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**INFORMATION SYSTEMS IN MANUFACTURING COORDINATION:
ECONOMIC AND SOCIAL PERSPECTIVES**

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ABSTRACT

Manufacturing is an important factor in national economic welfare, and information technology is increasingly seen as a vital instrument in manufacturing performance. Manufacturing is one area where a vision of extensive coordination through computerization has been articulated. This vision, computer integrated manufacturing (CIM), is usually advanced as a next stage for improving manufacturing efficiencies and performance by reducing intra-organizational coordination costs. The typical arguments advanced for CIM focus on improving organizational efficiencies through sharing, reusing and sometimes standardizing information. This paper shows how four theoretical perspectives — transaction cost economics, agency theory, resource dependency theory, and institutional theory — help us better understand the strengths and dilemmas of organizational integration through computerization. This approach of using multiple alternative theories is being applied in empirical studies conducted by the Advanced Integrated Manufacturing Environments (AIME) project at CRITO, UC-Irvine.

INFORMATION SYSTEMS IN MANUFACTURING COORDINATION: ECONOMIC AND SOCIAL PERSPECTIVES ¹

1. THE VISION OF COMPUTER INTEGRATED MANUFACTURING

Substantial hopes have been placed on the exploitation of modern information technology for revitalizing the U.S. manufacturing sector. As the vision of information technology in manufacturing has moved beyond the level of the discrete tasks to the spanning of organizational divisions and boundaries, the fundamental challenges have become as much managerial as technological. In this vision, computerized manufacturing systems play a central role in *coordinating* activities at three levels: within manufacturing firms; between manufacturing firms along the production chain (e.g., between manufacturing firms and their suppliers); and between manufacturing firms and key outside organizations such as financial institutions (e.g., Melnyk and Narasimhan, 1992). In a systems view of organizations, information systems can bind manufacturing organizations, their suppliers and service providers, and eventually their customers into a finely tuned, integrated production organism (Morton, 1991).

This paper examines key organizational assumptions about the visions of computer integrated manufacturing (CIM). Our objectives are to characterize the organizational processes which would facilitate or impede coordination through computerization, the specific kinds of effects we can expect from intensive computerization in manufacturing, and the conditions under which varying levels of computer-based integration can be achieved. Long experience in studying the effects of computerization in administrative data processing and other "knowledge work" domains reveals a complex and bewildering array of technical and social obstacles to the vision of seamless integration. We examine some of the coordination problems in manufacturing, and we examine Information Technology (IT) as a possible medium for reducing their costs and complexities. In the process, we outline four analytical perspectives that offer special help for understanding the likely promises and problems in large-scale application of IT to facilitate coordination in manufacturing.

We could have studied coordination in any of several application arenas such as banking, insurance, air transportation, or manufacturing. We chose to study manufacturing because it is the arena in which there is a clear vision of integration through information technology which has been promoted for two decades. One anchor of this vision lies in material control, and material requirements planning (MRP) systems. Other early elements of the CIM vision were anchored in engineering design (CAD/CAM) and shop floor control. Full blown CIM visions integrate these

elements, and others, through shared databases (Scheer, 1991). Also, coordination problems tend to be highly visible in manufacturing where several discrete groups -- professional and technical, line and staff -- have differing objectives, resources, and perspectives and yet tend to work together in one place. Consequently, manufacturing is a good arena to examine how much computerized systems serve as coordinating media, the nature of such integration, and the anticipated and unanticipated effects.

2. MANUFACTURING AND COORDINATION

The fundamental importance of coordination derives from the need for *specialization* in social and economic systems. Specialization is the process by which individuals and groups focus their attention and become expert within a narrow range of activities, thus permitting greater accomplishments. Specialization, however, reduces an individual's or group's ability to deal with the full array of survival resources available in the environment. Progress in the specific is thwarted by failures in the general. Coordination among specialized individuals and groups overcomes this dilemma by ordering and arranging the interdependency among specialized subunits. The essential importance of social dependencies as phenomenon was recognized first by sociologists like Emile Durkheim and economists like David Ricardo. The simultaneous importance of the these two lines of inquiry regarding coordination – the social and economic – are summarized well by Moore who identifies markets and hierarchies as key mechanisms of coordination:

The mechanisms of effecting coordination are chiefly two: exchange, whether through relatively impersonal monetary markets or other forms of complementary reciprocities; and administrative authority, a mode of allocating duties and insuring compliance by exercise of institutionalized power (Moore, 1967:16).

