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How IT Reshaped the Manufacturing Enterprise—Its Competitive Advantages and Organizational Requirements

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INTRODUCTION

In recent years, information technology (IT) has dramatically altered the structure of markets in a number of industries. Significant advances in the related technologies of computers, telecommunications, data access and storage devices, and software packages have created a wide spectrum of new opportunities for organizations. The speed, cost, size and capabilities of the new information technology continue to improve rapidly, and there appear to be unlimited applications that could be "computer enhanced". The U.S. manufacturing industry may well be the biggest beneficiary of all these IT innovations. This paper attempts to draw from both information systems (IS) literature and manufacturing management literature to illustrate the profound impact of IT on manufacturing enterprise. The discussions also point to some possible future research directions on the interface of IT and manufacturing management.

It is necessary to first clarify the concept domain of IT in this paper. In a narrow sense, the MIS literature define IT as information systems (IS) used to organize, store, retrieve, transfer data and facilitate communication, such as office automation systems, management information systems and decision support systems. While in a broader sense, IT has now encompassed both IS and a wide variety of advanced manufacturing technologies (AMT) such as computer-aided design and manufacturing (CAD/CAM), computer-aided process planning (CAPP), computer numerically controlled (CNC) machines, and flexible manufacturing systems (FMS) (Gerwin and Kolodny, 1992; Hill, 1994). A common characteristic of IS and AMT is the use of computers to manipulate data and control operations (Dean et al., 1992). When islands of AMTs are integrated through IS, the result is a computer integrated manufacturing (CIM) system, which is commonly regarded as the basis for factory of the future (Rosenthal, 1984). Doll and Vonderembse (1987) define CIM as a computer automation system that blends recent developments in both manufacturing and information technology to achieve competitive advantage.

Manufacturing has traditionally been viewed as merely a functional area buffered from environment, while Skinner (1969) pointed out that some of the seemingly routine manufacturing decisions might in fact significantly influence corporate strategy. Wheelwright (1984) further defined this missing link between manufacturing strategy and corporate strategy. Since then, manufacturing has increasingly been viewed as a strategic enterprise covering the entire value chain of new product development, materials purchasing, production, product distribution and customer service (Doll and Vonderembse, 1991). This changing role of manufacturing is due on a large part to the rapid advances in new IT, especially the supply chain management (SCM) systems. Interestingly, during about the same time frame, the IS literature was also advocating the changing role of IS from a back office supportive function into a competitive weapon (Ives and Learmonth, 1984). Today, IT has been widely recognized as new competitive weapon due to rapidly increasing power and speed, and decreasing cost of computers (Parsons, 1983; McFarlan, 1984; Jelinek and Goldhar, 1984).

COMPETITIVE ADVANTAGES OF IT

Boddy and Buchanan (1984) suggested that the advantages of new IT should be evaluated at both strategic and operational levels.

Strategic Benefits of IT

1. *Improved strategic flexibility*. Hayes and Pisano (1994) states that in a turbulent environment, the primary strategic goal of the manufacturing firm should be strategic flexibility. Skinner's (1974) notion of "focused factory" has been dominating US manufacturing for a long time. He argued that firms cannot achieve all objectives at the same time, but have to focus on one or two competencies that fit their competitive strength. Thus they always have to make tradeoffs, such as Cost vs. Quality, Cost vs. Variety, Quality vs. Delivery, and Quality vs. Productivity. Anderson (1989) suggested that trade-offs are not necessary. World class manufacturers are achieving them simultaneously (Oliver et al, 1994). Goldhar and Jelinek (1985) termed this technology enabled strategic flexibility "economies of scope". Many auto manufacturers, especially Japanese firms, have enjoyed the added flexibility of new IT (Jaikumar, 1986).
2. *Enhanced competitive position.* Porter and Miller (1985) stated that information technology is transforming the nature of competition. According to Porter's competitive forces model, firms' competitive position is determined by five forces: existing competition, potential entrants, substitute products, and bargaining power of buyers and suppliers. First of all, IT can increase the entry barrier and switching cost of new competitors due to the significant amount of IT investment and higher level of "know-how" in the new technology. Secondly, IT can change the bargaining power of suppliers. Many auto manufacturers have been able to achieve JIT purchasing from suppliers through real time connection of information systems. Thirdly, IT can change the bargaining power of buyers. GM has been able to locate the best parts supplier through the successful implementation of EDI system. Fourth, IT has created significant new business opportunities, such as the emerging area of electronic commerce. Finally, IT can change existing competition by restructuring the industry structure. Segars and Grover (1995) did a longitudinal study of the impact of IT on industry structure. They found strong evidence that IT can restructure strategic groups thus improving a firm's competitive position.
3. *Facilitating global manufacturing strategy*. Manufacturing activities are increasingly going global (Miller, De Meyer and Nakane,1992). In fact, a global organizational scope is the key dimension of generic manufacturing strategy (Kotha and Orne, 1989). By going global, firms can expect to achieve cost reduction by using low cost production factors, and improve delivery speed and flexibility through market proximity (Ferdows, 1989). In the process of manufacturing globalization, IT has played a critical role by connecting global customers and suppliers, offering global product services, sharing global information resources and reducing global risks (Ives and Jarvenpaa, 1991).

