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A Framework to Evaluate the Relationship Between Manufacturing and Information System Practices: The Effect on Competitive Capabilities and Firm Performance

by

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the Doctor of Philosophy Degree in
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An Abstract of

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The evolution of manufacturing from the industrial to post-industrial model of competition has created an organizational environment characterized by unpredictable, often radical change, destabilizing many firms' manufacturing and work system practices in the process. When I.S. practices are based on organizational practices, those firms whose manufacturing and work system practices fail to keep adequate pace with the need for change

may find their I.S. function's ability to develop effective information system strategies to be severely limited as well.

This research represents an initial cross-functional investigation between the manufacturing and information systems fields of study. A major contribution is the development of instruments designed to measure several key constructs including the work system practices of the firm, organizational involvement in I.S., the I.S. management practices of the firm, and I.S. performance.

An extensive literature review facilitated theory development. Interviews with practitioners, consultants, and academics helped to refine the questionnaire and ensured that the domain of each construct was adequately addressed. A pilot study was executed with 37 respondents from a target group of senior manufacturing managers drawn from firms of 250 employees or more, representing several different industries. The large-scale study yielded 265 responses that were used to test the generalizability of the results. The statistical methods employed include exploratory factor analysis in the instrument development phase and LISREL to test the hypothesized relationships.

The results confirm the existence of a strong positive relationship between time-based manufacturing practices and work system practices. That is, firms who implement time-based manufacturing-practices will generally exhibit greater work system standardization, formalization, routinization, and integration than those firms who do not adopt such practices. Second, this research confirms the existence of a strong positive relationship between time-based manufacturing practices and greater organizational involvement in I.S. related activities.

Third, this research confirms the existence of strong positive relationships between the work system practices of the firm and the effectiveness of its I.S. management practices. Fourth, this research confirms the existence of a positive relationship between the I.S. management practices of the firm and its competitive capabilities. The major implication of these findings being that the adoption of time-based manufacturing practices enables the development of more effective I.S. management practices which in turn contribute to the creation of greater competitive capability and firm performance.

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CHAPTER 1: INTRODUCTION

Observers of global competition have noted that firms will face increasing pressure to rethink and reinvent themselves, not only in terms of their products and services, but also in terms of their organizational structure and operational controls (Clark & Fujimoto, 1991; Bolt, 1988; Porter, 1990). This phenomena closely follows and may be explained by a general shift away from the industrial to the post-industrial model of manufacturing enterprise development and competition (Doll & Vonderembse, 1991; Huber, 1984). Industrial era manufacturing firms are characterized by a long-linked technology environment, structured by assembly lines, where manufacturing operations occur in a fixed sequence by specialized functions (Thompson, 1967). In contrast, post-industrial firms are generally characterized by an information intensive technology environment, possessing a high customer orientation, that is capable of flexible resource deployment, and contains a rich information environment of direct and continuous feedback and control.

Other authors have similarly described this phenomenon in terms of the evolution/revolution of the manufacturing organization from the industrial to information society (Gupta, 1988; Forester, 1985). They state that industrial societies are primarily concerned with the utilization of technology to produce physical products more efficiently. The goal being cost reduction through higher production volumes corresponding to a reduction in the need for skilled labor. Alternatively, they state the information society is concerned with the effective use of information and technology to create better products of higher quality. The direct concern being the final information or knowledge content of the product from which greater competitive advantage may be derived.

Ebner and Vollman (1987) have discussed the industrial to post-industrial transition in terms of the impact of the changing competitive thrust of the firm on its manufacturing information systems. In the 1960s and 1970s, they describe the competitive thrust of the firm as being low cost and marketing competence. This resulted in the adoption of basic reorder point (ROP) information systems and later material requirements planning systems (MRP) whose primary purpose was to improve the efficiency of production planning and control activities. In the 1980s, the competitive thrust of the firm changed to quality. This lead to the adoption of computing technologies such as computer aided design (CAD), computer aided manufacturing (CAM), and statistical process control (SPC) systems that assisted the firm in developing better product designs, producing products with fewer defects, and identifying the exact nature of quality problems.

In the 1990s, the competitive thrust of the manufacturing firm changed to time-based competition as these firms became more post-industrial in nature. Time-based competitors seek to reduce both product development and manufacturing throughput time in order to improve the competitive capabilities of the firm (Blackburn, 1991; Stalk & Hout, 1990; Susman & Dean, 1992). This change has required the firm of the 1990s to become more process oriented, interdependent, and information rich than those of yesterday (Rockart & Hofman, 1992).

Within these firms, the traditionally centralized information systems (I.S.) function has struggled to keep pace with the rapid transition from industrial to post-industrial manufacturing. To operate effectively, centralized organizations depend upon highly standardized, routinized, and formalized work system practices to be successful (Price & Mueller, 1986). The dynamic nature of the post-industrial manufacturing environment imposes destabilizing forces on the centralized firm's manufacturing and work systems practices (Doll & Vonderembse, 1991). The centralized I.S. function's ability to develop, implement, and maintain effective strategies on a timely basis may be severely restricted when organizational practices are in a constant state of change. Thus, many I.S. functions have become gradually more decentralized as they have sought to maintain or improve the alignment between their I.S. capabilities and diverse business unit requirements (Brown & Magill, 1994; Ebner & Volman, 1987; Jarvenpaa & Ives, 1993).

1.1 PROBLEM STATEMENT

The study of the alignment of a firm's information technology with its core business processes has recently gained greater momentum with the rise of business process reengineering (Currid, 1994; Boynton, Jacobs, & Zmud, 1992; Teng, Grover, & Fiedler, 1994). Recent I.S. research has proposed that firms gain greater competitive capability when their information systems are closely aligned with their core business processes (Brown & Magill, 1994; Henderson & Venkatraman, 1993). The concept of functional alignment is not new. A prior study measuring the alignment of the marketing and administrative functions with manufacturing found a significant and positive relationship between the strategic alignment of these functions and firm performance (Venkatraman, 1990). However, while multiple studies of general business and information systems alignment have been presented within the literature, there have been few large scale survey studies documenting the relationship between manufacturing and information system practices.

A major problem with many prior studies has been their initial assumption that the I.S. function itself is the primary source of the misalignment problems. That is, the I.S. function's failure to adapt to changing organization structures, strategies, policies, and procedures is the root cause of I.S. misalignment. Most never consider the possibility that I.S. practices, designed to reflect the firm's organizational practices, are destined to fail when the organizational practices themselves are flawed. Thus, poor organizational practices may limit I.S. performance while good organizational practices present new and exciting opportunities to improve I.S. performance.

The central tenet of this study is that the adoption of time-based manufacturing practices enhance work system stability within the post-industrial manufacturing firm. While time-based manufacturing practices may not enhance the routinization (i.e., repetitiveness) of post-industrial work, it is proposed that they do greatly enhance its integration through improved decision process management (DPM). Organizations whose managers adopt DPM seek to manage decision processes via extensive cross-functional involvement and cooperation designed to replace mechanistic, functionally controlled decision processes (Skinner, 1985). In doing so, the firm is able to achieve greater levels of standardization and formalization through improved work system integration.

This creates a more stable work system environment that is engaged in highly effective work system practices. Important opportunities for improved I.S. effectiveness are subsequently created as the I.S. function redefines its role within the firm to better serve its users. A revised set of I.S. management practices, more closely associated with the true information system requirements of the firm, commonly results. As such, end-user perceptions of I.S. performance may improve dramatically as the benefits of these revised I.S. management practices are realized in the form of enhanced competitive capabilities and improved firm performance.

1.2 RESEARCH OBJECTIVES AND CONTRIBUTION

The major objectives of this research are therefore to study (1) the direct effects of time-based manufacturing practices on the work system practices of the firm and organizational involvement in I.S., (2) the direct effects of the work system practices of the firm and organizational involvement in I.S. on the I.S. management practices of the firm, (3) the direct effects of time-based manufacturing practices and I.S. management practices on competitive capabilities, (4) the direct effects of I.S. management practices on I.S. performance, and (5) the direct effects of competitive capabilities and I.S. performance on overall firm performance. The most important linkages to be tested include the links between time-based manufacturing practices and work system practices, work system practices and I.S. management practices, I.S. management practices and competitive capabilities, and competitive capabilities and firm performance.

To test the significance of these relationships, measures of each of these constructs have either been developed or adopted. A significant contribution of this research is the development of reliable instruments to measure (1) the work systems practices of the firm, (2) organizational involvement in I.S. activities, (3) the I.S. management practices of the firm, and (4) information system performance. Other instruments, such as time-based manufacturing practices and competitive capabilities (Koufteros, 1995), and firm performance (Tracey 1996), have been adapted for use in this study.

When viewed from a practitioner's point of view, this study presents an exciting opportunity to explore the relationship between manufacturing and information system practices. Though it makes good sense, it has yet to be substantiated that the time-based manufacturing and information system practices of a firm are positively related. The substantiation of such a relationship would be an important first step in the realization that improvements in I.S. function effectiveness may be contingent upon manufacturing function effectiveness. This finding would be compatible with the basic tenets of business process reengineering and in itself an important contribution to practicing managers everywhere.

CHAPTER 2: THEORETICAL MODEL, LITERATURE REVIEW, AND HYPOTHESIS DEVELOPMENT

A key distinction between industrial and post-industrial firms is the nature of the firm's manufacturing and work systems (Doll & Vonderembse, 1991; Huber, 1984). Industrial era firms have traditionally had the luxury of a predictable, constant time dimension where manufacturers could preplan routine product and process innovations. This luxury gave them the ability to develop and implement innovations using the least costly methods and most convenient times possible. The advent of the post-industrial era eliminated this luxury as time became more compressed, variable, and volatile in nature. Firms often found themselves unable to adequately evaluate and react to the increased rate of radical innovation that has characterized the post-industrial era (Huber, 1984; Nord & Tucker, 1987).

Many authors have described the work system of the industrial-era manufacturing firm as being highly standardized, formalized, and routinized in nature. Industrial era firms sought to attain high levels of work system standardization, formalization, and routinization through the specialized, functional subdivision of work. This was made possible because of a relatively slow rate of technological change coupled with few product offerings (Braverman, 1974; Skinner, 1985; Weick, 1990). In contrast, the work systems of post-industrial firms have been described as being non-standard, informal, and non-routine in nature (Doll & Vonderembse, 1991; Huber, 1984).

When viewed from an innovation change management perspective, however, a much different assessment of the role of the work system practices of the firm emerges. Lewin's (1951) theory of change management identified three critical stages that were necessary for a successful change process to occur within organizations. The first stage, *unfreezing*, creates a climate for change through the discontinuation of existing, stable work patterns (i.e., work system standardization, formalization, and routinization). The second stage, *moving*, involves the analysis, design, and installation of the new work patterns. However, it is the final stage, *refreezing*, that institutionalizes the change that restores the equilibrium of the organization after the change has occurred.

Most prior change management research has shown that it is the refreezing stage that is most strongly associated with implementation success (Grover, Jeong, Kettinger, & Teng, 1995). The freezing stage allows for prescribed work methods (i.e., standards) and written documentation (i.e., formal knowledge) to be developed. The successful implementation and subsequent repetitive application (i.e., routine use) of new innovations within firms is dependent upon the outcome of this stage. Thus, the diffusion of new technologies may be inhibited when clear standards and written documentation fail to emerge.

A central tenet of this study is that post-industrial firms actually achieve high levels of work system standardization and formalization through the implementation of cross-functional decision processes designed to support rapid technological change across a wide range of product offerings. Cross-functional decision processes create greater work system integration, collapse traditional organizational boundaries, and promote the interdependencies of work (Gerwin & Kolodny, 1992). Thus, while formal work standards were often prescribed by management and imposed upon industrial era workers, such standards often emerge from the cross-functional decision processes engaged in by post-industrial workers.

The direct effects of a firm's work system practices on its information system management practices have been discussed extensively within the I.S. literature. The primary focus of these discussions being the need for greater alignment between the firm's business and information systems strategies, goals, and objectives (Brown & Magill, 1994; Cash, 1992; Henderson & Venkatraman, 1991; Wiseman, 1988). Misalignments between manufacturing and information systems strategies, goals, and objectives are frequently caused by changing customer demands, frequent product revisions, and rapidly evolving process capabilities (Boynton, 1992). A lack of synchronization between the two has been hypothesized to reduce the contribution of the firm's information systems from that of greater competitive advantage to that of competitive burden, decreasing organizational performance in the process (Floyd, 1990; Warner, 1987).

Previous studies have indicated that many misalignment problems can be avoided through greater end-user and cross-functional involvement in I.S. (Barki & Hartwick, 1994; Doll & Torkzadeh, 1990; Vroom & Jago, 1988). The primary reason being that increased end-user and cross-functional involvement has been shown to create excellent opportunities for organizational learning. Firms that capitalize on these opportunities are able to explore and adopt new principles, assumptions, and paradigms, turning them into competitive advantage much more quickly than those firms with lower levels of end-user and cross-functional involvement (Stein & Vandenbosch, 1996).

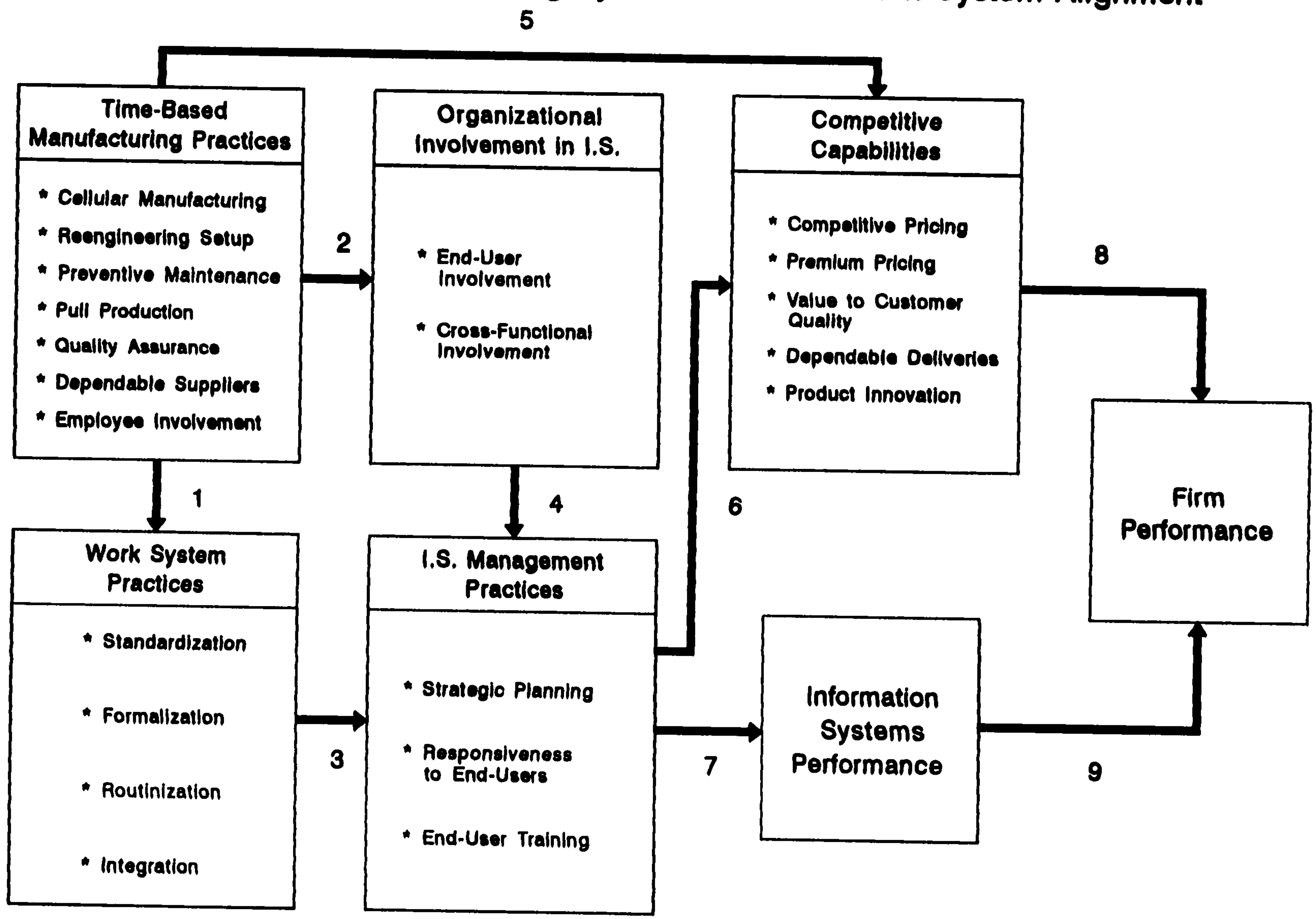
In a recent empirical study, Koufteros (1995) found significant and positive direct effects between the time-based manufacturing practices of post-industrial firms and their level of competitive capabilities. A similar relationship is proposed to exist between the I.S. management practices of such firms and their level of competitive capabilities. While the role of information technology may vary from firm to firm, there are many alternative forms of competitive advantage that may be derived from the information systems strategies and practices in place within most firms (Earl, Sampler, & Short, 1995). The assessment of the relationship between the I.S. management practices of the firm and its competitive capabilities is of great importance in this study.

The relationship of the competitive capabilities of the firm to firm performance has been widely discussed. Tracey (1996) found that improvements in the firm's capacity to satisfy customers allowed it to react more effectively to the growing rate of market change and market variety, creating greater customer satisfaction and financial performance in the process. While Tracey's measures of the firm's capacity to satisfy customers are not the same as Koufteros' measures of competitive capabilities, they share many similarities. Thus, it is logical to hypothesize that competitive capabilities are directly and positively related to firm performance.

2.1 THEORETICAL MODEL

The model presented in **Figure 2.1** displays the proposed relationships between the constructs which are of central importance to this research. These constructs (i.e., Time-Based Manufacturing Practices, Work System Practices, I.S. Management Practices, Organizational Involvement in I.S., Competitive Capabilities, I.S. Performance, and Firm

Figure 2.1. Manufacturing System and Information System Alignment



Performance) are defined in the following sections. The numbers next to the lines correspond to the major hypotheses that will be specified in the following sections.

The central relationships to be examined, as shown in **Figure 2.1**, pertain to:

1. The effect of *TIME-BASED MANUFACTURING PRACTICES* (i.e., Cellular Manufacturing, Reengineering Setup, Preventive Maintenance, Pull Production, Quality Assurance, Dependable Suppliers, and Employee Involvement) on the firm's *WORK SYSTEM PRACTICES* (i.e., Standardization, Formalization, Routinization, and Integration).
2. The effect of *TIME-BASED MANUFACTURING PRACTICES* on the firm's level of *ORGANIZATIONAL INVOLVEMENT IN INFORMATION SYSTEMS* (i.e., End-User Involvement in I.S. Activities, Cross-Functional Involvement in I.S. Activities).
3. The effect of *WORK SYSTEM PRACTICES* on the firm's *I.S. MANAGEMENT PRACTICES* (i.e., I.S. Planning Effectiveness, I.S. Function Responsiveness, I.S. Training Comprehensiveness).
4. The effect of *ORGANIZATIONAL INVOLVEMENT IN INFORMATION SYSTEMS* on the firm's *I.S. MANAGEMENT PRACTICES.*
5. The effect of *TIME-BASED MANUFACTURING PRACTICES* on the firm's *COMPETITIVE CAPABILITIES* (i.e., Competitive Pricing, Premium Pricing, Value to Customer Quality, Dependable Deliveries, Product Innovation).
6. The effect of *I.S. MANAGEMENT PRACTICES* on the firm's *COMPETITIVE CAPABILITIES.*

7. The effect of the firm's *I.S. MANAGEMENT PRACTICES* on *INFORMATION SYSTEM PERFORMANCE.*

8. The effect of *COMPETITIVE CAPABILITIES* on *FIRM PERFORMANCE.*

9. The effect of *INFORMATION SYSTEM PERFORMANCE* on *FIRM PERFORMANCE.*

2.2 TIME-BASED MANUFACTURING PRACTICES

Time-based manufacturers not only seek to reduce product development time, they also seek to reduce production throughput time as well (Blackburn, 1991; Stalk & Hout, 1990). The measures of time-based manufacturing practices to be used in this study include cellular manufacturing, reengineering setup, preventative maintenance, pull production, quality assurance, dependable suppliers, and employee involvement. They are based upon a set of time-based manufacturing instruments developed by Koufteros (1995).

(1) Cellular Manufacturing. Post-industrial manufacturing firms often adopt product oriented layouts which enable families of products to be produced by a group of machines in a manufacturing cell. Because all parts produced in a cell share similar design or manufacturing process characteristics, a minimal amount of time is required for the setup of machines. The machines themselves are usually general purpose in nature, are closely positioned to minimize the physical movement of parts between machines, and may be operated by as few as one operator. Firms that have adopted the cellular manufacturing approach have experienced a wide variety of improvements including decreased inventory levels, decreased product throughput time, increased quality, and increased flexibility (Fry, Wilson, & Breen, 1987; Hyer & Wemmerlov, 1984; Pullen, 1976; Wemmerlov & Hyer, 1989).

(2) Reengineering Setup. The major focus of reengineering setup is the reduction in setup time penalties incurred when the firm switches production between products. This is commonly achieved through the implementation of the single minute exchange of die (SMED) system which can result in significant reductions in setup time when implemented properly. The SMED system divides setup activities into internal activities which may only be done when a machine is down and external activities which may be done while a machine is running. Internal setup activities are minimized through the external creation of dies which may be installed with little or no machine adjustment effort (Shingo, 1985).

(3) Preventative Maintenance. Improvements in throughput time may also be achieved through increased preventative maintenance efforts. Machinery, tools, and other equipment that has not been properly maintained may become unreliable causing unnecessary defects, operate at a reduced speed, or induce work stoppages. In any case, the result is usually decreased product throughput time, missed production deadlines, and increased product cost. All of which could be avoided by allocating time for preventative maintenance and teaching operators to perform minor maintenance tasks on a regular basis (Bockerstette & Shell, 1993; Nakajima, 1988; Schonberger, 1986).

(4) Pull Production. Industrial-era manufacturing systems are generally characterized as processing large product lots which are pushed through the system according to a production schedule which may be fixed for weeks or months in advance. As such, production is scheduled according to the most efficient processing sequence, not according to the sequence which will best meet customer demand. This results in large work in process queues, which may clog production lines and further reduce the firms flexibility to respond to changing customer demand. In contrast, post-industrial manufacturing systems often engage pull production systems which are driven by customer demand. Pull systems employ simple signal mechanisms such as kanban cards or bins to control material movement and machine processing. Because material buildup between work centers is limited, the overall time parts stay in the system is reduced. This allows for greater manufacturing flexibility in responding to rapidly changing customer demand (Hall, 1987; Schonberger, 1986; Shingo, 1985).

(5) Quality Assurance. Quality assurance efforts include the use of a wide variety of tools such as statistical quality control or methods such as employee involvement and empowerment. Quality assurance efforts are targeted toward improving customer satisfaction, reducing throughput time, and reducing costs. An essential element of Juran's quality trilogy (i.e., quality planning, quality control, and quality improvement) is that a reduction in time spent recovering from quality problems results in a decrease in total product throughput time. Thus, the major focus of quality improvement efforts should be the prevention of defects to avoid rework completely (Deming, 1982, 1986; Evan & Lindsay, 1989; Juran, 1989)

(6) Dependable Suppliers. Doll & Vonderembse (1991) view suppliers as an integral part of the post-industrial manufacturing system. The three measures of supplier performance which are most commonly cited in the purchasing literature are material and component delivery reliability, quality, and part count accuracy. Supplier dependability in meeting these performance measures is therefore critically important in reducing throughput time and improving manufacturing capabilities (Blackburn, 1991; Chapman & Carter, 1990;

Clark, 1989; Handfield & Pannesi, 1995; Ho & Carter, 1988).

(7) **Employee Involvement.** Employee involvement programs include such activities as setup time reduction, better customer service, quality improvements, and inventory reduction (Hall, 1987; Showalter & Mulholland; 1992). Pace (1989) has identified three general categories of employee involvement programs including parallel suggestion involvement, job involvement, and high involvement work systems. These programs may utilize suggestion boxes, employee teams, goal setting, gainsharing and other tools or methods to increase overall levels of employee involvement. The ultimate goal again being reduced throughput time and improved manufacturing capabilities.

2.3 WORK SYSTEM PRACTICES

The measures of the firm's work system practices that will be used in this study include standardization, formalization, routinization, and integration. Each of these factors has been identified previously as an important dimension of the work systems practices construct (Doll & Vonderembse; Gerwin & Kolodny, 1992; Huber, 1984; Skinner, 1985).

