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THE ROLE OF THE BUYER-SUPPLIER
LINKAGE IN AN INTEGRATED
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By
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ABSTRACT

THE ROLE OF THE BUYER/SUPPLIER LINKAGE IN AN INTEGRATED PRODUCT DEVELOPMENT ENVIRONMENT

By

Laura Marie Birou

The focus of this research was to identify the supplier's role in the new product development process. More specifically, the purpose of this research was to gain an understanding of what constitutes supplier involvement in the new product development process which utilizes a Integrated Product Development (IPD) strategy, and determine what impact this involvement had on the success of IPD. The first objective involved defining supplier involvement, and how it can be accurately measured. The ability to accurately characterize and measure supplier involvement facilitated the accomplishment of the second objective, the identification of the relationship between supplier involvement and the results obtained by employing the IPD strategy.

The research methodology involved a large scale empirical investigation of firms utilizing the IPD strategy. Data was gathered from 133 respondents, a 51.9 percent response rate, through the use of a self-administered questionnaire. Indepth information was provided regarding the organizational, project, and interorganizational variables which impact the success of new product development efforts. The data collected was used to test several hypotheses concerning the impact of supplier involvement on the success of IPD and the market performance of the firms.

The research demonstrated that supplier involvement in the new product development process in an integrated environment had a detrimental impact on product cost, quality, performance, and development time. These findings are contrary to current convention which advocates procurement strategies fostering a high level of supplier involvement such as, partnering, strategic alliances, joint ventures, risk-sharing agreements, and technology sharing arrangements. This research calls into question the strategic advantage of supplier involvement in the new product development process and reveals a need to actively monitor the contributions made through these relationships.

AS THE BENEFICIARY

OF UNCONDITIONAL LOVE

I DEDICATE THIS WORK OF LOVE

TO MY HEROES,

MY PARENTS.

ACKNOWLEDGEMENTS

I begin this acknowledgement with trepidation as there are many factors which contribute to the success of any project, as my research has discovered, and I fear that my list will not be all inclusive. In analyzing projects that were considered successes and failures, the underlying question remained--How do we duplicate success? What is the key success factor? Many conversations, brainstorming sessions, and case studies revealed a variable called group cohesion, commitment, leadership, and personal trust. The underlying dimension was the degree to which individuals were willing to extend themselves for the benefit of another or a cause--LOVE. This dissertation is the product of the love demonstrated by many individuals. I will do may best to include them all in this acknowledgement.

First of all, I would like to extend my appreciation to the members of my dissertation committee Dr. Stan Fawcett, Dr. Steve Melnyk, and especially my chairperson, Dr. Ram Narasimhan. Their personal dedication to me demonstrated through the countless hours of mentoring, encouraging, developing, pushing, and perfecting this project will forever be remembered. In addition, I would like to thank Dr. John Hoagland for the role he has played in my life. His passion for the field of purchasing has served as a model of dedication. He has served as a mentor, teacher, and most importantly a friend. I can never repay his kindness. I can only try to duplicate it with my students.

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To my students, who have who have been very understanding and supportive during a very demanding part of my life. Your love has helped sustain me during difficult times. Aut Disce Aut Discede--Carpe Diem! To my friends--Barb Cofield, Abby Daniell, Gayle DeBruyn, DeDe Dezelski, Carol Dougherty, Steve Durand, Lisa Ellram, Jeannine Kerwin, Marty and Kerry Mullane, Sue Polhamus, Barb Shannon, Trent Whitehead, and Sue Zarish--who have sacrificed with me in giving me one of the greatest gifts of all in the focused pursuit of this goal, my time. To my family--Mom, Dad, Grandma, Ronn, Diane, Todd, Lisa, Jeff, Kevin, Kelli, and Randi, thanks for believing in me when my belief in myself was wavering. For two angeles--Vittal Anantatmula and Nancy Manuszak--who have made this process infinitately more bearable. You helped me carry the football into the end zone--the longest yard.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

1.0 The dependence of the United States economy on the manufacturing sector is evidenced as "the traditional industrial sector has long been the leader in U.S. growth in productivity, the wellspring of innovation, and the generator of a rising standard of living - Akio Morita" (Norman, 1986: 57). This reliance on manufacturing as the source of wealth for the United States economy is of significant concern as our manufacturing strength continues to deteriorate and the service sector becomes the fastest growing segment of the United States economy. The service sector has not been able to duplicate the wealth-generating capability of the manufacturing sector because of low productivity levels and the limited value-added nature of the product. Revitalizing U.S. manufacturing prowess, therefore, is a critical element in sustaining the standard of living enjoyed by the American population.

New Product Development (NPD) is rapidly becoming the key issue in the quest for sustained growth and profitability for manufacturing firms. NPD involves the range of product development activities from the enhancement of existing products, often referred to as model change, to the development of brand new products which may require the adoption of new technology. A survey conducted in 1981 by Booz, Allen and Hamilton involving 700 U. S. companies revealed that new products would account for one-third of all profits in the 1980s, an increase from one-fifth in the 1970s, and the trend is projected to continue (Takeuchi and Nonaka, 1986). In addition, a comparison of firms and the lengths of their new product development cycles revealed that firms with shorter product development cycles demonstrate higher performance (Birnbaum, 1988; Davidson, 1988).

The challenge to rapidly develop and introduce new products in the marketplace is the focus of contemporary manufacturing concerns. One strategy being utilized to meet this challenge is known as Integrated Product Development (IPD). The essence of IPD is the integration of the design of the product with the process utilized to manufacture it. The objective of IPD is improving product quality and performance, while reducing product development time and product cost. Traditionally, product and process designs have been done sequentially, effectively ignoring the interaction between the two sources of innovation (see Figure 1-1). The IPD strategy represents a departure from the traditional approach in that product and process designs are developed concurrently (see Figure 1-2).

The purpose of the present research was to gain a deeper understanding of the new product development process in an IPD environment. The intention was to determine the impact an IPD strategy has on the NPD process and the performance of the firm, and the supplier's role and contribution. More specifically, the research sought to determine what constitutes supplier involvement in the development of a new product which utilized the IPD strategy

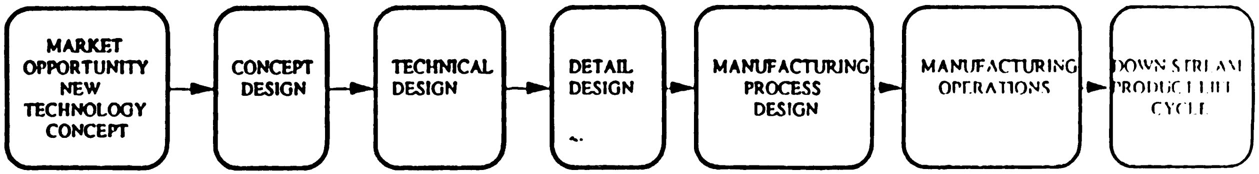

FIGURE 1-1

Traditional/Sequential NPD Process

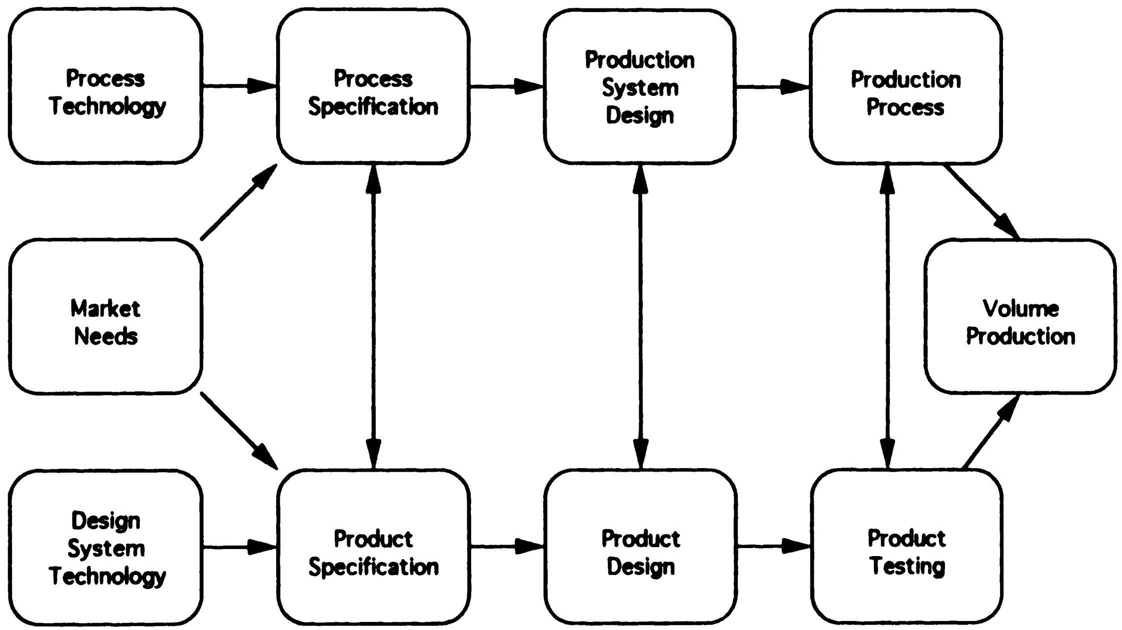

FIGURE 1-2.

INTEGRATED / SIMULTANEOUS
NPD PROCESS

and to determine what impact this involvement had on the success of an IPD effort.

1.1 External Pressures for NPD in Manufacturing

"America's Third Industrial Revolution" (Helfgott, 1986) and "Post-Industrial Manufacturing" (Jaikumar, 1986) are phrases which have been coined in an attempt to capture the significant trends causing the rapid re-structuring of the U.S. manufacturing industry. Historically, the shift from an agricultural society to an industrial society took place over the course of 100 years. In the new era of manufacturing, the U.S. economy has gone through a transition from an industrial to an information orientation in a mere 20 years (Warnat, 1983). The unprecedented rate of technological obsolescence--the rate at which current technology is replaced by new, improved methods and practices--raises concerns as to whether the United States is losing the innovative capacity necessary to compete in the world market (Van De Ven, 1986). Achieving competitive success in the future, and sustaining it, will depend on our ability to innovate (Howell and Higgins, 1990; Hayes, et al., 1988; Kanter, 1983; Peters and Waterman, 1982; Porter, 1980).

Technological obsolescence as a force in the U.S. marketplace is driven by the emergence of foreign competition and the changes in the buying patterns of consumers. Consumers have become increasingly quality conscious. Perceived value and reliability are seen as key components of every product in today's highly competitive marketplace (Phillips, et al., 1990). As such, consumers have become accustomed to and demand new products and frequent model changes as they seek to satisfy their desire for individualism (Bolwijn and Kumpe, 1986; Gutenberg, 1984; Helfgott, 1986). Success in today's marketplace depends on a firm's ability to keep pace with rapid changes in market demands. Product life cycles have been reduced dramatically, placing significant pressure on corporations to introduce new products in quick succession to remain competitive (Howell and Higgins, 1990; Bolwijn and Kumpe, 1986; Harris, 1986).

A survey conducted by Gupta and Wilemon (1990) identified several factors leading to the need for accelerated development of new products. The two primary reasons cited were increased competitive pressure from both domestic and foreign sources and the rapid rate of technological change. Respondents also mentioned the following as contributing factors: consumer demand for new products; business growth objectives; shortened length of the Product Life Cycle (PLC); pressure coming from senior management; and the desire to be the first supplier in the market. Welter (1989) stated that by 1990, the average company would generate 40 percent of its sales from products which were less than five years old. For example, corporate objectives at 3M dictate that each division be evaluated on the percentage of sales generated from new products. The "25% Rule" states that a quarter of a division's sales must be derived from products introduced within the last five years (Mitchell, 1989: 61).

This heavy reliance on new products points to a major weakness in the manufacturing segment of the United States economy. Manufacturers in the United States take 25 percent more time to develop and deliver a product than in the best of the overseas companies. (Spencer, 1990: 49). While the United States has long held a leadership position in the development of new technology (Clark and Hayes, 1988), industry has failed to capitalize on this position. The problem resides in the inability of firms to effectively "transfer technology" from basic research to applications which provide value to the consumer. Duffy and Kelly (1989) support the importance of being the first supplier to the market, as it tends to ensure a 50 percent market share for the company. The eventual outcome of this situation is the loss in profits by United States manufacturers to competitors who have the ability to rapidly adopt new technology and convert it into a commercial product, preempting the developer of the technology in the delivery of the product to the market.

1.2 Accelerating NPD Cycles

The importance of Time-Based Competition (Stal, 1988) is beginning to be recognized as a source of competitive advantage. Firms introducing high-tech products six months past the projected release date, but within budget, realized a 33 percent decrease in expected profits over the first five years. On the other hand, firms introducing products on-time, 50 percent over budget, suffered only a 4 percent reduction in profits (Gupta and Wilemon, 1990). Research conducted by Clark, Chew, and Fujimoto (1987) concluded that each day of delay in the introduction of an automobile with a market value of $10,000, leads to a loss of at least $1 million in expected profits. The authors state that this is a conservative estimate since it does not include the impact lost sales have on cost or future market share. The length of development time is, therefore, a crucial factor in the success of any new product in the market and the continuing success of a business.

The motorcycle industry provides an excellent example of the relationship between the rate and timeliness of new product introductions, and competitive success. In the battle over market share between Honda and Yamaha in the early 1980s (Abegglen and Stalk, 1985), Honda was able to take the leadership position in the industry by introducing 113 model changes in 18 months compared to 37 model changes by Yamaha during the same time period. Consumers responded positively to the rapid product introductions with leading-edge designs incorporating new technology, quality, and value.

1.3 Product Cost, Quality, Performance and NPD

It would be inappropriate to conclude that NPD focuses strictly on the timing of new product introductions. Customer satisfaction demands not only new products but also that these products simultaneously deliver high quality and value. Research involving the use of the Profit Impact on Market Strategy (PIMS) database revealed a strong correlation between high quality, high productivity, high market share, high profitability, and high return on investment (Bhote, 1987). The scope of the NPD process therefore encompasses the delivery of a high quality, cost-effective product incorporating the latest technology in the shortest possible time from concept to market.

Post-World War II manufacturing has carried most of the blame for the decline of the U.S. competitive position in the world market. Poor quality and high product cost were attributed to inefficient and ineffective manufacturing practices. The focus is now shifting from manufacturing to design as the primary cause of poor performance in the marketplace. Forty percent of all quality problems can eventually be traced back to inferior product design. In addition, 60 to 80 percent of a product's total cost is determined in the design stage of product development (Raia, 1989: 58). The realization that quality and cost must be designed into the product instead of "built-in" by downstream operations (manufacturing/purchasing) has brought new attention to the process and priority of NPD. Product design is now seen as a formidable weapon in the search for a global competitive position and Integrated Product Development (IPD) is being touted as a solution for the "Transfer of Technology" problem in the area of new product development.

1.4 Research Purpose

The purpose of this research was to advance the understanding of what constitutes supplier involvement in the NPD process which utilizes an IPD strategy and what impact this involvement has on the success of IPD. The essence of this strategy involves the integration of the design of the product and the process used to manufacture the product. One objective of the IPD strategy is to design the product for ease of manufacturing and assembly (Stoll, 1988). The goals of this approach are to improve product quality and performance, while simultaneously reducing product cost and development time.

With an average of 56 percent of each sales dollar spent on the procurement of production materials, the impact of the supply base on product quality and cost cannot be over-emphasized (Burt, 1989: 127). Research conducted by Clark (1989) involving 29 NPD projects in the automotive industry provided a comparison of performance among firms in Europe, Japan and the United States. The comparisons were based on two variables: the number of engineering man-hours required and the project lead time. Results indicated that one-third of the reduction in man-hours and the four to five months of the lead time advantage enjoyed by the Japanese can be attributed to the impact of their relationship with the supply base and early supplier involvement. It is generally agreed that early supplier involvement in the NPD process should result in beneficial gains for the firm; what remained to be determined was the nature and degree of involvement, and the specific IPD objectives influenced by this involvement.

Through this research effort, the term supplier involvement (SI), its meaning and measurement, was developed and interpreted in the context of the IPD strategy. The ability to accurately characterize and measure the level of supplier involvement facilitated the accomplishment of the second objective, which involved identifying the relationship that exists between the level of supplier involvement and the results obtained by employing the IPD strategy.

