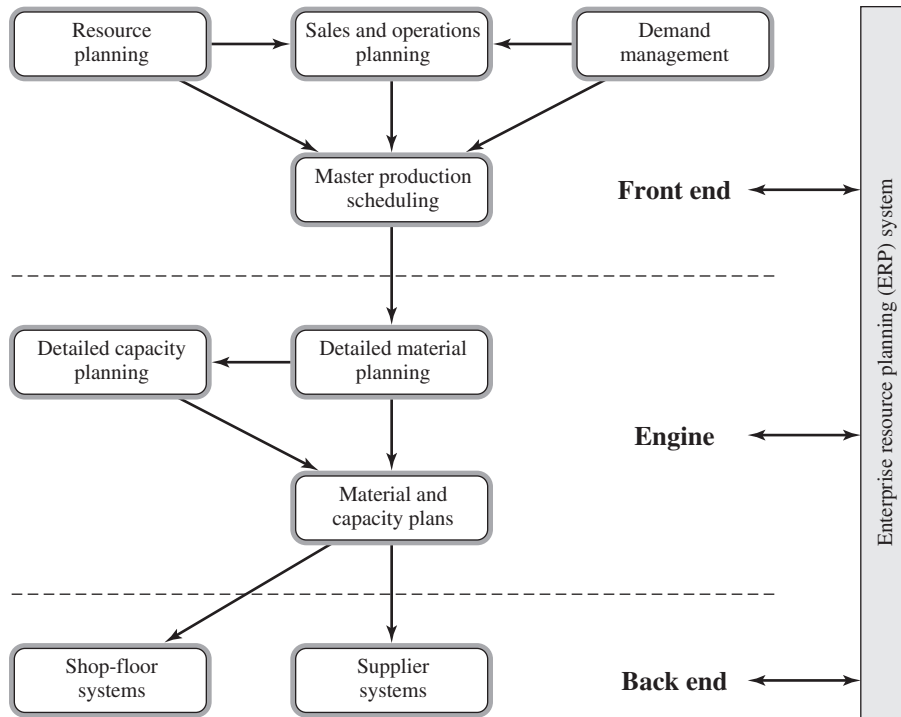
It is most typical now to find the MPC system imbedded in an enterprise resource planning (ERP) system. Many essential activities that need to be performed in the MPC system have not changed. However, the details have evolved as changes in our knowledge, technology, and markets have occurred. The MPC activities are now carried out in more areas of the firm and differ to meet the strategic requirements of the company. In this section, we'll provide our framework for understanding the MPC system.

MPC System Activities

Figure 1.1 is a schematic of the general MPC system that would be used within a firm for planning and controlling its manufacturing operations. But linking customer and supplier firms in a supply chain requires coordinating the MPC activities between the firms. The model shown in Figure 1.1 is essentially what one will find as a key part of any packaged ERP system. The figure is divided into three parts or phases. The top third, or front end, is the set of activities and systems for overall direction setting. This phase establishes the overall company direction for manufacturing planning and control. Demand management encompasses forecasting customer/end-product demand, order entry, order promising, accommodating interplant and intercompany demand, and spare parts requirements. In essence, demand management coordinates all activities of the business that place demands on manufacturing capacity.

Sales and operations planning balances the sales/marketing plans with available production resources. The result is an agreed-on company game plan that determines the manufacturing role in meeting company strategy. Increasingly, this activity is receiving more management attention as the need for coordination is recognized in progressive firms. The master production schedule (MPS) is the disaggregated version of the sales and operations plan. That is, it states which end items or product options manufacturing will

FIGURE 1.1
Manufacturing
Planning and
Control System
(simplified)



build in the future. The MPS must support the sales and operations plan. Resource planning determines the capacity necessary to produce the required products now and in the future. In the long run this means bricks and mortar, while in the short run it means labor and machine hours. Resource planning provides the basis for matching manufacturing plans and capacity.

The middle third, or engine, in Figure 1.1 encompasses the set of MPC systems for detailed material and capacity planning. The master production schedule feeds directly into the detailed material planning module. Firms with a limited product range can specify rates of production for developing these plans. However, for firms producing a wide variety of products with many parts per product, detailed material planning can involve calculating requirements for thousands of parts and components, using a formal logic called material requirements planning (MRP). MRP determines (explodes) the period-by-period (time-phased) plans for all component parts and raw materials required to produce all the products in the MPS. This material plan can thereafter be utilized in the detailed capacity planning systems to compute labor or machine center capacity required to manufacture all the component parts.