(1) **Standardization.** The term standardization is used to refer to either product or process standardization when discussed in a manufacturing context. In terms of the work system of the firm, standardization refers to the uniformity of operating policies, procedures, and methods used to build products. These policies, procedures, and methods may emerge over time by consensus in the form of unwritten work rules (i.e., commonly accepted practices) or they may be prescribed by management as mandatory (i.e., prescribed work practices) (Price & Mueller, 1986).

The value of work system standardization in the industrial firm has often varied by the maturity of the product(s) being produced. In the early stages of a product's life, before its final form became fixed, a premature rush toward process standardization could severely limit its final design and capabilities. However, during the growth stages of a product's life, after its final form had become fixed, process standardization allowed for greater learning and skill development through the replication of tasks. Greater learning and skill development allowed industrial era firms to achieve high levels of efficiency and further standardization through experience (i.e., learning) curve effects (Bodde, 1976).

A major problem with the industrial model of standardization is the false assumption that the firm will be able to sell increasingly higher volumes of products at a lower cost on an indefinite basis. In today's global manufacturing environment, time-based competition renders many products and processes obsolete well before the lower levels of the experience curve can be explored. Many time-based competitors find their products and processes have become inadequate or obsolete before this state is ever reached (Blackburn, 1991; Bockerstette & Shell, 1993; Stalk, 1988). Thus, a mechanistic approach of first developing and then implementing prescribed standards is not a realistic one for most firms.

Most post-industrial manufacturers have instead chosen to standardize around the time-based model of competition. Many have adopted cellular manufacturing techniques enabling their firms to flexibly produce a wide variety of products, in variable quantities, using machinery and equipment standardized around similar groups of products (Gerwin & Kolodny, 1992; Stalk, 1988; Wemmerlov & Hyer, 1989). The use of common components within product groups has led to greater modular standardization (Bodde, 1976; Duimering, Safayeni, & Purdy, 1993). Many firms have also adopted computer integrated manufacturing (CIM) strategies that enable them to implement flexible manufacturing technologies capable of operating a job shop like an assembly line or continuous processing environment (Adler, 1988; Wheelwright & Hayes, 1985).

Such firms often implement preventive maintenance programs as well, allowing them to perform machine and equipment maintenance in a scheduled, uniform manner (Bockerstette & Shell, 1993). Many also implement standardized quality assurance methods designed to prevent product defects and to avoid rework and scrap entirely (Evan & Lindsay, 1989). Finally, the majority of these firms choose suppliers based upon their ability to meet uniform material requirements as well as to maintain dependable delivery dates (Blackburn, 1991; Chapman & Carter, 1990).

(2) Formalization. Formalization refers to the degree to which the standard norms of an organization are explicitly formulated (i.e., written down). Formalization may take the shape of written operating procedures, job codification, employee handbooks, and other types of documentation (Price & Mueller, 1986).

Formalization and standardization are quite different dimensions that are highly related. While standard operating procedures and work methods may emerge by consensus or be prescribed by management, they are subject to great misinterpretation and often lose meaning as they are communicated orally from one person to the next. Over time, organizations may forget their purpose, including the many reasons why they were developed originally (Levitt & March, 1988). When formalized, their meaning becomes fixed allowing for the creation of a more consistent definition with a historical record of their evolution maintained. Thus, the forgetting of learned knowledge is reduced through greater formalization with the full meaning and benefits of the written documentation shared freely between departments, across plants, and throughout the firm (Argotte & Epple, 1990; Levitt & March, 1988).

Formalization can be both a positive and/or a negative force within the firm. On one hand it can help clarify the unknown, aiding individual workers to learn new operating procedures and production methods quickly. For example, formalization plays a positive role in the large scale implementation of preventive maintenance and quality assurance programs through the capture and clarification of how, when, and why these processes should take place. On the other hand, formalization can inhibit the innovation process through the adoption of mechanistic practices that promote the functional versus cross-functional development and implementation of new ideas (Burns & Stalker, 1961; Walsh, 1997). Great care is therefore required to avoid the creation of inflexible policies and procedures that favor improved functional efficiencies over enhanced firm performance.

(3) **Routinization.** Doll & Vonderembse (1991) describe the work systems of industrial firms as being highly routine in nature. In such firms, routinization was considered to be a co-requisite requirement for the standardization and formalization of work (Skinner, 1985; Thompson, 1967). Routinization refers to the degree to which a job is performed over and over again. For example, a routine production environment may be characterized by workers who repeatedly perform the same tasks, operate the same machinery and equipment, use the same tools, and follow the same procedures on a daily basis. As such, a high degree of repetition is thought to signify a highly routine job while a low degree of repetition signifies

a highly non-routine job (Price & Mueller, 1986).

An important contributor to greater routinization in industrial era firms was the implementation of efficiency oriented manufacturing technologies. In contrast, a significant feature of post-industrial manufacturing firms is the less routine nature of their machine, equipment, and process technologies allowing for the continuous processing of customized products. These technologies enable post-industrial firms to produce less standard, low volume, often unique products in a semi-standard, quasi-continuous manner that formally could only be done in job shops (Huber, 1984; Weick, 1990). Thus, while post-industrial firms may never recapture the high levels of routinization enjoyed by their industrial era predecessors, the more flexible and responsive manufacturing technologies and processes they employ has allowed them to maintain a moderate degree of repetitiveness.

(4) Integration. Industrial era technologies are generally deterministic in nature with clear cause and effect relationships related to the usage and outcomes of these technologies. In contrast, post-industrial era technologies operate in a stochastic environment dominated by randomly occurring and unpredictable events. Their processes and materials may never be fully understood before the next revision of a product or process is implemented due to continuous improvement philosophies (Weick, 1990). As the firm's management struggles to gather and process more information, make increasingly complex decisions, and implement these decisions on a more timely basis, the delegation of decision making to lower level groups of workers begins to occur. The increased interdependence and cross-training of workers that results gradually diminishes existing job and work group boundaries, increases individual task meaningfulness, and expands the exchange of information between individual work group members (Susman, 1990).

In this process, workers often join together to form cross-functional teams for decision making purposes. When workers join multiple teams, these teams become inter-linked as their members share information and mutual learning experiences. The linkages between these teams may be intended (i.e., prescribed by management) or unintended (i.e., occur by chance). In any case, they provide a valuable service by facilitating greater organizational learning while serving as a forum for integrated decision making (Romme, 1997). This allows for the overlapping of product and process development activities governing the exchange of information and the execution of previously sequential activities in parallel (Krishnan, Eppinger, & Whitney, 1997).

Greater work system integration through cross-functional involvement and decision making is necessary to effectively implement planned change. Planned changes are proposals for action that alter organizational practices. They promote the revitalization of organizations by responding to demands for new products, services, internal operations, and organizational policies (Nutt, 1986). The more discontinuous the change, the greater the level of cross-functional interaction, mutual support, and decision making that is required for its successful implementation (Shrivastava & Souder, 1987).

For example, the implementation of quality function deployment (QFD) requires intense vertical and horizontal integration to effectively drive customer requirements down and throughout the firm (Sullivan, 1986). Quality planning, improvement, and control all require team-based solutions that capture the collective knowledge and experience of the firm. The QFD implementation process is considered much too large and complex for any single person or department to manage on their own (Imai, 1986; Juran, 1989; Robinson, 1991; Flynn, Schroeder, & Sakakibara, 1994). Therefore, the greater the firm's level of work system integration the more likely it will be to succeed in the implementation of planned change such as quality function deployment.

2.3.1 Research Hypothesis 1

It is hypothesized that time-based manufacturing practices have a positive impact on the work system practices of the firm. For example, time-based manufacturing practices such as cellular manufacturing may result in greater standardization (i.e., modular standardization by similar component characteristics), quality assurance programs such as TQM may result in greater formalization (i.e., extensive quality process documentation), reengineering setup may result in greater routinization (i.e., the frequent, repetitive interchange of dies), and employee involvement programs may result in greater work system integration (i.e., group decision processes).

Hypothesis 1: There is an overall positive relationship between the Time-Based Manufacturing Practices and the Work System Practices of the firm.

2.4 ORGANIZATIONAL INVOLVEMENT IN INFORMATION SYSTEMS

In years past, user involvement in information systems projects and activities primarily took place at a senior management level via executive steering committees (Doll, 1985). These senior managers were seldom the actual end-user of the firm's information systems and may have never actually used them to perform work. The end-users and lower level managers who actually used these information systems were seldom consulted, much less involved in the firm's efforts to evaluate and select new information technologies and/or application systems.

As personal computers and network technologies evolved, the characteristics of today's I.S. environment and information technologies changed as well (Rockart & Hofman, 1992). Today's information technologies must be both flexible and widely adaptable to support constantly changing business requirements. This has led to distinctions between computing technologies and their use becoming blurred over time. Both end-users and line managers must now work together in partnership with the I.S. function to create joint ownership of new applications for development and implementation success (Earl, 1993).

(1) End-User Involvement. Information system usage has simultaneously become more specialized according to the intellectual content of individual end-user tasks (Benjamin & Blunt, 1992). This specialized usage often requires greater levels of end-user involvement to successfully develop and implement new applications. Greater levels of end-user involvement have in turn been associated with improved I.S. management practices, greater end-user satisfaction, and improved information systems success (Amoaka-Gyampah & White, 1993; Doll & Torkzadeh, 1989).

End-user involvement is generally considered to be important because it helps ensure accurate requirements specifications, facilitates the development of relevant application designs, and fosters a greater sense of empowerment and ownership among users of I.S. services. By providing end-users additional opportunities to influence I.S. decisions, end-user involvement is thought to foster a greater sense of control, increase motivation and satisfaction, and reduce resistance toward organizational change (Kappelman & Guynes, 1995). It is therefore thought to have direct and positive effects on the I.S. management practices of the firm.

As firms seek to better integrate organizational processes, more interactive and highly collaborative work tools are required to better support these processes. Sophisticated information system applications that allow end-users to simultaneously create, share, and manage large amounts of information have become increasingly more important (Benjamin & Blunt, 1992). Within such an environment, greater cross-functional involvement in I.S. activities is also required to reduce functional isolation and to stimulate organizational process improvements (Delligatta & Umbaugh, 1993).

(2) Cross-functional Involvement. The uses and consequences of information technology often emerge unpredictably to form complex social interactions. Decisions related to the computing infrastructure of the firm may be segmented and discontinuous in nature due to conflicting organizational objectives and preferences (Markus & Robey, 1988). The diffusion of technology is moderated by the nature of the organizational context in which it is deployed throughout the firm. Organizational context consists of a firm's structure, culture, and employment contracts and can be thought of as characterizing the nature of its resistance to change. Management's role in the implementation of new technologies is therefore to modify or alter organizational context to minimize resistance (Markus, 1983).

From an information technology perspective, implementation is defined as "an organizational effort directed toward diffusing appropriate information technology (I.T.)

within a user community" (Cooper & Zmud, 1990). Implementation success occurs when commitment to change exists and an implementation actually occurs. This requires that the diverse interests of vested I.T. stakeholders be managed jointly for a successful implementation to occur. Cross-functional involvement is therefore thought to be a critical component of implementation success, especially during the initiation, adoption, and adaption stages of I.T. implementation (Kwon & Zmud, 1987).

Zuboff's (1988) work on the effects of the ***automating*** (i.e., industrial era) versus ***informating*** (i.e., post-industrial era) powers of computer technology on the nature and evolution of work is closely related to this discussion. While acknowledging the past successes of technology as an automating force, she presents a strong case for the increased use of technology as an informating force. The informating power of technology is unleashed when workers are allowed to "act-with" co-workers to process information, make decisions, and create solutions to problems (Zuboff, 1988). As such, the organization's capacity to learn and innovative is significantly enhanced through greater levels of cross-functional involvement, allowing it to more fully realize the potential of intelligent technologies (Cohen & Levinthal, 1990).

2.4.1 Research Hypothesis 2

Time-based manufacturing practices are hypothesized to positively impact organizational involvement in I.S. For example, greater employee involvement may result in increased end-user involvement in I.S. via their participation in the development and implementation of manufacturing information systems. Quality assurance improvements may result in greater cross-functional involvement in I.S. as the firm becomes more concerned with issues such as enterprise-wide data management, the integration of software applications, and the development of I.S. policies and procedures.

Hypothesis 2: There is an overall positive relationship between the Time-Based Manufacturing Practices of the firm and Organizational Involvement in Information Systems.

2.5 INFORMATION SYSTEMS MANAGEMENT PRACTICES

The I.S. organization's ability to develop and maintain a stable set of information systems (I.S.) management practices is severely impacted by increasing global and time-based competition. Frequent misalignments between manufacturing system and information system management practices have forced many firms to adopt more proactive and flexible approaches to managing their information systems and technologies. This may explain why some firms fall into a pattern of decentralizing their information systems only to recentralize them again at a later date and vice versa (Brown & Magill, 1994). It may also explain why some firms choose to downsize or outsource their information system capabilities only to find themselves reversing this decision at a later date.

While the decisions to downsize or outsource are quite different, both reflect a high degree of organizational dissatisfaction with the I.S. management practices of the firm. The important I.S. management practices that most influence these decisions include: (1) the relative effectiveness of the I.S. strategic planning process and its ability to generate clear I.S. mission and vision statements, define specific I.S. objectives, and identify a clear scope of operating responsibility (Doll & Doll, 1992; Huber, 1993; Huff, 1991; Powell, 1993; Rowley & Smiley, 1993); (2) the responsiveness of the I.S. function in promptly resolving end-user questions, issues, and concerns (Benko, 1993; Dearden, 1987; Lowell, 1992; Rowley & Smiley, 1993); and (3) the comprehensiveness of the information system training delivered to end-users (Harrison & Rainer, 1992; Huber, 1993; Raho & Belohlav, 1985).

(1) I.S. Strategic Planning. Formal I.S. planning is critical because it is where I.S. strategies are both developed and linked to corporate and functional strategies. This is consistent with Parson's (1983) contention that the firm's business strategy should lead the development and adoption of new information and automation technologies. Specific I.S. goals and objectives emerge, technologies are chosen, and policies and procedures adopted during the I.S. strategic planning process. (Davis & Olson, 1985; Teng, Grover, & Fiedler, 1994; Henderson & Venkatraman, 1993; Tayntor, 1993).

Better performing organizations exhibit a greater degree of key personnel involvement in strategic planning activities (Veliyath & Shortell, 1993). Therefore, effective information systems planning involves end-users and explores multiple detailed scenarios which integrate complex business, technical, application, and cost issues (Fried, 1995). Furthermore, the integrative nature of the I.S. planning process requires that it reach beyond these issues to incorporate the politics and personalities of the enterprise in the final solution as well (Hodge, 1989). Thus, the final I.S. plan must project a clear vision of the future business and information systems organization and the ways in which the firm must operate these systems to be effective in the future (Rockart & Hofman, 1992).

(2) I.S. Responsiveness to End-Users. A lack of responsiveness to end-user issues, questions, and concerns by the I.S. function is commonly cited as one of the primary reasons behind I.S. downsizing and outsourcing initiatives. Many end-users are frustrated by the inability of their I.S. departments to deliver useful project results within budget and on time. They are further frustrated by these same I.S. departments' delays in fixing computer hardware and software problems and in supporting special information reporting requests. As such, these I.S. departments are often the focus of intense end-user dissatisfaction and the target of extremely poor end-user performance evaluations (Doll & Doll, 1992; Due, 1992; Kallman & Sanford, 1989; Powell, 1993; Rowley & Smiley, 1993).

(3) **I.S. End-User Training.** The level of end-users' computer literacy and experience is increasingly being recognized as an important enabler of information system implementation success (Currid, 1994). Of particular concern is the availability of PC-based educational and training programs for end-users to improve or enhance their cognitive computing skills (Raho & Belohlav, 1985). End-user education involves teaching problem solving approaches including abstract reasoning while end-user training involves teaching specific skills to solve problems (Nelson, 1991). The attainment of both is especially critical in IS environments where the individual cognitive skills, necessary for continued learning in an end-user computing environment, vary greatly from their optimum desired levels (Harrison & Rainer, 1992).

Effective end-user education and training can delivery many benefits that extend far beyond the improvement of computing knowledge or the development of application specific skills. It can enable the rapid acceptance of new technologies and software applications. It can empower users to experiment more freely and motivate them to deploy new technologies more quickly throughout the firm. Finally, it can foster more positive attitudes toward the I.S. function resulting in improved levels of end-user satisfaction and I.S. performance (Kappleman & Guynes, 1995).

2.5.1 Research Hypothesis 3

It is hypothesized that the work system practices of the firm have a positive impact on the I.S. management practices of the firm. For example, the more standardized the manufacturing practices of the firm, the more likely the I.S. function will be able to create comprehensive end-user information system training programs The more routine the manufacturing practices of the firm, the more likely the I.S. function will be able to respond to end-user issues, questions, and concerns in a timely manner. Finally, the more formalized the manufacturing practices of the firm, the more effective the I.S. function will be in conducting planning processes such as the development of written I.S. objectives that are closely linked to manufacturing objectives.

Hypothesis 3: There is an overall positive relationship between the Work System Practices and I.S. Management Practices of the firm.

2.5.2 Research Hypothesis 4

It is hypothesized that organizational involvement in I.S. will have a positive impact on the I.S. management practices of the firm. For example, greater end-user involvement may result in a more responsive I.S. organization that better understands its users' computing requirements while greater cross-functional involvement may result in a more effective I.S.

strategic planning effort.

Hypothesis 4: There is an overall positive relationship between Organizational Involvement in I.S. and the I.S. Management Practices of the firm.

2.6 COMPETITIVE CAPABILITIES OF THE FIRM

Industrial-era strategists have argued that the optimal way for firms to compete successfully is to select a single strategy such as cost or differentiation (Porter, 1990). Others have argued that firms may successfully use more than one strategy at a time to maximize overall firm performance while carefully balancing the many trade-offs which may negatively affect firm performance (Skinner, 1969). However, more recent research indicates that firms may compete on multiple dimensions, employing many different strategies with no tradeoffs among strategic objectives required (Ferdows & De Meyer, 1990; Roth & Miller, 1992). The measures of competitive capability which will be used in this study include competitive pricing, premium pricing, value to the customer, dependable deliveries, and product innovation. They were adapted from a proven set of time-based manufacturing instruments developed by Koufteros (1995).

(1) Competitive Pricing. A firm's ability to competitively price products is a direct reflection of its ability to withstand competitive pressure based upon low price. This ability is essentially limited by the firm's product development, production, marketing, and overhead costs (Giffi, Roth, & Seal, 1990).

(2) Premium Pricing. A firm's ability to command premium prices is a function of its capability to develop, produce, and market products quickly. These products must have the features and quality that customers want and be delivered to market first, enabling these firms to capture those customers willing to pay premium prices before competitors are able to do so. A second way the firm is able to charge premium prices is for the development of more innovative, superior product designs and performance (Blackburn, 1991; Karagozoglu & Brown, 1993; Rosenau, 1990; Stalk, 1988; Stalk & Hout 1990).

(3) Value to the Customer. Value to the customer measures the extent to which the manufacturing enterprise is capable of offering product quality and performance that will create high value to its customers (Hall, Johnson, & Turney, 1991). At a more detailed level, Garvin (1984) defines value to the customer as including product performance, reliability, conformance, durability, aesthetics, features, serviceability, and perceived quality.

(4) Dependable Deliveries. Dependable deliveries measures the extent to which the manufacturing enterprise is capable of meeting customer delivery requirements. The variable nature of customer demand has traditionally been accommodated by holding large inventories of finished goods, component parts, and raw materials. Time-based competition quickly renders existing products obsolete, requiring firms to reduce their on-hand stock of finished goods and service parts to the lowest possible levels (Stalk, 1988). Firms must now anticipate and understand the current and future needs of customers, then develop, produce, and market new products quickly. This requires greater manufacturing flexibility than was ever needed before (Giffi et al., 1990; Hall et al., 1991; Mescal, 1991; Miller, DeMeyer, & Nakin, 1992), As such, the capability of firms to respond quickly to a constantly changing product mix and production volumes is severely tested in the post-industrial manufacturing environment.

(5) **Product Innovation.** Product innovation measures the capability of the firm to introduce new products and services into the marketplace in response to customer demands. True innovations create new markets, support freshly articulated customer needs, and demand new channels of distribution and aftermarket support (Abernathy & Clark, 1985; Kanter, 1983). A firm's rate of product innovation is often driven by the pace of technological change requiring firms to bring new products to market quickly (Blackburn, 1991). The fiercely competitive environment that post-industrial firms operate in requires these firms to innovate frequently and in small increments (Clark & Fujimoto, 1991). A firm's speed of product introduction is therefore used to measure its effectiveness in converting new ideas into products. The number of new products or enhancements to existing products that a firm introduces within a given time period is used to measure its rate of innovation (Mescal, 1991).

2.6.1 Research Hypothesis 5

The positive relationship between time-based manufacturing practices and competitive capabilities has been empirically tested and found to exist by Koufteros (1995). This relationship will be tested primarily to verify that the modified time-based manufacturing and competitive capabilities instruments adapted for this study provide results consistent with Koufteros' original work.

Hypothesis 5: There is an overall positive relationship between the Time-Based Manufacturing Practices and Competitive Capabilities of the firm.

2.6.2 Research Hypothesis 6

The relationship between the I.S. management practices of the firm and its competitive capabilities is of particular interest in this study. Many authors have discussed the relationship between the I.S. management practices of the firm and the creation of strategic advantage through improved levels of competitiveness (Cash, McFarlan, McKenny, & Applegate, 1992). However, few have demonstrated this relationship to exist empirically.

Hypothesis 6: There is an overall positive relationship between the Information Systems Management Practices and Competitive Capabilities of the firm.

2.7 INFORMATION SYSTEMS PERFORMANCE

Management satisfaction is generally based upon the I.S. function's ability to facilitate better decision making (Raghunathan & Raghunathan, 1996). The importance of management satisfaction will vary according to whether the firm's information technology is strategic and can be shown to effect overall firm performance or is non-strategic with little effect on performance. Non-strategic I.S. departments are vulnerable to budget cuts if they are perceived to contribute little to the firm's bottom line (Miranda & Tellerman, 1993).

The challenge faced by the I.S. function is to develop clear, objective measures of I.S. performance that are both quantitative and qualitative in nature. Manufacturing information technologies must quantitatively demonstrate how their use facilitates the reduction of such things as direct labor, product defect, or product design costs (Costea, 1990). In addition, the I.S. function must also demonstrate support for non-routine decision making or reduced end-user effort for standard decision process (Laudon & Laudon, 1997). Only then will end-users express satisfaction with the services and benefits provided by the I.S. function.

Previous studies have documented the relationship between I.S. strategy and business strategy (Cash et al., 1992; Wiseman, 1988). Management perceptions of I.S. performance are strongly influenced by the degree of alignment between the two (Henderson & Venkatraman, 1993, Teng et al., 1994). Other research has shown that the level of responsiveness of the I.S. function to end-user issues, questions, and concerns greatly affects management perceptions of I.S. performance (Doll & Doll, 1992; Due, 1992; Rowley & Smiley, 1993). Last of all, the degree and quality of end-user training has been found to enhance or limit end-users' ability to use information technologies effectively also affecting management perceptions of I.S. performance (Harrison & Rainer, 1992).

2.7.1 Research Hypothesis 7

The information systems practices of the firm are hypothesized to positively impact management perceptions of I.S. performance. Better performing I.S. organizations facilitate better decision making, meet end-user expectations, and create an environment where the I.S. function is perceived as enhancing the manufacturing function's ability to support overall firm strategies, goals, and objectives. In contrast, poor performing I.S. organizations negatively impact management perceptions of I.S. performance.

Hypothesis 7: There is an overall positive relationship between the Information Systems Management Practices and Information Systems Performance of the firm.

2.8 FIRM PERFORMANCE

An important goal of the firm is to satisfy customers (Innis & LaLonde, 1994). The measurement of customer satisfaction is important to understand how and why your customers are (or are not) satisfied with your firm's products and services. This knowledge is critical in understanding existing customer perceptions related to product quality and value, understanding how to retain existing customers, and understanding how to gain new customers through satisfied customers' referrals. Firms that satisfy customers regularly develop a loyal following that insures continued sales and profitability for many years. However, high levels of customer satisfaction do not always result in increased sales or greater market share and it is important to develop additional measures of firm performance (Heskitt, Jones, Loveman, Sasser, & Schlesinger, 1994; Whiteley, 1991).

Therefore, perceptual measures of financial performance such indicators as sales growth, market share gain, return on investment (ROI), product profitability, and the competitive position of the firm will be used as well. An instrument, developed by Tracey (1996), has been adopted to measure firm performance. It included perceived measures of both customer satisfaction and financial performance. The instrument has been tested and proven both valid and reliable.