A causal model developed and validated by Susman and Dean (1991), which represents the process associated with the utilization of the IPD strategy (see Figure 1-3), was adapted for the purpose of this research. This model presents a framework for the identification of important variables and their relationship to

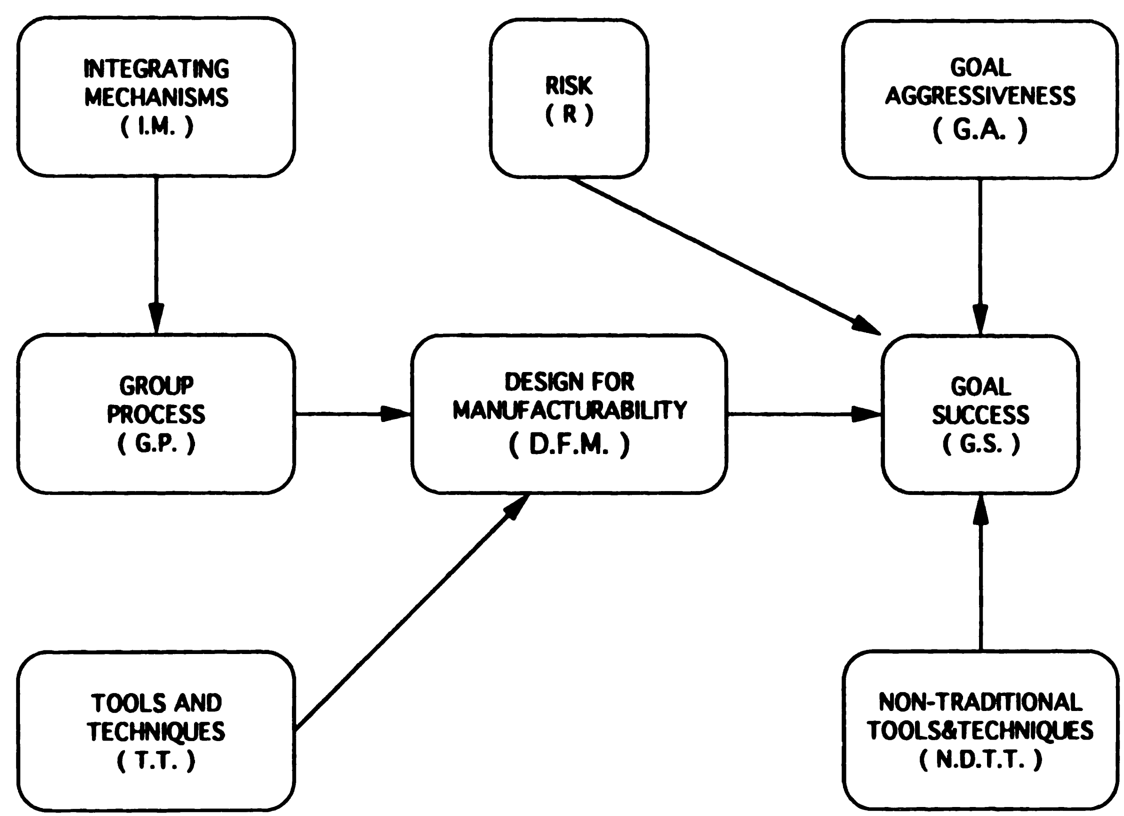

FIGURE 1-3

SUSMAN & DEAN (1990) CAUSAL MODEL OF
VARIABLES
LEADING TO PROJECT GOAL SUCCESS VIA D.F.M.

the success of IPD. Susman and Dean's model was enhanced to isolate the impact of suppliers and their role in and contribution to the achievement of IPD (see Figure 1-4).

The research questions which were investigated in this study included: 1) Does an IPD strategy impact the performance of the firm? 2) Does supplier involvement in the NPD process influence project performance? 3) Which elements of project performance (cost, quality, product performance, development time) are influenced by supplier involvement?

The research design utilized a self-administered survey to facilitate the collection of data from a large and diverse population providing for sufficient depth and breadth of analysis. The research utilized exploratory data analytic techniques and multiple regression analysis to test the research hypotheses.

1.5 Research Contributions

Insights gained by this research are of particular importance to practionners facing an accelerated NPD environment during periods of corporate restructuring and downsizing. The ability to compete on time in a resource constrained environment will prove to be a significant competitive advantage. Understanding the dynamics of an IPD environment will serve to improve project success and facilitate the allocation of scarce resources. In addition, the research will provide management with information regarding the relative advantage of including the primary external resource, the supply base, in the NPD process. Understanding the transfer of technology in a resource-sharing arrangement between the buyer

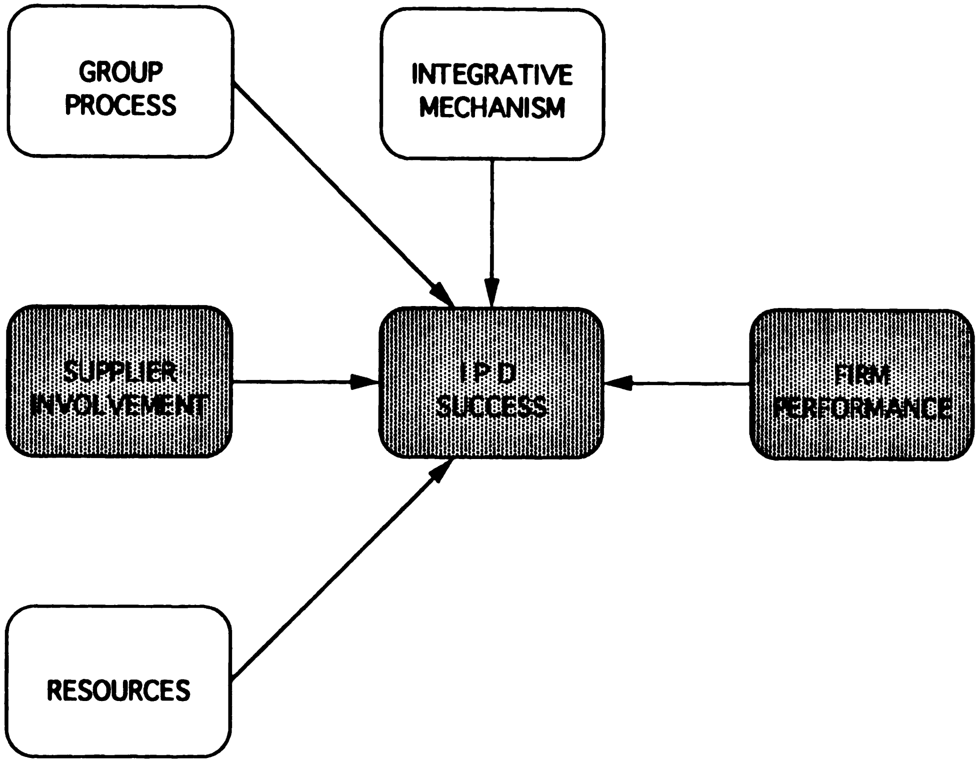

FIGURE 1-4

SUPPLIER INTERFACE IN THE IPD STRATEGY

and the supplier will enhance management's ability to coordinate the NPD effort.

This research builds on previous research through an empirical investigation of the relationships postulated in the literature. It serves to identify the strength of the relationships between the independent and dependent variables, and provide future research efforts in this area with valid reliable measures of constructs of inherent interest in the NPD environment.

Subsequent sections of this dissertation address the supporting literature, a description of the conceptual model with the definitions of variables, the research methodology including the research hypotheses, research design, results, and contributions and conclusions.

CHAPTER II

LITERATURE REVIEW

2.0 This literature review begins with a presentation of the historical evolution of the NPD environment to facilitate a deeper understanding of the research problem. Previous research dedicated to the process of product and process innovations will then be discussed beginning with the research dedicated to an organizational level analysis, followed by those with a project level focus, and concluding with the interorganizational literature. The goal of this literature review is to identify the variables which are postulated to impact the effectiveness of the innovation process (see Figure 2-1).

2.1 Historical Background

Clark and Hayes (1988) present an analysis of the evolution and transformation of American manufacturing over the last century which provides an excellent framework for understanding the development and decline of United States manufacturing strength and overall competitiveness in the world market. The progression can be categorized into three eras of manufacturing: The Artisan Era, The Scientific Management Era, and The Management Science Era. The progression is marked by a movement away from an integrated product development process to a compartmentalized new product development structure. A brief description of each period provides the foundation for this research effort.

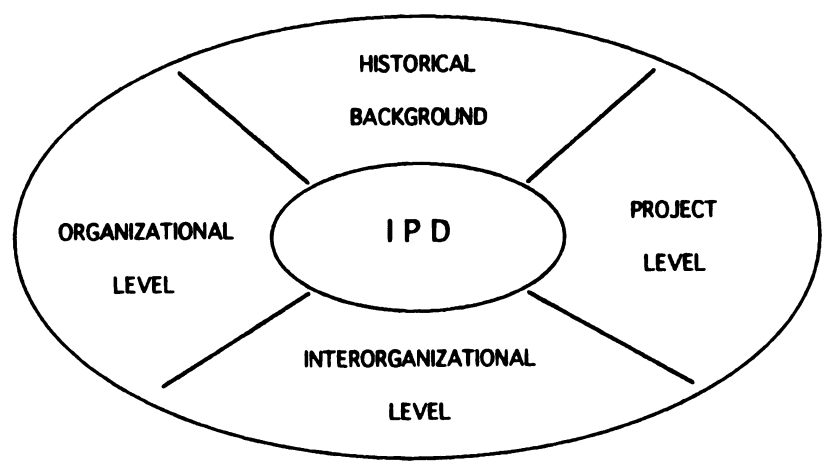

FIGURE 2-1

LITERATURE REVIEW

2.1.1 The Artisan Era

The Artisan Era, which took place in the late 1800s and early 1900s, is described by Clark and Hayes as a blending of art and science. It was marked by the craftsman/inventor who became an entrepreneur responsible for the delivery of a desirable product to the customer. Success hinged on the entrepreneur's ability to interpret customer needs and to develop the product production, and delivery processes effectively. Meshing of product and process development occurred naturally, as the responsibility resided with one individual. This stage of manufacturing development was characterized by "individual responsibility, technical excellence, attention to detail, loyalty, personalized customer service, and continual improvement" (Clark and Hayes, 1988: 14).

The main drawback of this form of manufacturing management is the inability to accommodate high volume production with the same degree of personalized attention to the entire process. Consequently, as the operation grows in scope or scale, division and delegation of responsibility become a necessity. What develops is the need for a systematic method of controlling the NPD process, as the separation between product and process development occurs.

2.1.2 The Scientific Management Era

From this conflict emerged the era of Scientific Management, governed by the principles of Frederick Taylor and implemented by a cadre of industrial engineers. The process of completing a job, which had once been viewed in a holistic sense, became viewed as piecemeal in nature. Each work element was scrutinized in the pursuit of productivity improvements. Work methods, such as time and motion studies, were developed in order to apply scientific methods to the task of production. The most efficient means of manufacturing was established and routinized as standard operating procedure.

This evolutionary stage involved a movement away from direct participation of management in the production process to clear demarcations of line and staff responsibility. Staff responsibility included determining the "right way" to produce the product and planning and controlling the production process. Line responsibility centered around the actual, physical production of the finished product. The adoption of scientific management practices served as a prerequisite to the automation of the manufacturing process as specialization increased repetition. Hence, a further separation occurred between those actually producing the product and those responsible for determining the production process.

While productivity improved dramatically during this time, the Scientific Management period represents the point in time when the art and science of New Product Development (NPD) were formally separated. Organizational structures arose to support this division of authority and responsibility, with "science" falling under the manufacturing domain, and the "art" being delegated to the research and development (R&D) arena. These organizational structures have been associated with a corporate culture fostering the "over-the-wall syndrome." The environment is marked by restricted communication flow between interdependent and linked departments which are further compartmentalized by the formal separation of authority and responsibility. The impact of this segregation was not readily apparent since established leaders of these functional areas were the products of a highly integrated era with instilled craftsman/artisan values and an entrepreneurial spirit. In addition, the NPD requirements present during World War II mandated a close cooperation between the product and process development functions. The urgent need to shift America's manufacturing capability from consumer to military goods resulted in coordinated NPD efforts characterized by a common goal (strategic defense) and cross-functional collaboration. World War II is cited as "the Golden Age of American Manufacturing," because, according to Clark and Hayes (1988: 21), it represented the "epitome of world-class manufacturing."

World-class manufacturing capability was defined as the ability to respond quickly to changing customer requirements through the introduction of new or improved products (Clark and Hayes, 1988: 21). This was accomplished by the integration of product and process design to condense the NPD cycle. At this point it is important to note that the competitive environment was much different from the environment facing firms today. Cost was not an important consideration during this time because of the nature of the product (defense) and the customer (government). Manufacturers could focus on one competitive priority--time.

Following World War II, the development and evolution of the United States economy was strongly influenced by the marketing and finance areas (Phillips, et al., 1990). The focus was on the marketing and exporting power of United States produced goods in the world market was parallelled by a corresponding neglect of the manufacturing and R & D functions. Investment in new capital equipment, and R & D consistently declined as a percentage of GNP (Kimmerly, 1983). Both the "art" and "science" of NPD suffered during this period, eroding the very source of previous strength of the United States economy.

2.1.3 The Management Science Era

This post-war period is referred to as the Management Science Era to convey the shift in focus from the application of science to the management of manufacturing, to the management of science. The emphasis on continual incremental improvement, characteristic of the Artisan Era, was replaced by the pursuit of quantum change and advancement in product and process technology. This shift in focus resulted in a corresponding drop in customer satisfaction caused primarily by a decline in quality and attention to customer needs. The customer-focus was replaced by a competitor-focus as the orientation and competitive strategy for many United States firms. Success was measured by comparative market share advantages, with little regard for customer retention and satisfaction. This period is also characterized by the continuing rise in the power and importance of the marketing and finance areas with an emphasis on the short-run return-on-investment (Phillips, et al., 1990)

"America's Third Industrial Revolution" (Helfgott, 1986) and "Post-Industrial Manufacturing" (Jaikumar, 1986) are phrases which have been coined in an attempt to capture the significant trends which have caused the rapid re-structuring of the United States manufacturing industry. The shift from an agricultural society to an industrial society took place over the course of 100 years. The new era of manufacturing has been marked by a transition from an industrial to an information orientation in a mere 20 years (Warnat, 1983). This unprecedented rate of technological obsolescence--the rate at which current technology is replaced by new, improved methods and practices--raises concerns as to whether the United States is losing the innovative capacity necessary to compete in the world market (Van De Ven, 1986). Achieving competitive success in the future, and sustaining it, will depend on our ability to innovate (Howell and Higgins, 1990; Hayes, et al., 1988; Kanter, 1983; Peters and Waterman, 1982; Porter, 1980).

2.2 Organizational Level Research

The main objective of this section of the review is to identify research related to the process of innovation, research and development (R&D) management, and the R&D process, specifically looking for variables which have been identified as having an impact on the effectiveness of the innovative process associated with NPD. "R&D management is concerned with the organization and management of technological innovative processes" (Radnor, Ettlie, and Dutton, 1978). Much of the macro-level research has involved the issues of R&D management and R&D effectiveness. This is a reflection of the traditional/sequential model associated with NPD which, since the Scientific Management era, has historically been initiated by the R&D function.

A survey of the relevant literature by James M. Utterback (1974) examined the impact of environmental issues on innovative behavior and concluded that communication architecture, access to resources, integration among functions, stability of the environment and organizational architecture were seen as influencing the process of innovation. Van De Ven (1986), offering a management orientation, supported these findings but grouped them into four basic concerns in the management of innovation: The Human Problem, The Process Problem, The Structure Problem, and The Strategic Problem. His main contribution was the identification of the "Process Problem," which recognizes the implementation and adoption of innovations as a process.

Other studies have addressed the elements of information flow (Tushman, 1982; Allen, 1970), resource allocation (Utterback and Abernathy, 1975; Marquis, 1969), task interdependence (Tushman, 1982; Rumelt, 1982; Christensen and Montegomery, 1981), and the planning process (Lorange and Vancil, 1977) as important organizational issues impacting the effectiveness of process innovation. For the purposes of this review, the organizational level literature will be discussed according to the following categorization scheme: structure, culture, information flow, support systems, and equity.

2.2.1 Organizational Structure

Early research in the area of R&D management stems from the basic strategy/structure relationship posed by Chandler in 1962. This also tends to be one of the most exhaustively treated areas in the R&D literature. Structure was initially analyzed by its basic components identified as complexity, formalization and centralization. Marquis and Allen (1967), and subsequently Johnson and Gibbons (1975), expanded this view of structure based on the inclusion of the "type of research," i.e. basic or applied, to the organizational design issue. Structure eventually grew to include the internal and external linkages between R&D and its environment (Keller, 1978).

According to Galbraith and Kazanjian (1986), innovation thrives in the absence of structure. Inappropriate organizational structures have often been identified as the culprit of innovation stagnation. Previous research has stressed the importance of "fit" in developing the organizational structure which facilitates successful innovation (Dean and Susman, 1989; Tushman, 1988; Shrivastava and Souder, 1987; Horwitch and Thiertart, 1987; Galbraith and Kazanjian, 1986; Van De Ven, 1986; Utterback, 1974).

"Fit" means a structure which is consistent with the business strategy, competitive environment, corporate culture, and rate of technological change. The objective of the organizational structure is to develop synergy in managing the complexity and interdependence in the NPD process (Van De Ven, 1986). The basic premise is that the organizational structure which fosters the highest level of coordination and integration will achieve the highest level of NPD effectiveness, providing the business unit with a competitive advantage.