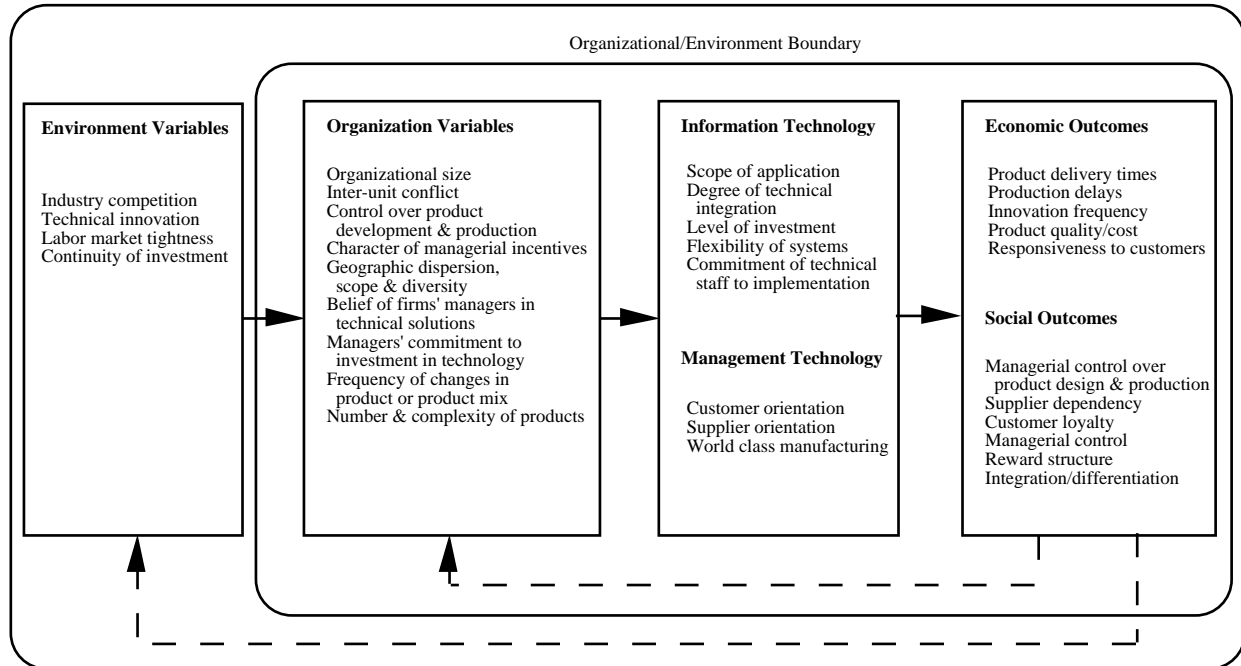
Manufacturing firms coordinate extensively at many levels. Marketing departments should propose to sell goods that the firm can design and manufacture at an acceptable price. Engineers should design products which the firm can sell and reliably manufacture at competitive prices. The production staff need the tools, skills, and materials to build reliable products on workable schedules. The materials staff is charged with insuring that adequate materials are on hand to ensure smooth production, without the uneconomical overstocking of supplies. Each of the groups which are charged with these responsibilities has deep specialized knowledge about their domains.

But their decisions and behavior are interdependent with the other groups. The skills and attention of these groups must be focused and choreographed for good organizational performance. But it is common for there to be conflicts of perspective and practice between any of these groups. Marketers may want to sell products that engineers can't effectively design. Engineers may design products which are difficult to sell or difficult for production departments to fabricate reliably, fast, and cheaply. Material staff work with complex tensions in economically ordering sufficient good quality material to keep the production line flowing while many product designs may be changing to reduce production costs, increase reliability in use, or accommodate changing suppliers.

Tasks are frequently separated geographically as well as temporally, and goods in process must cross intra- and inter-organizational boundaries on their way toward incorporation in a finished product and, eventually, the market. The vision of integrated manufacturing is to enhance the quality of such manufacturing coordination, in part through the use of information technology.

A framework for thinking about information systems in organizations is shown in Figure 1. This is a general model in that it could be applied to other arenas equally well, but we have chosen to apply it to thinking about information systems in manufacturing. Moreover, we have chosen to apply the framework to the level of the firm rather than between manufacturing firms along the production chain, or between manufacturing firms and key outside organizations such as financial institutions. Broadly, the framework distinguishes the *technology* from its *environment*, from the *organization* within which it functions, and from the *outcomes* it produces.