2.8.1 Research Hypothesis 8

Both Koufteros (1995) and Tracey (1996) hypothesized that the competitive capabilities of the firm are positively related to firm performance. Customers demand custom products, at lower prices, delivered at ever faster response times. The existing literature suggests that the economic penalties for being late to market include lower market share and reduced profit margins (Hendricks & Singhal, 1997). Tracey did test some aspects of this hypothesis and found a significant, positive relationship to exist. However, his study did not test Koufteros' full competitive capabilities instrument, excluding several key dimensions in the process. As such, this study seeks to assess the relationship between the competitive capabilities of the firm and firm performance using all five of Koufteros' original dimensions.

Hypothesis 8: There is an overall positive relationship between the Competitive Capabilities of the firm and Firm Performance.

2.8.2 Research Hypothesis 9

Many authors have hypothesized the existence of a positive relationship between information systems performance and firm performance (Cash et al., 1992; Wiseman, 1998). This study seeks to evaluate whether such a relationship actually exists within manufacturing firms. While intuitively sound, it is not known if I.S. function performance directly impacts overall firm performance or if I.S. function performance indirectly affects firm performance via its impact on the competitive capabilities of the firm.

Hypothesis 9: There is an overall positive relationship between the Information Systems Performance of the firm and Firm Performance.

CHAPTER 3: INSTRUMENT DEVELOPMENT
PHASE ONE - ITEM GENERATION AND PILOT STUDY

Figure 2.1 illustrates the nine hypothesized relationships to be tested between the following seven constructs: (1) time-based manufacturing practices, (2) work system practices, (3) organizational involvement in I.S., (4) I.S. management practices, (5) competitive capabilities, (6) information systems performance, and (7) firm performance. The major contribution of this research is the development of four instruments designed to measure the work system practices, organizational involvement in I.S., I.S. management practices, and I.S. performance of the firm. The development and pilot testing of these instruments will be discussed in greater detail in **Sections 3.3** and **3.4**. Instruments proven to be valid and reliable were either adapted from Koufteros (1995) to measure time-based manufacturing practices and competitive capabilities or from Tracey (1996) to measure overall firm performance. These instruments will be discussed further in **Section 3.4.**

The instrument development process involved multiple steps, the first being an extensive review of the relevant manufacturing and information systems literature. The literature review facilitated new theory development, construct definition, and the identification of useful measures developed previously. The second step involved conducting structured interviews with four practicing managers from manufacturing firms (three production managers and one product development manager) to further refine the definitions and content of each construct being developed. In the third step, input was requested in the form of a pre-pilot involving an additional three practicing production managers and eight academics experts from the fields of operations management and industrial engineering. These individuals were asked to comment on the appropriateness of the research constructs including the methods and measures to be used. The final step involved conducting a pilot study targeted toward senior and executive level manufacturing managers. These steps were taken to insure the content validity, reliability, and brevity of the instruments developed, as well as their internal and external validity.

3.1 ITEM GENERATION

The content validity of a measure depends on the proper formulation of measurement items that encompass the entire content domain of a variable. A measure has content validity if both the research subjects and the researchers agree that the measurement items contained within an instrument cover the major aspects of the variable being measured (Nunnally, 1967). A list of potential items was generated for each variable after an extensive literature review. Each item was designed to measure a particular dimension of an individual construct.

Potential WORK SYSTEM PRACTICES (i.e., Standardization, Formalization, Routinization, and Integration) items were developed based upon a review of the industrial and post-industrial manufacturing literature (e.g., Doll & Vonderembse, 1991; Forester, 1985, Gupta, 1988, Huber, 1984, Skinner, 1985). The work of Price and Mueller (1986) on organizational measurement strongly influenced this process. Potential items designed to measure ORGANIZATIONAL INVOLVEMENT IN I.S. (i.e., End-User Involvement in I.S.

and Cross-Functional Involvement in I.S.) were developed from a review of the end-user involvement literature (e.g., Dodd & Carr, 1994; Doll & Torkzadeh, 1989; Kappelman & Guynes, 1995; Manella, 1993) and the implementation literature (e.g., Cooper & Zmud, 1990, Kwon & Zmud, 1987, Markus, 1983; Zuboff, 1988). Finally, items designed to measure I.S. MANAGEMENT PRACTICES (i.e., Strategic Planning, Responsiveness to End-Users, and End-User Training) were developed from the I.S. strategic planning literature (e.g., Davis & Olson, 1985; Parson, 1983; 1994; Henderson & Venkatraman, 1993; Tayntor, 1993.), the I.S. downsizing and outsourcing literatures (e.g., Benko, 1993; Doll & Doll, 1992; Huff, 1991; Loh & Venkatraman, 1992; Suh, 1992), and the end-user training literature (e.g., Currid, 1994; Nelson, 1991; Raho & Belohlav, 1994).

Identical five-point Likert scaled questions were utilized for both the WORK SYSTEM PRACTICES and I.S. MANAGEMENT PRACTICES. Respondents were asked to indicate the strength of their agreement to each question asked. The possible responses included: 1 = Strongly Disagree, 2 = Mildly Disagree, 3 = Neutral, 4 = Mildly Agree, 5 = Strongly Agree, and NA = Not Applicable or Do Not Know. The ORGANIZATIONAL INVOLVEMENT IN I.S. questions used a different five-point Likert scale where respondents were asked to indicate their existing level of (1) end-user involvement in software application development and (2) cross-functional involvement in the development and administration of software applications. The possible responses included: 1 = None, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High, and NA = Not Applicable or Do Not Know.

This list of questions was then presented to the four practicing manufacturing managers for review. They were given one week to examine the model (i.e., Figure 2.1) to be tested, review the format of the questionnaire, evaluate the target respondent information, and assess the language and clarity of each question in detail. After completing their assessment of the questions, the managers were instructed to mark them as either keep, modify, or drop. During the structured interview process that followed they were asked to comment in detail on their reasons for marking a particular question to be modified or dropped. They were also encouraged to provide suggestions for improving the overall design, structure, and wording of the questionnaire.

The questionnaire was then revised to include many of the suggestions given by the four manufacturing managers. A pre-pilot was then conducted. The questionnaire was then given to a larger group which included the three additional practicing manufacturing managers and the eight academics experts. These individuals were also instructed to mark each question to be kept, modified, or dropped. While they were encouraged to provide written suggestions, structured interviews were not conducted. However, several individuals were later contacted to clarify the meaning of their written comments.

The questionnaire was revised once again to include the feedback given by the pre-pilot participants. A pilot test was then conducted. The names of 500 subjects were systematically selected from an overall mailing list of 7,323 potential respondents. The overall mailing list was created from a commercial mailing list purchased from Manufacturers' News, Inc. Potential respondents were selected through a data base search in which senior manufacturing managers and executives were drawn from SIC codes: #25 -- Furniture & Fixtures, #34 -- Fabricated Metals, #35 -- Industrial Machinery & Equipment, #36 -- Electronic & Other Equipment, #37 -- Transportation Equipment, and #38 -- Instruments &

Related Products. Only those senior manufacturing managers and executives who represented manufacturing firms with at least 250 employees were selected. It was believed that firms with fewer employees would not be of sufficient size to support an I.S. department.

Thirty-seven usable responses were received from the pilot study mailing. Seven solicitation letters were returned unopened with markings that the respondent no longer worked at that address. Nine letters were returned opened with markings indicating that their company executives do not complete unsolicited questionnaires as a matter of company policy due to limited time constraints. The pilot sample was large enough to perform some initial statistical analysis. As such, it provided a useful means for assessing the preliminary reliability and validity of the instruments developed.

3.2 PILOT STUDY METHODOLOGY

The responses from the pilot study were used to explore the instruments developed with several objectives in mind: purification, reliability, brevity, and internal and external validity. The instrument was purified by examining the corrected item-total correlations (CITC) of the items with respect to a particular dimension (e.g., Standardization) of a specific construct (e.g., Work System Practices) as described by Churchill (1979). The item inter-correlation matrices provided by SPSSX were utilized to drop items if they did not strongly contribute to Cronbach's alpha for the dimension under consideration (Flynn, Schroeder, Sakakibara, 1995). Some items which did not contribute strongly to alpha, but whose content was considered important to the research, were designated for modification.

The Organizational Involvement in I.S. and the I.S. Management Practices instrument purification process involved the elimination of all items whose CITC scores were below 0.50. For the Work Systems Practices, a more conservative three-step approach was adopted because many items initially demonstrated very low CITC scores. As the suspected outliers were removed at each step, the CITC scores for the remaining items gradually increased to within acceptable levels. By slowly reducing the set of items for each dimension, many items were retained that might have otherwise been deleted.

In step one, after the initial SPSSX reliability analysis was run, those items with CITC scores of less than 0.30 were eliminated. In step two, the SPSSX reliability analysis was run once again with those items with CITC scores of less than 0.40 eliminated afterward. In step three, the final SPSSX reliability analysis was run with those items with CITC scores of less than 0.50 eliminated. In this manner, several Work System Practices items that may have been incorrectly dropped were retained for factor analysis.

The items related to a specific dimension (e.g., Standardization) were next submitted as a group to exploratory factor analysis to assess the dimension's internal consistency. Principal components was selected for the extraction procedure with the varimax method used for factor rotation. The MEANSUB command was used within SPSSX to replace missing values with the variable mean for that item. Items which did not load at 0.60 or above were generally eliminated at this stage. Some items which had weak factor loadings were designated for modification during this initial phase of the analysis if their content was considered important to the research. This is consistent with Dillon & Goldsteins' (1984) recommendation that the researcher consider the item's importance to the research as well as its loading during factor interpretation. To further streamline the factor interpretation process, loadings below 0.40 were not reported.

The external consistency of each construct was appraised by submitting the items for the entire construct (e.g., Work System Practices) to exploratory factor analysis to uncover any significant cross-loadings. Principal components extraction with varimax rotation and MEANSUB was again utilized. Loadings below 0.40 were not reported. While a sample size of at least 50 observations has been recommended to justify factor analysis (Hair, Anderson, Tatham, & Black, 1995), the actual sample size required may vary according to the number of items and dimensions used to measure the overall construct.

A second method of determining the adequacy of a sample size for factor analysis is to calculate the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for each construct using SPSSX. Kaiser (1974) has characterized KMO measures in the 0.90's as outstanding, the 0.80' as very good, the 0.70's as average, the 0.60's as tolerable, the 0.50's as miserable, and below 0.50 as unacceptable. KMO measures were calculated for the WORK SYSTEM PRACTICES (0.76), ORGANIZATIONAL INVOLVEMENT IN I.S. (0.85), and I.S. MANAGEMENT PRACTICES (0.74). While the pilot sample size of 37 is smaller than one would ideally desire, each construct's KMO measure indicates that factor analysis is possible. Therefore, construct-level factor analysis was conducted with the reliability of each construct dimension assessed using Cronbach's alpha.

3.3 PILOT STUDY RESULTS

The following sections give the results of the pilot study methodology as described in **Section 3.2** using the 37 usable responses. **Sections 3.3.1** through **3.3.3** present the outcomes related to each of the constructs of interest: Work System Practices, Organizational Involvement in I.S., and I.S. Management Practices. In each section, the initial pilot study items regarding the construct are listed in the first table. The dimension-level corrected item-total correlations, alphas if deleted, and Cronbach's alpha are given in the second table. The third table contains the dimension-level factor loadings while the fourth table contains the construct-level factor loadings. The fifth table contains the final reliability analysis after the conclusion of the construct-level factor analysis and the sixth table contains the text of the final pilot study items retained for large-scale study testing purposes. Tables 5 and 6 are provided only if one or more items were dropped from a construct during the analysis.

3.3.1 WORK SYSTEM PRACTICES (WSP)

The Work System Practices (WSP) construct was initially represented by four dimensions and 36 items: Standardization (11 items), Formalization (11 items), Routinization (8 items), and Integration (6 items). The original 36 items for WSP are shown in **Table 3.3.1.1.**

Construct Purification. As described earlier, the construct purification process involved a three step, dimension-level analysis. Step-1 involved the elimination of all items with a CITC score of less than 0.30 after the first SPSSX reliability analysis was run. Five Standardization items (ST1, ST6, ST8, ST9, and ST11),three Routinization items (RO3, RO7, and RO8), and three Integration items (IN1, IN5, and IN6) were dropped after step-1 due to CITC scores below the 0.30 minimum level.

Table 3.3.1.1 Work System Practices (Pilot Study): Original Construct Items.

Item	*Question*
STANDARDIZATION	
ST1	Production workers may determine the best method(s) for completing work. *
ST2	Well defined methods exist for measuring production worker productivity.
ST3	Well defined methods exist for measuring the quality of production work.
ST4	Work day start and stop times are strongly enforced.
ST5	Well defined methods exist for measuring the quality of first-line supervisors'/managers' work.
ST6	First-line supervisors/managers are free to reschedule production as required to meet customer demand. *
ST7	Production workers may set their own work pace. *
ST8	First-line supervisors/managers are free to revise existing manufacturing processes as required to improve productivity. *
ST9	First-line supervisors/managers are free to purchase parts and materials as required to meet production requirements. *
ST10	Well defined methods exist for measuring the productivity of first-line supervisors/managers.
ST11	First-line supervisors/managers are free to set their own work pace. *
FORMALIZATION	
FO1	Written management policies/procedures exist that govern employment hiring practices.
FO2	Written management policies/procedures exist that govern employee promotion practices.
FO3	Written job descriptions exist that specify the job responsibilities of first-line supervisors/managers.
FO4	Written operating procedures exist that define the sequence of steps required for every production process.
FO5	Production workers regularly follow written operating procedures when performing work.
FO6	Written job descriptions exist that specify the job responsibilities of production workers.
FO7	Written operating procedures exist that define the required day-to-day activities of first-line supervisors/managers.
FO8	First-line supervisors/managers normally follow written operating procedures when performing work.
FO9	Written management policies/procedures exist that govern employee performance evaluation practices.

Table 3.3.1.1 Work System Practices (Pilot Study): Original Construct Items. (continued)

Item	*Question*
FORMALIZATION (continued)	
FO10	Written policies/procedures exist that define how production scheduling should be done.
FO11	Written policies/procedures exist that clearly define how product cost accounting should be done.
ROUTINIZATION	
RO1	Production workers perform the same tasks each day.
RO2	Production workers are seldom taught new job skills.
RO3	Production workers regularly perform unplanned tasks. *
RO4	First-line supervisors/managers perform the same tasks each day.
RO5	First-line supervisors/managers make the same decisions each day.
RO6	Production workers build the same product(s) each day.
RO7	First-line supervisors/managers are seldom taught new job skills.
RO8	First-line supervisors/managers regularly perform unplanned tasks. *
INTEGRATION	
IN1	Work groups are primarily organized by function. *
IN2	Work groups are frequently organized around projects and tasks.
IN3	Important decisions are often made by work group consensus.
IN4	Cross-functional work groups are frequently formed to solve problems or undertake special projects.
IN5	Important decisions are made through the functional chain of command. *
IN6	Cross-functional work groups require detailed supervision and instructions to get anything done. *
*** = Question is reverse scaled for analysis purposes.**	

Step-2 of the construct purification process involved the elimination of all items with a CITC score of less than 0.40 after the second SPSSX reliability analysis was run. One Standardization item (ST7) and one Routinization item (RO2) were dropped after step-2 due to CITC scores below the 0.40 minimum level. No additional Formalization or Integration items were dropped.

Step-3 of the construct purification process involved the elimination of all items with a CITC score of less than 0.50 after the third SPSSX reliability analysis was run. One Standardization item (ST3), three Formalization items (FO7, FO8, and F11), two Routinization items (RO4 and RO5), and one Integration item (IN3) were dropped after step-3 due to CITC scores below the 0.50 minimum level. No additional Formalization items were dropped.

A final SPSSX reliability analysis was run in which the remaining items representing the four dimensions of the WSP construct were all found to have CITC scores greater than 0.50. No additional items were dropped. The final alphas were 0.87 for Standardization (4 items), 0.91 for Formalization (8 items), 0.85 for Routinization (2 items), and 0.71 for Integration (2 items). **Table 3.3.1.2** contains the construct purification results.

Dimension-Level Factor Analysis. The dimension-level factor analysis took place in one step. A separate factor analysis was run for each of the four dimensions of the WSP construct using SPSSX. In each case, a single factor clearly emerged with all items loading greater than the 0.60 level. The results of the dimension-level factor analysis are shown in **Table 3.3.1.3.**

Construct-Level Factor Analysis. The construct-level factor analysis took place in two separate steps. In step-1, the four Standardization items, eight Formalization items, two Routinization items, and two Integration items were submitted to a construct-level factor analysis using SPSSX. Four distinct factors, representative of the WSP construct emerged.

Table 3.3.1.2 Work System Practices (Pilot Study): Purification Results.

Reliability Analysis				
Item	***Step-1 CITC***	***Final CITC***	***alpha if deleted***	***alpha (α)***
STANDARDIZATION				
ST2	0.52	0.75	0.82	**α = 0.87**
ST4	0.46	0.53	0.90	
ST5	0.32	0.82	0.79	
ST10	0.39	0.79	0.80	
ST1	0.01	Items dropped after purification Step-1 (CITC<0.30).		
ST6	0.17			
ST8	0.09			
ST9	0.17			
ST11	0.16			
ST7	0.31	Item dropped after purification Step-2 (CITC<0.40).		
ST3	0.50	Item dropped after purification Step-3 (CITC<0.50).		
FORMALIZATION				
FO1	0.58	0.57	0.91	**α = 0.91**
FO2	0.66	0.66	0.90	
FO3	0.76	0.76	0.89	
FO4	0.73	0.71	0.89	
FO5	0.75	0.79	0.89	
FO6	0.83	0.84	0.88	
FO9	0.77	0.81	0.88	
FO10	0.66	0.58	0.91	
FO7	0.39	Items dropped after purification Step-3 (CITC<0.50).		
FO8	0.47			
FO11	0.47			

Table 3.3.1.2 Work System Practices (Pilot Study): Purification Results. (continued)

Reliability Analysis				
Item	***Step-1 CITC***	***Final CITC***	***alpha if deleted***	***alpha (α)***
ROUTINIZATION				
RO1	0.51	0.74	NA	$\alpha = 0.85$
RO6	0.52	0.74	NA	
RO3	0.14	Items dropped after purification Step-1 (CITC<0.30).		
RO7	0.16			
RO8	0.12			
RO2	0.43	Items dropped after purification Step-2 (CITC<0.40).		
RO4	0.51	Items dropped after purification Step-3 (CITC<0.50).		
RO5	0.52			
INTEGRATION				
IN2	0.47	0.52	0.63	$\alpha = 0.71$
IN4	0.63	0.62	0.50	
IN1	0.12	Items dropped after purification Step-1 (CITC<0.30).		
IN5	0.21			
IN6	0.11			
IN3	0.34	Items dropped after purification Step-3 (CITC<0.50).		

Three Formalization items (FO2, FO3, and FO10) were dropped after the step-1 analysis due to low primary factor loadings of 0.61 or less and high secondary factor loadings of 0.50 or higher. The measure of KMO was 0.76.

In step two, a construct-level factor analysis using SPSSX was once again run, minus the three items dropped after the step-1 analysis. Four distinct factors, representative of the WSP construct emerged. Two items (FO9 and ST2) experienced some minor cross-loading

Table 3.3.1.3 Work System Practices (Pilot Study): Dimension-Level Factor Analysis.

Dimension-Level Factor Analysis	
Item	*Factor Loading*
STANDARDIZATION	
ST5	0.91
ST10	0.89
ST2	0.87
ST4	0.70
FORMALIZATION	
FO6	0.90
FO9	0.87
FO5	0.86
FO3	0.84
FO4	0.78
FO2	0.75
FO10	0.66
FO1	0.65
ROUTINIZATION	
RO6	0.93
RO1	0.93
INTEGRATION	
IN4	0.88
IN2	0.88

problems. The measure of KMO remained at 0.76. **Table 3.3.1.4** contains the results of construct-level factor analysis.

Reliability Analysis. A reliability analysis for all four dimensions was then run to verify that each of the remaining items had CITC scores greater than 0.50. No additional

Table 3.3.1.4 Work System Practices (Pilot Study): Construct-Level Factor Analysis.

Questionnaire Item	Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.76 Factors loadings of 0.40 and above are shown.			
	F1 - Formalization (Written Documentation)	F2 - Standardization (Uniformity of Work)	F3 - Routinization (Repetitiveness of Work)	F4 - Integration (Cross-Func. Decision Making)
FO5	0.93			
FO4	0.86			
FO6	0.73			
FO9	0.72	0.46		
FO1	0.64			
ST5		0.83		
ST4		0.80		
ST10		0.75		
ST2	0.44	0.73		
RO1			0.93	
RO2			0.88	
IN4				0.88
IN2				0.80
Eigenvalue	5.65	1.64	1.52	1.22
% of Variance	43.5	12.6	11.7	9.4
Cumulative % of Variance	43.5	56.1	67.8	77.1

items were dropped. The final reliabilities after construct-level factor analysis were 0.87 for Standardization, 0.89 for Formalization, 0.85 for Routinization, and 0.71 for Integration. They are listed in **Table 3.3.1.5.** **Table 3.3.1.6** lists the final construct items.

Construct Revisions. While four factors representative of each of the major WSP dimensions emerged from the pilot, the results were not considered to be entirely satisfactory.

Table 3.3.1.5 Work System Practices (Pilot Study): Final Reliabilities.

Final Reliability Analysis (after construct-level factor analysis)			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
Factor 1 – FORMALIZATION			
FO5	0.88	0.88	$\alpha = 0.89$
FO4	0.73	0.87	
FO6	0.76	0.86	
FO9	0.76	0.86	
FO1	0.53	0.91	
Factor 2 – STANDARDIZATION			
ST5	0.82	0.76	$\alpha = 0.87$
ST4	0.53	0.89	
ST10	0.79	0.80	
ST2	0.75	0.82	
Factor 3 – ROUTINIZATION			
RO1	0.74	NA	$\alpha = 0.85$
RO2	0.74	NA	
Factor 4 – INTEGRATION			
IN4	0.55	NA	$\alpha = 0.71$
IN2	0.55	NA	
All items have a CITC> 0.50.			

The primary reason being that the remaining items did not clearly and adequately and address each of the four dimensions. Therefore, the following changes were identified.

First, Standardization items ST2 and ST5; Formalization items FO4, FO5, FO6, and FO9; and Integration items IN2 and IN4 were designated for minor modification. It was determined that these questions could easily be rewritten to improve their clarity. Second,

Table 3.3.1.6 Work System Practices (Pilot Study): Final Construct Items. (Organized by Factor Loadings).

Item	*Question*
FACTOR 1 – FORMALIZATION	
FO5	Production workers regularly follow written operating procedures when performing work.
FO4	Written operating procedures exist that define the sequence of steps required for every production process.
FO6	Written job descriptions exist that specify the job responsibilities of production workers.
FO9	Written management policies/procedures exist that govern employee performance evaluation practices.
FO1	Written management policies/procedures exist that govern employment hiring practices.
FACTOR 2 – STANDARDIZATION	
ST5	Well defined methods exist for measuring the quality of first-line supervisors'/managers' work.
ST4	Work day start and stop times are strongly enforced.
ST10	Well defined methods exist for measuring the productivity of first-line supervisors/managers.
ST2	Well defined methods exist for measuring production worker productivity.
FACTOR 3 – ROUTINIZATION	
RO1	Production workers perform the same tasks each day.
RO2	Production workers are seldom taught new job skills.
FACTOR 4 – INTEGRATION	
IN4	Cross-functional work groups are frequently formed to solve problems or undertake special projects.
IN2	Work groups are frequently organized around projects and tasks.

while Formalization item FO1 and Routinization item RO2 did load properly on the correct factors, it was determined that item FO1 pertained more to the formalization of employee hiring practices than the formalization of manufacturing work system practices. It was determined that item RO2 could be misleading because it pertained more to the frequency of training than the routine application of job skills. For example, workers in a mechanistic work environment could receive frequent or infrequent training. However, this item tells little about the range and repetitive use of skills actually employed doing work. As such, these questions were determined to be either too difficult or confusing to answer correctly and were designated to be dropped. Third, Standardization item ST4 and Routinization item RO1 were designated to be kept "as is."