Organizational structures have been described by their degree of complexity, number of hierarchial levels, span of control, centralization, and formalization (Mintzberg, 1979; Daft and Becker, 1978; Rothman, 1974; Hage and Aiken, 1970; Argyris, 1965). Research has sought to predict which organizational structure is the most conducive to a given operating environment. Two generic structural forms are most commonly used to describe the structural organization of the firm--functional segregation and matrix.

Research indicates that under conditions of high environmental uncertainty (competitive environment, task environment, and organizational environment) informal or process oriented structures are more effective, and under low environmental uncertainty, formal structures with functional segregation are more appropriate (Montoya-Weiss and Calantone, 1992; Tushman, 1988; Shrivastava and Souder, 1987).

Contemporary research views effective organizational structures as a continuum of possible alternatives ranging from independent to interdependent models (Horwitch and Thiertart, 1987). Structural types have been described as Stage-Dominant, Process-Dominant, and Task-Dominant (Shrivastava and Souder, 1987). Dean and Susman describe the range of structural possibilities as Manufacturing Sign-Off, Integrator, Cross-Functional Teams, Product-Process Design Department (1989). The continuum moves from structures with highly specialized functional groupings, routine operations, and formal policies and procedures emphasizing operating efficiency to structures characterized by a process orientation with no functional identity, continuous overlap of responsibility and communication emphasizing task effectiveness. Effective organizational structures are recognized as those which do not impede, but facilitate the NPD process.

2.2.2 Organizational Culture

A related organizational-level issue is that of culture. While there is no agreement regarding the definition of culture, it is recognized as an important force in the organizational environment (Hofstede, et al., 1990). Knight (1967) observed that innovation is largely dependent on a firm's ability to develop an "innovative environment." Components of this environment include open communication, appropriate reward systems, group support, encouragement of unusual approaches to problem solving, and a high degree of employee freedom to determine tasks and minimize job routine.

The elusive nature of the concept of culture, while complicating its definition and measurement, does not diminish its significant impact on the process of NPD. "Indeed, research conducted over the past decade indicates that organizational factors (i.e., nontechnical factors) are often the most critical barriers to effective innovation" (Tushman, 1988: 261). Its use became popular as an explanatory variable in corporate performance following the success of the Peters and Waterman book, In Search of Excellence (1982).

Climate, management style, procedures, practices, routines, and corporate history or stories are often used as surrogates for the concept of culture. Further confusion is added by utilizing slogans to convey a description of the culture in terms of its operating characteristics such as "The HP Way" (Hewlett-Packard), MBWA (Management-By-Walking-Around), participatory management, and Intrapreneur (Kanter, 1983).

Creating innovative environments is viewed as a strategic issue, and of central importance, as a means of improving the competitive posture of firms (Van De Ven, 1986; Kanter, 1983). While some researchers state that the appropriate culture is contingent on the organizational strategy, structure, and the nature of the product (Horwitch and Thiertart, 1987; Shrivastava and Souder, 1987), another body of knowledge indicates that innovative cultures share similarities regardless of the environmental conditions. Innovative cultures are described as learning organizations characterized by an entrepreneurial spirit, collaboration, tolerance for mistakes, trust, open communication, and risk-taking behavior (Takeuchi and Nonaka, 1986; Kanter 1983; Farris, 1982).

2.2.3 Organizational Information Flow

Van De Ven (1986: 591) describes the process of innovation "as the development and implementation of new ideas by people who over time engage in transactions with others within an institutional context." These transactions can be viewed as information transfer points or nodes in the communications network. Integration among the functions within an organization is highly dependent upon the flow of information. "Research indicates that engineers and applied scientists spend between 50 and 75 percent of their time communicating with others" (Tushman, 1988: 262). Barriers to communication are associated with poor performance, including budget overruns, time delays, inferior quality, higher cost, and poor morale. Effective, timely communication results in improvement in problem-solving, time-to-market, flexibility, cooperation, commitment, initiative, responsibility, market sensitivity, and diversified skills (Takeuchi and

Nonaka, 1986; Utterback, 1974).

Fujimoto treated information as a resource to be managed and defined the construct "as a pattern of materials or energy which potentially represent some other events or objects" (1989: 72). While this definition is rather vague, the author is concerned with the creation and transmission of information in an organizational system within the context of NPD. The creation of information is treated as a value-added activity. The transmission of the information is seen as a vital link in the NPD process or system. Maintaining system integrity relates to the level of consistency of information shared both internally and externally. The level of system integrity and, therefore, the success of the NPD effort, is dependent on the effectiveness of information transmittal within the organization.

The linkage concept, which is based on the effective transmission of information, has largely focused on communication patterns involving information flow and idea-generation (Kelly and Kranzberg, 1978; Utterback, 1971; Gruber and Marquis, 1969; Baker, Seigman and Rubenstein, 1967). Communication was initially measured on the scale of the degree of formal versus informal, and direct versus indirect channels. Information search patterns were monitored and analyzed in the idea-generation phase for both basic and applied research situations revealing different information requirements and sources being utilized. Other studies viewed the communication as a network and evaluated the impact and type of key "players" in the process: Boundary-Spanning individuals (Keller and Holland, 1978), Gatekeepers (Allen and Cohen, 1969), and Key Communicators (Pelz and Andrews, 1966).

A related area of interest is the resource flow model which evaluates the organizational linkages based on the resources shared between facilities and departments (Blois and Cowell, 1979; Aiken and Hage, 1968; Levine and White, 1961). Of significant importance to the present study is the application of the contingency theory approach involving R&D management (Souder, 1977), which established that some interdepartmental linkage structures may be more effective than others.

Galbraith (1982) suggests that to foster information flow key functions should be simultaneously coupled. Takeuchi and Nonaka (1986) advocate the "rugby approach," facilitated by overlapping development phases to minimize the potential loss of information and the time delays caused by transmission. For the purpose of this research, information on the organizational level is evaluated as a function of the accessibility of important information and information flow, whether it is centralized and structured or decentralized and informal.

2.2.4 Organizational Support Systems

The important elements of the support system were revealed in a study by Gupta and Wilemon (1990) involving 38 members of twelve large firms. This study identified the lack of support for innovation as a major concern and a factor contributing to the delays of new product introduction. Compatible goals and reward policies, sufficient resources, top management commitment, delegation of authority, training, and education have all been linked to effective NPD (Susman and Dean, 1991; Gupta and Wilemon, 1990; Van De Ven, 1986). Autonomy, group recognition, special compensation, and dual career ladders are viewed as rewards that facilitate an innovative environment (Galbraith and Kazanjian, 1986).

A central issue to the effective management of the R&D resource is the policy planning function which must establish the role R&D will play in supporting corporate strategy. The policy planning activity was the focus of research conducted by Baker and Pound (1964), Ettlie (1982, 1983), and Cole (1979), with the length of the planning horizon and goal congruency with that of the hierarchical corporate structure as factors influencing company performance.

2.2.5 Organizational Equity

Another barrier mentioned as limiting the effectiveness of NPD is a function of the degree of bias or inequity perceived to exist in the organization and is manifested in the phrase "over-the-wall syndrome" (Heidenreich, 1988: 41). Developing an IPD environment is influenced by the Human Problem, or the basic beliefs and attitudes held by employees, and the Structural Problem, which involves the relationships between the functional groups (Van De Ven, 1986). Minimizing the organizational barriers is fostered by sharing of responsibility, decision-making authority, budget allocation, and a perceived equity among all participants on the basis of pay, rewards, and status (Susman and Dean, 1991). A summary of the organizational literature is presented in Table 2-1.

Table 2-1. Summary of Orgnizational Level Research

AREA	AUTHOR	COMMENTS
STRUCTURE	Argyris,Rothman,Hage and Aiken et.al.	Classification of organizational structures based on complexity, control, centralization etc.
	Chandler (1962)	Relationship between structure and strategy.
	Dean and Susman (1989)	Range of possible structures
	Galbraith and Kazanjian (1986)	Better innovation in the absence of structure.
	Keller (1978)	Structure to include linkages between R&D and its environment.
	Marquis & Allen (1967) Johnson & Gibbons(1975)	Type of research influencing organizational design/structure.
	Shrivastava,Souder(1987) Tushman (1988) Montoya-weiss, Calantone (1992)	Influence of environment on effectiveness of various kinds of structures.
CULTURE	Hofstede (1990)	Culture has an important effect on organizational environment.
	Horwitch,Theitart(1987) Shrivastava,Souder(1987)	Appropriate culture is contingent on the organizational strategy, structure and nature of product.
	Knight (1967)	Good culture will have positive effect on innovative environment.
	Takeuchi,Nonaka (1986) Kanter,Farris (1982)	Innovative cultures have similarities regardless of environment.
	Tushman (1988)	Organizational factors are critical barriers to effective innovation.
	Van De Ven,Kanter(1983)	Innovative environment is important to improve competitiveness.

Table 2-1 Cont'd.

AREA	AUTHOR	COMMENTS
INFORMATION FLOW	Fujimoto (1989)	Information as a resource for NPD process.
	Tushman (1988)	50-75 percent of time is spent by engineers and scientists for communicating with others.
	Utterback (1974) Takeuchi,Nonaka (1986)	Barriers to communication is poor performance. Identified the reasons for increased communication also.
	Galbraith (1982)	Coupling of key functions will improve information flow.
	Keller,Holland (1978) Allen,Cohen (1969) Pelz,Anderson (1966)	Impact of key players on the communication process which is seen as a network.
	Souder (1977)	Contingency theory approach establishing interdepartmental linkage structures and their effectiveness.
	Takeuchi,Nonaka (1986)	Overlapping of development phases to reduce loss of information.
SUPPORT SYSTEMS	Baker,Pound (1964) Ettlie (1982,1983) Cole (1979)	Length of planning horizon and goal congruency with corporate structure influence the performance of a company.
	Galbraith,Kazanjian (1986)	Factors that will facilitate innovative environment are classified.
	Gupta,Wilemon (1990)	Lack of support for innovation is a major factor for delay in new product introduction.
	Van De Ven (1986) Susman,Dean (1990) Gupta,Wilemon (1990)	Identified the factors linked to effective NPD.
EQUITY	Heidenreich (1988)	Inequity perceived limits the effectiveness of NPD.
	Susman,Dean (1990)	Perceived equity, responsibility, decision making authority minimize organizational barriers.
	Van De Ven (1986)	Human problem, structural problem influence IPD environment.

2.3 Project Level Research

Another dimension of the NPD literature addresses the issues associated with the individual NPD project. This section of the literature review serves to present the variables identified in the literature as influencing the effectiveness of the NPD team in an IPD environment. The scope of this review included the associated concepts of simultaneous engineering, concurrent engineering, Design for Manufacturability, Design for Assembly, and producability. Previous research of interest to this research has been categorized by the following project level variables: structure, information flow, leadership, group cohesion, resources, and project performance.

Historically, the NPD process was characterized as the product of individuals rather than groups of individuals. This scenerio has been labeled the "Newton syndrome" (Hakansson, 1987).

> According to the legend Newton got his idea which led the theory of gravitation when he was lying under an apple tree watching an apple falling. The lonely innovator and the flash of genius has since then characterized our way of looking at knowledge development and thereby also at technical development. . . Our view is quite different. An important part of the development process, we suggest, takes place in the form of technical exchange between different 'actors' such as individuals or companies (Hakansson, 1987: 3).

2.3.1 Structure

A central issue in contemporary NPD environments involves the selection, development, and implementation of a project-level structure which will facilitate rather than impede the process. The ability to establish a project-level structure which is congruent with the overall corporate structure presents one of the greatest challenges. Management is plagued by traditional structures dictated by functional specialization and segregation with formal conveyance of information, authority, and responsibility through a hierarchy of vertical linkages. This process has been described as a sequential process, linear in thinking and approach. It is known to foster the attitude and culture associated with the "over-the-wall syndrome."

Contemporary NPD processes are described as simultaneous recognizing the importance of integrating process and product design as an IPD process. The word integration is derived from the word integrity. "Integrity is fostered by a sense of independence and by the ability to see one's work through from beginning to end. Conversely, principles unfriendly to wholeness are impersonal corporate structures or the failure by employers to delegate responsibility to employees and the division of labor and the divorce between process and product" (Grudin, 1990: 80).

Evans (1988), in his work on NPD, blamed the division of product and process designs on the growth of organizations and the impact of job specialization. He stressed the importance of organizational structure and its ability to inhibit the IPD process unless product and process designs are viewed as a joint responsibility "housed under the same roof." Dean and Susman (1989) developed a continuum of organizational structures suited for the IPD process which demonstrates the trade-offs between the effectiveness of the structures and the associated degree of change on the organizational environment. A number of issues are raised by these authors: Which structure is the most effective? What is the impact of various corporate cultures? How do the rate of technological change and competitive pressures determine structure? Dixon and Duffey (1990) presented a six-stage model of the product design process, starting with the product concept and ending with all the support activities (manufacturing, purchasing, distribution, etc.). The authors called the first four stages of the model "Engineering Design," which includes the development of the manufacturing process and the product. The model presented resembles the sequential flow of information of the traditional NPD process currently in use by the majority of United States manufacturers.

The benefits of operating efficiency, control, functional specialization, and technical excellence offered by the traditional, sequential process have been nullified in some industries because of changes in the competitive market. The need for rapid product development and introduction is being created by increasing competition, rapid technological changes, increasing market demands, and an ever-shortening Product Life Cycle (Gupta and Wilemon, 1990).

Utterback (1974) identified a need for integration among the functions, regardless of the degree of specialization, as a prerequisite to successful innovation. Galbraith (1982) suggests that key functions should be "simultaneously coupled" to facilitate information sharing. This view is supported by Takeuchi and Nonaka (1986) who advocate the use of the "rugby approach" to NPD, characterized by overlapping the distinct phases of the development cycle to move the process from a strictly linear or sequential flow of information to a simultaneous sharing of information. The issue of proximity and its impact on communication are also seen as a function of the structure utilized (Martin, 1987).

An alternative structure incorporates multi-functional teams devoted to the NPD project from the conception of the idea through product delivery to the market (Evans, 1988; Stauffer, 1988; Vasilash, 1987). This is often referred to as a matrix where integration is facilitated by functional specialists who are considered a dedicated resource to the NPD project but maintain their functional allegiance.

A step further in the structural evolution requires NPD teams to be staffed by generalists with specialized backgrounds and no functional reporting channels. This treats the team as a profit center concerned with the effectiveness of the entire value-added chain. It has been referred to as a process structure (Shrivstava and Souder, 1987). Kodak employs this structure within their photography division, exemplified by the black-and-white film unit known as the "zebra team" (Jacob, 1992: 95).

Researchers are quick to point out that structural choice is contingent on many factors. Corporate culture, rate of technological change and competitive pressures influence which structure is the most effective given the degree of impact on the operating environment (Dean and Susman, 1989; Fujimoto, 1989). Supporting this position is the research addressing the level of environmental uncertainty. Internal and external uncertainty in an organization's environment is viewed as an important variable in understanding the success of various organizational structures (Montoya-Weiss and Calantone, 1992; Shrivstava and Souder, 1987).

The purpose of the project organizational structure is to facilitate the delivery of a new product from Concept-to-Market through the effective coordination and control of internal and external resources (people, materials, equipment, facilities, information, suppliers, customers, time, etc.). That structure which serves to offer the highest level of coordination, control, and integration of resources is expected to yield higher project rewards (Fujimoto, 1989).

2.3.2 Information Flow

Competitive necessity supported by the forces of industrial "Darwinism" have dictated a need to improve the NPD process by rewarding firms with shorter product development cycles (Davidson, 1988; Birnbaum, 1988). Time-Based Competition is the term used to describe this industrial climate, where the source of competitive advantage is time (Smith and Reinertsen, 1991; Stalk, 1988). A major component, and source of time in the NPD process, involves the creation and transmittal of information (Fujimoto, 1989). Compression of the development cycle is therefore enhanced by structures which foster rapid information creation and exchange.

Overall project performance is contingent upon information flow at both the organizational-level and the team or project-level. Removing barriers to communication has been consistently cited as a key variable to successful innovation (Stauffer, 1988; Van De Ven, 1986; Utterback, 1974). The linkage between structure and communication is evident. Research indicates that communication flow and frequency are inversely related to physical barriers and the distance between people (Utterback, 1974). Case studies consistently revealed that proximity among team members is of paramount importance to the success of the project. The popular press refers to this as the "coffee machine organizational chart" (Martin, 1987).

In addition, successful research and development projects are known to exhibit extensive intra-project communication (Tushman, 1988). The discussion of communication patterns would be incomplete without consideration of the form of communication along with the flow and frequency. Engineers and applied scientists devote 50 to 75 percent of their time communicating. Decentralized patterns of communication are linked with high-performing projects, with the most efficient form being verbal (Tushman, 1988). Verbal communication is also facilitated by the proximity of team members.