The bottom third, or back end, of Figure 1.1 depicts MPC execution systems. Here, again, the system configuration depends on the products manufactured and production processes employed. For example, firms producing a large variety of products using thousands of parts often group all equipment of a similar type into a single work center. Their shop floor system establishes priorities for all shop orders at each work center so the orders

can be properly scheduled. Other firms will group mixtures of equipment that produce a similar set of parts into work centers called production cells. For them, production rates and just-in-time (JIT) systems for execution are appropriate.

The supplier systems provide detailed information to the company suppliers. In the case of arm's length relationships with these suppliers, the supplier systems will produce purchase orders that will be transmitted to the suppliers. Thereafter, the company MPC systems should provide suppliers with updated priority information, based on current conditions in the company—as well as in their customers' companies. In the case of closer (partnership) relations with suppliers, information can also include future plans—to help the suppliers understand expected needs. In a general sense the receiving end of this information is the demand management module of the front end in the suppliers' MPC systems.

In firms using MRP systems, execution of the detailed material and capacity plans involves detailed scheduling of machines and other work centers. This scheduling must reflect such routine events as starting and completing orders for parts and any problem conditions, such as breakdowns or absenteeism. These schedules are often available on a real-time basis from the ERP system database. Real-time data are particularly important in factories with complex manufacturing processes and/or customers demanding responsiveness to volume, design, or delivery schedule changes.

Components and materials sourced from outside the organization require an analogous detailed schedule. In essence, purchasing is the procurement of outside work center capacity. It must be planned and scheduled well to maximize final customer satisfaction. Best-practice purchasing systems typically separate the procurement or contractual activity from routine order release and follow-up. Procurement, a highly professional job, involves contracting for vendor capacity and establishing ground rules for order release and order follow-up. These tasks take on extra dimensions as procurement involves global sourcing and multinational coordination of schedules.

An important activity that is not depicted in Figure 1.1 is the measurement, follow-up, and control of actual results. As products are manufactured, the rate of production and timing of specific completion can be compared to plans. As shipments are made to customers, measures of actual customer service can be obtained. As capacity is used, it too can be compared to plans. If actual results differ from plan, appropriate actions to bring the results back to plan or modifications of the plan must be made. These measurements and control actions are part of all three of the phases of the MPC system.

The three-phase framework for manufacturing planning and control is supported by widely available MPC systems and software, from master production scheduling to the back-end systems. This software is not only integrated to follow the framework, it is also linked to other business activities in the ERP systems of many firms. That means that the MPC systems provide inputs to the financial, distribution, marketing, and human resources systems that require the information.

Matching the MPC System with the Needs of the Firm

The specific requirements for the MPC system design depend on the nature of the production process, the degree of supply chain integration, customers' expectations, and the needs of management. As the MPC system is required to integrate with other company

systems in the supply chain and/or with the ERP system of the firm, additional design parameters are introduced. Moreover, these MPC system requirements are not static. As competitive conditions, customer expectations, supplier capabilities, and internal needs change, the MPC system needs to change. In addition, the changes that are being addressed as we make one set of modifications may well be different when we move to another change that needs addressing. The result is a different emphasis on various MPC system modules over time.

MPC technology continues to change over time as well. The present trend is to more online data access and systems. MPC status is also a product of the increasing speeds, decreasing costs, and increasing storage capabilities of modern computers. Online systems provide multiple advantages, particularly between firms. Internet-based systems are becoming an important way to support intrafirm coordinated efforts. For these firms the amount of paper moving between departments of a company or between companies has been greatly reduced. Planning cycles have been speeded up. Inventories between partners in the supply chain are being replaced by speedier information. All of these changes dramatically affect the way users interact with the MPC system. As information-processing capabilities increase, MPC systems have evolved to utilize the latest technologies.

MPC systems must also reflect the physical changes taking place on the factory floor. Outsourcing, contract manufacturing, and the hollowing out of the corporation dramatically affect MPC systems design. Moves from job shops to flow processes to cellular manufacturing approaches affect the MPC systems design as well. Providing information at the level where decisions are made in appropriate time frames has greatly augmented the use of computers on the factory floor and the speed of interaction between planning and execution.

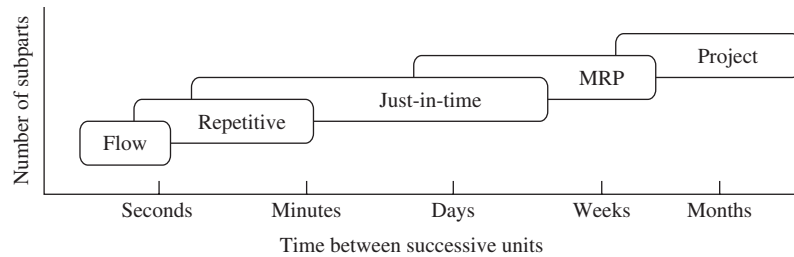
It's not, however, just on the factory floor that changes dictate the MPC system needs. As the firm shapes its manufacturing strategy, different modules of the MPC system may need to be modified to respond. As an example, firms that are increasing product variety may need to strengthen the master production scheduling and detailed material planning modules in order to more quickly phase in and phase out new products. Firms that are competing on delivery speed may need to improve shop floor execution and feedback systems to more closely monitor the progress of products through the manufacturing facility. This matching of strategic direction with MPC system design is as dynamic as any of the other elements that shape the MPC system requirements.