At the conclusion of the pilot study, it was decided that several new questions per dimension would be developed before the large-scale survey mailing took place. In the case of the routinization and integration dimensions, the pilot study yielded factors containing only two items each. While these items were considered to be meaningful to the research, they were by themselves insufficient measures of the routinization and integration dimensions. In the case of the standardization and formalization dimensions, the pilot study yielded factors with questionable content validity. For example, it was determined that item FO1 pertained more to the formalization of a firm's administrative practices than to the formalization of its work system practices. Similarly, item ST4 pertained more to the development of a standard attendance policy than the level of standardization of its work system practices. Therefore, it was determined that both of these items should be dropped. While the pilot study results did capture some important aspects of the four WSP dimensions, it was apparent that extensive rework would be required before the large-scale survey took place.

3.3.2 ORGANIZATIONAL INVOLVEMENT IN I.S. (OIIS)

The Organizational Involvement in I.S. (OIIS) construct was initially represented by two dimensions and 14 items: End-User Involvement in I.S. (7 items) and Cross-Functional

Table 3.3.2.1 Organizational Involvement in I.S. (Pilot Study): Original Construct Items.

Item	*Question*
	END-USER INVOLVEMENT IN I.S.
UI1	Management of manufacturing software application development projects.
UI2	Analysis of manufacturing software application problems and opportunities.
UI3	Specification of manufacturing software application requirements.
UI4	Design of manufacturing software applications.
UI5	Development of manufacturing software applications.
UI6	Testing of manufacturing software applications.
UI7	Implementation of manufacturing software applications.
	CROSS-FUNCTIONAL INVOLVEMENT IN I.S.
CI1	Software application development.
CI2	Integration of software applications.
CI3	Enterprise-wide data management.
CI4	Resolution of software application problems.
CI5	Elimination of redundant I.S. related activities.
CI6	Elimination of redundant software applications.
CI7	Integration of I.S. planning activities.

Involvement in I.S. (7 items). The original 14 items for OIIS are shown in **Table 3.3.2.1.**

Construct Purification. The OIIS construct did not require the use of the three step purification process previously applied in **Section 3.3.1.** The SPSSX reliability analysis for the two OIIS dimensions yielded CITC scores greater than 0.50 for all OIIS construct items. Therefore, no OIIS items were designated to be dropped at this stage. The alphas were 0.93 for End-User Involvement in I.S. and 0.92 for Cross-Functional Involvement in I.S. The OIIS construct purification results are shown in **Table 3.3.2.2.**

Table 3.3.2.2 Organizational Involvement in I.S. (Pilot Study): Purification Results.

Reliability Analysis			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
END-USER INVOLVEMENT IN I.S.			
UI1	0.74	0.92	$\alpha = 0.93$
UI2	0.83	0.91	
UI3	0.75	0.92	
UI4	0.69	0.92	
UI5	0.71	0.92	
UI6	0.89	0.90	
UI7	0.78	0.91	
CROSS-FUNCTIONAL INVOLVEMENT IN I.S.			
CI1	0.63	0.92	$\alpha = 0.92$
CI2	0.84	0.89	
CI3	0.74	0.91	
CI4	0.78	0.90	
CI5	0.71	0.91	
CI6	0.72	0.91	
CI7	0.82	0.90	
No items to be dropped. All items have a CITC > 0.50.			

Dimension-Level Factor Analysis. The dimension-level factor analysis took place in two steps. In the first step, a separate factor analysis was run for each of the two OIIS dimensions using SPSSX. In the case of End-User Involvement in I.S. (UI), a single factor with all items loading greater than 0.76 resulted. However, Cross-Functional Involvement in I.S. (CI) yielded two factors. CI factor #1 contained items CI1, CI2, CI3, CI4, and CI7 while CI factor #2 contained items CI6 and CI7. The results of the step-1 dimension-level factor

Table 3.3.2.3a Organizational Involvement in I.S. (Pilot Study): Step-1 Dimension-Level Factor Analysis.

Step-1 Dimension-Level Factor Analysis		
Item	*Factor Loading*	
END-USER INVOLVEMENT IN I.S.		
UI6	0.93	
UI2	0.88	
UI7	0.85	
UI3	0.82	
UI1	0.82	
UI5	0.78	
UI4	0.76	
CROSS-FUNCTIONAL INVOLVEMENT IN I.S.		
Item	*Factor 1*	*Factor 2*
CI1	0.93	
CI2	0.84	
CI4	0.77	
CI3	0.67	0.46
CI7	0.67	0.57
CI5 *		0.94
CI6 *		0.93
*** Items to be deleted from further analysis.**		

analysis are shown in **Table 3.3.2.3a.**

It was decided that items CI5 and CI6 may have been confusing to respondents. Most end-users do not think of their firm as having redundant I.S. staff or duplicate software applications. Because outliers were suspected, these items were deleted after step-1 of the dimension-level factor analysis. In step-2, a second factor analysis was run for the CI dimension of the OIIS construct. This time a single CI factor with all items loading greater than 0.82 resulted. The step-2 dimension-level factor analysis is shown in **Table 3.3.2.3b.**

Construct-level Factor Analysis. The construct-level factor analysis took place in one step. The seven End-User Involvement in I.S. items and the five Cross-Functional Involvement in I.S. items were submitted to a construct-level factor analysis using SPSSX. Two distinct factors, representative of the OIIS construct emerged. Three UI items (UI2, UI6, and UI7) and one CI item (CI1) were retained in their original form despite significant cross loading problems as they were considered to be important to this research. No items were dropped from the analysis. The measure of KMO was 0.86. **Table 3.3.2.4** contains the results of the construct-level factor analysis.

Reliability Analysis. A reliability analysis for both OIIS dimensions was then run using SPSSX to verify that each of the remaining items had CITC scores greater than 0.50. The final reliabilities after the conclusion of construct-level factor analysis were 0.91 for End-User Involvement in I.S. and 0.93 for Cross-Functional Involvement in I.S. They are listed in **Table 3.3.2.5. Table 3.3.2.6** lists the the final construct items.

Construct Revisions. While there were some cross loading problems, the two factors that emerged representing the Organizational Involvement in I.S. construct were considered to be quite promising. No further modifications to the existing OIIS items were made. However, it was decided that two new CI items would be written before the large-scale survey to replace those that had been dropped earlier. The new items, if correctly written, could potentially reduce the cross-loading problems observed in the pilot study. Otherwise, no additional changes were made to the OIIS construct.

Table 3.3.2.3b Organizational Involvement in I.S. (Pilot Study): Step-2 Dimension-Level Factor Analysis.

Step-2 Dimension-Level Factor Analysis	
Item	*Factor Loading*
END-USER INVOLVEMENT IN I.S.	
UI6	0.93
UI2	0.88
UI7	0.85
UI3	0.82
UI1	0.82
UI5	0.78
UI4	0.76
CROSS-FUNCTIONAL INVOLVEMENT IN I.S.	
CI2	0.91
CI4	0.87
CI7	0.86
CI1	0.83
CI3	0.82

Table 3.3.2.4 Organizational Involvement in I.S. (Pilot Study): Construct-Level Factor Analysis.

Questionnaire Item	Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.86 Factors loadings of 0.40 and above are shown.	
	F1 - End-User Involvement in Information Systems	F2 - Cross-Functional Involvement in Information Systems
UI4	0.83	
UI5	0.79	
UI3	0.75	
UI6 *	0.74	0.54
UI1	0.71	
UI7*	0.66	0.51
CI7		0.88
CI4		0.81
CI2	0.47	0.79
CI3		0.78
UI2 *	0.62	0.65
CI1 *	0.60	0.63
Eigenvalue	7.65	1.19
% of Variance	63.7	9.9
Cumulative % of Variance	63.7	73.6

* To be retained. Item is considered important to the research.

Table 3.3.2.5 Organizational Involvement in I.S. (Pilot Study): Final Reliabilities.

Reliability Analysis (after construct-level factor analysis)			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
Factor 1 – END-USER INVOLVEMENT IN I.S.			
UI4	0.69	0.90	**α = 0.91**
UI5	0.71	0.89	
UI3	0.75	0.89	
UI6	0.86	0.87	
UI1	0.69	0.90	
UI7	0.76	0.89	
UI2	0.79	0.91	
Factor 2 – CROSS-FUNCTIONAL INVOLVEMENT IN I.S.			
CI7	0.77	0.92	**α = 0.93**
CI4	0.81	0.91	
CI2	0.88	0.90	
CI3	0.73	0.92	
CI1	0.78	0.92	
All items have a CITC> 0.50.			

Table 3.3.2.6 Organizational Involvement in I.S. (Pilot Study): Final Construct Items. (Organized by Factor Loadings)

Item	*Question*
FACTOR 1 – END-USER INVOLVEMENT IN I.S.	
UI4	Design of manufacturing software applications.
UI5	Development of manufacturing software applications.
UI3	Specification of manufacturing software application requirements.
UI6	Testing of manufacturing software applications.
UI1	Management of manufacturing software application development projects.
UI7	Implementation of manufacturing software applications.
UI2	Analysis of manufacturing software application problems and opportunities.
FACTOR 2 – CROSS-FUNCTIONAL INVOLVEMENT IN I.S.	
CI7	Integration of I.S. planning activities.
CI4	Resolution of software application problems.
CI2	Integration of software applications.
CI3	Enterprise-wide data management.
CI1	Software application development.

3.3.3 I.S. MANAGEMENT PRACTICES (ISMP)

The I.S. Management Practices (ISMP) construct was initially represented by three dimensions and fourteen items. The three ISMP dimensions include I.S. Strategic Planning (5 items), I.S. Responsiveness to End-Users (6 items), and I.S. End-User Training (3 items). The original 14 items for ISMP are shown in **Table 3.3.3.1.**

Construct Purification. The ISMP construct did not require the use of the three step purification process previously applied in **Section 3.3.1.** The SPSSX reliability analysis for the two ISMP dimensions yielded CITC scores greater than 0.50 for all ISMP construct items

Table 3.3.3.1 Information Systems Management Practices (Pilot Study): Original Construct Items.

Item	*Question*
	I.S. STRATEGIC PLANNING
SP1	Has created I.S. strategies that strongly support manufacturing strategies.
SP2	Has developed policies and procedures that clearly define the scope of functional I.S. activities.
SP3	Has developed a well defined mission statement.
SP4	Has developed I.S. objectives which may be closely linked to manufacturing objectives.
SP5	Has developed policies and procedures that clearly define the scope of I.S. responsibility.
	I.S. RESPONSIVENESS TO END-USERS
RU1	Promptly replaces obsolete software applications.
RU2	Promptly repairs computer hardware problems.
RU3	Promptly resolves software application problems.
RU4	Promptly replaces obsolete computer hardware.
RU5	Promptly responds to special information reporting requests.
RU6	Promptly responds to special software programming requests.
	I.S. END-USER TRAINING
UT1	End-users receive extensive on-the-job training on how to use our existing manufacturing information systems.
UT2	End-users receive formal classroom training on how to use our existing manufacturing information systems.
UT3	End-users receive additional training in the use of new and emerging manufacturing information technologies.

except item UT3. Item UT3 was subsequently dropped and the SPSSX reliability analysis rerun. No further ISMP items were designated to be dropped at this point. The alphas were 0.90 for I.S. Strategic Planning (SP) , 0.88 for I.S. Responsiveness to End-Users (RU), and 0.90 for I.S. End-User Training (UT). The ISMP purification results are presented in **Table 3.3.3.2.**

Table 3.3.3.2 Information Systems Management Practices (Pilot Study): Purification Results.

Reliability Analysis				
Item	*Initial CITC*	*Final CITC*	*alpha if deleted*	*alpha (α)*
I.S. STRATEGIC PLANNING				
SP1	0.77	0.77	0.88	$\alpha = 0.90$
SP2	0.80	0.80	0.87	
SP3	0.72	0.72	0.89	
SP4	0.63	0.63	0.91	
SP5	0.86	0.86	0.85	
I.S. RESPONSIVENESS TO END-USERS				
RU1	0.56	0.56	0.88	$\alpha = 0.88$
RU2	0.70	0.70	0.86	
RU3	0.83	0.83	0.83	
RU4	0.58	0.58	0.88	
RU5	0.72	0.72	0.85	
RU6	0.74	0.74	0.85	
I.S. END-USER TRAINING				
UT1	0.72	0.81	NA	$\alpha = 0.90$
UT2	0.74	0.81	NA	
UT3	0.41	Item dropped after the initial purification.		

Dimension-Level Factor Analysis. The dimension-level factor analysis took place in one step. A separate factor analysis was run for each of the three dimensions of the ISMP construct using SPSSX. In each case, a single factor clearly emerged with all items loading greater than the 0.60 level. The results of the dimension-level factor analysis are shown in **Table 3.3.3.3**.

Construct-Level Factor Analysis. The construct-level factor analysis took place in

Table 3.3.3.3 Information Systems Management Practices (Pilot Study): Dimension-Level Factor Analysis.

Dimension-Level Factor Analysis	
Item	*Factor Loading*
I.S. STRATEGIC PLANNING	
SP5	0.92
SP2	0.89
SP1	0.85
SP3	0.83
SP4	0.75
I.S. RESPONSIVENESS TO END-USERS	
RU3	0.90
RU6	0.84
RU5	0.82
RU2	0.80
RU4	0.69
RU1	0.67
I.S. END-USER TRAINING	
UT2	0.91
UT1	0.91

two separate steps. In step-1, the five I.S. Strategic Planning items, six I.S. Responsiveness to End-Users items, and two I.S. End-User Training items were submitted to a construct-level factor analysis using SPSSX. Three distinct factors, representative of the ISMP construct emerged. Item RU1 was dropped after the step-1 analysis due to an incorrect factor loading on the SP dimension. Two SP items (SP1 and SP4) and one RU item (RU4) were retained in their original form despite significant cross loading problems as they were considered to be important to this research. No further items were dropped from the analysis. The measure of KMO was 0.74. **Table 3.3.3.4a** contains the results of the step-1 analysis.

In Step-2, the twelve remaining ISMP items were then resubmitted as a group for construct-level factor analysis. Three distinct factors, representative of the ISMP construct once again emerged. This time all items loaded on the correct factors. Two SP items (SP1 and SP4) and two RU items (RU2 and RU4) were retained in their original form despite significant cross loading problems as they were considered to be important to the research. No items were dropped from the analysis. The measure of KMO for the final construct-level factor analysis was 0.70. **Table 3.3.3.4b** contains the results of the step-2 analysis.

Final Reliability Analysis. A reliability analysis for all three ISMP dimensions was then run to verify that each of the remaining items had CITC scores were greater than 0.50. The final reliabilities after construct-level factor analysis were 0.87 for I.S. Responsiveness to End-Users, 0.90 for I.S. Strategic Planning, and 0.89 for I.S. End-User Training. **Table 3.3.3.5** contains the results of this analysis. **Table 3.3.3.6** lists the final ISMP construct items.

Construct Revisions. While there were some cross loading problems, the three factors that emerged representing the three dimensions of I.S. Management Practices were considered to be promising. Therefore, no further modifications to the existing ISMP items were made. However, it was determined that several new items would be written to replace the one that had been dropped earlier. It was determined that these items, if correctly written, could reduce the cross-loading problems observed in the pilot study. Otherwise, no further changes were made to the ISMP construct.

Table 3.3.3.4a Information Systems Management Practices (Pilot Study): Step-1 Construct-Level Factor Analysis.

Questionnaire Item	Step-1 Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.74 Factors loadings of 0.40 and above are shown.		
	F1 - I.S. Strategic Planning	F2 - I.S. Responsiveness to End-Users	F3 - I.S. End-User Training
SP3	0.85		
SP5	0.84		
RU1 **	0.81		
SP2	0.79		
SP4 *	0.67	0.46	
SP1 *	0.66	0.52	
RU6		0.87	
RU3		0.85	
RU5		0.83	
RU2		0.71	
RU4 *	0.41	0.52	
UT1			0.93
UT2			0.89
Eigenvalue	6.53	1.90	1.37
% of Variance	50.3	14.6	10.6
Cumulative % of Variance	50.3	64.8	75.4

* To be retained. Item is considered important to the research.
** To be deleted because of incorrect factor loading.

Table 3.3.3.4b Information Systems Management Practices (Pilot Study): Step-2 Construct-Level Factor Analysis.

Questionnaire Item	Step-2 Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.70 Factors loadings of 0.40 and above are shown.		
	F1 - I.S. Responsiveness to End-Users	F2 - I.S. Strategic Planning	F3 - I.S. End-User Training
RU6	0.87		
RU3	0.85		
RU5	0.83		
RU2 *	0.69	0.43	
RU4 *	0.50	0.43	
SP3		0.89	
SP5		0.84	
SP2		0.81	
SP1 *	0.52	0.66	
SP4 *	0.48	0.61	
UT1			0.93
UT2			0.89
Eigenvalue	6.02	1.88	1.26
% of Variance	50.1	15.7	10.6
Cumulative % of Variance	50.1	65.8	76.4
* To be retained. Item is considered important to the research.			

Table 3.3.3.5 Information Systems Management Practices (Pilot Study): Final Reliabilities.

Final Reliability Analysis (after construct-level factor analysis)			
Item	***CITC***	***alpha if deleted***	***alpha (α)***
Factor 1 – I.S. RESPONSIVENESS TO END-USERS			
RU6	0.73	0.83	$\alpha = 0.87$
RU3	0.81	0.80	
RU5	0.69	0.84	
RU2	0.69	0.84	
RU4	0.55	0.87	
Factor 2 – I.S. STRATEGIC PLANNING			
SP3	0.72	0.89	$\alpha = 0.90$
SP5	0.86	0.85	
SP2	0.81	0.87	
SP1	0.76	0.87	
SP4	0.62	0.91	
Factor 3 – I.S. END-USER TRAINING			
UT1	0.81	NA	$\alpha = 0.89$
UT2	0.81	NA	
All items have a CITC > 0.50.			

Table 3.3.3.6 Information Systems Management Practices (Pilot Study): Final Construct Items (Organized by Factor Loadings).

Item	*Question*
	FACTOR 1 – I.S. RESPONSIVENESS TO END-USERS
RU6	Promptly responds to special software programming requests.
RU3	Promptly resolves software application problems.
RU5	Promptly responds to special information reporting requests.
RU2	Promptly repairs computer hardware problems.
RU4	Promptly replaces obsolete computer hardware.
	FACTOR 2 – I.S. STRATEGIC PLANNING
SP3	Has developed a well defined mission statement.
SP5	Has developed policies and procedures that clearly define the scope of I.S. responsibility.
SP2	Has developed policies and procedures that clearly define the scope of functional I.S. activities.
SP1	Has created I.S. strategies that strongly support manufacturing strategies.
SP4	Has developed I.S. objectives which may be closely linked to manufacturing objectives.
	FACTOR 3 – I.S. END-USER TRAINING
UT1	End-users receive extensive <u>on-the-job training</u> on how to use our existing manufacturing information systems.
UT2	End-users receive <u>formal classroom training</u> on how to use our existing manufacturing information systems.

3.4 INSTRUMENTS NOT PILOT TESTED

Initially, there were four instruments adopted for use in this study that were not pilot tested. This includes two instruments developed by Koufteros (1995) that were designed to measure the Time-Based Manufacturing Practices and Competitive Capabilities and a single instrument developed by Tracey (1996) designed to measure Firm Performance. Because these instruments had been tested previously and proven to be both valid and reliable, it was decided that it would not be necessary to evaluate them as part of the pilot study.

However, because they were also quite large it was decided that they should be simplified before use in the large-scale study. Therefore, the number of items representing each construct dimension was reduced to a maximum of four. This was done by first reviewing the authors' reported results and then retaining the four items with the highest factor loadings for each construct dimension. In the case of a tie, the item with the highest corrected item-total correlation was chosen to be retained.

One other change was made to the Time-Based Manufacturing Practices instrument. The Pull Production dimension of the TBMP construct contained only 3 items in Koufteros' original instrument. To strengthen his instrument, a single item designed to measure the use of kanban bins or positions was added (See item PP4 in **Table 4.2.1.1**). Because kanban is an essential component of many pull production systems, the addition of a question such as this was both valid and appropriate. No other original TBMP instrument items were added or altered. This resulted in a final Time-Based Manufacturing Practices instrument containing 28 items (7 dimensions), a final Competitive Capabilities instrument containing 20 items (5 dimensions), and a final Firm Performance instrument containing 8 items (2 dimensions).

A fourth instrument developed by Raghunathan and Raghunathan (1996) was initially to be used to measure I.S. Performance. The instrument was proven to be both valid and reliable and was based upon conceptual measures outlined by Cash, McFarlan, Mckenny, and Applegate (1992). It is was originally designed to be completed by an I.S. manager or director and not a senior manufacturing manager or executive. At the conclusion of the pilot study, there was some concern as to whether this instrument would be well understood and could be properly completed by the subjects surveyed in this study.

The primary issue was that the original I.S. Performance instrument was designed to capture the general perceptions of I.S. performance that I.S. managers believed their end-users held of the I.S. function. In this study, senior manufacturing managers would be asked directly to complete the instrument. There was also some concern that the original instrument was not strongly manufacturing oriented enough. The question was, would the subjects who were asked to complete the questions properly understand the context of the questions and provide valid responses?

After much thought, it was decided that a new I.S. Performance instrument should be developed to better capture the perceptions of I.S. performance as held by senior manufacturing managers and executives. This instrument was reviewed by the original group of four manufacturing managers who participated in the structured interview process as well as the dissertation committee. Their feedback was critical in redeveloping the original Raghunathan & Raghunathan (1996) to better capture the desired information in such a way that senior manufacturing managers and executives would clearly understand.

While the new I.S. Performance (IP) instrument was not administered as part of the pilot study survey, it is believed that the final instrument used is a more appropriate measure of the target audience's perceptions of I.S. Performance than was the original instrument. A list of the five (IP) questions that emerged that emerged from this process can be found in **Table 4.2.6.1** in **Section 4.2.**

CHAPTER 4: INSTRUMENT DEVELOPMENT
PHASE TWO - LARGE-SCALE DATA ANALYSIS

Interdisciplinary research requires the careful selection of a pool of respondents possessing detailed knowledge of two or more functional areas. In this study, the respondents needed to be in positions which enabled them to develop detailed perceptions of the effectiveness of their firm's manufacturing and information system environments. This included perceptions of their firm's time-based manufacturing practices, work system practices, organizational involvement in I.S., I.S. management practices, competitive capabilities, information systems performance, and firm performance. It was also important that the results of this study prove to be generalizable across industry classification, by firm size (by annual sales dollars and number of employees), and by level of information system expenditures (by I.S. dollars and percent of sales).

The mailing list used in this study contained 7,323 potential respondents. It was purchased and refined according to the process described in Chapter 3. The names of 500 subjects were systematically selected from this list for the pilot study. Before the large-scale mailing took place, the remaining subjects' addresses were verified using a U.S. Postal Service certified mailing program. A total of 867 subject addresses were found to be invalid or to contain errors. Of these, 313 were found to be correctable and were subsequently corrected before the large-scale study mailing took place. The remaining pool of 6,269 potential subjects were mailed an introductory cover letter on University of Toledo stationary, the questionnaire resulting from Phase One of the instrument development process, and a return mailing envelope with postage paid.

A total of 351 responses were received from the large-scale study mailing. Of these, 53 questionnaire packets were returned unopened as undeliverable. 27 letters were returned incomplete with markings indicating that their company executives do not respond to unsolicited questionnaires due to limited time constraints or as a matter of company policy. An additional 6 questionnaires were appraised as being unsuitable for further analysis. This yielded 265 responses that were deemed suitable for large-scale analysis giving an effective response rate of 4.3 % [265 ÷ (6,269 - 53 - 27 - 6)].

One problem faced in conducting interdisciplinary research is the identification of a proper pool of qualified subjects capable of answering questions related to two or more functional disciplines. In this study, only executive or senior level manufacturing managers such as those who responded were judged to possess detailed knowledge of both their firm's manufacturing operations and related information systems. A second problem is that senior and executive level managers receive a great many requests to participate in such studies each year. Most have little or no extra spare time available to participate in academic research with many firms limiting their participation as a matter of policy.

Because interdisciplinary research must by nature collect information on multiple functional areas, the size and scope of the research instrument used may necessarily be larger and more time consuming to complete. As such, the increased size of the interdisciplinary research questionnaire may further contribute to response rate problems. While the response rate for this study was less than desired, the makeup of the pool of respondents was considered to be excellent with the large-scale study statistical results being very good as well. Thus, it is important to consider not only the quantity but also the quality of the respondents participating in such studies.

Detailed information regarding the 265 subjects whose information was utilized in the large-scale analysis is provided in **Appendix A**. The vast majority of respondents described themselves as either a Vice President, General Manager, or Plant Manager in charge of Manufacturing and/or Operations. Detailed information on industry classification, firm size (both annual sales dollars and number of employees), and level of information system expenditures (both I.S. dollars and percent of sales) is also given.