2.3.3 Leadership

Structure and communication patterns primarily concern the infrastructural component of the project level dynamics. The human element is represented in the process by the impact of leadership and group cohesion. A major portion of the literature is devoted to the management of the process of innovation represented by such titles as: Managing for Innovation-Leading Technical People (Humphrey, 1987), Managing Technology (Steele, 1989), Managing the Dynamics of New Technology (Noori, 1990), and Managing the Design-

Manufacturing Process (Ettlie and Stoll, 1990).

Management of a process is concerned with efficiency and the utilization of resources. Effective management styles have been categorized as collaboration, delegation, domination and abdication (Farris, 1982), with collaboration surfacing as most successful with technical professionals under most circumstances. Leadership, is concerned with the mobilization of resources and their effective utilization.

The role of the project leader has been the focus of research seeking to understand the similarities of effective leaders. Lists of behavioral characteristics, education, personality, and values, have been presented as surrogate guidelines for the selection of project leaders (Howell and Higgins, 1990; Kanter, 1983; Keller and Holland, 1978; Lambright, et al, 1977; Gee, 1976; Chakrabarti, 1974; Rogers and Shoemaker, 1971; Allen and Cohen, 1969; Roberts, 1969; Pelz and Andrews, 1966). Many descriptive labels have been presented by the authors; the most widely recognized are Boundary-Spanners (Keller and Holland, 1978), Intrapreneurs (Kanter, 1983), and Champions (Howell and Higgins, 1990; Chakrabarti, 1974).

Product Champions are known to demonstrate higher risk-taking behavior and greater degrees of innovativeness, to initiate more attempts at influence, and to utilize transformational leadership behavior (Howell and Higgins, 1990: 317). What remains to be determined is the level of impact the leader has on the NPD process.

2.3.4 Group Cohesion

The second component of the human portion of the project level focus relates to the dynamics exhibited by the group, or group cohesion.

> It has long been recognized that the dedication which produces superior performance is best obtained through deep personal commitment. It is through such commitments to specific goals that truly outstanding achievements are made. An effective commitment is based on both the intellectual belief in the goal and the emotional desire to achieve it. When people want to accomplish something so deeply that they put everything else aside, they will perform not only at their very best but often far beyond what even they thought was possible (Humphrey, 1987: xiii).

Historically, the call for integration may have served as a surrogate for the central issue of cohesion. Contemporary NPD project management recognizes the importance of cohesion and dedicates time and effort to team building experiences. These efforts are referred to as "bonding" experiences symbolic of the gain in closeness, or cohesion of the group. Case studies revealed the importance of two prerequisites to successful teams: professional and personal trust. Professional trust is the degree of functional competence demonstrated by team members. Personal trust is the emotional chemistry between team members manifested by the degree of genuine liking and concern for each other's welfare.

2.3.5 Resources

The next group of studies focused on the various tools and techniques used to facilitate the IPD process. Raia (1989) and Bhote (1987) directed their attention to the actual product design component of the IPD strategy. Design has been painted as the culprit in the loss of United States competitiveness, and the primary means to regaining the competitive edge. Both Raia and Bhote advocated the use of Taguchi methods--specifically, the design-of-experiments--to improve product quality and cost. Stoll (1988) developed an excellent comparison of ten tools utilized in the IPD process based on their methodologies, advantages, disadvantages and applications. He stressed the need to separate the analysis of the IPD strategy into two components, the process and the tools and techniques. These authors leave unanswered the questions regarding which tools are most effective and in what type of environment they should be utilized.

Utterback (1974) identified access to resources as one of the key variables in successful innovation. Marquis found that projects benefitted from slack resources by achieving lower cost, better schedule performance, and better technical performance. The degree of resource utilization is intrinsically tied to the degree of coordination and integration among functions.

> The cost of innovation will clearly be lower, and the chance of effective technical performance greater, if needless environmental uncertainties can be avoided or reduced, because the resources required for integration will be correspondingly less (Utterback, 1974: 620-626).

A lack of sufficient resources has been identified as a major contributing factor in the delays of new product introductions (Gupta and Wilemon, 1990). Commitment of resources (Stauffer, 1988) and the degree of resource sharing among facilities and departments (Blois and Cowell, 1979; Aiken and Hage, 1968; Levine and White, 1961) is correlated with higher project performance.

2.3.6 Project Performance

Stoll's model of the IPD design process demonstrates the iterative nature of the process. The model draws from the list of objectives Stoll presented for IPD, including: identifying product concepts that are inherently easy to manufacture; focusing on component design for ease of manufacture and assembly; and integrating manufacturing process design to ensure the best matching of needs and requirements.

There is a high degree of consistency in the literature regarding the positive outcomes of the IPD strategy and the factors associated with its success (Burt, 1989; Vasilash, 1989, 1987; Ettlie, 1988; Martin, 1987; Stauffer, 1988; Takeuchi and Nonaka, 1986). The agreement among the authors lends face validity to their claims; however, their assertions need to be tested empirically. A summary of the key success factors and reported results of these case studies is presented here and again in Figure 2-2. The key success factors are supplier involvement, single sourcing, multi-functional teams, simultaneous engineering, organizational structure, proximity, cross training, Computer Aided Design (CAD), Quality Function Deployment (QFD), Group Technology (GT), status equality between engineering and manufacturing, commitment, resources, and free exchange of information.

The results achieved by firms utilizing the IPD strategy include a 30-50 percent reduction in development time, 30-50 percent reduction in engineering changes, 10 percent reduction in product cost, 93 percent reduction in rejects, 20-50 percent reduction in warranty claims, 20-60 percent reduction in start-

	Burt, David N., Harvard Business Review, 1989	Vasilash, Gary S., Production, 1989	"A Smarter Way to Manufacture", Business Week, 4/30/90	Duffy, James & John Kelly Management Today, 1989	Stauffer, Robert M., Manufacturing Engineering, 1988	Martin, John M., Manufacturing Engineering, 1988	Musselwhite, W. Christopher, Training and Development Journal, 1990
Reduction in Development Time	50%	30 - 50%	30 - 70%	25%		M	
Reduction in Evgineering Changes		30 - 50%	65 - 90%	50%	M		
Reduction in Product Cost	10%			M		M	M
Reduction in Rejected Materials	93%						
Reduction in Warranty Claims		20 - 50%					
Reduction in Start-up Cost		20 - 60%			M	M	M
Reduction in Production Lead Time	65%						
Improved Communication					M	M	
Improved Quality			200 - 600%	M		M	M
Reduction in Concept to Market TIMS			20 - 90%		M	M	50 - 75%
Improved Dollar Sales			5 - 50%				
Improved Return on Assts			20 - 120%				
Improved White Collar Productivity			20 - 110%				

M = Mentioned but no specific percentage given.

FIGURE 2-2
IPDS Key Success Factors

upcost, 65 percent reduction in production leadtime, and better communication. A summary of the project level research is summarized in Table 2-2.

2.4 Interorganizational Research

The interorganizational portion of this literature review serves two purposes. The first objective is to understand the dynamics associated with an interorganizational relationship. The second objective is to specifically focus on the interorganizational relationship of interest to this research, that of the buyer/supplier. The review begins by delineating the motives and catalysts for fostering highly integrated buyer/supplier relationships. This is followed by a presentation of the previous research which has identified the nature of the relationship, interorganizational structure, information flow, and resources as some of the key variables which serve to impact the degree of integration between organizations. The section will conclude with the expected benefits of an integrated buyer/supplier relationship in the NPD environment.

2.4.1 Motives for Integrated Buyer/Supplier Relationships

The primary motive for including suppliers in the NPD process is the quest for a sustainable competitive advantage. The source of this competitive advantage is derived during the product design phase of the NPD process which drives 70to 80 percent of the final production cost, 70 percent of the life cycle cost, and 80 percent of the product's quality performance (Dowlatshahi, 1992: 22). Firms seeking to capitalize on the strategic importance of product design are extending

Table 2-2. Summary of Project Level Research

AREA	AUTHOR	COMMENTS
STRUCTURE	Dixon, Duffey (1990)	Developed a six stage model for product design which is similar to traditional NPD process.
	Evans (1988)	Division of product and process designs and organizational structure impede IPD process.
	Fujimoto (1989)	Factors responsible for success of NPD team and project.
	Gupta, Wilemon (1990)	Changes in competitive market demands rapid product development.
	Shrivastava, Souder(1987)	NPD team as a profit center and referred as process structure.
	Susman, Dean (1989)	Trade off between effectiveness of structure and change in organization environment to suit IPD process.
	Susman, Dean (1989) Fujimoto (1989)	Identified factors for structural choice.
	Utterback (1974)	Need for integration of functions for successful innovation.
	Vasilash (1987) Evans (1988) Stauffer (1988)	Multifunctional teams for NPD project from concept to market delivery.
INFORMATION FLOW	Fujimoto (1989)	Creation and transmission of information as a major component and source of time in NPD process.
	Martin (1987)	Proximity among team members is important for the success of project.
	Stalk (1988) Smith, Reinertsen (1991)	Time is a Source of competitive advantage.
	Tushman (1988)	Successful R&D projects exhibit extensive intraproject communication. Decentralized patterns of communication are linked with high performing projects.
	Utterback (1974) Van De Ven (1974) Stauffer (1988)	Removing barriers to communication is seen as key variable to successful innovation.
	Utterback (1974)	Communication flow and frequency are inversely related to physical barriers and distance between people.

Table 2-2 Cont'd.

AREA	AUTHOR	COMMENTS
LEADERSHIP	Farris (1982)	Effective management styles are categorized as collaboration, delegation, domination and abdication.
	Howell,Higgins (1990)	Product champions demonstrate higher risk taking attitude, greater degree of innovation, initiate more attempts at influence and utilize transformational leadership behavior.
	Keller,Holland (1978) Allen,Cohen (1969) Many others	Education,personality and values have been presented as guidelines for selection of project leaders.
GROUP COHESION	Humphrey (1987)	Deep personal commitment based on intellectual belief in the goal and emotional desire to achieve it will bring results beyond expectations.
RESOURCES	Gupta,Wilemon (1990)	Lack of sufficient resources is a major factor for the delay of new product introduction.
	Levine,White (1961) Aiken,Hage (1968) Blois,Cowell (1979)	Degrees of resource sharing among facilities and departments correlate to higher project performance.
	Marquis (1969)	Projects benefit from slack resources.
	Raia (1989) Bhote (1987)	Advocated for design of experiments to improve product quality and cost - Taguchi methods.
	Stauffer (1988)	Commitment of resources correlate to higher project performance.
	Stoll (1988)	Identified the need to separate analysis of IPD strategy into two components 1) Process and 2)Tool and Techniques.
	Utterback (1974)	Access to resource is one of the key variables in successful innovation.
PROJECT PERFORMANCE	Stoll (1988)	Demonstrates the iterative process of IPD.
	Vasilash (1987,1989) Many others	High degree of consistency between positive outcomes of IPD strategy and factors associated with success.

the scope of influence over the process to include the supplier. Inclusion of the supplier in the process is commonly referred to as supplier involvement or "early sourcing" which encompasses a wide spectrum of purchasing strategies including buying in advance of production, and forward buying or hedging. Stone's (1983) definition of early sourcing states that "key suppliers will be established during the design phase of new product programs. This early supplier involvement in quality-oriented value engineering activities is aimed toward obtaining quality designs, quality processes, and quality parts." The goals of early supplier involvement include a reduction in manufacturing costs, improved manufacturing competitiveness, fewer part numbers, and technology transfer.

A nationwide survey of purchasing professionals and design engineers conducted in 1979, 1988 and 1990 by "Purchasing" and "Design News" consisted of 1,000 respondents from each profession. The respondents overwhelmingly indicated that suppliers are involved earlier in the design cycle in order to capitalize on the vendor's expertise, capitalize on the latest technology, achieve better quality, achieve better manufacturability, lower costs, gain access to the latest technology, and as a response to shortened design cycles.

A comprehensive list of the potential advantages of utilizing an integrated product design process is offered by Dowlatshahi (1992: 22) and includes reduction in product development cycle time, avoidance of costly future redesigns, reduction in duplication of effort, better communication and dialogue, more efficient operations and higher productivity, overall cost savings, avoidance of product recalls, lower maintenance costs, more reliable products, better customer satisfaction, and improved bottom-line earnings.

2.4.2 Interorganizational Relationships

One framework for understanding interorganizational relationships is based on the scope of the strategic planning environment. Business level strategic planning encompasses the task environment focusing on the immediate competitive environment (industry, customers, competitors). Corporate strategic planning involves domain definition, or the determination of the desired operating environment. Interorganizational strategy is concerned with the mutual interdependence of firms operating in a network. The interorganizational level planning approach moves the focus from the individual organization to a population of organizations. This approach has been referred to as collective strategies which frames the "...concept of strategy in terms of collective mobilization of action toward the achievement of ends shared by the members of the interorganizational network" (Astley and Fombrun, 1983: 577).

The rise in the strategic importance of interorganizational relationships has mirrored the movement of the focus of strategic planning from the firm to the network level. An example of this movement is presented by the hierarchial trilogy of the popular strategic planning texts by Michael E. Porter--Competitive Strategy, Competitive Advantage, and The Competitive Advantage of Nations (1980, 1985, 1990).

The nature of the interorganizational relationship has been portrayed in the literature dichotomously as either independent/dependent or interdependent

(Bresser and Harl, 1986; Campbell, 1985), and individualist or communal (Astley and Fombrun, 1983), competitive or collaborative/cooperative (Gerlach, 1987; Astley, 1984). The source of the distinction between the models is often the distribution of power in the relationship (Thorelli, 1986). The collective or network models recognize the shared interdependence and distribution of power. Spekman (1988) refers to this distribution as bilateral, recognizing that the balance of power is essential to successful conflict resolution. Competitive models are based on dependency and a skewed distribution of power. These relationships are marked by a win-lose mentality on the part of participating organizations.

Historically, the model adopted by United States firms has been based on the dictates of the capitalist economy which fosters competition. The network model, adopted by Japanese firms, is facilitated by structures which foster complex, long-term business alliances based on long-term reciprocity. The impressive competitive position of Japanese firms operating in a variety of industries has elevated the interest in understanding the dynamics of these "strategic alliances", and their contribution to technological innovation and market development (Gerlach, 1987).

Trust has been identified as a key component of effective long-term integrated relationships (Campbell, 1985; Thorelli, 1986; Johnston and Lawrence, 1988). This characteristic is inconsistent with the market-based competitive model which views this as establishing the environment for the greatest exploitation of opportunistic behavior (John, 1984). Mutual commitment, close collaboration, long-term cooperative attitude, repeated contacts, shared information, joint long-term planning, and a non-adversarial approach have also been cited as instrumental in establishing integrated relationships (Sriram and Mummalaneni, 1990).

Spekman (1988) refers to this change in buyer-supplier relationship as the "Quiet Revolution" which can only be facilitated by a reduced set of suppliers. Single-sourcing arrangements have been advocated in the supply management literature to improve quality, cost, and innovation (Burt, 1989; Raia, 1989). Some concerns have been raised with regard to a single-sourcing strategy. As the dependency between the buyer and supplier grows there is a corresponding decrease in strategic flexibility (Newman, 1989; Bresser and Harl, 1986). Dual-sourcing has been offered as a strategic alternative and buffering mechanism against the disadvantages of a single-sourcing policy, while capable of delivering many of the same benefits (Newman, 1989).

Frazier (1983) has identified goal compatibility between organizations as a requirement for long-term relationships. Congruent goals and expectations are seen as leading to a higher level of role satisfaction and perceived equity in the distribution of rewards stemming from participation in the relationship.

The supplier evaluation program developed by General Motors, Targets for Excellence, recognizes this important linkage in the development of integrated supplier relationships. The first section of the audit is dedicated to the identification of the suppliers mission, values, and operating philosophy to assess whether they are compatible with those of General Motors--Continuous

Improvement.

An empirical examination (Clark, 1989) of 29 NPD projects representing Japanese, European, and United States automotive manufacturers demonstrated that the Japanese automobile producers enjoy an 18-month development time advantage over their European and United States counterparts. Clark (1989) concluded that one-third of the manhour, and four to five months of the leadtime advantage, was attributable to their relationship with suppliers and early supplier involvement. This finding is consistent with early research conducted by Gee (1978) which identified the use of external sources with a lower average innovation period.

A component of successful interorganizational relationships in process or product innovation involves the geographic distance between organizations. The critical role of distance is evidenced by the influx of transplant supply organizations to support the Japanese automobile manufacturers who have located in the United States. Proximity and "co-location" of suppliers acts as a facilitating variable in the NPD process (Burt, 1989; Bhote, 1987). Large geographic distances have been identified as a barrier to efficient communication and tends to explain why technical cooperation is a product of domestic partners (Hakansson, et.al., 1987).