An MPC Classification Schema

Figure 1.2 shows the relationship between MPC system approaches, the complexity of the manufactured product as expressed in the number of subparts, and the repetitive nature of production, expressed as the time between successive units. Figure 1.2 also shows some example products that fit these time and complexity scales.

Several MPC approaches presented in Figure 1.2 are appropriate for products that fit in various points in the schema. The figure demonstrates that the MPC emphasis changes as the nature of the product, process, or both change. For example, as a product's sales volume grows over time, the MPC emphasis might shift from right to left. Regardless of where the company is on Figure 1.2, it's necessary to perform all the activities depicted in Figure 1.1. However, how they are performed can be quite different for firms at different points on Figure 1.2.

FIGURE 1.2
MPC
Classification
Schema



Examples: Oil, food, drugs, watches, TVs, trucks, planes, houses, ships

The lower left-hand corner of Figure 1.2 shows a flow-oriented manufacturing process typical of many chemical, food, petroleum, and bulk product firms. Because products are produced in streams instead of discrete batches, virtually no time elapses between successive units. With these processes, the front-end concern of the MPC system is primarily the flow rates that become the master production schedule. Typically, these products have relatively few component parts, so engine management is straightforward. Depending on how components are purchased, the back end may involve some complexity. Typically, these firms' major cost is for raw materials, although transportation costs can also be significant.

Repetitive manufacturing activities are found in many plants that assemble similar products (e.g., automobiles, watches, personal computers, pharmaceuticals, and televisions). For such products, component-part management is necessary, but everything is coordinated with the flow or assembly rate for the end items.

In the middle of the figure we show a large application area for just-in-time systems. Using lean manufacturing approaches, many firms today try to move their processes from right to left in the figure. That is, they try to make processes more repetitive as opposed to unique in order to achieve the operational advantages of repetitive manufacturing (shorter production cycles, reduced lead times, lower inventories, and the like). JIT is shown as spanning a wide variety of products and processes. This MPC approach is increasingly being integrated with more traditional MRP-based systems. The goal is to achieve better MPC system performance and to reduce costs of maintaining the MPC system.

Figure 1.2 also shows material requirements planning as spanning a wide area. MRP is often the platform for ERP applications and is key to any MPC system involving management of a complicated parts situation. The majority of manufacturing firms have this sort of complexity, and MRP-based systems continue to be widely applied. For many firms, successful use of MRP is an important step in evolving their approaches to MPC. Once routine MRP operation is achieved, portions of the product and processes that can be executed with JIT methodologies can be selected.

The last form of MPC depicted in Figure 1.2, the project type, is applied to unique long-lead-time products, such as ships and highly customized products. Here, the primary concern is usually management of the time dimension. Related to time is cost. Project management attempts to continually assess partially completed projects' status in terms of expected completion dates and costs. Some firms have successfully integrated MRP approaches with the problems of project management. This is particularly effective in planning and controlling the combined activities of engineering and manufacturing.

Evolution of the MPC System

Throughout this chapter, we have discussed the dynamism of the MPC system. This notion is so important that we devote an entire section to the topic. Although the activities shown in Figure 1.1 are performed in every manufacturing company, whether large or small, MPC system configuration depends strongly on the company’s attributes at a particular point in time. The key to keeping the MPC system matched to evolving company needs is to ensure system activities are synchronized and focused on the firm’s strategy. This ensures that detailed MPC decision making is in harmony with the company’s game plan. But the process is not static—the need for matching is ongoing.