4.1 ITEM REFINEMENT METHODOLOGY

The 265 acceptable responses that resulted from the large-scale survey were further refined using the same methodology as that used in the pilot study. Once again, the survey results were explored with several objectives in mind: purification, reliability, brevity, and internal and external validity. In addition, the large-scale survey results were examined for their predictive validity.

The instrument was purified by examining the corrected item-total correlations (CITC) of the items with respect to a particular dimension (e.g., Standardization) of a specific construct (e.g., Work System Practices) as described by Churchill (1979). The item inter-correlation matrices provided by SPSSX were utilized to drop items if they did not strongly contribute to Cronbach's alpha for the dimension under consideration (Flynn, et al., 1994).

This involved the elimination of all items whose CITC scores were below 0.50.

The items related to a specific dimension (e.g., Standardization) were next submitted as a group to exploratory factor analysis to assess the dimension's internal consistency. Principal components was selected for the extraction procedure with the varimax method used for factor rotation. The MEANSUB command within SPSSX was used to replace missing values with the variable mean for that item. Items which did not load at 0.60 or above were generally eliminated at this stage. To further streamline the factor interpretation process, loadings below 0.40 were not reported. The adequacy of the sample size for factor analysis was calculated using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for each dimension using SPSSX.

The external consistency of each construct was appraised by submitting the items for the entire construct (e.g., Work System Practices) to exploratory factor analysis to uncover any significant cross-loadings. Principal components extraction with varimax rotation and MEANSUB was once again utilized. Loadings below 0.40 were not reported. The adequacy of the sample size for factor analysis was once again calculated using KMO.

The final reliability of the remaining items comprising each dimension after factor analysis was assessed using Cronbach's alpha as calculated by SPSSX. Predictive validity was assessed by correlating (1) a composite measure of TIME-BASED MANUFACTURING PRACTICES with a composite measure of WORK SYSTEM PRACTICES, (2) a composite measure of TIME-BASED MANUFACTURING PRACTICES with a composite measure of ORGANIZATIONAL INVOLVEMENT IN I.S., (3) composite measures of WORK SYSTEM PRACTICES and ORGANIZATIONAL INVOLVEMENT IN I.S. with a composite measure of I.S. MANAGEMENT PRACTICES, (4) composite measures of WORK SYSTEM PRACTICES and I.S. MANAGEMENT PRACTICES with a composite measure of COMPETITIVE CAPABILITIES, (5) a composite measure of I.S. MANAGEMENT PRACTICES with a composite measure of INFORMATION SYSTEMS PERFORMANCE, and (5) composite measures of COMPETITIVE CAPABILITIES and INFORMATION SYSTEM PERFORMANCE with a composite measure of FIRM PERFORMANCE.

4.2 LARGE-SCALE STUDY RESULTS

The following sections give the results of the large-scale study methodology as described in **Section 4.1** using the 265 usable responses. **Sections 4.2.1** through **4.2.7** present the outcomes related to each of the constructs of interest: Time-Based Manufacturing Practices, Work System Practices, Organizational Involvement in I.S., I.S. Management Practices, Competitive Capabilities, Information Systems Performance, and Firm Performance. In each section, the original large-scale study items regarding the construct are listed in the first table. The dimension-level corrected item-total correlations, alphas if deleted, and Cronbach's alpha are given in the second table. The third table contains the dimension-level factor loadings while the fourth table contains the construct-level factor loadings. The fifth table contains the final reliability analysis after the conclusion of the construct-level factor analysis and the sixth table contains the final set of large-scale study items retained for hypothesis testing purposes. Tables 5 and 6 are only provided if one or more items were dropped from a construct during the analysis.

Table 4.2.1 Time-Based Manufacturing Practices

The Time-Based Manufacturing Practices (TBMP) construct was represented by seven dimensions and 28 items (4 items per dimension): Cellular Manufacturing (CM), Reengineering Setup (RS), Preventive Maintenance (PM), Pull Production (PP), Quality Assurance (QA), Dependable Suppliers (DS), and Employee Involvement (EI). The 28 TBMP construct items are given in **Table 4.2.1.1.**

Construct Purification. The SPSSX reliability analysis for the seven TBMP dimensions yielded CITC scores greater than 0.50 for all construct items. Therefore, no items were designated to be dropped at this stage of the analysis. The final alphas were 0.83 for Cellular Manufacturing, 0.89 for Reengineering Setup, 0.93 for Preventive Maintenance, 0.86 for Pull Production, 0.82 for Quality Assurance, 0.88 for Dependable Suppliers, and 0.90 for Employee Involvement. The TBMP reliability analysis is presented in **Table 4.2.1.2.**

Dimension-Level Factor Analysis. A separate factor analysis was then run for each of the seven dimensions of the TBMP construct using SPSSX. In each case, a single factor with all items loading greater than 0.70 and a KMO score of 0.70 or more resulted. No items were dropped. The results of the dimension-level factor analysis are shown in **Table 4.2.1.3.**

Construct-Level Factor Analysis. The TBMP construct items were then submitted to further construct-level factor analysis. While Koufteros (1995) identified seven dimensions of the TBMP construct, he excluded the EI dimension from this analysis. His argument was that shop-floor employee involvement is an antecedent to the other six TBMP dimensions and would therefore fail to emerge as a unique factor when analyzed in conjunction with the other six dimensions of the TBMP construct. Therefore, the EI dimension was not included in the

Table 4.2.1.1 Time-Based Manufacturing Practices (Large-Scale Study): Construct Items.

Item	*Question*
	CELLULAR MANUFACTURING
CM1	Products that share similar design or processing requirements are grouped into families of products.
CM2	Products are classified into groups with similar routing requirements.
CM3	Products are classified into groups with similar processing requirements.
CM4	Equipment is grouped to produce families of products.
	REENGINEERING SETUP
RS1	Employees redesign or reconfigure equipment to shorten setup time.
RS2	Employees redesign jigs or fixtures to shorten setup time.
RS3	Employees work on setup improvement.
RS4	Our employees are trained to reduce setup time.
	PREVENTIVE MAINTENANCE
PM1	We maintain our equipment regularly.
PM2	We emphasize good preventive maintenance.
PM3	We do preventive maintenance.
PM4	Records of routine maintenance are kept.
	PULL PRODUCTION
PP1	Production is "pulled" by the shipment of finished goods.
PP2	We use a "pull" production system.
PP3	Production at stations is "pulled" by the current demand of the next stations.
PP4	Production is "pulled" by an open kanban bin/position.
	QUALITY ASSURANCE
QA1	We conduct process capability studies.
QA2	We use fishbone type diagrams to identify causes of quality problems.
QA3	Our employees use quality control charts (e.g., SPC charts).
QA4	We use design of experiments (i.e., Tageuchi methods).

Table 4.2.1.1 Time-Based Manufacturing Practices (Large-Scale Study): Construct Items (continued).

Item	*Question*
DEPENDABLE SUPPLIERS	
DS1	We receive the correct type of parts from suppliers.
DS2	We receive high quality parts from suppliers.
DS3	We receive parts from suppliers that meet our specifications.
DS4	Our suppliers accommodate our needs.
EMPLOYEE INVOLVEMENT	
EI1	Shop-floor employees are involved in problem solving efforts.
EI2	Shop-floor employees are involved in improvement efforts.
EI3	Shop-floor employees are involved in problem solving teams.
EI4	Shop-floor employees are involved in suggestion programs.

construct-level factor analysis to remain consistent with Koufteros' original work.

Clear CM, PM, PP, QA, and DS factors emerged that were representative of the TBMP construct. All TBMP items had primary factor loadings greater than 0.60 with no cross-loadings greater than 0.40. No items were dropped from the analysis. The measure of KMO was 0.89 indicating the sampling adequacy was very good. The results of the construct-level factor analysis are given in **Table 4.2.1.4.**

Table 4.2.1.2. Time-Based Manufacturing Practices (Large-Scale Study): Purification Results.

Reliability Results			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
CELLULAR MANUFACTURING (Mean = 3.99, SD = 0.76)			
CM1	0.62	0.80	$\alpha = 0.83$
CM2	0.68	0.78	
CM3	0.76	0.74	
CM4	0.59	0.82	
REENGINEERING SETUP (Mean = 3.29, SD = 0.89)			
RS1	0.78	0.85	$\alpha = 0.89$
RS2	0.77	0.86	
RS3	0.78	0.85	
RS4	0.71	0.88	
PREVENTIVE MAINTENANCE (Mean = 3.95, SD = 0.92)			
PM1	0.81	0.91	$\alpha = 0.93$
PM2	0.86	0.89	
PM3	0.89	0.88	
PM4	0.76	0.93	
PULL PRODUCTION (Mean = 3.27, SD = 0.99)			
PP1	0.71	0.83	$\alpha = 0.86$
PP2	0.79	0.79	
PP3	0.75	0.81	
PP4	0.62	0.87	
QUALITY ASSURANCE (Mean = 3.01, SD = 1.00)			
QA1	0.67	0.76	$\alpha = 0.82$
QA2	0.63	0.78	
QA3	0.65	0.77	
QA4	0.62	0.79	

Table 4.2.1.2. Time-Based Manufacturing Practices (Large-Scale Study): Purification Results (continued).

Reliability Results			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
DEPENDABLE SUPPLIERS (Mean = 4.01, SD = 0.60)			
DS1	0.73	0.85	$\alpha = 0.88$
DS2	0.77	0.83	
DS3	0.78	0.83	
DS4	0.67	0.87	
EMPLOYEE INVOLVEMENT (Mean = 3.65, SD = 0.89)			
EI1	0.79	0.87	$\alpha = 0.90$
EI2	0.84	0.85	
EI3	0.87	0.83	
EI4	0.64	0.93	
No items to be dropped. All items have a CITC > 0.50.			

Table 4.2.1.3. Time-Based Manufacturing Practices (Large-Scale Study): Dimension-Level Factor Analysis.

Dimension-Level Factor Analysis	
Item	***Factor Loading***
CELLULAR MANUFACTURING (KMO = 0.77)	
CM3	0.88
CM2	0.84
CM1	0.77
CM4	0.72
REENGINEERING SETUP (KMO = 0.82)	
RS1	0.90
RS3	0.89
RS2	0.88
RS4	0.84
PREVENTIVE MAINTENANCE (KMO = 0.84)	
PM3	0.94
PM2	0.92
PM1	0.89
PM4	0.86
PULL PRODUCTION (KMO = 0.76)	
PP2	0.90
PP3	0.86
PP1	0.83
PP4	0.76
QUALITY ASSURANCE (KMO = 0.81)	
QA3	0.83
QA1	0.82
QA4	0.81
QA2	0.79

Table 4.2.1.3. Time-Based Manufacturing Practices (Large-Scale Study): Dimension-Level Factor Analysis (continued).

Dimension-Level Factor Analysis	
Item	***Factor Loading***
DEPENDABLE SUPPLIERS (KMO = 0.82)	
DS3	0.88
DS2	0.86
DS1	0.85
DS4	0.77
EMPLOYEE INVOLVEMENT (KMO = 0.82)	
EI3	0.94
EI2	0.92
EI1	0.89
EI4	0.77

Table 4.2.1.4. Time-Based Manufacturing Practices (Large-Scale Study): Construct-Level Factor Analysis.

Questionnaire Item	Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.86 Factor Loadings of 0.40 and above are shown.					
	F1-Preventive Maintenance	F2-Reengineering Setup	F3-Dependable Suppliers	F4-Pull Production	F5-Quality Assurance	F6-Cellular Manufacturing
PM3	0.89					
PM2	0.85					
PM1	0.83					
PM4	0.78					
RS2		0.85				
RS1		0.81				
RS3		0.76				
RS4		0.64				
DS2			0.84			
DS3			0.84			
DS1			0.83			
DS4			0.75			
PP2				0.91		
PP1				0.85		
PP3				0.78		
PP4				0.66		
QA3					0.79	
QA2					0.76	
QA4					0.76	
QA1					0.68	
CM3						0.87
CM2						0.82
CM1						0.75
CM4						0.69
Eigenvalue	7.83	2.92	2.31	1.83	1.48	1.22
% of Variance	32.6	12.2	9.6	7.6	6.2	5.1
Cumulative % of Variance	32.6	44.8	54.4	62.1	68.2	73.4

Table 4.2.2 Work System Practices

The Work System Practices (WSP) construct was represented by four dimensions and 39 items. This includes 10 Standardization (ST) items, 9 Formalization (FO) items, 11 Routinization (RO) items, and 9 Integration (IN) items. The original 39 WSP construct items are given in **Table 4.2.2.1.**

Construct Purification. The construct purification process involved the elimination of all WSP items with a CITC score less than 0.50. After the initial SPSSX reliability analysis was run, one Standardization item (ST4), four Routinization items (RO9, RO16, RO17, and RO18), and one Integration item (IN9) were dropped from further analysis due to CITC scores below the 0.50 minimum level. One Standardization item (ST16, CITC = 0.49) that did not meet the minimum CITC level was retained for further analysis because it was considered to be important to the research. The revised list of WSP items was once again subjected to SPSSX reliability analysis. Item (ST14) was dropped after the second reliability analysis because its CITC score was below the 0.50 minimum level. All other items representing the four dimensions of the WSP construct were found to have CITC scores greater than 0.50. The final CITC scores and alphas for these factors are listed in **Table 4.2.2.2.** They are 0.85 for Standardization, 0.87 for Formalization, 0.86 for Routinization, and 0.91 for Integration.

Dimension-Level Factor Analysis. The dimension-level factor analysis process took place in two steps. In step-1, a separate factor analysis was run for each of the four dimensions of the WSP construct using SPSSX. In the cases of the Standardization and Integration dimensions, single factors with all items loading greater than 0.60 resulted.

Table 4.2.2.1 Work System Practices (Large-Scale Study): Original Construct Items.

Item	*Question*
	STANDARDIZATION
ST4	Work day start and stop times are strongly enforced.
ST12	Uniform methods are used to assess production worker productivity.
ST13	We use uniform measures of manufacturing performance.
ST14	Production takes place at a constant, uniform pace.
ST15	We use uniform methods of manufacturing.
ST16	We use uniform methods of inventory management.
ST17	We use uniform methods for assessing first-line supervisor/manager productivity.
ST18	We use uniform measures of product quality.
ST19	We use uniform methods of product costing.
ST20	We use uniform methods for assessing first-line supervisor/manager work quality.
	FORMALIZATION
FO12	Written operating procedures specify the precise sequence of steps required to perform each production process.
FO13	Production workers regularly follow written operating procedures.
FO14	Written job descriptions exist for most employees.
FO15	Production workers regularly follow written quality control procedures.
FO16	Written policies/procedures specify how to assess product quality.
FO17	Written performance evaluation policies/procedures exist.
FO18	First-line supervisors/managers regularly follow written employee performance evaluation policies/procedures.
FO19	Written policies/procedures specify how inventory should be controlled.
FO20	Written policies/procedures specify how production scheduling should be done.

Table 4.2.2.1 Work System Practices (Large-Scale Study): Original Construct Items. (continued).

Item	*Question*
ROUTINIZATION	
RO1	Production workers build the same product(s) each day.
RO9	First-line supervisors/managers use the same reports on a regular basis.
RO10	Production workers perform the same tasks each day.
RO11	First-line supervisors/managers perform the same tasks on a regular basis.
RO12	First-line supervisors/managers make the same decisions regularly.
RO13	Production workers use the same set of tools each day.
RO14	Production workers operate the same machinery and equipment each day.
RO15	Production workers follow the same set(s) of operating procedures each day.
RO16	Employee break times are predetermined and fixed.
RO17	First-line supervisors'/managers' responsibilities pretty much stay the same.
RO18	First-line supervisors/managers attend the same meetings regularly.
INTEGRATION	
IN7	Cross-functional teams make important decisions on a regular basis.
IN8	Important cross-functional decisions are often made by consensus.
IN9	Cross-functional teams require minimum management supervision.
IN10	Cross-functional teams are formed to undertake special projects.
IN11	Cross-functional teams are an important source for new ideas.
IN12	Cross-functional teams are formed to solve problems.
IN13	Cross-functional teams frequently organize around projects and tasks.
IN14	Important decisions are often made cross-functional consensus.
IN15	Senior management values the input of cross-functional teams.

Table 4.2.2.2 Work System Practices (Large-Scale Study): Purification Results.

Reliability Analysis				
Item	***Initial CITC***	***Final CITC***	***alpha if deleted***	***Final alpha (α)***
STANDARDIZATION				
ST12	0.52	0.53	0.84	**α = 0.85**
ST13	0.62	0.60	0.83	
ST15	0.57	0.57	0.83	
ST16 *	0.49	0.52	0.84	
ST17	0.65	0.64	0.83	
ST18	0.61	0.64	0.83	
ST19	0.50	0.54	0.84	
ST20	0.70	0.67	0.82	
ST4	**0.37**	**Item dropped after the initial analysis.**		
ST14	**0.51**	**Item dropped after the revised analysis.**		
FORMALIZATION				
FO12	0.62	0.62	0.85	**α = 0.87**
FO13	0.69	0.69	0.84	
FO14	0.52	0.52	0.86	
FO15	0.66	0.66	0.85	
FO16	0.60	0.60	0.85	
FO17	0.56	0.56	0.86	
FO18	0.60	0.60	0.85	
FO19	0.53	0.53	0.86	
FO20	0.61	0.61	0.85	

*** Item was retained. Considered important to this research.**

Table 4.2.2.2 Work System Practices (Large-Scale Study): Purification Results (continued).

Reliability Analysis				
Item	***Initial CITC***	***Final CITC***	***alpha if deleted***	***Final alpha (α)***
ROUTINIZATION				
RO1	0.55	0.63	0.84	α = 0.86
RO10	0.65	0.69	0.83	
RO11	0.60	0.60	0.84	
RO12	0.56	0.56	0.85	
RO13	0.67	0.61	0.84	
RO14	0.65	0.65	0.83	
RO15	0.62	0.61	0.84	
RO9	**0.22**	**Items dropped after the initial analysis.**		
RO16	**0.37**			
RO17	**0.48**			
RO18	**0.38**			
INTEGRATION				
IN7	0.68	0.68	0.90	α = 0.91
IN8	0.63	0.60	0.91	
IN10	0.73	0.73	0.90	
IN11	0.58	0.58	0.91	
IN12	0.79	0.83	0.89	
IN13	0.80	0.82	0.89	
IN14	0.78	0.78	0.89	
IN15	0.67	0.68	0.90	
IN9	**0.40**	**Items dropped after the initial analysis.**		
All retained items have CITC scores greater than the 0.50 minimum level.				

However, the Formalization and Routinization dimensions each yielded two separate factors. The results of the step-1 dimension-level factor analysis are shown in **Table 4.2.2.3a.**

Items FO17 and RO12 were dropped from the analysis because after careful consideration they were judged to be misleading. It was decided that item FO17 dealt more with the formalization of performance evaluation procedures and was not a good measure of the formalization of work system practices. While RO12 did address the routinization of supervisory work, it was believed that this question was unclear because many managers may routinely make the same kinds of decisions but the do not repeat the exact same decision each day.

After their deletion, a second dimension-level factor analysis was run with a single factor, representative of each of the four WSP dimensions emerged. The factor loadings for the remaining WSP items all were greater than 0.60. No further items were dropped at this stage of the analysis. The results of the step-2 dimension-level factor analysis are shown in **Table 4.2.2.3b.**

Construct-Level Factor Analysis. The construct-level factor analysis of the remaining WSP items took place in two steps using SPSSX. In step-1, six factors initially emerged. These included ST, FO, RO, and IN factors as well as two unexpected unknown factors. Items ST15 and ST18 were dropped due to incorrect Formalization factor loadings. Items FO18 and ST19 were dropped due to strong incorrect factor loadings on unknown factors #5 and $6. Although other items had either low factor loadings less than 0.60 (ST20) or incorrect unknown factor loadings (Factor #5 -- FO14, FO20; Factor #6 -- ST16, FO19), no further items were deleted at this point. The primary reason being a desire to maintain a

Table 4.2.2.3a Work System Practices (Large-Scale Study): Step-1 Dimension-Level Factor Analysis.

Step-1 Dimension-Level Factor Analysis		
Item	***Factor Loading***	
STANDARDIZATION (KMO = 0.85)		
ST20	0.76	
ST18	0.74	
ST13	0.73	
ST17	0.73	
ST15	0.71	
ST12	0.67	
ST16	0.66	
ST19	0.65	
FORMALIZATION (KMO = 0.83)		
Item	***Factor 1***	***Factor 2***
FO12	0.82	
FO16	0.81	
FO13	0.79	
FO15	0.77	
FO17 *		0.85
FO18		0.84
FO14		0.58
FO20	0.42	0.56
FO19		0.51
*** Item to be deleted from further analysis.**		

Table 4.2.2.3a Work System Practices (Large-Scale Study): Step-1 Dimension-Level Factor Analysis (Continued).

Step-1 Dimension-Level Factor Analysis		
Item	***Factor Loading***	
ROUTINIZATION (KMO = 0.80)		
Item	***Factor 1***	***Factor 2***
RO10	0.85	
RO1	0.79	
RO14	0.75	
RO13	0.74	
RO15	0.68	
RO12 *		0.91
RO11		0.89
INTEGRATION (KMO = 0.92)		
IN12	0.89	
IN13	0.88	
IN10	0.85	
IN14	0.85	
IN7	0.80	
IN15	0.76	
IN8	0.71	
IN11	0.69	
*** Item to be deleted from further analysis.**		

conservative approach that first assessed the impact of deleting WSP items ST15, ST18, ST19, and FO18 on the analysis. The measure of KMO was 0.89 indicating the sampling adequacy was very good. The results of the step-1 construct-level factor analysis are shown in **Table 4.2.2.4a**.

Table 4.2.2.3b Work System Practices (Large-Scale Study): Step-2 Dimension-Level Factor Analysis.

Step-2 Dimension-Level Factor Analysis	
Item	*Factor Loading*
STANDARDIZATION (KMO = 0.85)	
ST20	0.76
ST18	0.74
ST13	0.73
ST17	0.73
ST15	0.71
ST12	0.67
ST16	0.66
ST19	0.65
FORMALIZATION (KMO = 0.84)	
FO12	0.83
FO15	0.82
FO12	0.77
FO16	0.75
FO20	0.69
FO14	0.64
FO18	0.64
FO19	0.63
No further items to be deleted. All item factor loadings > 0.60.	

In step-2, the remaining WSP construct items were once again submitted for construct-level factor analysis using SPSSX. Four factors emerged (ST, FO, RO, and IN) as originally expected. No further items were deleted at this point. The measure of KMO was 0.87 indicating the sampling adequacy was very good. The results of the step-2 construct-

Table 4.2.2.3b Work System Practices (Large-Scale Study): Step-2 Dimension-Level Factor Analysis (Continued).

Step-2 Dimension-Level Factor Analysis	
Item	*Factor Loading*
ROUTINIZATION (KMO = 0.81)	
RO10	0.83
RO14	0.78
RO1	0.78
RO13	0.76
RO15	0.75
RO11	0.65
INTEGRATION (KMO = 0.92)	
IN12	0.89
IN13	0.88
IN10	0.85
IN14	0.85
IN7	0.80
IN15	0.76
IN8	0.71
IN11	0.69
No further items to be deleted. All item factor loadings > 0.60.	

level factor analysis are shown in **Table 4.2.2.4b.**

Final Reliability Analysis. A final SPSSX reliability analysis was run for the four resulting WSP dimensions to verify that each dimensions' alpha value was greater than 0.70 and that the remaining items had CITC scores greater than 0.50. The final alphas were 0.91 for Integration, 0.85 for Routinization, 0.87 for Formalization, and 0.79 for Standardization. **Table 4.4.2.5** contains the final reliability analysis at the conclusion of WSP construct-level

Table 4.2.2.4a Work System Practices (Large-Scale Study): Step-1 Construct-Level Factor Analysis.

Questionnaire Item	Step-1 Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.89 Factor Loadings of 0.40 and above are shown.					
	F1 - Integration	F2 Formalization	F3 Routinization	F4 Standardization	F5 Unknown	F6 Unknown
IN12	0.88					
IN13	0.87					
IN14	0.83					
IN10	0.82					
IN7	0.76					
IN15	0.74					
IN11	0.68					
IN8	0.68					
FO12		0.78				
FO15		0.72				
FO16		0.72				
FO13		0.70				
ST18 *		0.65				
ST15 *		0.58				
RO10			0.82			
RO14			0.81			
RO13			0.76			
RO1			0.76			
RO15			0.67			
RO11			0.61			
ST12				0.83		
ST13				0.73		
ST17				0.60		
ST20				0.47	0.47	

* To be dropped due to incorrect factor loading.