2.4.3 Interorganizational Structure

An issue highly related to the nature of the relationship is the form of the relationship. The structural form of the interorganizational relationship has been presented in the literature as a continuum of possibilities ranging from Full Integration, Tapered Integration, Quasi Integration, to Contracts (Harrigan, 19). The distinguishing characteristic between these forms is the level of contractual agreement and investment. Contemporary literature incorporates new terminology to describe highly integrated relationships such as Value-Adding Partnerships (Johnston and Lawrence, 1988), Networks (Hakansson 1989; Hakansson, et al., 1987; Thorelli, 1986; Jonsson, 1986), Business Alliances (Gerlach, 1987), and Strategic Alliances (Harrigan, 1987).

These structural forms are facilitated by agreements between the organizations which extend beyond purely legal obligations. They are based on the investment in relationships over time which are developed by the individual actors from each organization acting in a boundary-spanning capacity (Hakansson, et al., 1987; Jonsson, 1986). Financial cross-holding arrangements between members of a network are offered as symbolic gestures designed to foster qualitative relationships between firms (Gerlach, 1987). Strategic Alliances are giving rise to many alternative arrangements to facilitate exchange such as research consortia, cross-distribution agreements, cross-production agreements, and cross-licensing agreements (Harrigan, 1987). The goal is structural stability of the entire network for long-term growth and improved information flow.

Transaction costs have been identified as an explanatory variable in the choice of interorganizational structures with respect to research and development activities between firms (Brockhoff, 1992). The author suggests that, 1) the degree of formality of cooperative agreements, 2) the scope of technological areas covered by an agreement, 3) the number of partners involved, and 4) the stage in the technological lifecycle influence the perception of high transaction costs and therefore impact the choice of strategic form.

Ohmae (1990) utilizes the term "The Borderless World" to convey the erosion of distinctive boundaries between organization. Overlapping organizations is another descriptive term designed to convey the evolution of integrated structural frameworks which recognize the strategic interdependence of networks and their impact on innovation and competitiveness (Jonsson, 1986). The purpose of interorganizational structures has been cited as enabling control, providing uniformity or flexibility, channeling communication, economies of scale, or accommodating environmental variables (Herbert, 1984). An extension of these goals is to improve the NPD process through effective integration of buying and supplying organizations.

2.4.4 Information Flow

These highly integrated interorganizational relationships have been made possible through technological advancements in information processing (Johnston, 1988). Telecommunication and information storage, analysis, retrieval, and transmittal technology have reduced the time necessary to transfer important information among members of a value-added chain improving the coordination and effectiveness of the firms operating as a linked system. Improved information flow allows the individual actors to react to changes in the operating environment of the entire network of firms enhancing the response time of the entire system.

Trust has been identified as an important component of an integrated relationship. It also has important connotations to the area of information sharing. The effectiveness of the network is enhanced by the timing, quantity, and quality of the information shared among members. Fujimoto (1989) has identified internal and external information system integrity as a key element in the NPD process. The integrity encompasses the area of quality which conveys the need for accuracy and the willingness to share proprietary information.

Improved information flow has also been identified as a benefit of, rather than a prerequisite to, integrated relationships (Gerlach, 1987). It has also been the source of great concern regarding a firm's competitive advantage, the issue of intellectual property (Newman, 1989), and the potential for the rapid diffusion of innovation through network partners (Hakansson, et al., 1987). There is no universal agreement on the seriousness of this undesirable transfer of technology, or how to resolve this source of conflict. One engineer from Saab-Scania diffused the issue by saying, "We learn from each other. We are not afraid of industrial espionage. Our factory is custom-made, and those who believe that one can copy a factory make a mistake" (Hakansson, et al., 1987: 39).

Establishing channels of communication between organizations is a function of the nature and structure of the relationship, and the technology to facilitate the exchange, but the ultimate responsibility resides with the individual actors representing their firms interest. The individual acts as an information processing agent to link the organization with the environment. This function has been called a "boundary-role" where the individual is designated as the "linking-pin" in the communication channel (Jonsson, 1986).

2.4.5 Resources

Resource dependency has been the focus for evaluating interorganizational relationships based on resource flow considerations (Pfeffer and Salancik, 1978). These initial premises were utilized to develop an understanding of structure and power distribution in these relationships (Sriram and Venkatapparao, 1990; Herbert, 1984). Cooperation between linked organizations has been identified as an important tool in the mobilization and efficient utilization of resources (Hakansson, et al., 1987).

Development of interorganizational relationships requires a commitment of time, labor, and capital and should therefore be regarded as an investment by the firm. The primary incentive for firms to engage in this type of investment is the acquisition and mobilization of valuable resources. "A company's total resources are in general small compared to the resources which are controlled in common by the other actors in the network. There is, for this reason, always cause for the individual company to attempt to acquire these resources" (Hakansson, et al., 1987: 128). In the area of NPD, these resources take the form of product and process supplier competence. The interaction between the buying and supplying organizations in an IPD environment has a synergistic potential capable of producing a "multi-competence effect" (Hakansson, et al., 1987: 4).

Williamson's model of markets and hierarchies (1975) based on transaction cost analysis has often been utilized as a framework for evaluating the efficiency and effectiveness of interorganizational linkages. Any exchange between the buying and supplying organizations including information, material, labor, or capital, constitutes a transaction cost to the organizations. Highly integrated relationships are hypothesized to lower the cost of transactions between member organizations achieving the benefits of vertical integration without the cost of ownership (Thorelli, 1986; Ettlie and Reza, 1992; Melnyk, et al., 1992, 1993).

Transactions between buying and supplying organizations are viewed as a means of developing integrated relationships. The transaction activities can be used to overcome barriers to integration in "hard dimensions," physical or geographic distance, and "soft dimensions," related to differences in attitudes, values, and culture. "The soft sections of the gap are of special importance in international transactions because differences in cultural concerns are more prominent in these situations. It is also likely to be of unique importance when the transaction activities are characterized by technological exchange" (Hakansson, et al., 1987: 159-160).

Transaction analysis has also focused on the area of transaction-specific investments and their contribution to "source loyalty" in the buyer-supplier relationship. Investments made by the supplying organization can be categorized as retrievable or irretrievable. Irretrievable investments demonstrate the commitment of the supplier and promote a durable relationship (Sriram and Venkatapparao, 1990).

Supplier involvement in the NPD process promotes resource concentration

(Hakansson, et al., 1987). In this scenario, firms are allowed to specialize and focus their contribution to the value-added chain. Theoretically, the benefits derived from resource concentration include improved utilization of resources, technological expertise, and network effectiveness. The increase in resource dependency in highly integrated buyer-supplier relationships raises the strategic importance of supplier selection. A reduced number of suppliers and the long-term commitment required make supplier selection a central issue in forming strategic partnerships (Burt, 1989; Spekman, 1988; Hakansson, et al., 1987).

> The problems with these kinds of relationships also cover such issues as choosing and maintaining individual suppliers, the number of suppliers to cooperate with, developing the cooperation patterns and so forth. From a network perspective the dynamics of the interplay between individual relationships and the company's total relationship structure is a vital concern (Hakansson, et al., 1987: 131).

> The choice of supplier can often be very strategic. A long-term reason for cooperation with a certain supplier can be, for example, that a specific supplier possesses important competence which the purchasing corporation wishes to take advantage of, not only by way of a developed product but also via the corporation learning form the supplier and at an early stage receiving information of new developments, etc. The purchasing corporation can also have long-term reasons for enhancing certain supplier competence (Hakansson, et al., 1987: 168).

Another area of interest is the issue of the specific tools utilized by the buyer and supplier in the development of new products in an IPD environment. Quality Function Deployment (QFD) and Value Analysis/Value Engineering (VA/VE) have been evaluated for their impact on the NPD process and their effectiveness as an interorganizational communications tool (Griffin and Hauser, 1992; Williams, Lacy and Smith, 1992). Raia (1989) and Bhote (1987) advocate the use of Design-of-Experiments (DOE) to improve product quality by creating a robust design.

Other tools which have been cited as contributing to cost reduction in the process include reverse engineering, product standardization, part-number reduction, group technology, and early supplier involvement (Bhote, 1987).

2.4.6 Project Performance

Case studies have been the primary means of assessing the impact of supplier involvement in the NPD process. Burt (1989: 129) reported a reduction in cost (10 percent), rejected material (93 percent), development time (50 percent), and production leadtimes (65 percent), through supplier partnership programs. Texas Instrument was able to attribute the following results to supplier involvement: 85 percent reduction in assembly time, 75 percent reduction in part numbers, 78 percent reduction in the number of assembly steps, and a 71 percent decrease in the time devoted to metal fabrication. IBM reported the following statistics with the development of the IBM Proprinter: 90 percent reduction in assembly time, and 65 percent fewer part numbers. Ford was able to trim $1.2 billion dollars from manufacturing cost through early supplier involvement.

In an empirical study conducted by Ettlie and Reza (1992) supplier integration was evaluated with seven scale items including: 1) We introduced procedures for JIT purchasing or delivery; 2) We introduced new purchasing policies; 3) We buy integrated components from suppliers; 4) We established programs to educate suppliers in areas such as statistical process control; 5) We have established a contingency supply policy; 6) We have reduced our inspection of incoming parts;

7) We use supplier award programs. Supplier integration in process innovation resulted in a reduction in scrap and improved cycle time target performance. Unfortunately, while the characterization and measurement of supplier integration demonstrates statistical reliability, a Cronbach's Alpha of .85 and interitem correlation of .45, the question of whether these items represent valid measures of supplier integration is debateable.

Supplier involvement in the NPD process involves the identification and evaluation of the cost of involvement. Development of dependency on partners, high cost of negotiations and transactions, problems of assigning contributions and results to the partners, secrecy problems, problems of technology transfer, loss of own technological competence, and inhibition of own developments were identified as the most important possible disadvantages to interorganizational cooperation in the development of new products (Brockhoff, 1992: 517). A summary of the interorganizational research is presented in Table 2-3.

These studies however, have not explicitly characterized supplier involvement in the NPD process. Without such characterization, it will be difficult to suggest ways in which supplier involvement can be gainfully used in ensuring the success of IPD. The need to further investigate the role and contribution of the suppliers and the supply management function in the IPD strategy is frequently mentionedin the literature (Emmanuelides, 1991; Susman and Dean, 1991). Research is needed to understand what constitutes supplier involvement, and how can it be measured and managed during the NPD process.

For the purposes of this research the characterization, definition, and

Table 2-3. Summary of Interorganizational Level Research.

AREA	AUTHOR	COMMENTS
BUYER AND SUPPLIER RELATIONSHIP	Dowlatshahi (1992)	Competitive advantage during product design of NPD process in terms of production cost, life cycle cost and quality performance.
	Dowlatshahi (1992)	Comprehensive advantages of IPD process.
	Stone (1983)	Establishment of key suppliers during NPD design phase with involvement to obtain quality designs,process and parts.
RELATIONSHIP	Astley,Fombrun (1983)	Strategy concept for collective mobilization action towards achievement of ends shared by interorganizational network.
	Astley,Fombrun (1983)	Interorganizational relationship as individual or communal.
	Bresser,Harl (1986) Campbell (1985)	Interorganizational relationship is portrayed as independent/dependent or interdependent.
	Gerlach (1987)	Strategic alliances adopted by Japanese firms and their contribution to technological innovation and market development.
	Gerlach (1987) Astley (1984)	Interorganizational relationship as collaborative, cooperative or competitive.
	John (1984)	Trust is inconsistent with market based competitive model.
	Johnston,Lawrence (1988)	Trust is the key component of effective longterm integrated relationships.
	Porter (1980,1985,1990)	Importance of interorganizational level relationships shifted the focus of strategy from firm to network level.
	Spekman (1988)	Interorganizational relationship as bilateral power distribution and balance of power is essential to successful conflict resolution.
	Spekman (1988)	Change in buyer-supplier relationship as "Quiet revolution" which can be facilitated by reduced set of suppliers.
	Sriram,Mummalaneni(1990)	Mutual commitment, collaboration, longterm cooperative attitude, repeated contracts, shared information, joint longterm planning are cited as instrumental in establishing integrated relationships.

Table 2-3 Cont'd.

AREA	AUTHOR	COMMENTS
RELATIONSHIP	Burt (1989) Bhote (1987)	Proximity and location of suppliers act as a facilitating variable in the NPD process.
	Burt (1989) Raia (1989)	Single sourcing improves quality,cost and innovation.
	Frazier (1983)	Goal compatibility between organizations is a requirement for longterm relationships.
	Gerlach (1987)	Financial cross holding arrangements between members of network are offered as a symbolic gesture to foster qualitative relationship between firms.
	Hakansson et.al. (1987)	Large geographic distances are identified as barrier to efficient communication.
	Harrigan (1987)	Structural form of interorganizational relationship is seen as continuum possibilities like full integration to contracts.
	Harrigan (1987)	Strategic alliances lead to facilitate exchange such as research consortia, cross distribution, cross production and cross licensing agreements etc.
	Herbert (1984)	Interorganizational structure serve the purpose of enabling control, providing uniformity or flexibility, channelling communication, economies of scale etc.
	Johnston,Lawrence (1988)	Highly integrated relationships are seen as Value-Adding relationships.
	Jonsson (1986)	Integrated structural frameworks - Strategic interdependence of networks and their impact of innovation and competitiveness.
	Newman (1989) Bresser,Harl (1986)	Increase in dependency between buyer-supplier decreases strategic flexibility.
INFORMATION FLOW	Fujimoto (1989)	Internal and external information system integrity is a key element in NPD process.
	Johnston (1988)	Highly integrated interorganizational relationships are possible through technological advancements in information technology.

Table 2-3 Cont'd.

AREA	AUTHOR	COMMENTS
STRUCTURE	Gerlach (1987)	Improved information flow is identified as a benefit rather than prerequisite to integrate relationships.
	Hakansson et.al. (1987)	Improved information flow as a potential for rapid diffusion of innovation through network partners.
	Jonsson (1986)	Individuals represent the firm are ultimately responsible for establishing channels of communication.
	Newman (1989)	Improved information flow is a source of great concern regarding firm's competitive advantage and issue of intellectual property.
RESOURCES	Bhote (1987)	Identified tools for cost reduction.
	Brockhoff (1992)	Identified important possible disadvantages to interorganizational cooperation in NPD.
	Burt (1989) Spekman (1988) Hakansson et.al. (1987)	Reduced number of suppliers and longterm commitment make supplier selection a central issue in strategic relationships.
	Ettlie,Reza (1992)	Evaluated supplier integration on seven items.
	Ettlie,Reza (1992) Thorelli (1986)	Highly integrated relationships achieve benefits of vertical integration without cost ownership.
	Griffin,Hauser (1992) William,Lacy,Smith (1992)	Quality Function Deployment, Value Analysis / Value Engineering are evaluated for impact on NPD process and as communication tool.
	Hakansson et.al. (1987)	Cooperation as an important tool in the mobilization and efficient utilization of resources.Interaction of buying and supplying organizations in IPD has a synergetic potential of producing "multi-competence effect".
	Hakansson et.al. (1987)	Supplier involvement in NPD process promotes resource concentration.
	Pfeffer,Salancik (1978)	Resource dependency as a focus for evaluating interorganizational relationships.
	Sriram,Venkatapparao (1990)	Irretrievable investments demonstrate durable relationship of the supplier.
	Williamson (1975)	Models of market and hierarchies utilized for evaluating efficiency of inter-organizational linkages.
PROJECT PERFORMANCE	Emmanuelides (1991) Susman,Dean (1991)	The need to further investigate role and contribution of suppliers and supply management function in IPD strategy.
	Stuart (1991)	Impact of purchase involvement in collaborative R&D activities.

measurement of the variable supplier involvement will be guided by the research conducted by Stuart (1991) which focused on the impact of purchasing involvement in collaborative research and development activities. The contributions of this research include the recognition of the differences between involvement, and "meaningful involvement". Meaningful involvement was defined as:

> The timely and useful collaboration of purchasing's expertise and the scientist's knowledge in all aspects of the equipment acquisition process. This includes the decision-making process leading to the best buy decision, with the objective of satisfying the immediate needs of the specifier and the long-term needs and strategic objectives of the research unit as a whole (Stuart, 1991: 30).

Four factors were deemed necessary to facilitate meaningful involvement: 1) need for proactive involvement, 2) need for physical proximity, 3) need for a high level of relevant technical expertise, and 4) need to define role in terms of client satisfaction, mutual objectives, and team membership (Stuart, 1991: 34).

The conclusions drawn by the 1983 study conducted by the National Science Foundation (Tornatzky, et al., 1983: 28-45) indicated that "researchers seem only to agree that there are no hard and fast ingredients in successful innovation." On the contrary, evidence indicates that the conclusions drawn by the research are generally in agreement with one another. Unfortunately, the pool of research related to the process of product innovation is not exhaustive, leaving many areas still unexplored or unsupported. One such area, and an incremental step forward, is the quantifiable evidence to support the relationships identified by the literature.

CHAPTER III

CONCEPTUAL FRAMEWORK

3.0 The preceding chapters have presented the purpose of this research and the literature from which it draws support and guidance. Previous studies served to identify variables hypothesized to impact the effectiveness of new product development efforts, but there are very few well-defined and empirically validated theoretical frameworks to support the current research effort.