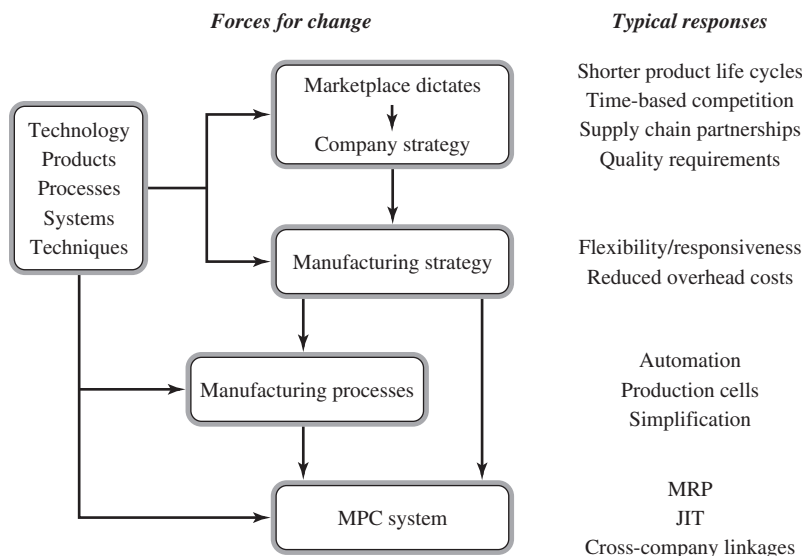
The Changing Competitive World

Figure 1.3 depicts some manufacturing firms’ typical responses to changing marketplace dictates. New technology, products, processes, systems, and techniques permit new competitive initiatives; global competition intensifies many of these forces. Marketplace dictates drive revisions in company strategy, which in turn often call for changes in manufacturing strategy, manufacturing processes, and MPC systems.

Shorter product life cycles come about partly because consumers have access to products from all over the world. This has spawned the move to “time-based competition.” Who can get to the market quickest? Similarly, today’s market insists on ever-higher quality, which in turn has led to many changes in manufacturing practices. Cost pressures have translated into reductions of all manufacturing cost components from material and labor to overhead and energy.

But increasingly, cost and quality are the ante to play the game—winning requires flexibility and responsiveness in dealing with even more fickle customer demands. Clearly, these pressures and responses require changes in both the MPC system and the underlying

FIGURE 1.3
Evolutionary Responses to Forces for Change



manufacturing process. As Figure 1.3 shows, typical MPC responses are MRP and JIT. Process responses include automation, simplification, and production cells for cellular manufacturing.

Reacting to the Changes

If the MPC system has remained unchanged for a significant length of time, it may no longer be appropriate to the company's needs. The system, like the strategy and processes themselves, must change to meet the dictates of the market. In many instances, this may simply imply a different set of evaluative criteria for the MPC system. In other cases, new modules or information may be required. In yet other cases, entire MPC activities may need to be eliminated. For example, JIT systems frequently move materials so quickly through the factory that MRP and shop-floor scheduling systems to track them are not needed. In supply chain management approaches, the emphasis shifts to the total costs (and values created) in the joint activities of more than one firm. The typical focus is on the dyad: two firms where time and inventories are substantially reduced.

The need for evolution in MPC systems implies the need for periodic auditing that compares system responses to the marketplace's requirements. The audit must address not only the system's focus but also the concomitant training of people and match with current objectives. Although the MPC framework in Figure 1.1 is general, its application is specific and evolving. Keeping it on track is an essential feature of MPC itself.

Concluding Principles

This chapter lays the groundwork for the rest of the book. Defining and adjusting the MPC system to support the manufacturing activity are an ongoing challenge. We hope that, as you read the rest of the book, you constantly ask how the general framework applies in specific instances, and what is happening to ensure a better match between MPC system design and marketplace dictates. From the chapter we draw the following principles:

- The framework for MPC is general, and all three phases must be performed, but specific applications necessarily reflect particular company conditions and objectives.
- In supply chain environments, the MPC system must coordinate the planning and control efforts across all companies involved.
- Manufacturing planning and control systems should support the strategy and tactics pursued by the firm in which they are implemented.
- Different manufacturing processes often dictate the need for different designs of the MPC system.
- The MPC system should evolve to meet changing requirements in the market, technology, products, and manufacturing processes.
- The manufacturing planning and control system should be comprehensive in supporting the management of all manufacturing resources.
- An effective MPC system can contribute to competitive performance by lowering costs and providing greater responsiveness to the market.
- In firms that have an integrated ERP system and database, the MPC system should integrate with and support cross-functional planning through the ERP system.

**Discussion
Questions**

1. The discussion of the framework for manufacturing planning and control seems to imply that overall direction setting must be done before detailed material and capacity planning activities can be accomplished. The latter must be done before executing and controlling the plans is possible. Do you agree? Give an example supporting your position.
2. Apply the MPC framework to a college setting. In particular, identify the front end, engine, and back end.
3. We have suggested that as changes take place in the world, the MPC system would require modifications to adapt. What changes can you see that will require changes in the MPC system?
4. One of the local company's production managers asked you to advise her on installing an MPC system. She starts by asking you which particular software brand you prefer and if you believe in ERP systems. What questions would you ask her?