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Operational Benefits of IT

The most commonly quoted operational benefits of IT include efficiency and productivity increase, cost reduction and quality improvement. An early empirical study by Boddy and Buchanan (1984) found IT bring about significant productivity gains at the operational level. More recently, Kelley (1994) verified that IT is positively related to production efficiency and productivity. Parthasarthy and Sethi (1993) found flexible manufacturing technology to have significant impact on the firm's cost and quality performance. While some others confirmed IT's positive influence on the firm's financial performance, such as return on investment (Mahmood and Mann, 1993; Byrd and Marshall, 1997). The increased power and speed and reduced cost of microcomputers also make it possible for manufacturing firms to migrate applications from mainframe architecture to a smaller platform. This is the increasingly popular trend of IT downsizing. Doll and Doll (1992) verified significant cost savings through downsizing at CBS/FOX video.

ORGANIZATIONAL REQUIREMENTS OF IT

Despite these widely acclaimed strategic and operational advantages provided by IT, new technology also placed significant strategic and organizational requirements or burdens on the manufacturing enterprise. Studies show that firms are experiencing more short-term operational benefits, such as local productivity gains, from IT but failed to explore long-term strategic opportunities (Boddy and Buchanan, 1984; Voss, 1988). Mansfield's (1993) survey of Japanese, European and American firms discovered that the diffusion of FMS technologies in US firms had been relatively slower due to the actual rate of return being lower in the US than elsewhere.

Jaikumar (1986) argued that the technology itself is usually not a problem, but the management of technology planning, justification and implementation processes. Rosenthal (1984) indicated that many AMT users were more interested in its technical capabilities and not sophisticated enough to utilize the unquantifiable strategic benefits. Blumberg and Gerwin (1984) also pointed out the problems arising from the incompatibility of new technology and existing socio-technical systems of most firms. The mind-sets of many senior management are still in the industrial paradigm of thinking. They believe that technology will implement themselves once installed. Thus their motives for adopting IT are mostly from external technological and competitive pressure rather than strategic needs (Blumberg and Gerwin, 1984). Some of the major requirements that new IT placed on the manufacturing enterprise include:

Strategic Justification of IT

The purpose of strategic justification is to make sure that the objectives of IT investment are properly aligned with those of business strategy. Traditional justification procedures tend to ignore strategic analysis and focus on financial criteria (Small and Chen, 1997). Goldhar and Jelinek (1985) indicated that traditional capital budgeting techniques are based on economy of scale and productivity criteria, thus can not reflect the new strategic advantage of economy of scope. Kaplan (1983) also argued that simple financial criteria are not appropriate for the justification of new manufacturing technologies because quantification of strategic benefits and synergistic effects from system integration are difficult. As a result, standard methods for strategic justification are scarce. Naik and Chakravarty (1992) proposed a very effective method utilizing QFD technique, which uses a series of relationship matrix to relate strategic objectives to AMT characteristics.

Strategic alignment of IT has long been a top issue in IT management (Niederman et al., 1991). Henderson and Venkatraman (1993) argued that the inability to realize value from IT investment is due to the lack of alignment between business strategy and IT strategy. Raghunathan and Raghunathan (1991) empirically verified that a well-aligned IS planning process had significant impact on system effectiveness. More recently, Reich and Benbasat (1996) proposed a methodology to measure the linkage between business and IT objectives.

Organizational Structure Issues

The fit between technology and organizational structure has been a classical theme. Zammuto and O'Connor (1992) argue that flexibility oriented organic structures are key to gaining AMT's benefits. Parthasarthy and Sethi (1993) empirically verified that flexible automation has significant positive impact on business performance when the organizational structure is highly organic. Leifer (1988) studied the fit between IS and organizational structure, and concluded that centralized systems need bureaucratic structure, while decentralized systems require team-based organic structure.

Work Design Issues

Zuboff (1988) pointed out that the new "informating" technology requires workers to have higher "intellective skills" such as abstract thinking, problem solving and inference. The traditional job specialization may limit workers' understanding of the new technology and hinder communication. Thus job enrichment such as cross-functional training will be necessary. Similarly, Susman (1990) suggested that AMT increases task interdependence and skill requirement, thus demands greater worker involvement and work group autonomy. Empirical evidences also show that increased operator control improves worker performance and well-being in AMT systems (Wall et al., 1990).

In the IS literature, new information technology has also brought about significant changes to the jobs of system users and managers. The increasing importance of end-user computing (Doll and Torkzadeh, 1989) and user involvement is in response to technology changes. In the meantime, the distributed systems and increasing user dominance are changing the job of IS managers, making them feel loss of control and stress (Cash, et al., 1992). Thus job enrichment methods are necessary to improve their job significance and increase level of commitment (Igbaria et al., 1991; Raghunathan et al., 1997).

Systems Integration Issues

Duimering et al. (1993) states that organizations must be redesigned for integration before implementing flexible manufacturing technologies. Johansen et al. (1995) observed that a major problem of CIM implementation is the predominant "bottom-up" approach. That is, individual components of the system grow through local adoption, resulting in islands of automation with localized benefits, while neglecting system integration. A strategic "top-down" approach should be more appropriate. More recently, Vonderembse, Raghunathan and Rao (1997) conducted a series of case study and confirmed that, to achieve higher organizational performance in the post-industrial environment, firms must first focus on integration across the value chain before implementing automation projects.

CONCLUSION

In summary, new information technology has offered manufacturing firms profound opportunities to achieve strategic and operational advantages. But to fully realize these benefits, strategic, organizational and operational issues must be addressed before implementing the new technology. These issues also present some interesting research opportunities in the field of IT and manufacturing management.

REFERENCES

Due to length limitation, references will be provided by the author upon request.