One of the intentions of this project is to build on the existing frameworks, offering quantifiable evidence to support the relationships postulated by previous research. To accomplish this, and at the same time address the focus of this research, it has been necessary to adapt existing models to match the interest of this endeavor. This chapter begins by presenting the primary conceptual frameworks adapted for the purposes of this research, followed by the presentation of the conceptual framework utilized in this research. The final section of the chapter is devoted to a detailed description of the development of the analytical framework. The detail is provided to facilitate the goal of theory building. It represents a synthesis of the supporting literature, and information obtained from focus group discussions, brainstorming sessions, and field observations.

Included in this section is (1) an operational definition of each construct which promotes measurement and testing of the hypotheses, (2) specific dimensions of each construct and the associated measures of those dimensions to facilitate the gathering of data, and (3) a discussion of the expected relationship among the variables represented in the model.

The previous research which provided the foundation for the development of the conceptual model for this research was conducted by Susman and Dean (1991) and by Shrivastava and Souder (1987). Susman and Dean's work, "Causal Model of Variables Leading to Project Goal Success Via DFM" (Figure 3-1), sought to depict the implementation process associated with utilizing the NPD strategy, Design-for-Manufacturability (DFM). The model was developed and validated based on case studies of twelve companies in the commercial and defense industries. Data collection spanned a one-year period and included two products from each of the participating firms in the sample.

The purpose of their research was to gain an understanding of the NPD process and to identify those variables which act as facilitators or barriers to the process employing the Design-for-Manufacturability strategy. Although successful in identifying these variables, the model remains to be empirically tested.

To capture the complexity of the new product development process in an integrated environment, formation of the conceptual framework was also guided by the insight obtained from the work of Shrivastava and Souder (1987). In their research, they discuss the need to incorporate project, organizational, and inter-organizational variables to capture the dynamics of an innovative environment. The conceptual framework developed for this research lends itself to analytical

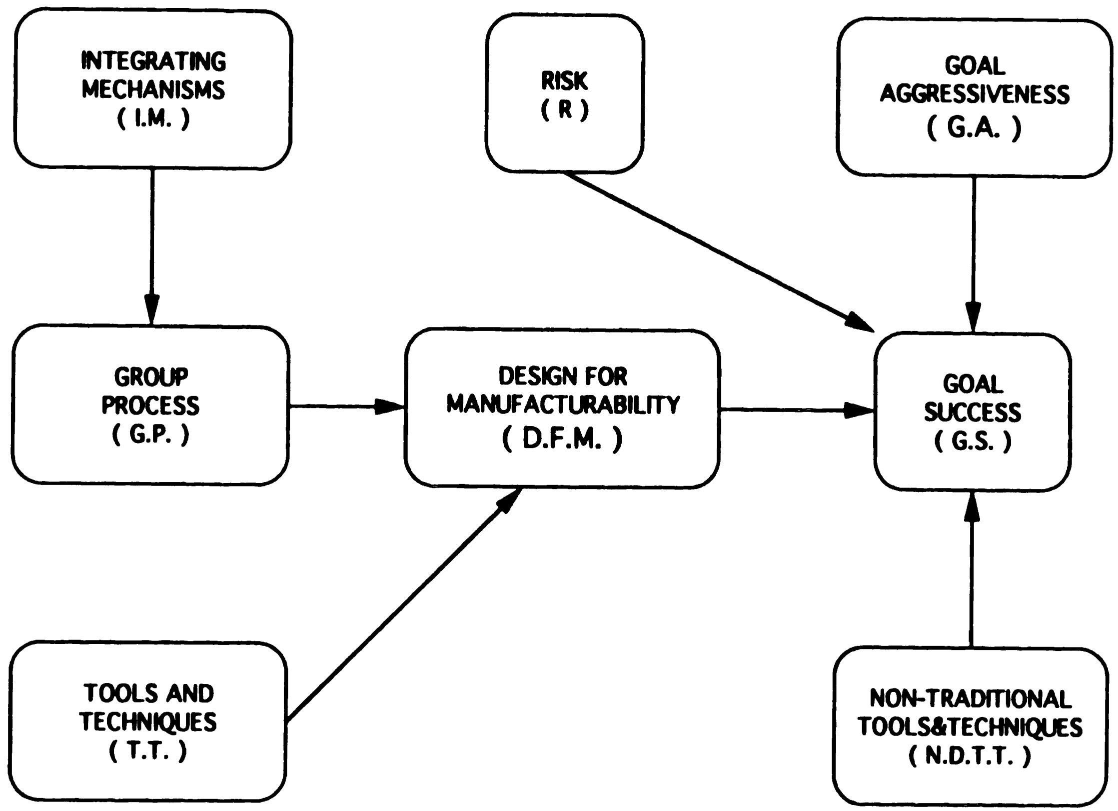

FIGURE 3-1

SUSMAN & DEAN (1990) CAUSAL MODEL OF
VARIABLES
LEADING TO PROJECT GOAL SUCCESS VIA D.F.M.

testing of relationships among these variables in an effort to understand the dynamics of this complex process. In addition, the ability to isolate the contribution of individual variables to the overall success of the new product development effort will facilitate the determination of the importance of supplier involvement.

These two independent research efforts provide the cornerstone and guiding principles for the development of a model which addresses the purpose of this research, the impact of the role of the supplier in the integrated new product development environment. The presentation of the model begins with an overview of the variables and the hypothesized relationships among the variables. This is followed by a detailed description, operational definition, and the dimensions and measures for each of the variables.

3.1 Overview of the Conceptual Framework

Figure 3-2 represents an adaptation of the Susman and Dean model (1991) based on a review of the literature and the intended focus of this research effort, which is to isolate the contribution of the supply base. A definition and brief description of each of the variables follows.

Integrative Mechanisms (IM) represents the organizational level environmental and infrastructural variables which influence the NPD process. Environmental variables are restricted to the internal environment. The infrastructural portion of this variable includes the systems and structures in operation which serve to foster integration of the NPD process. Integrative

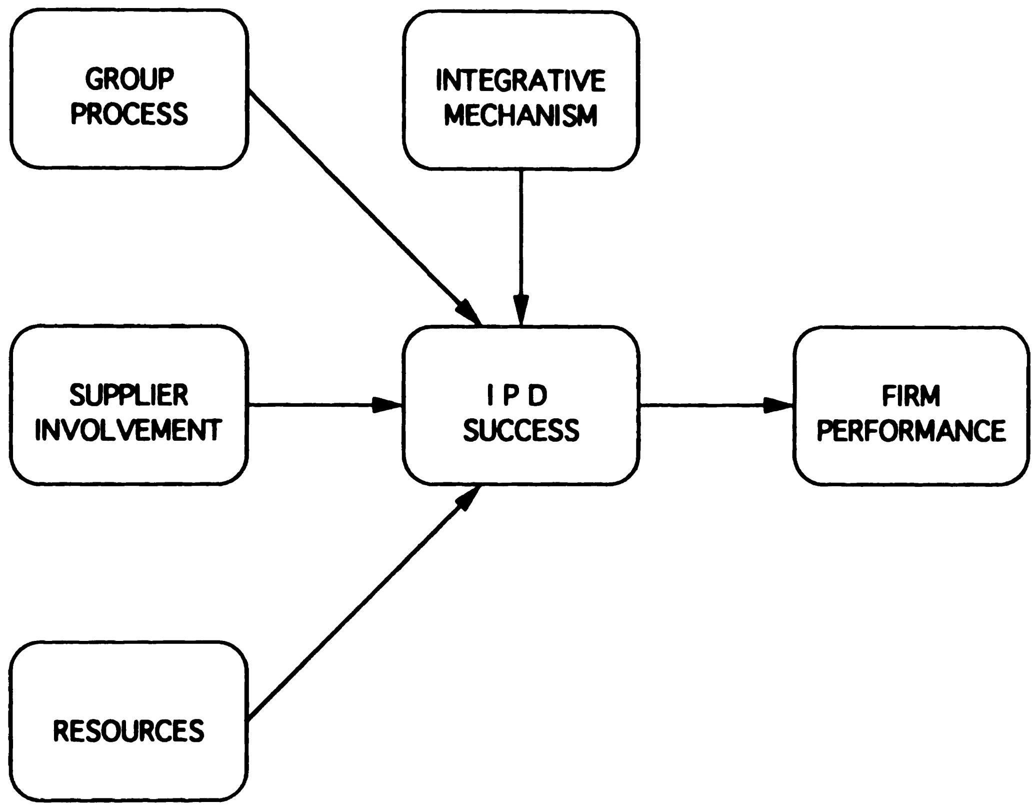

FIGURE 3-2

SUPPLIER INTERFACE IN THE IPD STRATEGY

Mechanisms (IM) are postulated to have a influence on the variables, Group Process (GP), Supplier Involvement (SI), and on IPD Success (IPDS). Examples of IM include:

- O Status equality between functions.
- O Project based rewards.
- O Communication channels and procedures which involve all functions.
- O Organizational Structure
- O Culture

The variable identified as Group Process (GP) represents the project level focus of the NPD process. Characteristics of GP variable are: the flow of communication; the degree of influence each member has on the finished design; and the degree of decision-making authority shared by members of the design process. The structure can range from the traditional/sequential flow of information and responsibility, to the concurrent/simultaneous approach to information exchange and work flow. A direct positive relationship is hypothesized between GP and IPD Success (IPDS). Group Process (GP) is expected to be influenced by level of Integrative Mechanisms (IM), Supplier Involvement (SI), and the level of Resources (R).

The incorporation of the variable Resources (R) represents the first departure from the Susman and Dean model (1991). It expands on their isolation of Tools and Techniques (T.T.), refer to Figure 3-1, which represents the arsenal of qualitative and quantitative aids available to the design team to include the overall level of resource support. Resources (R) will therefore include labor, capital, information, and equipment available to the NPD team (Figure 3-2). The level of Resources (R) is expected to influence IPD Success (IPDS), Group Process (GP), and Supplier Involvement (SI).

A variable which has been added to the original model (Figure 3-3), and which represents the primary focus of this research effort, is Supplier Involvement (SI). Supplier Involvement (SI) represents the degree and influence the suppliers' role has in the NPD process. Supplier Involvement (SI) will be determined based on the level of resource commitment, at which stage of the NPD process the supplier becomes involved, and what degree of influence the supplier exercises on the NPD process. Supplier Involvement (SI) is expected to influence Group Process (GP) and IPD Success (IPDS). The inclusion of this new variable represents an extension to the original Susman and Dean model (1991).

All of the previously mentioned variables are hypothesized to have a positive relationship with IPD Success (IPDS). IPD Success (IPDS) represents the actual outcomes of the NPD process utilizing the IPD strategy. The objective outcome measures incorporate the goals of the IPD strategy: improved quality, reduced cost, improved product performance, and reduced product development time. Subjective assessment of IPD Success involves perceptions of the NPD process and the final product. A direct positive relationship is postulated between IPD Success (IPDS) and the dependent variable Firm Performance (FP).

Research has served to identify the relationship between the introduction of

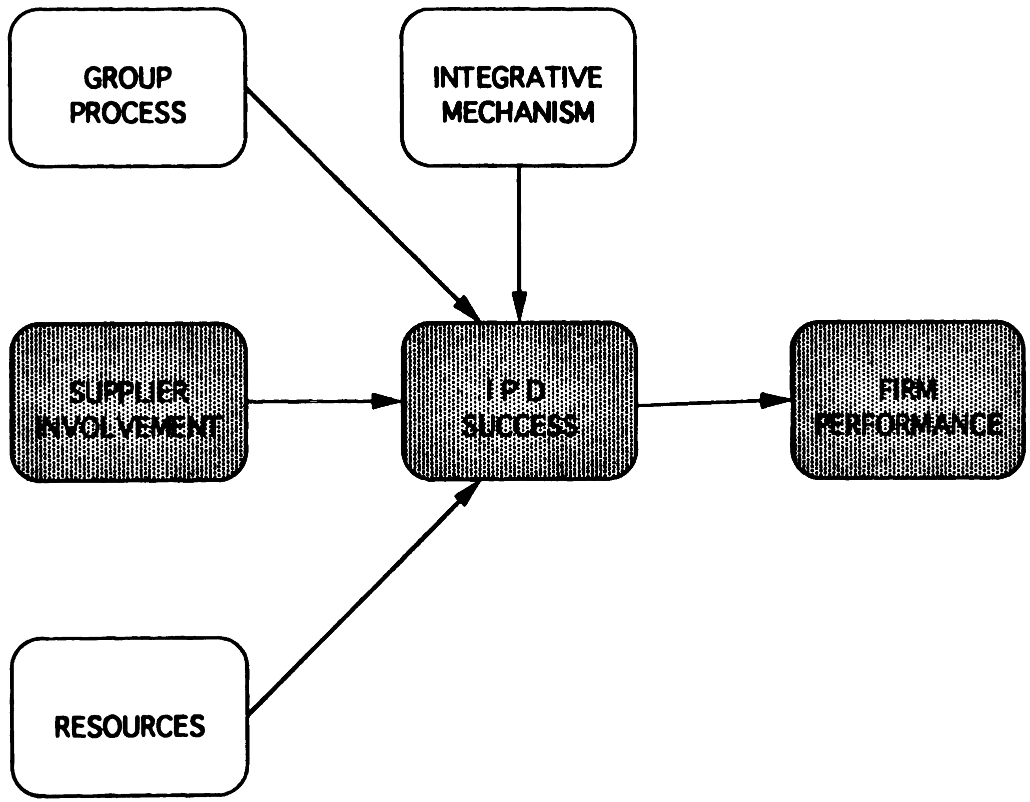

FIGURE 3-3

SUPPLIER INTERFACE IN THE IPD STRATEGY

new products and firm performance. The inclusion of the variable Firm Performance (FP) will serve to identify the relationship between utilizing the IPD strategy in new product development efforts and the impact on the competitive position of the firm. Firm Performance (FP) will be measured based on the relative competitive advantage achieved which will be referred to as Relative Performance (RP), and actual performance in the market or, Market Performance (MP).

A presentation of each construct, an operational definition of the construct, a list of dimensions that characterize the construct, and the perceptual and objective measures of each construct will follow.

Detailed Development of the Conceptual Framework--Definitions, Dimensions, and Measures

3.2 Supplier Involvement

Because control of the design-manufacturing process in the context of the strategic initiative Integrated Product Development is essential for effective management, the variables which impact this process needed to be identified and evaluated to improve NPD performance. Exploratory research (Susman and Dean, 1991) identified the following variables as influential in this process: Integrative Mechanisms, Group Process and Tools and Techniques. The authors acknowledged that a more comprehensive model would include the role of suppliers.

Therefore, the variable which has been added to the original model (Figure 3-3), and which represents the primary focus of this research effort, is Supplier Involvement (SI). SI represents the degree and influence the supplier's role has in the NPD process. SI will be determined based on the level of resource commitment, the stage of the NPD process the supplier becomes involved, and the degree of influence the supplier exercises on the NPD process. SI is expected to influence Group Process (GP) and IPD Success (IPDS). Supplier Involvement (SI) is the level of active involvement on the part of the supplying organization in the operations of the buying firm to facilitate the accomplishment of the business objectives of the buying firm.

3.2.1 Operational Definition of Supplier Involvement (SI)

Supplier Involvement will be defined along six dimensions. The dimensions of quantity, quality, communication, and investment are designed to measure the extent of involvement indicated by the commitment and investment of resources (time, labor, capital) by the supplier to facilitate the accomplishment to the buying organizations business objectives. The last two dimensions, relationship and expertise, characterize the type of involvement the supplier has in the process.

3.2.1 Dimensions and Measures of Supplier Involvement

The individual dimensions, measures, and survey questions utilized in this research can be identified in Table 3-1. A copy of the survey utilized in this research is included in the Appendix I for reference.

Table 3-1. Dimensions and Measures of Supplier Involvement

SUPPLIER INVOLVEMENT (SI)	
DIMENSIONS (SI)	MEASURES
QUANTITY (SI1)	1. Number of Different Suppliers 2. Total Number of Supplier Personnel 3. Level of Involvement 4. Length of Time 5. Number of Hours Committed
QUALITY (SI2)	1. Number of Ideas 2. Ideas realized 3. Autonomous Contribution 4. Creativity 5. Level of Influence 6. Technical Vs Administrative Support
COMMUNICATION (SI3)	1. Proximity 2. Attendance 3. Type and Form 4. Frequency 5. Flow/Two-way Communication
INVESTMENT (SI4)	1. Commitment to Purchase Tools 2. Training 3. Research & Development 4. Tooling/Equipment 5. Technology 6. Structure 7. Material/Prototypes 8. Labor Hours 9. Co-location
EXPERTISE (SI5)	1. Process Technology 2. Product Technology
RELATIONSHIP (SI6)	1. Compensation/Commitment 2. Dependence/Supplier 3. Length of Relationship 4. Risk Sharing/Supplier 5. Cooperation 6. Commitment to Goals/Supplier 7. Group Cohesion

3.3 Integrative Mechanisms

Fostering an innovative environment has long been recognized as critical to successful product innovation. Elements of an innovative environment include organizational structure, open communication, reward systems, and integration among functions (Knight, 1967; Utterback, 1974). The conceptual model utilizes Integrative Mechanisms (IM) to represent the organizational-level environmental and infrastructural variables which influence the NPD. Environmental variables for this construct relate to the internal environment of the business unit. The infrastructural portion of this variable includes the systems and structures in operation which serve to foster integration of the NPD process.