FIGURE 1: Framework of Information Systems in Organizations



The *environment* refers to variables outside the organization's control which might influence the behavior of managers and technical staff in the selection of technology, such as the level of competition, technical innovation, and availability of skilled labor.

The *organization* is the manufacturing firm, including the variables of organizational size, geographic dispersion, number and complexity of its products, frequency of changes in products and/or product mix, beliefs of firm managers in technical solutions and commitment to investments in technology, patterns of control over information systems development and use, levels of conflict between subunits, and character of managerial incentives.

The *technology* encompasses the package of people, equipment, techniques and management practices that constitute intervening variables between the organization and its environment, usually by facilitating communication and coordination. We distinguish *information technology* from *management technology* in the framework to signify the importance of organizational and management practices (e.g., lean production, world-class manufacturing) that frequently accompany or precede the use of information technology for coordination. Technology's actual role will be determined by the scope of its application, the degree of technical integration, the level and continuity of investment, and the commitment of technical and user staff to successful implementation.

The *outcomes* are the social and economic consequences from use of technology, including *economic outcomes* (e.g., product delivery times, production delays, innovation frequency, product quality, product cost, responsiveness to customers, etc.), and *social outcomes* (e.g., the degree of managerial control over product design and production, the locus of decision authority, the relative power and independence of organizational subunits, the degree of cooperation among organizational subunits, the number of hierarchical levels in the organization, the degree of centralization, the degree of organizational integration, etc.).

The very use of the technology creates consequences that serve as independent variables affecting the environment and the organization. Feedback loops indicate the influence of the use of coordination technology on various services, benefits, problems and costs, that can alter both the internal and external environment of the organization. However, to understand the ways in which use of information technology alters the dynamics of manufacturing coordination, we must approach the role of information technology from established analytical perspectives that, taken together, capture the key elements of coordination.

3. ORGANIZATIONAL PERSPECTIVES AND COORDINATION THROUGH INFORMATION SYSTEMS

The simplest approach to coordination of manufacturing tasks treats the manufacturing enterprise as a large mechanism. The full set of tasks to be accomplished can then be decomposed into discrete, atomic tasks and assigned to "processors" that might be machines or factors. Given known capacities for the processors in handling specific tasks, the entire manufacturing enterprise could be deterministically scheduled. Manufacturing management in this model consists mainly of assignments of processors to tasks. This was the basic vision of Fredrick Taylor's Scientific Management movement, and it found its most explicit expression in the Fordist manufacturing processes of the early 20th century (Abramovitz, 1972).

This mechanistic vision of manufacturing is powerful in its simplicity, and in the absence of viable alternative options for the "processors" and the managers who schedule them, it is a tractable approach to manufacturing coordination. However, the growth of the modern industrial economy changed these conditions significantly between the period 1920-1960. Between 1960 and 1990 intense international competition has arisen based, in part, on application of new manufacturing technologies and management practices that capitalize on manufacturing flexibility in pursuit of both product variety and quality. The mechanistic view of manufacturing is a useful crude starting point, but it must be replaced by social and economic perspectives that assumes actors will behave as groups in a social context, or as economic agents.

3.1 Economic Perspectives

A major function of economic systems is the coordination and governance of economic agents in their transactions with one another. Economic perspectives generally assume that agents behave opportunistically and rationally in their own interests. Organizations, markets and institutions provide incentive and enforcement mechanisms for governance through compensation schemes, contracting procedures, enforcement mechanisms, performance evaluation, measurement systems and so on. The choice among governance mechanisms as well as their structure and effectiveness are dependent on the costs of the underlying processes. To the extent that information technology affects the governance processes in organizations, it influences organizational structure and performance. *Agency theory* and *transaction cost economics* can be used to explain the effect of information technology on a number of organizational variables crucial to the objectives of these systems, including the location of decision authority and the size of a firm.

3.1.1 Agency theory

Alchian and Demsetz (1972) and Jensen and Meckling (1976) propose a view of the firm as a nexus of contracts among self-interested individuals. Accordingly, a firm represents a set of agency contracts under which a *principal* (entrepreneur) employs *agents* to perform some service on behalf of the principal. Research from this perspective, called agency theory, focuses on the costs incurred as a result of discrepancies between the objectives of a principal and his or her agents. According to Jensen and Meckling, agency costs are the sum of (a) monitoring costs, (b) bonding costs and (c) the residual loss. Monitoring costs are incurred by the principal in assessing the performance of the agent; bonding costs are incurred by the agent in assuring the principal of his commitment and the residual loss is the loss resulting from having an agent (with his own utility function) perform the task.