Table 4.2.2.4a Work System Practices (Large-Scale Study): Step-1 Construct-Level Factor Analysis (continued).

Questionnaire Item	Step-1 Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.89 Factor Loadings of 0.40 and above are shown.					
	F1 - Integration	F2 Formalization	F3 Routinization	F4 Standardization	F5 Unknown	F6 Unknown
FO18 **					0.73	
FO20					0.59	0.41
FO14		0.44			0.51	
ST19 **						0.71
FO19					0.47	0.58
ST16						0.50
Eigenvalue	9.51	3.92	2.75	1.35	1.08	1.03
% of Variance	31.7	13.1	9.2	4.5	3.6	3.5
Cumulative % of Variance	31.7	44.8	54.0	58.5	62.1	65.6
** To be dropped. Item has caused an unknown factor to develop. All other items to be retained for revised factor analysis.						

factor analysis. **Table 4.4.2.6** contains the final WSP construct items organized by factor loadings.

Table 4.2.2.4b Work System Practices (Large-Scale Study): Step-2 Construct-Level Factor Analysis.

Questionnaire Item	Step-2 Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.87 Factor Loadings of 0.40 and above are shown.			
	F1 - Integration	F2 - Routinization	F3 - Formalization	F4 - Standardization
IN12	0.88			
IN13	0.88			
IN14	0.83			
IN10	0.83			
IN7	0.76			
IN15	0.75			
IN11	0.68			
IN8	0.68			
RO10		0.83		
RO14		0.81		
RO1		0.78		
RO13		0.76		
RT15		0.66		
RT11		0.60		
FO12			0.83	
FO13			0.79	
FO15			0.76	
FO16			0.73	
ST12				0.81
ST17				0.75
ST13				0.74
ST20				0.65
Eigenvalue	7.10	3.77	2.26	1.31
% of Variance	32.3	17.1	10.3	5.9
Cumulative % of Variance	32.3	49.4	59.7	65.6

Table 4.2.2.5 Work System Practices (Large-Scale Study): Final Reliabilities.

Final Reliability Analysis (after construct-level factor analysis)			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
FACTOR 1 – INTEGRATION (Mean =3.92 , SD = 0.77)			
IN12	0.83	0.89	**α = 0.91**
IN13	0.82	0.89	
IN14	0.78	0.89	
IN10	0.73	0.90	
IN7	0.68	0.90	
IN15	0.68	0.90	
IN11	0.58	0.91	
IN8	0.60	0.91	
FACTOR 2 – ROUTINIZATION (Mean = 3.71, SD = 0.83)			
RO10	0.71	0.80	**α = 0.85**
RO14	0.67	0.81	
RO1	0.64	0.82	
RO13	0.62	0.82	
RO15	0.62	0.82	
RO11	0.51	0.84	
FACTOR 3 – FORMALIZATION (Mean = 4.04, SD = 0.94)			
FO12	0.74	0.83	**α = 0.87**
FO13	0.75	0.82	
FO15	0.72	0.83	
FO16	0.67	0.85	
FACTOR 4 – STANDARDIZATION (Mean = 3.84, SD = 0.85)			
ST12	0.57	0.76	**α = 0.79**
ST17	0.66	0.71	
ST13	0.61	0.74	
ST20	0.58	0.76	
No further items to be dropped. All items have a CITC > 0.50.			

Table 4.2.2.6 Work System Practices (Large-Scale Study): Final Construct Items. (Organized by Factor Loadings).

Item	*Question*
FACTOR 1 – INTEGRATION	
IN12	Cross-functional teams are formed to solve problems.
IN13	Cross-functional teams frequently organize around projects and tasks.
IN14	Important decisions are often made cross-functional consensus.
IN10	Cross-functional teams are formed to undertake special projects.
IN7	Cross-functional teams make important decisions on a regular basis.
IN15	Senior management values the input of cross-functional teams.
IN11	Cross-functional teams are an important source for new ideas.
IN8	Important cross-functional decisions are often made by consensus.
FACTOR 2 – ROUTINIZATION	
RO10	Production workers perform the same tasks each day.
RO14	Production workers operate the same machinery and equipment each day.
RO1	Production workers build the same product(s) each day.
RO13	Production workers use the same set of tools each day.
RO15	Production workers follow the same set(s) of operating procedures each day.
RO11	First-line supervisors/managers perform the same tasks on a regular basis.
FACTOR 3 – FORMALIZATION	
FO12	Written operating procedures specify the precise sequence of steps required to perform each production process.
FO13	Production workers regularly follow written operating procedures.
FO15	Production workers regularly follow written quality control procedures.
FO16	Written policies/procedures specify how to assess product quality.
FACTOR 4 – STANDARDIZATION	
ST12	Uniform methods are used to assess production worker productivity.
ST17	We use uniform methods for assessing first-line supervisor/manager productivity.
ST13	We use uniform measures of manufacturing performance.
ST20	We use uniform methods for assessing first-line supervisor/manager work quality.

4.2.3 Organizational Involvement in I.S.

The Organizational Involvement in I.S. (OIIS) construct was represented by two dimensions, End-User Involvement in I.S. (UI) and Cross-Functional Involvement in I.S. (CI), each with 7 items per dimension. The 14 OIIS construct items are given in **Table 4.2.3.1.**

Construct Purification. The SPSSX reliability analysis for the two OIIS dimensions yielded CITC scores greater than 0.80 for all construct items. Therefore, no items were designated to be dropped at this stage of the analysis. The final alphas were 0.95 for End-User Involvement in I.S. and 0.96 for Cross-Functional Involvement in I.S. The OIIS reliability analysis is presented in **Table 4.2.3.2.**

Dimension-Level Factor Analysis. The dimension-level factor analysis took place in one step. A separate factor analysis was run for each of the two dimensions of the OIIS construct using SPSSX. In both cases, a single factor with all items loading greater than 0.70 resulted. No items were dropped. The results of the dimension-level factor analysis are shown in **Table 4.2.3.3.**

Construct-Level Factor Analysis. The construct-level factor analysis took place in one step using SPSSX. Two distinct factors emerged that were representative of the UI and CI dimensions of the OIIS construct. All items loaded correctly on their primary factor with factor loadings of 0.60 or more. Only item CI1 had a cross-loading of 0.40 or more. However, the secondary loading was so small (0.42) that it was considered to be non-significant. This was confirmed by its strong CITC score (0.84) during reliability analysis. Therefore, no items were deleted. The measure of KMO was 0.90 indicating outstanding sampling adequacy. The construct-level factor analysis results are shown in **Table 4.2.3.4.**

Table 4.2.3.1 Organizational Involvement in I.S. (Large-Scale Study): Construct Items.

Item	*Question*
END-USER INVOLVEMENT IN I.S.	
UI1	Management of manufacturing software application development projects.
UI2	Analysis of manufacturing software application problems and opportunities.
UI3	Specification of manufacturing software application requirements.
UI4	Design of manufacturing software applications.
UI5	Development of manufacturing software applications.
UI6	Testing of manufacturing software applications.
UI7	Implementation of manufacturing software applications.
CROSS-FUNCTIONAL INVOLVEMENT IN I.S.	
CI1	Software application development.
CI2	Integration of software applications.
CI3	Enterprise-wide data management.
CI4	Resolution of software application problems.
CI7	Integration of I.S. planning activities.
CI8	Development of I.S. policies/procedures.
CI9	Prioritization of I.S. related activities.

Table 4.2.3.2 Organizational Involvement in I.S. (Large-Scale Study): Purification Results.

Reliability Analysis			
Item	***CITC***	***alpha if deleted***	***alpha (α)***
END-USER INVOLVEMENT IN I.S. (Mean = 2.92, SD = 0.96)			
UI1	0.81	0.95	**α = 0.95**
UI2	0.87	0.94	
UI3	0.85	0.95	
UI4	0.84	0.95	
UI5	0.85	0.95	
UI6	0.86	0.95	
UI7	0.81	0.95	
CROSS-FUNCTIONAL INVOLVEMENT IN I.S. (Mean = 2.53, SD = 0.83)			
CI1	0.84	0.95	**α = 0.96**
CI2	0.86	0.95	
CI3	0.80	0.95	
CI4	0.83	0.95	
CI7	0.87	0.95	
CI8	0.85	0.95	
CI9	0.87	0.95	
No items were dropped. All items have a CITC > 0.50.			

Table 4.2.3.3 Organizational Involvement in I.S. (Large-Scale Study): Dimension-Level Factor Analysis.

Dimension-Level Factor Analysis	
Item	*Factor Loading*
END-USER INVOLVEMENT IN I.S. (KMO = 0.88)	
UI5	0.87
UI2	0.86
UI6	0.85
UI4	0.85
UI3	0.83
UI7	0.82
UI1	0.79
CROSS-FUNCTIONAL INVOLVEMENT IN I.S. (KMO = 0.87)	
CI7	0.84
CI9	0.83
CI2	0.83
CI3	0.81
CI8	0.80
CI1	0.79
CI4	0.75
No items were dropped. All items have factor loadings > 0.60.	

Table 4.2.3.4 Organizational Involvement in I.S. (Large-Scale Study): Construct-Level Factor Analysis.

Questionnaire Item	Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.90 Factor loadings of 0.40 and above are shown.	
	F1 - End-User Involvement in I.S.	F2 - Cross-Functional Involvement in I.S.
UI5	0.84	
UI4	0.83	
UI2	0.82	
UI6	0.81	
UI3	0.79	
UI7	0.77	
UI1	0.77	
CI8		0.83
CI7		0.82
CI9		0.81
CI3		0.77
CI2		0.76
CI4		0.70
CI1	0.42	0.68
Eigenvalue	7.45	2.12
% of Variance	53.2	15.1
Cumulative % of Variance	53.2	68.4

4.2.4 Information Systems Management Practices

The I.S. Management Practices (ISMP) construct was represented by three dimensions and 16 items. This includes 7 I.S. Strategic Planning (SP) items, 7 I.S. Responsiveness to End-Users (RU) items, and 2 I.S. End-User Training (UT) items. The 16 ISMP construct items are given in **Table 4.2.4.1.**

Construct Purification. The SPSSX reliability analysis for the two ISMP dimensions yielded CITC scores greater than 0.60 for all ISMP items. Therefore, no items were designated to be dropped at this stage of the analysis. The final alphas were 0.94 for I.S. Strategic Planning, 0.91 for I.S. Responsiveness to End-Users, and 0.80 for I.S. End-User Training. The ISMP reliability analysis is presented in **Table 4.2.4.2.**

Dimension-Level Factor Analysis. The dimension-level factor analysis took place in one step. A separate factor analysis was run for each of the three dimensions of the ISMP construct using SPSSX. In each case, a single factor with all items loading greater than 0.60 resulted. No items were dropped. The results of the dimension-level factor analysis are shown in **Table 4.2.4.3.**

Construct-Level Factor Analysis. The construct-level factor analysis took place in three steps. In step-1, the entire set of ISMP construct items was submitted to construct-level factor analysis using SPSSX. Three distinct factors emerged that were representative of the SP, RU, and UT dimensions of the ISMP construct. All items loaded correctly on their primary factor, each with factor loadings greater than 0.60. The one exception was item RU4 which loaded well below (0.44) the 0.60 minimum cutoff and was therefore deleted. Some minor factor cross-loadings for items SP6, SP8, RU2, and RU9 did occur. However, no

Table 4.2.4.1 Information Systems Management Practices (Large-Scale Study): Initial Construct Items.

Item	*Question*
	I.S. STRATEGIC PLANNING
SP3	Has developed a well defined mission statement.
SP6	Has developed a clear vision of its role within this organization.
SP7	Has developed a well defined set of I.S. objectives.
SP8	Has clearly defined its contribution to this organization.
SP9	Has developed a well defined set of I.S. strategies.
SP10	Has developed policies and procedures that clearly define the scope of I.S. functional activities within this organization.
SP11	Has developed policies and procedures that clearly define the scope of I.S. responsibility within this organization.
	I.S. RESPONSIVENESS TO END-USERS
RU2	Promptly repairs computer hardware problems.
RU3	Promptly resolves software application problems.
RU4	Promptly replaces obsolete computer hardware.
RU6	Promptly resolves computer network problems.
RU7	Promptly responds to special software programming requests.
RU8	Promptly responds to end-user questions and concerns.
RU9	Promptly implements software application upgrades.
	I.S. END-USER TRAINING
UT1	End-users receive extensive <u>on-the-job training</u> on how to use our existing manufacturing information systems.
UT2	End-users receive <u>formal classroom training</u> on how to use our existing manufacturing information systems.

further items were designated for deletion at this point. The measure of KMO was 0.92 indicating the sampling adequacy was outstanding. The results of the step-1 construct-level factor analysis are shown in **Table 4.2.4.4a.**

Table 4.2.4.2 Information Systems Management Practices (Large-Scale Study): Purification Results.

Reliability Analysis			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
I.S. STRATEGIC PLANNING			
SP3	0.76	0.94	α = 0.94
SP6	0.75	0.94	
SP7	0.86	0.93	
SP8	0.79	0.93	
SP9	0.89	0.92	
SP10	0.78	0.93	
SP11	0.81	0.93	
I.S. RESPONSIVENESS TO END-USERS			
RU2	0.66	0.90	α = 0.91
RU3	0.81	0.88	
RU4	0.57	0.91	
RU6	0.74	0.89	
RU7	0.75	0.89	
RU8	0.79	0.88	
RU9	0.71	0.89	
I.S. END-USER TRAINING			
UT1	0.67	0.	α = 0.80
UT2	0.67	0.	
No items were dropped. All items have a CITC > 0.50.			

In step-2, the remaining 15 ISMP items were then resubmitted as a group for construct-level factor analysis. Three distinct factors emerged that were representative of the SP, RU, and UT dimensions of the ISMP construct. Items SP6, SP8, and RU2 demonstrated strong factor cross-loadings and were subsequently deleted.

Table 4.2.4.3 Information Systems Management Practices (Large-Scale Study): Dimension-Level Factor Analysis.

Item	*Factor Loading*
I.S. STRATEGIC PLANNING (KMO = 0.91)	
SP9	0.92
SP7	0.89
SP11	0.87
SP6	0.85
SP10	0.84
SP8	0.84
SP3	0.79
I.S. RESPONSIVENESS TO END-USERS (KMO = 0.88)	
RU3	0.89
RU8	0.85
RU7	0.81
RU6	0.80
RU9	0.79
RU2	0.72
RU4	0.66
I.S. END-USER TRAINING (KMO = 0.50)	
UT2	0.91
UT1	0.91
No items were dropped. All items have factor loadings > 0.60.	

In step-3, the remaining 12 items were once again submitted for final construct-level factor analysis. Three distinct factors emerged with all items loaded correctly on their primary factor, each with factor loadings greater than 0.60. There were no item cross-loadings above 0.40 observed and no further items were designated for deletion. The measure of KMO was

Table 4.2.4.4a Information Systems Management Practices (Large-Scale Study): Step-1 Construct-Level Factor Analysis.

Questionnaire Item	Step-1 Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.92 Factor loadings of 0.40 and above are shown.		
	F1 - LS. Strategic Planning	F2 - LS. Responsiveness to End-Users	F3 - LS. End-User Training
SP7	0.84		
SP9	0.83		
SP3	0.80		
SP10	0.80		
SP11	0.78		
SP6	0.72	0.46	
SP8	0.71	0.46	
RU3		0.83	
RU8		0.81	
RU7		0.78	
RU6		0.72	
RU9		0.64	0.42
RU2	0.41	0.64	
RU4 *		0.44	
UT2			0.88
UT1			0.82
Eigenvalue	8.60	1.57	1.24
% of Variance	53.8	9.8	7.7
Cumulative % of Variance	53.8	63.6	71.3
* To be deleted. Factor Loading < 0.60.			

0.90 indicating the sampling adequacy was outstanding. The results of the step-3 construct-level factor analysis are shown in **Table 4.2.4.4b.**

Final Reliability Analysis. A final SPSSX reliability analysis was run for the

Table 4.2.4.4b Information Systems Management Practices (Large-Scale Study): Step-3 Construct-Level Factor Analysis.

Questionnaire Item	Step-3 Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.90 Factor loadings of 0.40 and above are shown.		
	F1 - I.S. Strategic Planning	F2 - I.S. Responsiveness to End-Users	F3 - I.S. End-User Training
SP7	0.84		
SP9	0.83		
SP3	0.82		
SP10	0.81		
SP11	0.79		
RU3		0.86	
RU7		0.84	
RU8		0.83	
RU6		0.69	
RU9		0.68	
UT2			0.88
UT1			0.85
Eigenvalue	6.50	1.49	1.15
% of Variance	54.2	12.4	9.6
Cumulative % of Variance	54.2	66.6	76.2
No further items to be deleted. All factor Loadings > 0.60.			

three resulting ISMP dimensions to verify that each dimensions' alpha value was greater than 0.80 and that the remaining items had CITC scores greater than 0.50. The final alphas were 0.93 for I.S. Strategic Planning, 0.90 for I.S. Responsiveness to End-Users, and 0.81 for I.S. End-User Training. **Table 4.2.4.5** contains the final reliability analysis at the conclusion of ISMP construct-level factor analysis. **Table 4.2.4.6** contains the final construct items

Table 4.2.4.5 Information Systems Management Practices (Large-Scale Study): Final Reliabilities.

Reliability Analysis (after construct-level factor analysis)			
Item	***CITC***	***alpha if deleted***	***alpha (α)***
FACTOR 1 – I.S. STRATEGIC PLANNING (Mean = 3.14, SD = 0.99)			
SP7	0.84	0.91	$\alpha = 0.93$
SP9	0.87	0.90	
SP3	0.75	0.93	
SP10	0.80	0.92	
SP11	0.81	0.91	
FACTOR 2 – I.S. RESPONSIVENESS TO END-USERS (Mean = 3.34, SD = 0.91)			
RU3	0.84	0.87	$\alpha = 0.90$
RU7	0.79	0.88	
RU8	0.80	0.87	
RU6	0.69	0.90	
RU9	0.69	0.90	
FACTOR 3 – I.S. END-USER TRAINING (Mean = 3.05, SD = 1.03)			
UT2	0.67	NA	$\alpha = 0.81$
UT1	0.67	NA	
No items were dropped. All items have a CITC > 0.50.			

organized by factor loadings.

Table 4.2.4.6 Information Systems Management Practices (Large-Scale Study): Final Construct Items (Organized by Factor Loadings).

Item	*Question*
	FACTOR 1 – I.S. STRATEGIC PLANNING
SP7	Has developed a well defined set of I.S. objectives.
SP9	Has developed a well defined set of I.S. strategies.
SP3	Has developed a well defined mission statement.
SP10	Has developed policies and procedures that clearly define the scope of I.S. functional activities within this organization.
SP11	Has developed policies and procedures that clearly define the scope of I.S. responsibility within this organization.
	FACTOR 2 – I.S. RESPONSIVENESS TO END-USERS
RU3	Promptly resolves software application problems.
RU7	Promptly responds to special software programming requests.
RU8	Promptly responds to end-user questions and concerns.
RU6	Promptly resolves computer network problems.
RU9	Promptly implements software application upgrades.
	FACTOR 3 – I.S. END-USER TRAINING
UT1	End-users receive extensive on-the-job training on how to use our existing manufacturing information systems.
UT2	End-users receive formal classroom training on how to use our existing manufacturing information systems.

Table 4.2.5 Competitive Capabilities

The Competitive Capabilities construct (CC) construct was represented by five dimensions and 20 items (4 items per dimension): Competitive Pricing (CP), Premium Pricing (PR), Value to Customer Quality (VC), Dependable Deliveries (DD), and Product Innovation (PI). The 20 CC construct items are given in **Table 4.2.5.1.**

Construct Purification. The SPSSX reliability analysis for the five CC dimensions yielded CITC scores greater than 0.70 for all CC construct items. Therefore, no CC items were designated to be dropped at this stage of the analysis. The final alphas were 0.93 for Competitive Price, 0.95 for Premium Pricing, 0.90 for Value to Customer Quality, 0.96 for Dependable Deliveries, and 0.94 for Product Innovation (PI). The CC reliability analysis is presented in **Table 4.2.5.2.**

Dimension-Level Factor Analysis. The dimension-level factor analysis process took place in one step. A separate factor analysis was run for each of the five dimensions of the CC construct using SPSSX. In each case, a single factor with all items loading greater than 0.70 resulted. No items were dropped. The results of are shown in **Table 4.2.5.3.**

Construct-Level Factor Analysis. The entire set of CC construct items was submitted to further construct-level factor analysis using SPSSX. Five distinct factors emerged that were representative of the CP, PR, VC, DD, and PI dimensions of the CC construct. All items loading correctly with primary factor loadings of 0.60 or more and no significant factor cross-loadings (0.40 or more). Therefore, no items were deleted. The measure of KMO was 0.86 indicating the sampling adequacy was very good. The results of the final factor analysis are shown in **Table 4.2.5.4.**

Table 4.2.5.1 Competitive Capabilities (Large-Scale Study): Construct Items.

Item	*Question*
	COMPETITIVE PRICING
CP1	Our capability of offering prices that match the competition is.
CP2	Our capability of competing based on price is.
CP3	Our capability of offering prices that are competitive is.
CP4	Our capability of offering prices as low or lower than competitors' prices is.
	PREMIUM PRICING
PR1	Our capability of selling at price premiums is.
PR2	Our capability of selling at prices above average is.
PR3	Our capability of commanding premium prices is.
PR4	Our capability of selling at high prices that only a few firms can achieve is.
	VALUE TO CUSTOMER QUALITY
VC1	Our capability of offering safe-to-use products that meet customer needs is.
VC2	Our capability of offering products that function according to customer needs over a reasonable lifetime is.
VC3	Our capability of offering reliable products that meet customer needs is.
VC4	Our capability of offering quality products that meet customer expectations is.
	DEPENDABLE DELIVERIES
DD1	Our capability of delivering the correct quantity of products needed on time is.
DD2	Our capability of providing on-time deliveries is.
DD3	Our capability of providing dependable deliveries is.
DD4	Our capability of delivering the kind of products needed on time is.
	PRODUCT INNOVATION
PI1	Our capability of developing new products and features is.
PI2	Our capability of developing a number of "new" product features is.
PI3	Our capability of developing a number of "new" products is.
PI4	Our capability of developing unique product features is.

Table 4.2.5.2 Competitive Capabilities (Large-Scale Study): Purification Results.

Reliability Analysis			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
COMPETITIVE PRICING (Mean = 3.32, SD = 0.88)			
CP1	0.81	0.91	$\alpha = 0.93$
CP2	0.83	0.90	
CP3	0.86	0.89	
CP4	0.82	0.91	
PREMIUM PRICING (Mean = 3.47, SD = 0.95)			
PP1	0.88	0.93	$\alpha = 0.95$
PP2	0.84	0.94	
PP3	0.94	0.91	
PP4	0.83	0.94	
VALUE TO CUSTOMER QUALITY (Mean = 4.32, SD = 0.60)			
VC1	0.70	0.91	$\alpha = 0.90$
VC2	0.78	0.88	
VC3	0.85	0.85	
VC4	0.82	0.86	
DEPENDABLE DELIVERIES (Mean = 4.00, SD = 0.83)			
DD1	0.84	0.96	$\alpha = 0.96$
DD2	0.92	0.93	
DD3	0.93	0.93	
DD4	0.89	0.94	
PRODUCT INNOVATION (Mean = 3.65, SD = 0.85)			
PI1	0.81	0.93	$\alpha = 0.94$
PI2	0.87	0.91	
PI3	0.89	0.90	
PI4	0.83	0.92	
No items were dropped. All items have a CITC > 0.50.			

Table 4.2.5.3 Competitive Capabilities (Large-Scale Study): Dimension-Level Factor Analysis.

Dimension-Level Factor Analysis	
Item	*Factor Loading*
COMPETITIVE PRICING (KMO = 0.85)	
CP3	0.91
CP2	0.89
CP4	0.88
CP1	0.88
PREMIUM PRICING (KMO = 0.84)	
PP3	0.96
PP1	0.92
PP2	0.91
PP4	0.88
VALUE TO CUSTOMER QUALITY (KMO = 0.78)	
VC3	0.89
VC4	0.87
VC2	0.82
VC1	0.70
DEPENDABLE DELIVERIES (KMO = 0.86)	
DD3	0.95
DD2	0.94
DD4	0.92
DD1	0.87
PRODUCT INNOVATION (KMO = 0.84)	
PI3	0.92
PI2	0.91
PI4	0.87
PI1	0.87
No items were dropped. All items have factor loadings > 0.60.	

Table 4.2.5.4 Competitive Capabilities (Large-Scale Study): Construct-Level Factor Analysis.