As Galbraith and Kazanjian (1986) point out, it is not the organizational structure, information processes, reward and support systems, or people acting in isolation that determine the degree of innovativeness, but the combination of those elements that is critical to success. Therefore, for the purpose of this research, the following definition has been utilized: "Integrative Mechanisms (IM) are organization-level initiatives that provide a favorable context for project-specific efforts by reducing differentiation and providing the basis for coordination of the design and manufacturing functions" (Susman and Dean, 1991: 13).

3.3.1 Operational Definition of Integrative Mechanisms (IM)

To facilitate the measurement of this construct and the testing of the research hypotheses, an operational definition has been developed. IM involve organizational level decisions and policies designed to foster the coordination of activities between functions involved in the NPD process, by reducing the perceived and actual differences between the functions which create barriers to effective interaction. IM seek to remove the culture manifested in the "over-the-wall syndrome."

3.3.2 Dimensions and Measures of Integrative Mechanisms (IM)

Table 3-2 presents the dimensions, measures, and reference to the specific survey questions utilized in this research to assess the impact of IM.

3.4 Group Process (GP)

The construct IM has been incorporated in the model to facilitate an understanding of the impact organizational-level issues have on the success of NPD in an integrated product development environment. To gain a similar understanding of the project-level influence, the variable Group Process (GP) has also been incorporated in the model. The focus of the Group Process construct is the individual team responsible for the development and introduction of the new product.

Case studies and focus group discussions involving practioners has demonstrated a strong desire to gain a greater understanding of the group dynamics which foster effective NPD introductions. Many firms have a history of both "successful" and "unsuccessful" NPD endeavors. Management frustration stems from attempts to duplicate successes by applying the same "formula" to

Table 3-2. Dimensions and Measures of Integrative Mechanisms

INTEGRATIVE MECHANISMS	
DIMENSIONS (IM)	MEASURES
STRUCTURE (IM1)	1. Structure 2. Culture
SUPPORT SYSTEM (IM2)	1. Awareness /Visibility 2. Education /Training 3. Communication 4. Reorganization 5. Delegate Decision Making 6. Sufficient Resources 7. Management Support 8. Give Recognition
INFORMATION ACCESSIBILITY (IM3)	1. Material Reliability 2. Material availability 3. Material Quality 4. Labor Costs 5. Machinery Tolerances 6. Parts Costs 7. Parts Configuration 8. Assembly Time 9. Ease of Fabrication 10. Ease of Assembly 11. Ease of Test
EQUITY (IM4)	1. Seniority 2. Budget Authority 3. Salary 4. Facilities 5. Organizational Status 6. Decision Making Authority

new endeavors which then produces disappointing results. The inability to transfer the technology, or learning, directly from one project to another elevates the importance of understanding the complexity of the NPD process (Takeuchi and Nonaka, 1986; Hayes, et al., 1988; Spencer, 1990). Group structure, communication patterns, leadership, and group cohesion have been consistently identified in the literature as influencing variables in successful innovation.

For the purpose of this research, Group Process (GP) represents project-level initiatives that provide a favorable context for new product development efforts by fostering the coordination of the new product development process (Susman and Dean, 1991: 21).

3.4.1 Operational Definition of Group Process (GP)

To facilitate accurate measurement of the construct, Group Process is defined as project-level decisions, policies, procedures, and characteristics designed to improve the effectiveness of the new product development team.

3.4.2 Dimensions and Measures of Group Process (GP)

Table 3-3 depicts the dimensions, measures and individual survey questions which were incorporated in the questionnaire to measure the Group Process construct.

3.5 Resources

Incorporation of the variable Resources (R) represents the first departure from

Table 3-3. Dimensions and Measures of Group Process

GROUP PROCESS (GP)	
DIMENSIONS (GP)	MEASURES
STRUCTURE (GP1)	1. Functional Groups 2. Functionally Related Tasks 3. Process Definition 4. Formal Transfer 5. Product/Process Design
COMMUNICATION (GP2)	1. Information Flow 2. Form 3. Frequency
LEADERSHIP (GP3)	1. Ability to mediate conflict 2. Resource requisition 3. Useful Contacts 4. Disseminated Information 5. Current Technology 6. Change Agent 7. Empowered Members 8. Project Vision 9. Communicated Vision 10. Secure Support
COHESION (GP4)	1. Establishing Project Goals 2. Agreement on Project Goals 3. Influence the Process 4. Attitude Like Trust, Support, Respect 5. Cooperation 6. Participation 7. Team Building

the Susman and Dean model (1991). It expands on their isolation of Tools and Techniques (T.T.) (Figure 3-2), which represents the arsenal of qualitative and quantitative aids available to the design team to include the overall level of resource support. Resources (R) refers to the existence, applicability, and accessibility of information, labor, capital, and equipment.

Because time tends to be the scarcest resource, a compressed product development cycle is expected to reduce the overall level of resource utilization. Furthermore, as time compression is primarily a function of the level of integration, resource utilization is expected to be inversely related to the degree of functional integration.

Resources (R) will be defined as the level of labor, capital, information, and equipment available to the NPD team. The level of Resources (R) is expected to influence IPD Success (IPDS), Group Process (GP), and Supplier Involvement (SI).

3.5.1 Operational Definition of Resources (R)

For the purposes of this research the absolute level of available resources is less important than the perception of the availability and utilization. Therefore, Resources is defined as the degree of utilization and level of information, labor, capital, and equipment available to the new product development team.

3.5.2 Dimensions and Measures of Resources (R)

Table 3-4 outlines the dimensions, measures, and survey items utilized to

Table 3-4. Dimensions and Measures of Resources

RESOURCES (R)	
DIMENSIONS (R)	**MEASURES**
UTILIZATION (R1)	1. Job Related Information 2. Tools 3. Materials and Supplies 4. Administrative Support/Services 5. Budgetary Support 6. Facilities 7. Equipment 8. Engineering Support (Person Hours) 9. Total Person Hours 10. Development Time 11. Education and Training 12. Upper Management Support
ADEQUACY (R2)	1. Job Related Information 2. Tools 3. Materials and Supplies 4. Administrative Support/Srevices 5. Budgetary Support 6. Facilities 7. Equipment 8. Engineering Support (Person Hours) 9. Total Person Hours 10. Development Time 11. Education and Training 12. Upper Management Support

determine the adequacy and availability of resources important to the NPD effort. All of the previously mentioned variables are hypothesized to have a positive relationship with IPD Success (IPDS).

3.6 Integrated Product Development Success (IPDS)

IPD in industry has been referred to variously as Design for Manufacturability, Design for Assembly, Design for Quality, Design for Customer Satisfaction, Design for Reliability, Design for Testability, Design for Fabrication, Design for Competitiveness, Design for Serviceability, Design for Producability, Simultaneous Engineering, Concurrent Engineering, etc. Hewlett-Packard has developed an all encompassing concept called Design for Competitive Advantage to convey the message "Doing the Right Things Right" (Concurrent Engineering Conference, 12/10/90).

These terms were presented to help convey the breadth of applications regarding IPD and the lack of a precise definition of the concept. Current efforts to define IPD are marked by inconsistent interpretations of the concept, presenting IPD as both a strategy and a NPD process. Examples of strategic oriented definitions from the literature illustrate the linkage between the design of the product and the attainment of business objectives.

Heidenreich (1988: 41) defines IPD as "the measure of a design's ability to consistently satisfy product goals while being profitable." Motorola defines their working construct as, "The ability to reproduce, identically and without waste, units of product so that they satisfy all customer physical and functional requirements (quality, reliability, performance, availability, and price) and also Motorola's business goals" (Motorola's Six Sigma Quality).

Digital Equipment Corporation (DEC) and General Motors incorporate in their IPD definitions both the strategic orientation and the process orientation.

> Design for Manufacturing is the process of insuring minimum Total Life Cycle cost, maximum quality and the shortest design cycle by applying to the design process: teamwork, benchmarking, simultaneous development, structured methods, analysis, simulation, manufacturing principles, and rapid prototyping (Concurrent Engineering Conference, 12/10/90).

> A General Motors strategy aimed at optimizing and continuously improving product designs for both customer satisfaction and buildability by using a multi-functional team approach (General Motors, Internal Document).

For the purpose of this research, IPD will be defined by strategic content and exclude the process characteristics incorporated in the DEC and General Motors definitions. The common characteristics that are associated with IPD in the literature are customer satisfaction, quality, total cost, sustained profitability, development time, value, and superior products. Therefore, IPDS can be defined by means of its objectives.

3.6.1 Operational Definition of Integrated Product Development Success (IPDS)

Integrated Product Development (IPD) leads to the delivery of a product in the shortest possible development time, provides superior value to the customer through the embodiment of physical, functional and psychological characteristics which satisfy customer requirements at the lowest possible cost of ownership, highest quality, and also provides a sustainable competitive advantage for the firm resulting in adequate returns and growth.

3.6.2 Dimensions and Measures of Integrated Product Development Success

IPDS dimensions, measures, and individual survey questions are presented in Table 3-5.

IPDS represents the actual outcomes of the NPD process utilizing the IPD strategy. The objective outcome measures incorporate the goals of the IPD strategy: improved quality and product performance, and reduced cost and product development time. Subjective assessment of IPDS involves perceptions of the NPD process and the final product. A direct positive relationship is postulated between IPDS and the dependent variable Firm Performance (FP).

3.7 Firm Performance

Research has served to identify the relationship between the introduction of new products and firm performance (Birnbaum, 1988; Davidson, 1988). The inclusion of the variable Firm Performance (FP) will serve to assess the relationship between utilizing the IPD strategy in new product development efforts and the impact on the competitive position of the firm.

Effectiveness of the IPD strategy is related to the degree of its contribution to the attainment of corporate goals and objectives. The eventual success of the NPD efforts is measured by the organization's performance in the marketplace. This research will determine if the implementation of an IPD strategy serves as

Table 3-5. Dimensions and Measures of IPD Success

INTEGRATED PRODUCT DEVELOPMENT SUCCESS (IPDS)	
DIMENSIONS (IPDS)	**MEASURES**
COST (IPDS1)	1. Product Cost 2. Start-up Costs 3. Tooling/Equipment Cost 4. Engineering Hours 5. Engineering Change Notices
QUALITY (IPDS2)	1. Overall Quality 2. Warranty Costs 3. Customer Complaints 4. Rejected Material 5. Rework Costs
TIME (IPDS3)	1. Development Time 2. Communication 3. Manufacturing Cycle Time 4. White Collar Productivity
PERFORMANCE (IPDS4)	1. Product Performance 2. Market Share 3. Perceived Value 4. Perceived Quality 5. Sales (Dollars) 6. Profitability 7. Product Capabilities

a source of competitive advantage by improving relative firm performance.

Firm Performance (FP) refers to the firm's competitive performance within its respective industry. Firm Performance (FP) will be measured based on the relative competitive advantage achieved which will be referred to as Relative Performance (RP), and actual performance in the market or, Market Performance (MP).

3.7.1 Operational Definition

Relative Performance (RP) represents the firm's performance compared to its leading competitors along the dimensions which serve as a source of competitive advantage in their operating environment. Performance measures, including market share, profitability, sales growth, and earnings growth, are designed to evaluate a firm's actual performance, referred to as Market Performance (MP). Overall Firm Performance (FP) is an aggregate measure of the firm's Relative Performance (RP) and Market Performance (MP).

3.7.2 Dimensions and Measures of Firm Performance (FP)

The relative and market performance of the firm is assessed by the dimensions, measures, and questions listed in Table 3-6.

This chapter began by presenting a detailed description of the conceptual model utilized in this research, building on the exploratory research conducted by Susman and Dean (1991) which identified Integrative Mechanisms, Group

Table 3-6. Dimensions and Measures of Firm Performance

FIRM PERFORMANCE (FP)	
DIMENSIONS (FP)	MEASURES
RELATIVE PERFORMANCE (FP1)	1. Responsiveness/Flexibility 2. Customer Service 3. Rate of Product Innovation 4. Product Cost 5. Product Performance 6. Product Quality 7. Process Innovation
MARKET PERFORMANCE (FP2)	1. Market Share Growth 2. Sales Growth 3. Earnings growth 4. Return on Assets

Process, and Tools and Techniques as variables which impact the success of NPD, and the research conducted by Fujimoto (1989) which identified the importance of the relationship with the supplier in this process. These variables, along with the dependent variables of Integrated Product Development Success and Firm Performance, have been supported with operational definitions to facilitate their measurement and the dimensions which serve to characterize their meaning and measurement. In addition, Supplier Involvement has been defined and operationalized in a manner which serves to provide meaningful interpretation of the role of the supplier in the Integrated Product Development process.

The next chapter on the research methodology discusses the research hypotheses, research design, unit of analysis, measurement issues, data collection, the sample population, and data analysis.

CHAPTER IV

RESEARCH METHODOLOGY

4.0 Previous chapters have established the importance and purpose of this research, its theoretical foundation, and the conceptual model utilized to conduct the research. The research effort encompassed those firms employing the Integrated Product Development (IPD) strategy in their new product development process. Variables included in this study were adapted from two previous research efforts, Fujimoto (1989) and Susman and Dean (1991). Integrative Mechanisms (IM), Group Process (GP), Resources (R), Supplier Involvement (SI), Integrated Product Development Success (IPDS), and Firm Performance (FP) represent the variables which were incorporated in this research.

This chapter presents the research questions of interest and the supporting research design utilized to address these questions. The presentation of the research design includes identification of the unit of analysis, construction of the survey instrument, description of the sample population, data collection procedures, variable measures, and the model specification. The chapter concludes with the data analysis procedures employed to test the hypotheses of interest in this research.

4.1 Firm Performance

Independent research conducted by Davidson (1988) and Birnbaum (1988) revealed that firms with shorter product development cycles demonstrated higher performance in the marketplace. Utilization of IPD was expected to shorten the product development time and, therefore, have a positive impact on firm performance.

Hypothesis 1:

H_o: Firm performance is unrelated to IPD Success.
H_1: Firm performance is related to IPD Success.

Market performance of the business unit was measured along the dimensions of profitability, market share, sales growth, and earnings growth. The IPD strategy is expected to be a source of competitive advantage yielding higher performance for the firm in their respective markets on these competitive dimensions.

Hypothesis 2:

H_o: Market performance of the firm is unrelated to IPD Success.
H_1: Market performance of the firm is related to IPD Success.

"The development of new products in a timely manner is increasingly becoming a source of competitive advantage in a growing number of industries" (Emmanuelides, 1991: 342). In addition to the impact on product development time, utilization of the IPD strategy was expected to have a positive impact on the competitive dimensions of product cost, product quality, customer service, product innovation, process innovation, product performance, and firm responsiveness. Higher firm performance relative to leading competitors along these competitive dimensions was anticipated.

Hypothesis 3:

H_o: Relative firm performance is unrelated to IPD Success.
H_1: Relative firm performance is related to IPD Success.

4.2 Supplier Involvement

The performance of the project was expected to improve due to supplier involvement in the new product development process. Objective measures of the individual dimensions of Integrated Product Development Success (IPDS) were then evaluated to determine the level of impact supplier involvement had on the various performance dimensions.

4.2.1 Cost

An estimated 60 to 80 percent of product cost is determined at the design stage of new product development (Raia, 1989; Business Week, 1989). With material bought from suppliers amounting to 56 percent of each sales dollar, the supply base represents an obvious source of cost reduction in the development of new products (Burt, 1989). Early supplier involvement in Integrated Product Development is expected to result in lower product cost due to a compatible design, increased visibility, and simplicity of design.

Supplier participation in the design phase will facilitate the development of a design more compatible with the supplier's capabilities and therefore, lead to lower product cost. In the event that significant process capability changes are required, the supplier will have the opportunity to pursue the most cost effective options to implement the required process improvements. In addition, the added visibility provides the suppliers with time to establish value-added relationships in its own supply chain.

Hypothesis 4:

H_o: Product cost is unrelated to the level of supplier involvement in IPD.

H_1: Product cost is related to the level of supplier involvement in IPD.

4.2.2 Quality

Raia (1989) reported that 40% of all quality problems can be traced to poor product design. The source of these quality problems is the inability of the product design to accommodate process variation. Sources of process variation include internal manufacturing systems and the manufacturing systems of the supply base. Product designs which are characterized as "robust" are insensitive to variance in the manufacturing process (Taguchi, 1988; Raia, 1989). Therefore, the more robust the design, the higher the associated level of product quality.