It then follows that firms will try to minimize these agency costs so as to improve their performance. Agency theory focuses on identifying the problems that occur due to the principal-agent relationship as well as on developing mechanisms to reduce these costs by more closely aligning the compatibility of individual and group actions with the goals of the organization.

Agency theory highlights the important roles of organization control systems and organization structure in determining organizational performance. In particular, it focuses attention on the information structure of an organization and its implications for the choice of organization control systems and organization structure. Information (or the lack of information) about agent effort and about an agent's private information are viewed as key characteristics of the information structure. The deployment of information technology in organizations has considerable potential to improve the information gathering process and could result in the design of improved control mechanisms and the subsequent lowering of agency costs.

One method by which agency costs can be lowered is by optimally locating decision authority at higher organizational levels, where it has been argued (Jensen 1976) that the goals of managers are more closely aligned with those of the principal. However, in situations where the decision process requires large volumes of local information that are acquired typically at lower levels such as the shop floor, this may lead to inefficiencies due to the costs of and subsequent delays in processing and communicating information upwards. Hayek (1945) has therefore argued that decision authority should be located where this local information is immediately available, namely the shop floor. There is therefore a tradeoff between agency costs and information pro
In the manufacturing setting, the implementation of manufacturing planning and control systems

results in the collection of detailed information at the shop-floor level, ease of processing, and rapid communication to all levels in the organization. Thus, by reducing the costs and delays of upward communication, the implementation of these systems can lead to greater centralization of decision authority. On the other hand, these systems also provide detailed information about the performance of lower level employees such as shop floor personnel. By facilitating improved monitoring, and by providing information that can be used in improving the compensation systems to more closely align the incentives of principals and agents, these systems may lead to a reduction in agency costs at lower levels in the organization. Thus, they may facilitate the decentralization of decision making in an organization.

Moreover, the implementation of manufacturing planning and control systems sometimes increases the interdependence between organizational processes raising the costs of poor coordination and delays. It is also the case that the impacts of the technology will be mediated by the frequency of decision making, the opportunity costs of delays in decision making and the opportunity costs of making decisions with incomplete or imperfect information, and a manager's preference for increased control. Thus, different decision processes could be impacted differently, with some processes becoming more centralized and others becoming more decentralized.

Perhaps the most interesting question is how one can assess the effectiveness or success of IT in manufacturing. Most large scale information systems affect the distribution of the ownership of information within an organization. Agency theory, with its focus on information and control, provides a framework to study the effects of shifts in the distribution of information, and thus aid in predicting the effects of systems as a result of shifting information distribution. For example, the effectiveness of systems is dependent in large part on the willingness of various organizational units to cooperate in the collection and the reporting of information. In organizations where the various agents have sharply divergent objectives, systems are likely to suffer from agent withholding of key information or even deliberate sabotage through incorrect information. On the other hand, agency theory holds that the compensation system of the firm plays an important role in mediating the divergence of managerial objectives, so incentives might be provided that promote cooperation instead of competition between managers.

Agency theory also suggests a way of addressing the possible shifts in emphasis within compensation systems. It is likely that use of IT in manufacturing will lead to a shift from input-based (e.g., hourly wage) criteria toward output or performance-based criteria playing larger roles in compensation schemes. Historically, input-based schemes have been utilized in situations

where the organization is unable to effectively measure the contribution of an employee or work group performance to its output. Some information systems enable finer grained monitoring and improved measurement of employee output. *Ceteris paribus*, these capabilities should enable firms to emphasize performance in their compensation schemes. However, as the incentive systems change, behavior of agents within the organization might change in unexpected ways.

Another interesting question is how manufacturing firms will make decisions for acquiring IT for manufacturing. Agency theory suggests that agents within firms have their own interests as well as the interests of those they represent. The interests of principals might reside in acquiring systems with particular characteristics, such as the most sophisticated or least costly. However, manufacturing managers who are concerned with the long term value of their own skills in the labor market will have an incentive to favor acquisition of transferable skills that increase their labor market value, and thus would tend to adopt industry-standard systems instead of unique systems, irrespective of other advantages.

3.2.2 Transaction cost economics

Transaction costs are the costs involved in using a market that are not related to the production costs of the traded product or service. A good example of a transaction cost is the cost of writing a contract and securing means to enforce it. The costs of contacting background references, the costs of a lawyer to evaluate the contract, and all the other costs of processing the contract are not part of the price of the good or service being contracted for. The theory posits that there are costs in using a market. Internal procurement, however, bypasses the market system. Within the firm, production is planned and directed by a central authority that can economize on transaction costs. Transaction cost economics attempts to explain when and why a firm will go to the market to procure what it needs instead of making it itself.