Questionnaire Item	Construct-Level Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.86 Factor loadings of 0.40 and above are shown.				
	F1 Dependable Deliveries	F2 Premium Pricing	F3 Product Innovation	F4 Competitive Pricing	F5 - Value to Customer Quality
DD3	0.93				
DD2	0.92				
DD1	0.88				
DD4	0.87				
PP3		0.93			
PP1		0.90			
PP2		0.89			
PP4		0.87			
PI3			0.90		
PI2			0.88		
PI1			0.84		
PI4			0.93		
CP2				0.88	
CP4				0.88	
CP3				0.88	
CP1				0.87	
VC3					0.84
VC4					0.80
VC2					0.80
VC1					0.67
Eigenvalue	5.89	3.85	2.93	1.92	1.41
% of Variance	29.5	19.2	14.7	9.6	7.1
Cumulative % of Variance	29.5	48.7	63.4	73.0	80.1

Table 4.2.6 Information Systems Performance

The Information Systems Performance (IP) construct was represented by one dimension and 5 items. The 5 IP construct items are given in **Table 4.2.6.1.**

Construct Purification. The SPSSX reliability analysis for the IP construct yielded CITC scores greater than 0.70 for all IP items. Therefore, no IP items were designated to be dropped at this stage of the analysis. The final alpha was 0.90 for Information Systems Performance. The IP reliability analysis is presented in **Table 4.2.6.2.**

Exploratory Factor Analysis. The exploratory factor analysis process took place in one step. The entire set of IP items was submitted to exploratory factor analysis with one distinct factor emerging that was representative of the construct. All five items had factor loadings of 0.80 or more. Therefore, no items were deleted. The measure of KMO was 0.86 indicating the sampling adequacy was very good. The results of the factor analysis are shown in **Table 4.2.6.3.**

Table 4.2.6.1 Information Systems Performance (Large-Scale Study): Construct Items.

Item	*Question*
	INFORMATION SYSTEMS PERFORMANCE
IP1 *	Our I.S. function has failed to meet end-user performance expectations.
IP2	The use of I.S. services has led to better management of manufacturing activities.
IP3	Our I.S. function is perceived as facilitating better decision making.
IP4	End-users are generally satisfied with the services of the I.S. function.
IP5	End-users recognize the benefits of our I.S. function's services.
	*** Item is reverse scaled.**

Table 4.2.6.2 Information Systems Performance (Large-Scale Study): Purification Results.

Reliability Analysis			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
INFORMATION SYSTEMS PERFORMANCE (Mean = 3.16, SD = 0.99)			
IP1	0.71	0.88	$\alpha = 0.90$
IP2	0.71	0.88	
IP3	0.80	0.86	
IP4	0.82	0.86	
IP5	0.70	0.88	
No items were dropped. All items have a CITC > 0.50.			

Table 4.2.6.3 Information Systems Performance (Large-Scale Study): Exploratory Factor Analysis.

Exploratory Factor Analysis **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.86**	
Item	*Factor Loading*
INFORMATION SYSTEMS PERFORMANCE	
IP4	0.89
IP3	0.87
IP5	0.82
IP2	0.81
IP1	0.81
Eigenvalue	3.56
% of Variance	71.1
No items were dropped. All items have factor loadings > 0.60.	

Table 4.2.7 Firm Performance

The Firm Performance (FP) construct was represented by one dimension and 8 items. The 8 FP construct items are given in **Table 4.2.7.1.**

Construct Purification. The SPSSX reliability analysis for the FP construct yielded CITC scores greater than 0.70 for all FP items. Therefore, no items were designated to be dropped at this stage of the analysis. The final alpha was 0.93 for Firm Performance. The initial FP reliability analysis is presented in **Table 4.2.7.2.**

Exploratory Factor Analysis. The entire set of FP items was submitted to exploratory factor analysis with two factors initially emerging. Factor #1 contained items FP1, FP2, FP3, FP4, FP7 and FP8. The factor loadings for items FP1, FP2, and FP3 were all greater than 0.60 while the factor loadings for items FP4, FP7, and FP8 were all less than 0.60. Factor #2 contained items FP5 and FP6 which both had factor loadings greater than 0.90. The measure of KMO was 0.82 indicating the sampling adequacy was very good. The results of the initial factor analysis are shown in **Table 4.2.7.3.**

Tracey (1996) originally found that a single factor best represented the Firm Performance construct. Because a single factor was also desired for this study and factor #2 did not strongly contribute to this research, item FP6 was dropped from the analysis and a second factor analysis run. A single factor, representative of the Firm Performance construct, emerged with all seven items loading at a level of 0.60 or more. The final measure of KMO was 0.85 indicating the sampling adequacy was very good. The results of the final factor analysis are shown in **Table 4.2.7.4.**

Final Reliability Analysis. A final SPSSX reliability analysis was then run for the

FP construct. The level of alpha was 0.92 with all remaining items having CITC scores greater than 0.50. **Table 4.2.7.5 contains the final reliability analysis results at the conclusion of factor analysis. Table 4.2.7.6** contains the final construct items organized by factor loadings.

Table 4.2.7.1 Firm Performance (Large-Scale Study): Original Construct Items.

Item	*Question*
FP1	Customers perceive they receive their money's worth when they purchase our products.
FP2	Customer retention rate.
FP3	Generation of new business through customer referrals.
FP4	Increased business from existing customers.
FP5	Sales growth position.
FP6	Market share gain.
FP7	Return on Investment.
FP8	Overall competitive position.

Table 4.2.7.2 Firm Performance (Large-Scale Study): Purification Results.

Reliability Analysis			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
FP1	0.74	0.92	
FP2	0.75	0.92	
FP3	0.68	0.92	
FP4	0.81	0.91	**α = 0.93**
FP5	0.79	0.91	
FP6	0.78	0.92	
FP7	0.67	0.92	
FP8	0.81	0.91	
No items were dropped. All items have a CITC > 0.50.			

Table 4.2.7.3 Firm Performance (Large-Scale Study): Initial Exploratory Factor Analysis.

Initial Exploratory Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.82 Factor loadings of 0.40 and above are shown.		
Item	***Factor 1***	***Factor 2***
FP1	0.79	
FP2	0.78	
FP7	0.63	
FP4	0.58	0.53
FP8	0.56	0.56
FP3	0.51	
FP6 *		0.92
FP5		0.91
Eigenvalue	4.14	1.00
% of Variance	51.8	12.5
Cumulative % of Variance	51.8	64.3
*** Item to be deleted from further analysis.**		

Table 4.2.7.4 Firm Performance (Large-Scale Study): Final Exploratory Factor Analysis.

Final Exploratory Factor Analysis Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.85	
Item	*Factor Loading*
I.S. STRATEGIC PLANNING	
FP4	0.80
FP8	0.77
FP2	0.73
FP5	0.71
FP1	0.68
FP7	0.66
FP3	0.65
Eigenvalue	3.60
% of Variance	51.4
No further items were dropped. All items have factor loadings > 0.60.	

Table 4.2.7.5 Firm Performance (Large-Scale Study): Final Reliabilities.

Reliability Analysis *Firm Performance (Mean = 3.76, SD = 0.63)*			
Item	*CITC*	*alpha if deleted*	*alpha (α)*
FP4	0.81	0.89	**α = 0.92**
FP8	0.80	0.90	
FP2	0.77	0.90	
FP5	0.73	0.90	
FP1	0.76	0.90	
FP7	0.67	0.91	
FP3	0.68	0.91	
No items were dropped. All items have a CITC > 0.50.			

Table 4.2.7.6 Firm Performance (Large-Scale Study): Final Construct Items (Organized by factor loadings).

Item	*Question*
FP4	Increased business from existing customers.
FP8	Overall competitive position.
FP2	Customer retention rate.
FP5	Sales growth position.
FP1	Customers perceive they receive their money's worth when they purchase our products.
FP7	Return on Investment.
FP3	Generation of new business through customer referrals.

4.3 COMPOSITE MEASURE CORRELATION

Table 4.3.1 contains a summary of the final construct- and dimension-level analysis for the large-scale study. The results of the instrument development process described in chapters 3 and 4 indicate that the items/measures presented here are both valid and reliable. For each construct dimension, the final alpha (α) value, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, and eigenvalue has been displayed. In every case, the final alpha value is greater than 0.70 indicating the instrument is reliable. The eigenvalue exceeds the minimum acceptable level of 1.00 indicating the factor should be retained (Hair, et al., 1995).

The measure of KMO indicates that factor analysis was appropriate for all 22 dimensions tested except for End-User Training (UT) (Kaiser, 1970). The UT dimension contains only two items which may have contributed to its very poor KMO score of 0.50. However, it was retained because it was considered to represent an important aspect of the I.S. Management Practices construct.

For each construct, the final alpha (α) value and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is also displayed. Cronbach's alpha was calculated for each construct by submitting the entire group of construct items to SPSSX reliability analysis. In every case, a final alpha value greater than 0.80 was found to exist. The measure of KMO, previously calculated in Section 4.2, indicates that construct-level factor analysis was appropriate for all 7 constructs tested (Kaiser, 1970).

The remaining items for each construct were then summed and divided by the total number of items to derive a composite measure for that construct. For example, the Work System Practices (WSP) composite measure was calculated by summing the scores for the

Table 4.3.1 Summary of Final Measurement Results (Large-Scale Study).

Final Construct-Level Analysis	Final Dimension-Level Analysis				
	Factor Name	**# of Items**	**alpha (α)**	**KMO**	**Eigen-value**
Time-Based Manufacturing Practices (TBMP) 28 Items, α = 0.90 KMO = 0.86 (EI not Included in α and KMO calculations)	F1 - Preventive Maintenance (PM)	4	0.93	0.84	7.93
	F2 - Reengineering Setup	4	0.89	0.82	2.92
	F3 - Dependable Suppliers (DS)	4	0.88	0.82	2.31
	F4 - Pull Production (PP)	4	0.86	0.76	1.83
	F5 - Quality Assurance (QA)	4	0.82	0.81	1.48
	F6 - Cellular Manufacturing (CM)	4	0.83	0.77	1.22
	F7 - Employee Involvement (EI)	4	0.90	0.82	3.10
Work System Practices (WSP) 22 Items, α = 0.89 KMO = 0.87	F1 - Integration (IN)	8	0.91	0.92	7.10
	F2 - Routinization (RO)	6	0.85	0.81	3.77
	F3 - Formalization (FO)	4	0.87	0.75	2.26
	F4 - Standardization (ST)	4	0.79	0.71	1.31
Organizational Involvement in I.S. (OIIS) 14 items, α = 0.93 KMO = 0.90	F1 - End-User Involvement in I.S. (UI)	7	0.95	0.88	7.45
	F2 - Cross-Functional Involvement in I.S. (CI)	7	0.96	0.87	2.12
I.S. Management Practices (ISMP) 12 items, α = 0.94 KMO = 0.90	F1 - Strategic Planning (SP)	5	0.93	0.86	6.50
	F2 - Responsiveness to End-Users (RU)	5	0.90	0.86	1.49
	F3 - End-User Training (UT)	2	0.81	0.50	1.15
Competitive Capabilities (CC) 20 items, α = 0.87 KMO = 0.86	F1 - Dependable Deliveries (DD)	4	0.96	0.86	5.89
	F2 - Premium Pricing (PP)	4	0.95	0.84	3.85
	F3 - Product Innovation (PI)	4	0.94	0.84	2.93
	F4 - Competitive Pricing (CP)	4	0.93	0.85	1.92
	F5 - Value to Customer Quality (VC)	4	0.90	0.78	1.41
Information Systems Performance	F1 - Information Systems Performance (IP)	5	0.90	0.86	3.56
Firm Performance	F1 - Firm Performance (FP)	7	0.92	0.85	3.60

8 Integration items, 6 Routinization items, 4 Formalization items, and 4 Standardization items and then dividing by 22, the total number of items. Each of these composite measures were then submitted to SPSSX to determine the Pearson product-moment correlation coefficients (*r*) for the nine hypothesized relationships of interest. **Table 4.3.2** summarizes the results of the correlations between the final composite measures for the purpose of assessing predictive validity. The resulting correlation coefficients are all significant at the $\alpha = 0.01$ level. This indicates that the major constructs of interest are statistically related which validates the possibility of the hypothesized causal relationships. These relationships will be explored further in Chapter 5 where the final testing of the model and hypotheses presented in Chapter 2 will take place.

Table 4.3.2 Correlations Between the Final Composite Measures to Assess Predictive Validity (Large-Scale Study).

Independent and Dependent Variable Correlations (*r*) *			
Hypothesis	**Independent Variable**	**Dependent Variable**	***r***
1	Time-Based Manufacturing Practices (TBMP)	Work System Practices (WSP)	0.68
2	Time-Based Manufacturing Practices (TBMP)	Organizational Involvement in I.S. (OIIS)	0.29
3	Work System Practices (WSP)	I.S. Management Practices (ISMP)	0.51
4	Organizational Involvement in I.S. (OIIS)	I.S. Management Practices (ISMP)	0.37
5	Time-Based Manufacturing Practices (TBMP)	Competitive Capabilities (CC)	0.42
6	I.S. Management Practices (ISMP)	Competitive Capabilities (CC)	0.35
7	I.S. Management Practices (ISMP)	Information Systems Performance (IP)	0.68
8	Competitive Capabilities (CC)	Firm Performance (FP)	0.60
9	Information Systems Performance (IP)	Firm Performance (FP)	0.17
* All correlations are significant at the $\alpha = 0.01$ level.			

CHAPTER 5: CAUSAL MODEL AND HYPOTHESIS TESTING

The development and testing of causal models assumes the prior presence of some sort of theoretical justification. A theory can be defined as a systematic set of relationships providing a consistent and comprehensive explanation of a phenomenon. It provides the rational for the development of causal models as well as their testing using structural equation modeling techniques. Theories may be based on ideas generated from one or more of the following principal sources: (1) prior empirical research; (2) other theories that when combined provide a new perspective for analysis; and (3) past experiences and observations of actual behavior, attitudes, or other phenomena (Hair, et al., 1992).

The primary causal model to be tested in this study was developed based upon the theoretical model presented in **Chapter 2**. Three existing constructs were adopted and four new ones developed based upon the literature review. Pilot and large-scale survey studies were conducted to collect data on the various dimensions of each of these constructs. Finally, composite measure correlations were calculated to assess the predictive validity of the seven constructs for hypothesis testing purposes. The resulting composite correlation coefficients calculated in **Section 4.3** for the nine hypothesis given in **Chapter 2** indicate the major constructs of interest are statistically related. All were significant at the $\alpha = 0.01$ level.

5.1 THE PRIMARY CAUSAL MODEL

Figure 5.1 is an extension of the model shown in **Figure 2.1**. It displays the primary causal model that emerged after the various phases of data analysis reported in **Chapter 4** were complete. In this section, the constructs and hypothesized relationships originally specified in Chapter 2 will be expressed in terms of causal relationships which may be tested using structural equation modeling techniques.

Hypothesis 1 is represented in **Figure 2.1** by the number 1 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Time-Based Manufacturing Practices and the Work System Practices of the firm.* In the causal model shown in **Figure 5.1**, Hypothesis 1 is represented as an arrow emanating from the TBMP construct to the WSP construct.

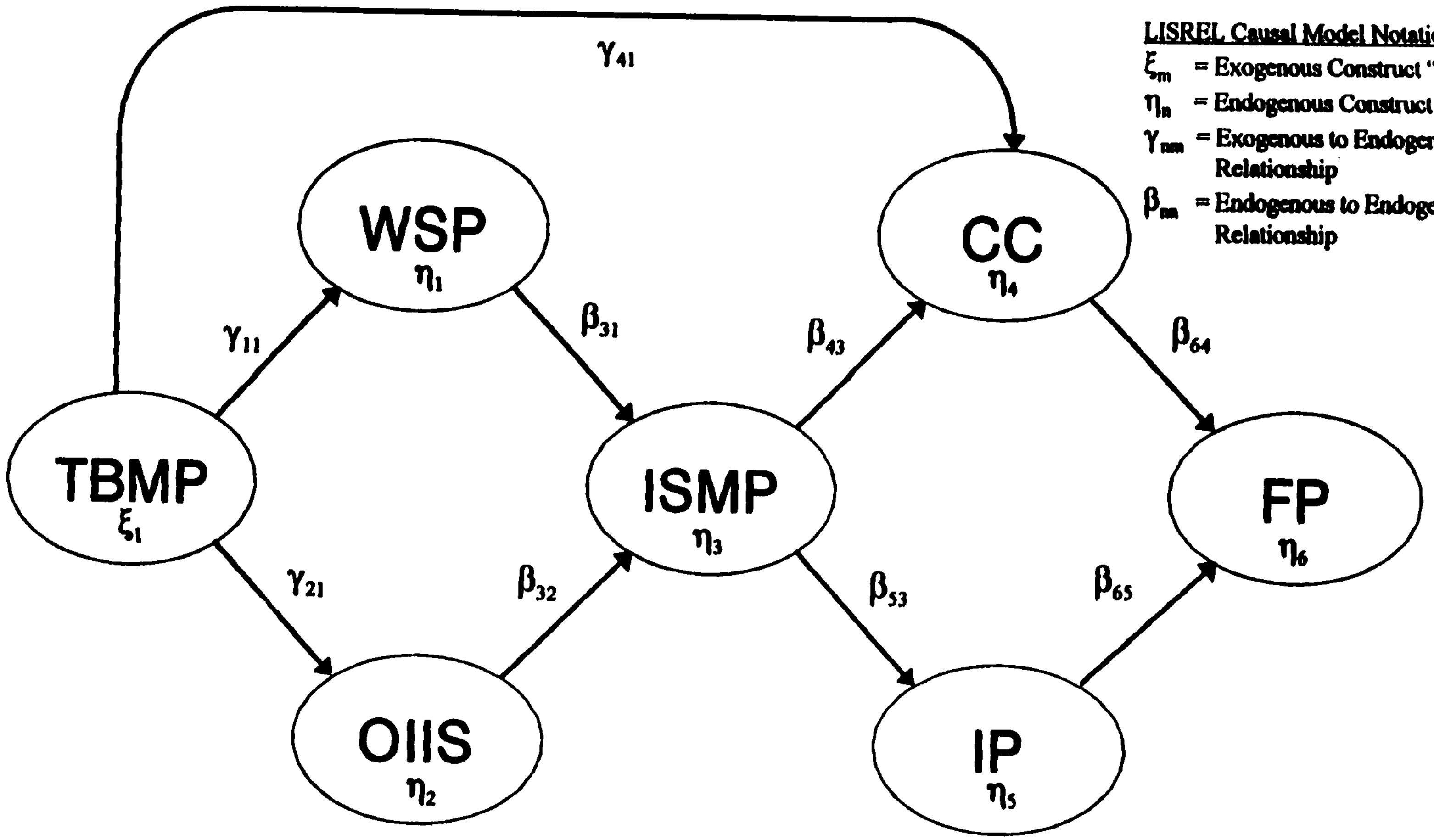
Hypothesis 2 is represented in **Figure 2.1** by the number 2 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Time-Based Manufacturing Practices of the firm and Organizational Involvement in Information Systems.* In the causal model shown in **Figure 5.1**, Hypothesis 2 is represented as an arrow emanating from the TBMP construct to the OIIS construct.

Hypothesis 3 is represented in **Figure 2.1** by the number 3 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Work System Practices and I.S. Management Practices of the firm.* In the causal model shown in **Figure 5.1**, Hypothesis 3 is represented as an arrow emanating from the WSP construct to the ISMP construct.

Hypothesis 4 is represented in **Figure 2.1** by the number 4 and is stated in Chapter 2 as follows: *There is an overall positive relationship between Organizational Involvement*

Figure 5.1: Primary Causal Model

LEGEND: TBMP = Time-Based Manufacturing Practices, WSP = Work System Practices, OIIS = Organizational Involvement in I.S., ISMP = Information System Management Practices, CC = Competitive Capabilities, IP = Information Systems Performance, FP = Firm Performance



LISREL Causal Model Notation

ξ_m = Exogenous Construct "m"

η_n = Endogenous Construct "n"

γ_{nm} = Exogenous to Endogenous Relationship

β_{nm} = Endogenous to Endogenous Relationship *in I.S. and the I.S. Management Practices of the firm.* In the causal model shown in **Figure 5.1**, Hypothesis 4 is represented as an arrow emanating from the OIIS construct to the ISMP construct.

Hypothesis 5 is represented in **Figure 2.1** by the number 5 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Time-Based Manufacturing Practices and Competitive Capabilities of the firm.* In the causal model shown in **Figure 5.1**, Hypothesis 5 is represented as an arrow emanating from the TBMP construct to the CC construct.

Hypothesis 6 is represented in **Figure 2.1** by the number 6 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Information Systems Management Practices and Competitive Capabilities of the firm.* In the causal model shown in **Figure 5.1**, Hypothesis 6 is represented as an arrow emanating from the ISMP construct to the CC construct.

Hypothesis 7 is represented in **Figure 2.1** by the number 7 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Information Systems Management Practices and Information Systems Performance of the firm.* In the causal model shown in **Figure 5.1**, Hypothesis 7 is represented as an arrow emanating from the ISMP construct to the IP construct.

Hypothesis 8 is represented in **Figure 2.1** by the number 8 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Competitive Capabilities of the firm and Firm Performance.* In the causal model shown in **Figure 5.1**, Hypothesis 8 is represented as an arrow emanating from the CC construct to the FP construct.

Finally, Hypothesis 9 is represented in **Figure 2.1** by the number 9 and is stated in Chapter 2 as follows: *There is an overall positive relationship between the Information Systems Performance of the firm and Firm Performance.* In the causal model shown in **Figure 5.1**, Hypothesis 9 is represented as an arrow emanating from the IP construct to the FP construct.

5.2 STRUCTURAL ANALYSIS METHODS

Structural equation modeling (SEM) techniques are a second-generation multivariate technique that have gained increasing popularity in the last decade. Causal models developed following the SEM approach have a number of advantages: (1) they make the assumptions, constructs, and hypothesized relationships in a researcher's theory explicit; (2) they add a degree of precision to a researcher's theory, since they require clear definitions of constructs, operationalizations, and the functional relationships between construct; (3) they permit a more complete representation of complex theories; and (4) they provide a formal framework for constructing and testing both theories and measures (Bagozzi, 1980; Chau, 1997; Fornell, 1982).

The linear structural relations (LISREL) statistical software package will be used for structural equation modeling purposes. LISREL allows researchers to evaluate both a measurement model (confirmatory factor model) and a structural equation model. In the measurement model, the researcher specifies the relations of the observed measures to their hypothesized underlying constructs. The measurement model is assessed first and respecified if necessary to improve its goodness of fit and parameter estimates. After the best model has been found it is then "fixed" before the hypothesized paths in the structural equation model are tested and possible relationships between the model constructs explored. Additional structural equation models may then be assessed to find a "best fit" model for the study data (Barki & Hartwick, 1994; Joreskog & Wold, 1982; Segars, 1994; Segars & Grover, 1993).

Assessing the overall goodness-of-fit for structural equation models is not as straightforward as with other multivariate techniques. Poor goodness-of-fit may result from possible model misspecifications, too little information provided by the data, outliers and nonnormalities, or empirical under identification (Wothke, 1993). There is no single statistical test that best describes the strength of a structural equation model's predictions. Rather, several measures may be used to assess its goodness-of-fit. In LISREL models, these measures may be divided into three categories: measures of absolute fit, measures of incremental fit, and measures of parsimonious fit (Hair, et al., 1992).

Measures of absolute fit determine the degree to which the overall model (structural and measurement models) predicts the observed covariance or correlation matrix. In this study, the measures of absolute fit to be used include the goodness-of-fit index (GFI) and root mean square residual (RMS). Measures of incremental fit compare the proposed model to some baseline model, most often referred to as the null model. In this study, the normed fit index (NFI) and the comparative-fit-index (CFI) will be used to measure incremental fit. Finally, measures of parsimonious fit relate the goodness-of-fit model to the number of estimated coefficients required to achieve this level of fit. Their basic objective is to diagnose whether model fit has been achieved by over fitting the data with too many coefficients. The adjusted goodness-of-fit index (AGFI) will be used to measure parsimonious fit.

While the chi-square statistic is a popular measure of absolute fit, it will not be used in this study because it is sensitive to both small and large sample sizes. As the sample size drops below 100 observations it tends to show acceptable fit (i.e., nonsignificant differences in the predicted and observed input matrices) even when none of the model relationships are shown to be statistically significant. As the sample size exceeds 200 it tends to indicate unacceptable fit (i.e., significant differences in the predicted and observed input matrices) even when the model relationships may statistically significant. Thus, for this study's sample size of 265 observations, the use of the Chi-square statistic was deemed to be inappropriate.

