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MRP or JIT - The Transformation from Industrial to Post-industrial Enterprise System

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Abstract: Many U. S. manufacturers are experiencing a fundamental transformation. The traditional industrial mindset is now obsolete. The accelerated changes in technology and world market require a new post-industrial paradigm. Using MRP and JIT as examples, this paper discusses some important changes from an industrial to a post-industrial enterprise system. The implications of these changes to Chinese manufacturing firms are also discussed.

I. Introduction

In his famous 1985 article, *The Taming of Lions*, Wickham Skinner pointed out that American manufacturing is experiencing a severe management problem. The problem is caused by an obsolete mind-set rooted in the dominant industrial paradigm that is now becoming dysfunctional in many ways. This industrial mind-set treats the factory as a productivity machine that emphasizes maximum efficiency and stability by buffering the technical core from external changes (Thompson, 1967). Company management seeks to maximize profit by reducing cost through process mechanization and high volume mass production. Workers are treated as an annoying and passive factor to be carefully controlled through division of labor and work measurement (Fredrick Taylor, 1911).

This industrial paradigm was very successful prior to 1960 and was primarily responsible for American industrial leadership. In the 1980s, the world market and technology experienced an ever-accelerating rate of change. American manufacturing started to lose its leadership to increasing global competition (Skinner, 1985; Hayes, Wheelwright and Clark, 1988). Doll and Vonderembse (1991) extended Skinner's ideas and suggested that manufacturing is entering a new post-industrial era characterized by growing global competition, changing customer demands, shorter product life cycles, increased market diversity, and advances in manufacturing and information technology.

This shift from industrial to post-industrial paradigm requires fundamental changes in manufacturing system design. We concur with other scholars that Material Requirements Planning (MRP) is a technique used by firms

operating in the industrial mode, while firms operating in the post-industrial mode use Just-In-Time (JIT).

II. MRP VS. JIT

MRP is basically an inventory control and production scheduling information system. The difference between MRP and traditional reorder point-based systems lie in MRP's ability to link future customer demand with the production planning process (Cooper and Zmud, 1990). The logic behind MRP is straightforward. It starts with a master production schedule (MPS) based on customer demand forecast. MPS specifies the quantity and due date of each end product. The MRP system then explodes the MPS into lower level component requirements using a bill of materials. Net requirements of each component part are then obtained by applying a lot-sizing technique while considering on-hand inventory and scheduled receipts.

JIT is both a philosophy and a set of tools to minimize waste and achieve a flexible and responsive manufacturing system capable of meeting customers' changing demands at the lowest cost (Lubben, 1988). JIT originated from the Toyota production system that advocates the production of the right product in the right quantities at the right time (Ohno, 1982). The JIT system is designed to eliminate all sorts of wastes, including wastes in overproducing, waiting time, transporting time, processing time, unnecessary motion, unnecessary stock on hand, and product defects (Ohno, 1982). Thus the ideal situation is zero inventory, zero lead-time, and zero defects, also known as "lean production" (Womack and Jones, 1991). One major benefit of lean production systems is that problems and bottlenecks submerged in mass production buffers are now so prominent and visible that they must be solved immediately and not merely patched up, or they will immediately reappear. The major manufacturing practices of JIT include setup time reduction, Kanban pull system, cellular layout, preventive maintenance, JIT supplier relationship, and flexible scheduling (Sakakibara et al., 1997).

III. The Shift to Post-Industrial Enterprise System

To understand why MRP is a typical industrial system while JIT is appropriate for post-industrial environment, we must

relate our discussions to the major changes during the shift from industrial to post-industrial society. Huber (1984) first described that a post-industrial society is characterized by more and increasing knowledge, more and increasing complexity, and more and increasing uncertainty. These environmental changes require modification to many aspects of organizational design, including decision-making process, technology usage, workforce management, information management and innovation management (Champlin and Olson, 1994). Similarly, under the manufacturing setting, Doll and Vonderembse (1991) define a post-industrial manufacturing organization as one whose structures and processes are appropriate for the post-industrial environment. We believe the changes that make MRP obsolete and JIT appropriate include the following:

Changes in value orientation

From Product focus to Customer focus. The industrial system focuses on productivity and conformance to product specifications since the market was relatively stable. Customer contact was regarded as an annoying and unstable factor affecting system efficiency (Chase, 1983). The turbulent and segmented post-industrial market forces manufacturing firms to be more customer-oriented (Bowen et al., 1989). Everybody must fully understand the customer, and all operations must provide value to customers. A similar idea was expressed by (Chase et al., 1989, 1992) in their discussion of the "service factory."