The decision of whether to make a product or develop a service in-house or go to the market determines the size of a firm. Transaction cost economics suggests that optimal firm size can be determined by trading off transaction costs, internal coordination costs, and production costs. Manufacturing industries have economies of scale in production that suggest a tendency toward larger size. Equally important to such firms are informational economies of scale (Wilson, 1975), which also favor larger size. However, it is incorrect to assume that optimal firm size is infinitely large. Internal agency and information costs increase as a firm grows larger. Furthermore, economies of scale in producing input factors will eventually provide an incentive for manufacturing firms needing such inputs to turn to outside vendors who can produce them at

lower cost on a large scale. Optimal firm size is therefore determined by balancing the marginal benefits from economies of scale and transaction cost savings against the increase in the cost of internal coordination.

Use of computer-based systems in manufacturing can have a direct impact on optimal firm size by changing the cost structures of these factors. Since internal coordination costs grow as the firm size increases, the availability of powerful computer-based systems might reduce internal coordination cost and thus induce increased firm size. Moreover, such systems can also reduce external, or market, transaction costs in a variety of ways. For example use of such systems might consolidate segregated markets, both temporally and geographically, thus reducing the cost of market search. On-line information systems might provide effective monitoring schemes and reduce opportunity costs related to uncertainty (e.g., credit card transactions, or the insurance companies' IVANS customer database network). Inter-organizational components of these systems can reduce firm size, by allowing a firm to subcontract with ease inputs that formerly had to be produced internally. The reduction of transaction costs due to the availability of cost-effective information technology will lead firms to turn to markets rather than to vertically integrate with factor supplier (see Malone et al., 1987) resulting in smaller firms.

Finally, transaction cost economics can provide important insights into the issue of whether customized IT systems in manufacturing are best developed internally or by outside contractor. Outsourcing can be efficient in terms of minimizing development costs. However, the idiosyncratic and complex nature of such systems raises transaction costs due to difficulties in the tasks of developing specifications for an external contractor, monitoring development progress, and evaluating final performance of the system.

3.2 Sociological Perspectives

Sociological analyses aim at descriptive accuracy rather than normative prescription. Sociological theories of organization assume that groups will conflict over goals and their preferences for effective arrangements among groups or individuals (Pfeffer, 1982; Scott, 1987). They depict organizations as aggregations of differentiated groups that might have parochial and conflicting interests. They differ from economic analyses by identifying social bases for group differences and interests, such as status, power, and social identification. Sociological theories are pertinent to understanding IT in manufacturing because such systems tie together organizational units with different occupational cultures and work practices. These systems automate decisions and transactions that cut across the boundaries of organizational subunits and

the boundaries between organizations. We focus on two organization-level theories that promise special insights into such systems: resource dependency, and institutional theories.

3.2.1 Resource dependency theories

Resource dependency theory holds that organizations are externally constrained in their actions, but that they nonetheless engage in political decision-making processes and seek to manage and strategically adapt to their environments" (Pfeffer, 1982:192). Organizations obtain resources from their environments, and usually become interdependent with other organizations. Generally, organizations respond most readily to the demands of organizations that control critical resources. Those groups inside organizations who manage relations with powerful external organizations gain internal influence. They follow strategies to ensure survival of their organizations, and in particular to increase their autonomy relative to powerful organizations in their environment (e.g., suppliers, customers, competitors). It is likely, therefore, that organizations will develop computer-based systems in order to help them manage key external dependencies. Order entry systems and electronic data exchange are obvious illustrations of such systems; order entry systems tie customers to the firm and increase the speed with which orders are received by production. MRP and CAD systems are less obvious illustrations; MRP and CAD systems increase the flexibility of the firm in scheduling production in response to changes in demand. Both help to manage external dependencies by increasing the flexibility of the firm to respond to uncontrollable variations in the external environment, e.g., customer orders, supplier production. Further, internal choices with regard to such systems will hinge on the autonomy-seeking behavior of organizational subunits.