Unlike the chi-square statistic, the goodness-of-fit index is independent of the sample size and relatively robust against departures from normality. GFI appraises all of a model's parameters, including measurement items, directional relationships, and error terms, at the same time. It is a nonstatistical measure ranging in value from 0 (very poor fit) to 1 (perfect fit) that represents the overall degree of fit (the squared residuals from prediction compared to the actual data), but is not adjusted for the degrees of freedom. Higher values indicate better fit, but no absolute threshold levels for acceptability have been established (Dillon & Goldstein, 1984; Hair, et al., 1992).

The adjusted goodness-of-fit index is an extension of the GFI. It is adjusted by the ratio of the degrees of freedom for the proposed model to the degrees of freedom for the null model. The minimum recommended AGFI acceptance level is a value greater than or equal to 0.90. AGFI values of 0.90 or more are considered evidence of good fit (Dillon & Goldstein, 1984; Hair, et al., 1992).

Both the normed-fit-index (NFI) and comparative-fit-index (CFI) are widely used measures of incremental fit. NFI is a relative comparison of the proposed model to the null model (Bentler & Bonnet, 1980). CFI avoids the underestimation of fit often noted in small samples for NFI (Bentler, 1990). In either case, values greater than 0.90 are considered to be indicative of good model fit.

Finally, the root mean square residual (RMS) is a measure of the average of the residuals between observed and estimated input matrices. Covariance or correlation matrices may be used for the input matrices (Dillon & Goldstein, 1984; Hair, et al., 1992). A smaller value of RMS is associated with better fitting models with a score below 0.10 (Chau, 1997) or 0.05 (Joreskog & Sorbom, 1984) considered to be evidence of good fit.

5.3 LISREL TESTING OF THE CAUSAL MODEL

Because this was an exploratory study, a LISREL measurement model was not created. Instead, the composite measures calculated for each construct at the conclusion of factor analysis were used as input to the LISREL structural equation modeling process for hypothesis testing purposes.

5.3.1 LISREL Testing of the Initial Causal Model

Figure 5.2 visually displays the results generated by LISREL after testing the initial causal model. **Table 5.3.1** displays a more detailed summary of these results related to each of the nine hypothesized relationships of interest. The initial values of GFI = 0.98, AGFI = 0.95, NFI = 0.97, and CFI = 0.99 were all well above the minimum 0.90 level. The value of RMS was 0.040 which was below the 0.05 maximum acceptable level. As a group, these

Figure 5.2: Results of Initial LISREL Analysis

LEGEND: TBMP = Time-Based Manufacturing Practices, WSP = Work System Practices, OIIS = Organizational Involvement in I.S., ISMP = Information System Management Practices, CC = Competitive Capabilities, IP = Information Systems Performance, FP = Firm Performance

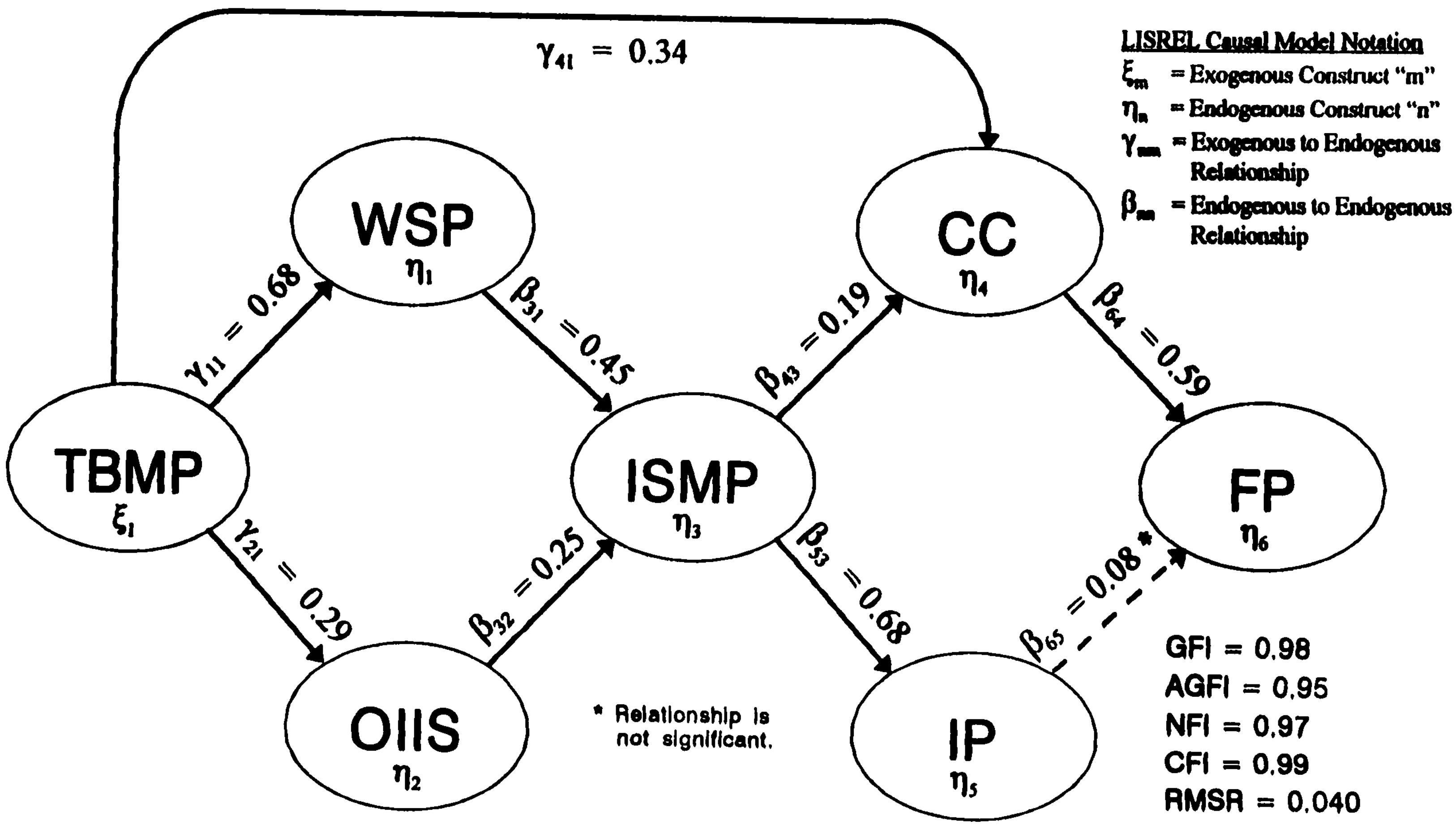


Table 5.3.1 LISREL Analysis: Initial Causal Model Results.

Initial Causal Model Results GFI = 0.98, AGFI = 0.95, NFI = 0.97, CFI = 0.99, RMS = 0.040					
Hypothesis	**Relationship**	***r***	**LISREL Coefficient**	***t*-value**	**Significant?**
1	TBMP → WSP	0.68	0.68	15.21	YES
2	TBMP → OIIS	0.29	0.29	4.84	YES
3	WSP → ISMP	0.50	0.45	8.67	YES
4	OIIS → ISMP	0.34	0.25	4.91	YES
5	TBMP → CC	0.41	0.34	5.68	YES
6	ISMP → CC	0.32	0.19	3.19	YES
7	CC → FP	0.61	0.59	11.79	YES
8	ISMP → IP	0.68	0.68	15.08	YES
9	IP → FP	0.20	0.08	1.52	NO

results present strong evidence of a good overall fit of the model to the data.

The t-values calculated by LISREL for hypotheses 1 through 8 are all greater than 2.00 indicating statistical significance at the $\alpha = 0.05$ level. The t-value calculated by LISREL for hypothesis 9 ($t = 1.52$) is less than 2.00 indicating statistical nonsignificance at the $\alpha =$ 0.05 level. Thus, research Hypotheses 1 through 8 are clearly supported because a highly significant positive relationship is demonstrated in each case. However, Hypothesis 9 was not supported as a nonsignificant relationship was demonstrated.

While information systems performance (IP) may not directly affect firm performance (FP), the results of this analysis suggest that a firm's information systems management practices (ISMP) indirectly affect firm performance through their impact on a firm's competitive capabilities. For example, improvements in the responsiveness of I.S.

management in resolving application problems or implementing new information systems may positively impact a firm's ability to provide dependable deliveries to customers. Improvements in the firm's ability to provide dependable deliveries may in turn result in increased business from existing customers. Thus, a revised causal model, less the relationship specified in Hypothesis 9, is appropriate.

5.3.2 LISREL Testing of the Revised Causal Model

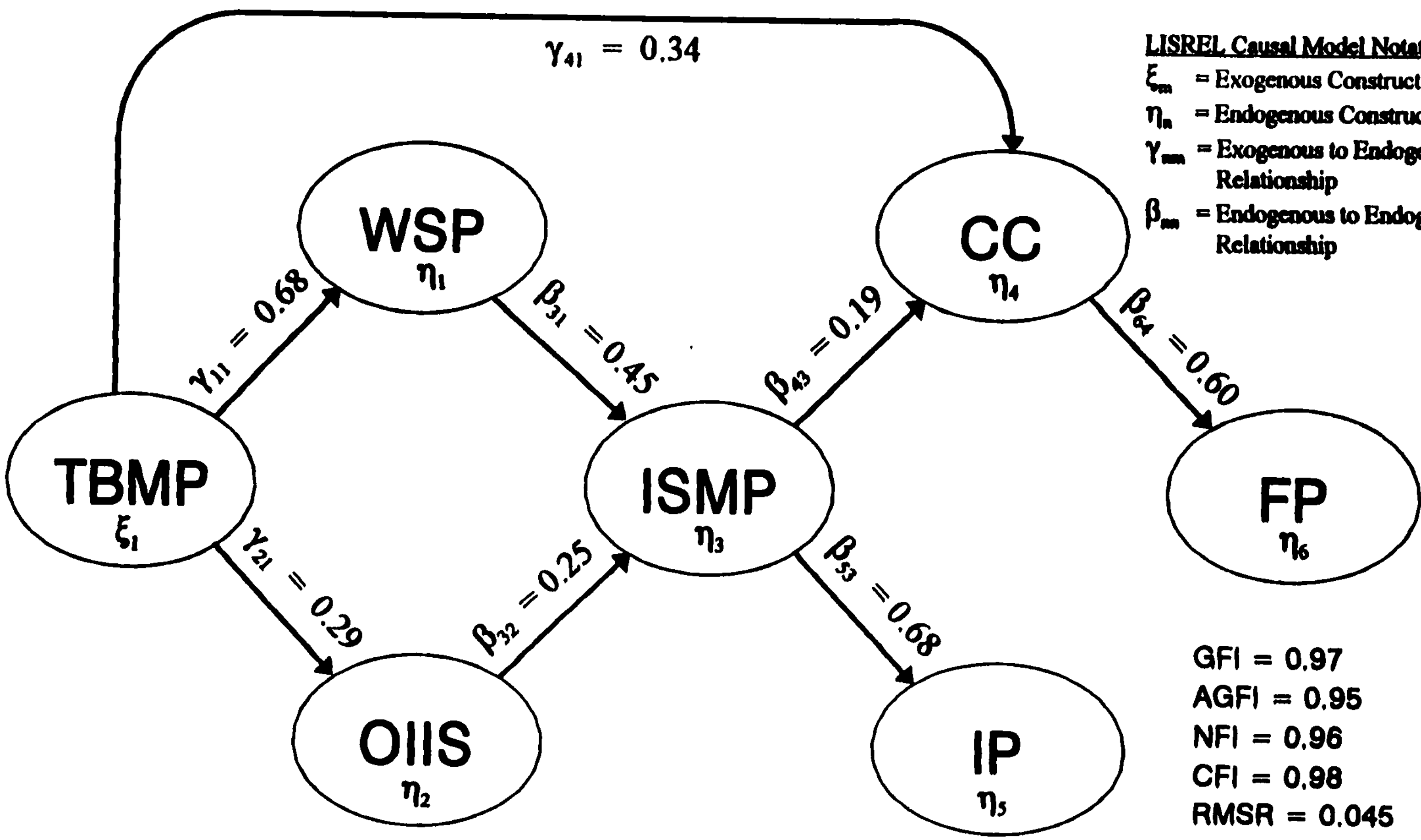
Figure 5.3 visually displays the results generated by LISREL after testing the revised causal model. The model shown in **Figure 5.3** is identical to that shown in **Figure 5.1** in all respects except one. That is, the causal relationship specified in Hypothesis 9 has been removed. The eight remaining hypotheses and their corresponding causal relationship are the same as originally specified in Section 5.1. No other changes to the initial causal model were made.

Table 5.3.2 displays a summary of the results generated by LISREL for the revised model related to the testing of the remaining eight relationships of interest between the constructs. The revised values of GFI = 0.97, AGFI = 0.95, NFI = 0.96, and CFI = 0.98 were all well above the minimum 0.90 level. The value of RMS was 0.045 which was below the 0.05 maximum acceptable level. Together, the revised results present strong evidence of a good overall fit of the model to the data.

The *t*-values calculated by LISREL for hypotheses 1 through 8 are all greater than 2.00 indicating statistical significance at the $\alpha = 0.05$ level. Thus, research Hypothesis 1 through 8 are clearly supported because a highly significant positive relationship is

Figure 5.3: Results of Revised LISREL Analysis

LEGEND: TBMP = Time-Based Manufacturing Practices, WSP = Work System Practices, OIIS = Organizational Involvement in I.S., ISMP = Information System Management Practices, CC = Competitive Capabilities, IP = Information Systems Performance, FP = Firm Performance



LISREL Causal Model Notation

ξ_m = Exogenous Construct "m"

η_n = Endogenous Construct "n"

γ_{nm} = Exogenous to Endogenous Relationship

β_{nn} = Endogenous to Endogenous Relationship

GFI = 0.97
AGFI = 0.95
NFI = 0.96
CFI = 0.98
RMSR = 0.045

Table 5.3.2 LISREL Analysis: Revised Causal Model Results.

Revised Causal Model Results GFI = 0.97, AGFI = 0.95, NFI = 0.96, CFI = 0.98, RMS = 0.045					
Hypothesis	Relationship	r	LISREL Coefficient	t-value	Significant?
1	TBMP → WSP	0.68	0.68	15.21	YES
2	TBMP → OIIS	0.29	0.29	4.84	YES
3	WSP → ISMP	0.50	0.45	8.67	YES
4	OIIS → ISMP	0.34	0.25	4.91	YES
5	TBMP → CC	0.41	0.34	5.68	YES
6	ISMP → CC	0.32	0.19	3.19	YES
7	CC → FP	0.60	0.60	12.26	YES
8	ISMP → IP	0.68	0.68	15.08	YES

demonstrated in each case. The removal of the causal relationship specified in Hypothesis 9 did not significantly alter the final results.

5.4 CONCLUSIONS

When evaluating the results of empirical research, it is important to go beyond a simple discussion of their statistical significance and/or academic importance. The point of business research should really be to gain a better understanding of the applied value of the results including the transfer of any new knowledge gained back to the research subjects (i.e., practitioners) themselves. As such, a discussion of the applied value of each the nine research hypotheses is warranted and follows.

Hypothesis 1. *There is an overall positive relationship between the Time-Based Manufacturing Practices and the Work System Practices of the firm.* While industrial era manufacturing firms generally achieved high levels of standardization, formalization and routinization through the functional subdivision of work, it has been widely posited that the post-industrial work system environment is significantly less standard, formal, and non-routine in nature. A major finding of this research is that successful post-industrial firms actually achieve a high degree of standardization, formalization, and routinization through greater work system integration.

It is suspected that these improved levels of work system integration are the direct result of the implementation of improved cross-functional decision-making processes associated with the adoption of time-based manufacturing practices. Greater work system integration enables the implementation of modular standardization through group technology for example. This in turn leads to greater process formalization and routinization based upon families of products rather than individual products, assemblies, and/or component parts.

From an organizational perspective, this implies significant revisions to the roles most managers and employees must play within their firms. While the primary role of the manager was once that of work director, it has changed to that of work facilitator chartered with the support of employee teams engaged in cross-functional decision processes. Such teams are generally more highly focused on the creation of greater organizational effectiveness and less on improving functional efficiencies. While other authors have also reached this conclusion, this study represents the first time it has been empirically tested through a survey of senior manufacturing managers and executives.

Hypothesis 2. *There is an overall positive relationship between the Time-Based Manufacturing Practices of the firm and Organizational Involvement in Information*

Systems. The results of this study indicate that a positive relationship between the time-based manufacturing practices of the firm and organizational involvement in I.S. does indeed exist. This is consistent with Hypothesis 1 where it was found that time-based manufacturing practices are positively related to increased levels of work system integration.

As senior management embraces business process reengineering and employee teams implement group decision processes, it is natural that individual group members will become involved in multiple teams both within and outside their original functional area. This includes line function employees becoming involved in staff function teams and vice versa. As such, it is logical to assume that the adoption of time-based manufacturing practices will promote greater end-user and cross-functional involvement in I.S. as employees seek to improve the I.S. management practices of their firm.

Hypothesis 3. *There is an overall positive relationship between the Work System Practices and I.S. Management Practices of the firm.* The stability of the work system is a critical prerequisite for the development of effective I.S. management practices. Rapidly changing work system practices can be extremely difficult to emulate and support. Long-term I.S. planning is virtually impossible in firms with inconsistent operational standards where information content, processing, and technology requirements are constantly changing. It is also difficult for I.S. functions to provide responsive customer services in a non-routine work environment where end-user service demand may vary tremendously from day to day. Finally, the development and implementation of common software applications and data bases used for shared learning and decision making can be difficult if not impossible in a non-standard work environment.

Hypothesis 4. *There is an overall positive relationship between Organizational Involvement in I.S. and the I.S. Management Practices of the firm.* A positive relationship between organizational involvement in I.S. and the I.S. management practices of the firm was found to exist. As end-users become more involved, either individually or cross-functionally, in the establishment of I.S. management practices, many benefits have been found to exist. Greater end-user involvement presents users with an opportunity to more clearly specify I.S. application requirements, issues and concerns, as well as individual functional priorities. Greater cross-functional involvement presents users with an opportunity to negotiate I.S. resource allocation and information sharing across functions as well as address a wide range of software application issues on an organizational basis.

Hypothesis 5. *There is an overall positive relationship between the Time-Based Manufacturing Practices and Competitive Capabilities of the firm.* As expected, Koufteros (1995) original findings were validated through hypothesis testing. However, It was necessary to validate the reliability of his instruments as well as the causal relationship between time-based manufacturing practices and competitive capabilities for two reasons.

First, the number of items in Koufteros' original instruments were reduced to four items per dimension as discussed in Chapter 4. Factors representative of each dimension of the reduced constructs could have failed to emerge as expected during exploratory factor analysis due to item reductions. Second, Koufteros 1995 study was primarily directed toward senior and executive level product development engineering managers. The subject pool for this study was primarily composed of senior and executive level manufacturing managers. As such, their perceptions of a firm's time-based manufacturing practices and competitive capabilities could have proven different for manufacturing managers than for engineering managers. Again, problems related to factor development and/or causal relationships may have emerged.

No such problems were encountered. Factors representative of each dimension emerged as expected with the positive causal relationship between time-based manufacturing practices and competitive capabilities being highly significant.

Hypothesis 6. *There is an overall positive relationship between the Information Systems Management Practices and Competitive Capabilities of the firm.* This research confirms what has often been speculated. That is (1) the effectiveness of the I.S. planning process, (2) the responsiveness of I.S. function to end-user issues, questions, and concerns, and (3) the extensiveness of I.S. end-user training all contribute toward the improvement of the competitive capabilities of a firm. Firms seeking to build competitive advantage may do so in multiple ways through the use of information technology to improve firm responsiveness to customers, reduce processing time, improve delivery dependability, and create additional product value for the customer.

Hypothesis 7. *There is an overall positive relationship between the Information Systems Management Practices and Information Systems Performance of the firm.* A positive relationship was found to exist between the I.S. management practices of the firm and information systems performance. The results affirm that increases in I.S. strategic planning, responsiveness to end-users, and end-user training effectiveness contribute to improved management perceptions of I.S. performance. From an I.S. management point of view, these findings are significant because those I.S. functions that are perceived as being highly effective are much less likely to be outsourced or downsized by senior management.

Hypothesis 8. *There is an overall positive relationship between the Competitive Capabilities of the firm and Firm Performance.* This finding is important because a key tenet of the time-based manufacturing literature is that a positive relationship between competitive capabilities and firm performance exists. In his original time-based manufacturing study, Koufteros (1995) did not test this hypothesis to verify that the relationship exists. While Tracey (1996) did include a portion of Koufteros competitive capabilities instrument in his work on transportation and logistical effectiveness, he did not test Koufteros' entire instrument which is much more robust. As such, the existence of a significant positive relationship between competitive capabilities and firm performance was found to exist and is included as an important research finding.

Hypothesis 9. *There is an overall positive relationship between the Information Systems Performance of the firm and Firm Performance.* While the hypothesized relationship was found to be not significant at the $\alpha = 0.05$ level, the association between I.S. performance and firm performance was positive. There could be several possible reasons for this. The most likely explanation is that an indirect relationship between I.S. management practices and firm performance via competitive capabilities best represents the true contribution of information technologies in most organizations. That is, the I.S. management practices of the firm play a supporting role in the creation of greater firm performance while competitive capabilities directly enhance firm performance.

CHAPTER 6: SUMMARY AND RECOMMENDATIONS FOR FUTURE RESEARCH

This research represents an initial cross-functional investigation between the manufacturing and information systems fields of study. While the subject of interdisciplinary research has received a great deal of attention over the past few years, few researcher have actually initiated such studies. The primary purpose of this research was to explore the effects of time-based manufacturing practices on the information systems management practices of a firm. Its second purpose was to explore the direct effects of information systems practices on the competitive capabilities of a firm.

A major contribution of this research has been the development of a valid and reliable instruments to measure: (1) the work systems work system practices of the firm; (2) organizational involvement in I.S. activities; (3) the I.S. management practices of the firm; and (4) information systems performance. The development of these instruments has enabled interdisciplinary research in the manufacturing and information systems fields of study. In the future, confirmatory factor analysis could be used to substantiate the appropriateness of each instrument developed.

A second contribution is the development of a causal model allowing for the thorough testing of the nine hypothesized relationships. These relationships are depicted in Figure 5.1 and have been validated using the LISREL statistical analysis software. The results provide evidence in support of research hypotheses 1 through 8. They did not support the hypothesis (Hypothesis 9) that information systems performance is positively associated with firm performance.

A third contribution is that this study provides a valuable tool for manufacturing executives to evaluate the impact of their firm's: (1) manufacturing practices on their work system practices; (2) work system practices on their information systems practices; and (3) information systems practices on competitive capabilities. The obvious benefit being a better understanding of how time-based manufacturing practices create a more stable work system environment. A second benefit being a better understanding of the necessity for greater work system stability for improved I.S. management effectiveness. The third benefit being a better understanding of how I.S. management practices directly affect competitive capabilities and indirectly affect firm performance.

While these contributions are significant, additional detailed information is needed to make these findings even more meaningful to the managers of manufacturing firms. This may include the exploration of other I.S. practices in relation to time-based manufacturing and work system practices. One such example is the software application development process employed by the firm's I.S. staff. These may include the software development strategy used such as a the employment of a prototyping versus the much more formal systems development life cycle approach. It might also include the specific data modeling and data base approaches used.

A more detailed, industry by industry comparison may be conducted to assess the degree to which time-based manufacturing practices affect the I.S. management practices of a particular industry. For example, while the causal relationship between I.S. performance and firm performance did not prove significant at the $\alpha = 0.05$ level for the general model, it is possible that it may prove to be highly significant for a select subset of industries. This assumes that different industries may deploy different types of information technology in different ways. Thus, I.S. performance may play a much greater role in the determination of firm performance in one industry than in the next.

Finally, the expansion of this research could lead to many interesting new studies. One such example is the use of the I.S. management practices instrument to test the possible causal relationship with end-user dependence (i.e., application development and computer technology) and end-user dominance (i.e., control over the I.S. function). This relationship has been hypothesized to exist in both the I.S. downsizing and outsourcing literatures. It proposes that end-users will become less dependent on the I.S. function and seek to develop greater dominance over I.S. resources as I.S. management effectiveness declines. In doing so, end-users will seek to adopt more responsive I.S. strategies such as the downsizing and/or outsourcing of the firm's information technologies and systems (Benko, 1993; Doll & Doll, 1992; Rowley & Smiley, 1993; Suh, 1992).

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