From Efficiency/Cost focus to Flexibility/Innovation focus. Traditional mass production firms seek maximum efficiency through standardization, while the uncertainty of post-industrial environment requires manufacturing flexibility (Jelinek and Goldhar, 1984; Gerwin, 1993; Hayes and Pisano, 1994). Moreover, instead of focusing mainly on cost reduction, a post-industrial firm has to promote product and process innovation to adapt to shorter product life cycles (Huber, 1984; Zahra and Das, 1993).

A major drawback of MRP system is that the MPS is based on forecasted customer demand and standardized bill of materials, thus the system will be very unresponsive and inflexible to drastic fluctuations of customer demands in a post-industrial environment. While JIT system is connected with customer orders in real time, it is flexible enough to quickly adjust production schedule and volume. Murakoshi (1994) gave a detailed explanation of how JIT created customer-driven manufacturing firms in Japan.

Changes in manufacturing strategic orientation

From Economy of Scale to Economy of scope. The traditional mass production strategy is based on "economy of scale," i.e., higher volume will result in lower unit cost. While today's increasing customer demand on product variety calls for "economy of scope" where it is more

economical to produce multiple products jointly than individually, due to sharing of technology and experiences (Jelinek and Goldhar, 1983).

From Buffered manufacturing to Lean manufacturing. Traditionally, various buffers, such as high inventory and long lead-time are created to absorb the uncertainty from environment in order to maintain the efficiency of the technological core (Thompson, 1967; Doll and Vonderembse, 1987). This resulted in the wasting of time and manufacturing resources that do not add value to customers. The concept of lean manufacturing advocates waste minimization and customer responsiveness (Womack and Jones, 1991). This can be achieved through the use of advanced manufacturing techniques such as Just-In-Time (Lubben, 1988).

The problem of MRP is that it utilizes a push production system. Materials are pushed in large lot sizes from workstation to workstation regardless of production requirements. Sometimes when the material is really in need, it takes long lead-time to order it. The result is waste in inventory and waiting time. The push system also makes it costly in product changeover. The JIT system utilizes Kanban pull system that uses material in small lot sizes starting from the end of the production line. Thus the entire system is driven by customer orders, thus eliminating excessive waste in buffers. The application of setup time reduction and JIT supplier relationship make it flexible and economical to change between product lines, eliminating the traditional tradeoff between cost and variety in MRP based systems.

Changes in organizational design

From Mechanistic structure to Organic structure. Burns and Stalker (1961) proposed the distinction between a flexible organic structure and a hierarchical mechanistic structure. Zammuto and O'Connor (1992) suggested that new technology firms should have an organic structure that can quickly respond to environmental changes. Nemetz and Fry (1988) also proposed that an organic organizational structure would be more suitable for implementing new flexible manufacturing technologies.

From Authority-based control to Learning-based control. Doll and Vonderembse (1991) pointed out that the traditional hierarchical authority-based control mechanism would no longer be appropriate in post-industrial firms. The new control system should emphasize mutual adjustment and learning. Sitkin et al. (1994) also proposed total quality learning as the new production control mechanism under higher levels of uncertainty.

MRP is by nature a hierarchical planning systems based on the explosion of different levels of bill of material, thus resulting in a hierarchical organizational structure. Control and stability are the major production management objectives of MRP. Buffers also lead to a delayed production

feedback system that inhibits timely learning. The operational flexibility of JIT system makes it ideal for an organic structure to make full use of flexible manufacturing technologies. Pull production control provides timely feedback of production performance information that promotes learning and adjustment.

Changes in workforce management

From Deskilling of labor to Intellectual nature of work. Unlike the unskilled, specialized nature of work in traditional industrial firms, post-industrial firms provide a multi-skilled, information intensive and intellectual work environment (Hirschhorn, 1981; Doll and Vonderembse, 1991). This change in the nature of work was also reflected in Zuboff's (1988) discussion of intellectual skills and Weick's (1990) discussion of mental skills.

From Division of labor to Teamwork. The industrial rationale of functional specialization has proved to be a severe barrier to successful communication in the information intensive post-industrial environment (Doll and Vonderembse, 1991). Self-managed work teams and cross-functional project teams are now extensively used on assembly lines, manufacturing cells, and new product development processes (Goldhar and Lei, 1994).

The hierarchical MRP system supports the traditional process-oriented job-shop production system. It promotes work specialization and requires little communication between functional areas, while product-oriented cellular manufacturing is common in JIT systems. Cell workers work in teams that promote communication and knowledge sharing. Cellular manufacturing uses dissimilar machines and this places higher technical and intellectual skill requirements on workers.

Changes in the nature of technology

From Efficient technology to Reliable technology. The industrial system tries to design specialized technology with the highest possible level of efficiency that can finally replace human labor (Braverman, 1974). Huber (1984) and Weick (1990) claim that post-industrial technologies are more stochastic and complex, making it very difficult and costly to recover from incomprehensible failures. As new technologies become more continuous, such as flexible manufacturing systems that can continuously process customized products, a small control problem at any link can cause the entire system to fail (Hirschhorn, 1981).