Conflict and cooperation often become important in actions related to use of information technology. Prevailing information system arrangements are not predetermined, but are the outcomes of inter-group struggles. Access to information system resources, such as programmers and computer time, is critical for developing and fine tuning a computer-based system for manufacturing coordination. However, access to these resources is frequently unequal. Some groups will receive better, faster, or greater amounts of information system services than others. Resource dependency suggests that preferred computing arrangements will tend to flow toward those applications and activities that support the agendas of the participants with greatest control over negotiating resources for the firm. In firms where engineering or marketing are dominant and these systems are under the control of manufacturing, development might receive inadequate resources.

Successful deployment of IT for manufacturing requires the coordination of many diverse groups, and negotiations over system designs and operational procedures are inevitable. Organizational political decision-making processes are a byproduct of negotiations of between groups with different levels of power and beliefs systems (Strauss, 1988). These negotiations are likely to involve groups in material control, purchasing, production, information systems, marketing, and engineering. And the preferences expressed by these groups will likely be based on expectations of consequences for the groups. Although often rationalized as advantageous to all groups, information systems sometimes work to the differential advantage of particular groups. For instance, MRP I and MRP II modules can work to the advantage of material control specialists, while CAD/CAM modules can work to the advantage of engineers. Some modules will be attractive because experience with them will enhance job skills marketable outside the organization. And, of course, professional associations representing some groups play an active role in mobilizing bias in favor of certain modules. For example, material handling specialists attend workshops promoting use of MRP sponsored by the American Production and Inventory Control Society, while engineers attend workshops promoting CAD/CAM systems sponsored by various engineering societies (Kling and Iacano, 1984a, b).

Negotiation is also involved extensively in the use of IT for manufacturing after deployment. For example, MRP systems produce lists of goods that purchasing agents should attempt to buy, optimized for current conditions (e.g., master production schedule, on-hand inventories). However, since the systems do not take account of purchases suggested during the last system run, confusion can arise regarding orders placed during the last run. Purchasing agents must then re-negotiate some of their sales contracts with suppliers. Similarly, the CAD/CAM linkages between engineering and production groups produce new needs for negotiation. A firm that customizes many of its products for specific customers can gain leverage through a CAD/CAM system because existing designs can be reused by the engineering design group. However, the specifications produced by CAD systems often have to be modified by the production group in order to create a product that can be built efficiently with existing facilities. Each new product variation can require new negotiations and coordination. CAD/CAM might reduce coordination costs when the production staff accept specifications produced by CAM, but there is no guarantee that they will do so because this is tantamount to accepting design engineers' judgments about detailed manufacturing processes and sequences. In reality, design engineers and production staff often jockey for power, and significant and ongoing political negotiation is required if CAD/CAM integration is to be effective.

The vision of the highly integrated computer-supported manufacturing firm depends upon agreement upon a common data infrastructure with common data standards and network protocols. However, individual subunits have their own preferences that might cause them to choose systems based on their own criteria rather than on their ability to integrate with the rest of the organization (Beuschel and Kling, 1992). Production and engineering subunits who choose their own CAD or shop floor control systems may deliberately separate them from the traditional mainframe-based MRP run by a centralized data center. By maximizing local control, the individual subunits insulate themselves from depending on other subunits for accurate data, and keep their local system flexible by ensuring that only they (and not the entire organization) have to approve of updates and modifications. Further, the highest performance application packages may not run on common operating system platforms. Today, for example, engineers may prefer Unix workstations for CAD while shop floor managers may prefer Macs or PCs, while the best MRP systems run on mainframes. By optimizing the system to their local needs, the individual subunits are also best able to manage the uncertainties in their particular sub-environment. These control issues raise fundamental questions about the conditions required for manufacturing firms to move from current "islands of automation" towards the integrated (e.g., CIM) ideal.

3.2.2 Institutional theories

Institutions are organized social arrangements that persist and are taken for granted by participants, even when they do not work well. Implementing computer-based systems for organizations of all kinds can require substantial changes in basic organizational practices, and such practices often have to be redesigned to make the best use of IT in manufacturing. Organizational routines that have facilitated efficient activities and stable environments in the past may prevent the changes required for successful use of newer computer-based systems (Kling and Iacano, 1989). This "institutional inflexibility" is not necessarily a result of resistant end-users or insensitive system designers. Organizations can be slow to change, even when change is desirable or necessary due to the shifting dependencies with other participants and conditions in their environment.

The essential features of institutionalization as a phenomenon are most clearly expressed by Hughes (1939): institutions are persistent features of social life which outlast their creators and which survive upheavals in the social order. In Western industrial societies, important institutions include nuclear families, capitalist markets and Christianity (Friedland and Alford, 1991). Within specific organizations, a board of directors, monthly shipment dates for manufacturing and end-of-the-year book-closings for accounting have institutional influence.

Institutionalization is the process by which something becomes an institution. We are concerned with the institutionalization of discrete packages of innovative artifacts and techniques within organizations, and the ways in which the potentials of computerization are limited by pre-existing institutionalized organizational arrangements.

Institutionalization is the organizational construction and internalization of values and beliefs that accompanies the routine use of these technologies. A practice is considered institutionalized when routine use is accompanied by a general sentiment among organizational actors that it is taken for granted in organizational life (Zucker, 1983). Different organizations can institutionalize computing use through different processes. Specific institutionalization processes conform to organizational participant's striving for legitimacy, resources, and survival (Meyer and Rowan, 1977; DiMaggio and Powell, 1983). The process of institutionalization is seldom smooth or conflict free within or across organizations. Indeed, within any organization there can be highly conflicting views about the appropriateness of automation, the need for computers, the way that specific systems are configured, the value of investment in the technology, and so on (Kling and Iacano, 1989; Friedland and Alford, 1991).

Coalitions within manufacturing firms which promote highly integrated information systems will also simultaneously encourage substantial changes in institutionalized practices of manufacturing work (Beuschel and Kling, 1992). The increased interdependence and interaction implied by tight systems integration through CIM is a major shift in assumptions about the proper organization of manufacturing work. Manufacturing firms have traditionally had strongly differentiated functional areas, the prime example being the "wall" between design and manufacturing engineers that many manufacturers have been trying to break down for years (Ettlie, 1988). Enabling these people to now work together productively requires overcoming real disincentives to cooperation and sharing of information. But more importantly, it requires overcoming a generations-old tradition that sees such differentiation as natural. This shift away from long-institutionalized manufacturing world views and practices comes at a time when American industry is already reeling under the weight of economic pressures arising, at least in part, from successful Japanese manufacturing practices (Schonberger, 1986).

Institutional theory suggests that the taken-for-granted beliefs about how to best model and measure the manufacturing firm which are tacitly embedded in the integrated information systems will affect their ability to coordinate. Fully integrated CIM visions imply an unprecedented amount of information standardization, as well as interconnection. Definitions of appropriate capacity plans, shop floor schedules, production operation times -- over which there

may be substantial disagreement -- are then locked into the common information systems and are difficult to change. As an example of the effects of these integrated systems, Roberts and Barrar (1992) report that the most successful MRP II implementers among those they studied adapted their manufacturing organizations to the software, rather than their software to their organization. The integrated information systems themselves become powerful sources of institutionalized inertia, because changes are either too complex or affect too many other parties. The implications of institutionalization for the "highly flexible" CIM factories of the future remain to be seen.

4. DISCUSSION

Our conception of the roles of information technology in manufacturing coordination is formed from organizational economics and organizational sociology. These are normally divergent theoretical perspectives (Table 1). Economics emphasizes the rationality of individual actors and builds up structures, like markets and hierarchies, based upon individual rationality. But economic theories are relatively mute about utility formation -- why actors have their particular preferences. And they are mute about the persistence of social structures when they outlast plausible short-run rationality arguments. While utility formation and institutional persistence are rarely explored within economic theories, they are central issues in sociological theories (Table 1).

Each perspectives which we have discussed lends some insight into the visions of computer integrated manufacturing. Each of these perspectives renders some aspect of computer-integrated information systems as an attractive direction of organizational development. But each perspective also helps us see some of the problematics of visions of computer integrated manufacturing. We are finding the simultaneous use of these contrasting perspectives specially useful in understanding the actual practices of manufacturing firms' uses of computerized systems in coordinating across major functional areas in our empirical studies.

Organizational economics encompasses *transaction cost economics* and *agency theory*. Transaction cost economics focuses on the conditions under which markets or hierarchies are the most efficient forms for organizing economic activities, given existing inter-organizational coordination costs (Gurbaxani and Whang, 1991). Agency theory, on the other hand, studies primarily the internal organization of hierarchies. Thus, institutional economic approaches identify the nature of coordination costs both within and between organizations (Malone, 1988).