From Islands of automation to Systems integration. The traditional approach of using specialized technology often results in "islands of automation" (Johansen et al., 1995; Doll and Vonderembse, 1987), while the information intensive, team-based post-industrial environment requires a highly integrated flexible manufacturing system to facilitate communication and improve system responsiveness to

uncertainty (Nemetz and Fry, 1988; Lei and Goldhar, 1996). Vonderembse, Raghunathan and Rao (1997) further verified that in the post-industrial environment, firms should first focus on integration across the entire value chain, then start automating the activities that add value to customers.

The MRP system may become very unstable and unreliable when there is dramatic change in customer demands due to the amplifying effects of hierarchical explosion. It also does not help in integrating islands of automation because MRP itself is a specialized production and inventory control system. While the common practices of preventive maintenance and the systematic view of JIT system can greatly increase the reliability of flexible manufacturing systems and facilitate systems integration.

From Systems Integration to Enterprise Integration. Systems integration was the solution to the lack of integration between islands-of-automation. However, it was not long after that companies realized that to run an effective manufacturing business the concept of integration had to extend beyond the confines of the manufacturing floor to include non-manufacturing systems such as finance, marketing, accounting, sales, personnel and so on. This initiative resulted in enterprise resource planning (ERP) systems that support the linking of cross-functional business units (Callaway, 1999). This cross-functional integration achieved by ERP is necessary for companies that take a systems approach to the design and manufacture of products. Such an approach utilizes up-to-date information from marketing, sales, accounting, finance and other non-manufacturing systems in the design and manufacture of products. More recently, vendors of ERP software have responded to customer demands to enhanced the technology to support Supply Chain Management, E-Commerce, Customer Relationship Management, and Business Intelligence (Callaway, 2000).

IV. Implications and Conclusion

While the concepts and principles of JIT have been around for almost two decades, they were introduced into China not very long ago. When many Chinese firms were still trying to realize the full benefits of MRP and MRP II, JIT is already knocking on their doors. Study shows that MRP II is in use at only 170 of the more than 18,000 medium to large firms in China (Davis, 1995). The number of Chinese firms implementing JIT is even fewer. The Chinese automotive companies are pioneering the implementation of JIT in China due to the increasing demand from their worldwide partners (Chen and Chen, 1997). However, there are several major barriers to JIT implementation in China:

1. The traditional management model under planned economy is still affecting the internal and external cooperation of Chinese firms. For example:
 - ✓ Most manufacturers are still accustomed to the mass production system, which promotes the "ad-

in-one" model and discourages inter-firm cooperation and coordination.

- ✓ Speed of decision-making tends to be slow, which directly affects the firm's response time.
- ✓ Many firms are still using high inventory to ensure continuous production, resulting in high costs that are hard to control.
- ✓ Employee initiatives and creativity are not fully utilized.

2. The difficulties arise from a still incomplete market economy mechanism. For example:

- ✓ Lack of formal system to monitor and regulate the transactions and contract fulfillment among firms.
- ✓ Lack of close cooperative relationship.
- ✓ Underdeveloped production system may not guarantee reliable delivery.

Considering the above problems, we think that some basic measures can be taken to improve the condition of JIT implementation in China:

1. Incremental changes to manufacturing system may not solve the fundamental problems. The need exists to implement advanced manufacturing management methods (e.g. JIT) to drastically reengineer the entire industry.
2. Many Chinese firms suffer from the use of obsolete technology and equipment, and lack of R&D investment. Consequently, they are unable to effectively deal with market changes in a timely manner. We suggest that these firms should first focus on waste reduction and resource exploration inside the firm, and then gradually develop a dynamic strategic alliance with major suppliers. This should result in a robust market oriented supply chain that can jointly work on product innovation and better respond to market changes.
3. Chinese firms must completely eliminate the tremendous waste of production capacity resulting from the traditional "all-in-one" management philosophy. This requires that Chinese manufacturers should develop a true market orientation and closely monitor market changes. Also, new projects should be evaluated in light of current and future market demands.

In summary, the shift from industrial to post-industrial society has created a turbulent environment that is not suitable for MRP systems. The philosophy and techniques of JIT are ideal for manufacturing systems design under post-industrial environment. In the long run, JIT is a definite path for Chinese manufacturers. While continuous improvement is important, we feel that Chinese manufacturing system needs radical reengineering to establish a true market orientation. We argue that with proper execution and support from top management, many medium to large sized Chinese firms can leapfrog to JIT, rather than going through the transition from MRP to MRP II to JIT.

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