Table 1: Organizing Concepts from Institutional Economics and Organizational Sociology

Concept	Economic Theories	Sociological Theories
Actors	Individual, households, firms	Individuals, groups, classes, institutions as social actors
Arena	Situations where choice and scarcity of resources are present	Any situation where organizational activity is taking place
Types of Organizational Action	Rational action, with emphasis upon choice	Economic actions as well as socially anchored actions
Action Drivers	Utility maximization	Increases of power/control, status, belonging/identity, as well as actions congruent with socialized norms.
Results of Economic Actions	Equilibrium outcomes emerge under certain conditions	Tendency to more or less institutionalize yet tension-filled interest struggles
Time	Planning horizon and timing of actions are important	Extended and variable; goes beyond frame of action under analysis, but not readily definable a priori
History	Incorporated in expectations of rational actions	Shapes current arrangements, coalitions, issues and beliefs about their appropriateness and viability
Focus of Action	Effectiveness of investment/adoption decisions	Adoption, implementation, infusion (systems life cycle)
Clarity of Organizational Action	Ambiguity modeled through information asymmetries and inconsistent objectives	Sometimes ambiguous, and subject to interpretation by parties with differing world-views and interests

Table 2: Economic and Social Perspectives of Information Systems

Concept	Economic Theories	Sociological Theories
Nature of IS	Tools (identified by information processing capabilities, costs and benefits)	Tools and social objects invested with meanings and institutional dimensions
Infrastructure for IS	Dependent upon organizational control mechanisms	Based on scarce (and often unexpected) resource requirements
Knowledge of IS	Recognizes information asymmetries among participating agents	Participants have partial knowledge, influenced by their location in a system of roles and social relationships. Key information about systems comes after important commitments are made
Flexibility of IS	Possible, but limited by switching costs and technological capabilities	Fluid when new, institutionalized over time
Choice of IS & Organizational Arrangements	Based on minimizing agency production and transaction costs	Based on expanding influence, status and solidifying identity of key factors

Organizational sociology comes into play when one asks where preferences come from and why organizational structures and beliefs persist. We have focused on two sociological theories: *resource dependency theory* and *institutional theory*. Resource dependency theory depicts organizational behavior as adaptive and political, constrained in action by the interdependencies on resources among organizations and the actors within them (Pfeffer, 1982). Institutional theory focuses on the ways that key organizational practices become inflexible due to participants' beliefs about "the way things are and the way things should be" (Scott, 1987; Kanter, 1983; Mohrman et al., 1989). These economic and social theories also imply different perspectives about the role of information systems in organizations (Table 2).

Despite the differences in conceptual emphasis between the economic and social theories of organization, we find many areas of commonalty and synergy between the approaches. Both the institutional economics and organizational sociology perspectives are fundamentally concerned with providing more detailed pictures of existing organizational arrangements, the established

patterns of relations between organizational actors, and organizational change. Advocates of revolutionary new information technologies have traditionally downplayed the importance of existing economic and social patterns (Kling, in press). The decidedly mixed record of CIM system success over the past 20 years has frequently been attributed to a lack of attention to organizational issues (Melnyk and Narasimhan, 1992). To understand the diffusion of technologies that promise to redraw the lines of communication, interdependence, and control within organizations, we must understand organizations in all their complexity.

Manufacturing is an interesting and important domain of information systems application. Unfortunately it has not been well studied empirically by information systems researchers. Given the crucial importance of manufacturing to national economic welfare, the lack of detailed research on the effective role of IT for facilitating high performance manufacturing constitutes a serious shortcoming in our field.

The theoretical thrust of this paper naturally leads to empirical research to help to build sound theories of technology and organizational change. Research in the information systems field has demonstrated that parochial theoretical research perspectives often produce little research of lasting value. We suspect that good theories of IT and organizational change are unlikely to be built from discrete intellectual perspectives which rest on narrow disciplinary or ideological assumptions. Our objective must be to study technology in the context of organizational and institutional practices, informed by robust economic and sociological theories.

This approach of using multiple alternative theories is being applied in empirical studies conducted by the Advanced Integrated Manufacturing Environments (AIME) project at UC-Irvine. Framing and conducting such studies has special complexities. While the theories which we examined here overlap, they also emphasize different units of analysis and different kinds of data. Consequently, the design and coordination of a multi-perspective research project is also more complex than of a study which emphasizes a single theoretical approach. However, we believe that this kind of hard theorizing can lead to a much deeper understanding of the role of IT in organizational life. Understanding the role of IT as a coordination medium in manufacturing is an occasion for working with alternative theoretical perspectives, and also seems to require it.

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6. ENDNOTES

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2. Interesting studies of IT in manufacturing published in the last decade by Bill King, Rob Kling, Ann Marjchrzak, Richard Walton, Bob Zmud and their collaborators stand out as relatively unusual.

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