Knowledge of process capabilities is essential in the pursuit of a robust product design. Supplier involvement in the design process serves to improve the robustness of the design by providing information about the supplier's process capability and process variation. Quality represents another dimension of IPD Success. Supplier involvement was expected to be associated with higher product quality.

Hypothesis 5:

H_o: Product quality is unrelated to the level of supplier involvement in IPD.

H_1: Product quality is related to the level of supplier involvement in IPD.

4.2.3 Development Time

Research involving 20 new product development efforts in the automotive industry sought to identify the source of competitive advantage Japanese firms held compared with U.S. and European auto manufacturers regarding lead time. Results indicated that the Japanese completed a vehicle 18 months faster than their competitors, and one-third of this advantage was attributable to supplier involvement in the design process (Clark, 1989).

Development time is one measure of IPD Success. Supplier involvement in the new product development process associated with Integrated Product Development was expected to demonstrate a similar relationship with product development time. Therefore, with supplier involvement in the process, product development time was expected to decline.

Hypothesis 6:

H_o: Product development time is unrelated to the level of supplier involvement in IPD.

H_1: Product development time is related to the level of supplier involvement in IPD.

4.2.4 Product Performance

The goal of NPD efforts is to provide the company with a product of value to the customer. Efforts to improve competitive position suggest that development efforts which do not provide a perceived distinction in the market, those that merely offer a "me-too" product, do nothing to enhance the competitive position of the firm. It is important that the perceived quality and value conveyed to the customer in the form of the final product result in tangible contributions to market share, sales, and profitability for the firm. A product capable of delivering these desired results to the firm is a source of competitive advantage.

Product performance was measured based on both subjective and objective criteria. The subjective evaluation involved a determination of the change in the perceived value and quality by the customer. Objective measures of product performance included the percentage of change in market share, sales, profitability, and product capabilities. Supplier involvement in the NPD process was expected to have a positive impact on quality and cost, two of the components of IPD Success. This relationship is expected to transfer into the subjective evaluations of customers' perceptions of quality and value and the capabilities of the product. Improved market share, sales and profitability are expected as a result of supplier involvement.

Hypothesis 7:

H_o: Product performance is unrelated to the level of supplier involvement in IPD.

H_1: Product performance is related to the level of supplier involvement in IPD.

4.3 Research Design

The ideal experimental research design allows the researcher to manipulate the independent variables of interest and observe the reaction of the dependent variable. Non-experimental research involves an empirical inquiry to demonstrate relationships among variables without direct control of the independent variable. Because of the nature of this research, the inability to control and manipulate the independent variables, non-experimental research design issues and considerations have guided the development of the methodology. The research effort was guided by a desire to (1) answer the research questions, (2) control for independent variables not involved in the study, (3) generalize the results across a wide spectrum of situations, and (4) establish internal and external validity of the measures (Kirlinger, 1986).

4.3.1 Unit of Analysis

In this research effort the unit of analysis was defined at the project-level. New product development projects in durable goods manufacturing firms utilizing the Integrated Product Development strategy were candidates for inclusion in this study. The choice of the unit of analysis was guided by the nature of the issues under investigation, the objectives of the investigation, and the facilitation of the data collection efforts.

This research involved a critical examination of the new product development process utilizing the Integrated Product Development strategy. The objective of the investigation was to determine the influence of supplier involvement on the success of new product development efforts during the execution of an Integrated Product Development strategy.

Because of the complexity and length of the design cycle and the critical role purchased material plays in the production of industrial and consumer durable goods, only projects which had reached the full-production and commercial sale stage of the product life cycle could provide adequate information.

Participating firms were allowed to submit the results from multiple new product development efforts provided the surveys were completed by different individuals. Concerns which needed to be addressed in the research design as a result of examining multiple projects from the same firm included the potential for bias introduced by the presence of corporate culture, learning curves, product life cycle, nature of the competitive environment, and the degree of product innovation.

4.3.2 Measurement Issues

The first step to ensure the success of this research effort rested with the ability to accurately operationalize the constructs of interest and relevance to the research. These were-Integrative Mechanisms (IM), Group Process (GP), Resources (R), Supplier Involvement (SI), IPD Success (IPDS), and Firm Performance (FP). The degree of accuracy with which data could be collected depended on the development of an operational definition for each variable which constituted a reliable, valid measure.

Reliability of the measurement refers to the ability of the measure to perform consistently over repeated applications yielding the same results over a variety of conditions. The exploratory nature of this research required the development of measures for the constructs of interest. Coefficient Alpha was utilized in this research to test the reliability of the measures (Nunnally, 1978: 212). A reliability coefficient of 0.70 was used consistent with the exploratory nature of this research (Nunnally, 1978: 245). "Reliability is a necessary but not sufficient condition for validity" (Nunnally, 1978: 192). Validity involves developing measures of a construct which provide a strong correlation between the construct and the item or behavior being observed as measurement of the construct (Schwab, 1980). Establishing the validity of a measurement involves the process of determining whether the desired variable of interest is actually what is being measured. Stone (1978) presents several methods of establishing the construct validity of the measures, including content and face validity which were incorporated in this research design.

Content validity is achieved when the measures used in the research to observe the construct of interest are considered to be representative of the domain of measures of that construct (Stone, 1978). Content validity is enhanced to the degree that the measures of the construct are mutually exclusive of other constructs. To establish content validity in this research, definitions of the constructs and the associated measures of those constructs were based on a thorough review of the literature, in-depth interviews with practitioners and academics familiar with this area of research, and focus group discussions.

Establishing face validity was a natural by-product of the process of establishing content validity in this scenario. Face validity addresses the question, "do the measures seem intuitively correct and are they based on logical linkages?" Qualitative assessment by a group of experts is the primary means of establishing face validity. Face validity was established through a pilot test of the survey instrument, and feedback from academics and practitioners.

4.4 Survey Instrument Development

Development of the survey instrument was an iterative process. The final draft of the survey was pilot tested with a group of ten industry representatives. Their comments were incorporated in the final version of the survey. The survey was ten pages in length and designed to be self-administered to facilitate data collection.

The survey contained several items relating to descriptive information on the sample population (e.g., industry, innovation, environmental uncertainty). The instrument contained individual and scale items to capture objective and perceptual measures of the independent and dependent variables. Multiple, interval scaled measures of each construct were incorporated in the survey to minimize the effect of mono-operational bias which results from the use of a single measure to evaluate a construct (Cook and Campbell, 1979: 66). The survey instrument primarily used a seven-point scale to collect the data.

In the development of the survey instrument, every effort was made to utilize existing measures of variables which have been validated by previous research in the operationalization of the constructs used in this research. This process required the identification of research from a wide variety of fields, including organizational theory, organizational behavior, marketing, and strategy. Because the conceptual model for this research was an adaptation of the model presented in the Susman and Dean research (1991), they were contacted at the Center for the Management of Technological and Organizational Change (CMTOC) of Penn State University to request permission to use portions of the survey instruments which they utilized. They responded with encouragement and provided copies of the various survey instruments utilized in their study. The format of their questions were altered for this research, but much of the content was incorporated in the constructs Integrative Mechanisms, Integrated Product Development Success, Group Process, and Resources. These items had been used by Susman and Dean to validate their conceptual model but no reliability measures were reported.

Another valuable source of validated, reliable measures came from the survey instrument used by Montoya-Weiss and Calantone (1992). Scale items were adapted in format and content for use in measuring dimensions and constructs of organizational structure, organizational culture, innovation, environmental uncertainty, and group cohesion. The reliability of these measures ranged from 0.74 to 0.90 for the constructs of interest (Montoya-Weiss and Calantone, 1992: 98).

Efforts to identify measures to classify a firm's business strategy based on the widely accepted framework presented by Porter (1980) into one of three generic categories (cost-leadership, differentiation, focus) led to a paper titled "Selective Interpretations of Competitive Methods by Middle Managers" (Nystrom, 1991). The reliability measures were reported for the cost-leadership strategy (coefficient alpha= 0.76) and differentiation strategy (coefficient alpha= 0.61) (Nystrom, 1991: 13). Although the reliability measures associated with the differentiation strategy are below the targeted 0.70 for exploratory research, they were selected for inclusion because they represented the only known measures available.

A dimension of the Group Process variable included in the aggregate measure is the role of the leader. A total of ten scale items were utilized to measure this construct. Five of the scale items were derived from the work conducted by Howell and Higgins (1990) who utilized self-reported measures in their research on champions of innovation. Their research focused on three variables that influence leadership: personality characteristics, leadership behavior, and influence tactics. For the purpose of this research, the dimensions of leadership behavior were incorporated. The reliability of the multiple scale items for dimensions of this construct ranged from 0.70 to 0.75 (Howell and Higgins, 1990: 329-330). The five remaining scale items were based on conclusions drawn from presentations made at four conferences dealing with Integrated Product Development.

Historically, the term supplier involvement has been restricted to an interpretation of the characteristics of the relationship between the buyer and supplier, or the length of the relationship. Although these two dimensions are important aspects of supplier involvement, they do not capture the complexity of this dynamic relationship. In order to portray this relationship accurately, input was sought from purchasing professionals in academia and industry. Three brainstorming sessions were conducted to define and operationalize the construct with members of the National Association of Purchasing Management, The International Federation of Purchasing and Materials Management, and the corporate staff of Asea Brown Boveri to provide both domestic and international perspectives. The sessions were successful in defining and identifying multiple dimensions and measures of the construct. Information obtained from the three independent sessions proved to be highly consistent in providing face validity for the measures. The goal of this process was to develop a full-faceted measure of the variable Supplier Involvement which could be utilized in this research and later tested for reliability.

Although the majority of the dimensions of Supplier Involvement required the development of new scale items to facilitate measurement, previous research in the areas of communication and organizational behavior provided scale items which were adapted for this research. Specifically, the dimension of communication and its associated form, frequency, and flow, were borrowed from the research conducted by Susman and Dean (1991).

Defining the relationship between the buyer and the supplier in terms of the quality of the relationship, rather than merely the duration, required a multi-dimensional scale which was adapted from the construct presented in the Montoya-Weiss and Calantone research (1992). The construct, designated Marketing's Communication Skills, was designed to measure the quality of the interaction between departments and had a reported coefficient alpha of 0.95 (Montoya-Weiss and Calantone, 1992: 98). The seventeen scale items were used to measure the quality of the interorganizational relationship between the buyer and the supplier.

The operationalization of the two independent variables, Integrated Product Development Success and Firm Performance, was driven by the need to collect and accurately measure information of a sensitive nature. Another issue which needed to be incorporated in the design of the measurement involved the impact of aggregating the results across firms of varying size, competitive environments, industries, and product complexity. To be able to draw distinct conclusions from the data, a method had to be used to normalize the data. The Handbook of Organizational Measurement (Price and Mueller, 1986) defined effectiveness as the financial ability of an organization (Price and Mueller, 1986: 128). Such financial ratios as "return of assets" and "return of equity" are recommended as they allow for comparisons between and among different organizations. Utilizing this schema, the measures of Integrated Product Development Success, or the effectiveness of the project, were requested from participants as the percentage change in performance from a target benchmark project or product. This method facilitated the aggregation of results for comparative statistics.

The individual measures of project effectiveness were derived from the literature and verified by industry executives as valid measures. The four main objectives of Integrated Product Development--improving quality, reducing cost, reducing development time, and improving product performance--were measured along multiple dimensions of these attributes.

To gather information regarding the competitive position of a firm, measures on key performance criteria known as competitive priorities (Wood, Ritzman and Sharma, 1989) and market criteria (market share, sales, profit) relative to leading competitors were measured as scale items. These perceptual measures were used because actual performance data of this nature is usually not published by the companies, and many of the participants would have been unwilling to disclose such critical information (Dess and Robinson, 1984). The use of perceptual measures along these dimensions also serves as a means of standardizing the data to allow for aggregation and comparisons.

The variable, organizational culture is a dimension of the construct Integrative Mechanisms. Although the definitions of this variable presented in the literature are rather nebulous--and this presented some initial difficulty in operationalizing the term--previous research did provide some useful measurement items. Specifically, the research conducted by Hofstede, Neuijen, Ohayv and Sanders (1990), involving twenty case studies of organizational culture, provided seven of the eleven scale items incorporated in the survey instrument. The items were selected based on the factor loadings to represent six dimensions identified in their research as explaining 73 percent of the variance at the 0.001 level. The factor loadings for these items ranged from 0.62 to 0.84 (Hofstede et al., 1990: 303). The remaining four items were adapted for use from the survey utilized by

Montoya-Weiss and Calantone (1992) in their research on the impact of environmental uncertainty.

Organizational structure was measured on two levels, the business or organizational level, and the project or team level. Like culture, the measurement of organizational structure presented some difficulty because it is undesirable to measure the construct using other constructs in the process. For example, there is a tendency to define organizational structure by using such terms as matrix, functional, centralized or decentralized which themselves need to be defined and operationalized.

This research was aided by the work of Shrivastava and Souder (1987) which hypothesized the need for different organizational structures and levels of integration to facilitate the NPD process under various levels of environmental uncertainty. The characteristics presented in their conceptual research to describe the three different structures were developed into five scale items to categorize organizational structures based on their framework. Additional scale items were taken from Susman and Dean (1991), and Montoya-Weiss and Calantone (1992) to identify the degree of centralization and formalization present in the organizational structure.

Providing meaningful measures of the construct "Resources" was complicated by the need to aggregate the data for comparative purposes. A measurement method which would allow for the inclusion of firms of different sizes and resource availability and projects of various sizes and orders of magnitude needed to be developed. In addition, the pilot test revealed that participants were resistant to provide the resource data in terms of the absolute or objective criteria (dollars, hours, square feet).

Utterback (1974) reported that the presence of slack resources resulted in better cost performance, schedule performance, and technical performance. Peters and O'Connor (1980) investigated this relationship in their research on the relationship between situational constraints (resources) and job performance. Content analysis of 62 interviews resulted in the identification of eight situational resources which impact performance.

In addition to the identification of eight important situational resources, their research revealed that it was not the absolute level of resources that was significant, but the availability, adequacy, and quality of the resources (Peters and O'Connor, 1980: 396). Based on this information, the eight resources identified were further refined into twelve scale items which were used to measure resources along the dimensions of utilization compared to previous projects and level of adequacy.

Communication flow, frequency, and form for this research were evaluated on the organizational and project level. Research in the area of organizational communication has distinguished four dimensions: formal-informal, vertical-horizontal, personal-impersonal, and instrumental-expressive (Price and Mueller, 1986: 84). These measures were incorporated in the organizational level construct Integrative Mechanisms. On the project level, these dimensions were utilized in different forms in conjunction with the measures of frequency and form provided by Susman and Dean (1991) in the construct Group Process.

Another dimension of the Group Process construct which was systematically measured through the survey instrument was group cohesion. Five scale items for this dimension were adapted from previous research reported in Price and Mueller (1986: 252-253) with reliability coefficients of 0.89 (Cronbach's Alpha). The four remaining measures were developed based on information obtained at formal presentations on team effectiveness in an IPD environment and from the Susman and Dean survey (1991).

The purpose of the previous section was to present the process used in developing the survey instrument used in this research. The development of individual scale items was based primarily on previous research in order to ensure reliable measures for important constructs. The final survey instrument used in this research is included in Appendix II. A cross reference of individual scale items (by question number) to the construct and dimension being measured is presented in Chapter III, Tables 3-1 to 3-6.

4.5 Sample Population

The next step involved the determination of the sample population and the required sample size to provide the desired level of statistical power. The focus of this research effort was the NPD process associated with firms utilizing the IPD strategy. Hence, the sample population included firms which demonstrated a product design strategy consistent with the IPD definition presented in Chapter III.

Other considerations addressed in determining the sample population include the threats to internal and external validity. Internal validity involves the control of extraneous independent variables which may influence the behavior of the dependent variable. The easiest method to control for the majority of threats to internal validity is randomization of subjects (Kirlinger, 1986; Cook and Campbell, 1979). The focus of this research, firms employing the IPD strategy in their NPD process, precluded the use of randomization as a feasible alternative. Two other alternatives rely on the manipulation of subjects, matching or homogeneous (Cook and Campbell, 1979). These methods also did not present themselves as feasible solutions for this research design. The final method of controlling extraneous variables is to incorporate the variables into the design. This was the desired method given the nature of the research.

Competition, government regulation, market forces, and rate of technological change have been identified in the literature as external influences impacting innovation and development time (Emmanuelides, 1991; Shrivastava and Souder, 1987; Freeman and Hannan, 1975). Therefore, degree of product innovation, environmental uncertainty, and the industry were the extraneous variables incorporated in the research to minimize the threats to internal validity.

External validity addresses the generalizability of the results and conclusions. Randomization assures the highest level of external validity, but this was not possible in the present study. Efforts to increase the generalizability was aided through the representation of multiple industries using the IPD strategy, including transportation, electronics, and machinery. The results and conclusions were

Other considerations addressed in determining the sample population include the threats to internal and external validity. Internal validity involves the control of extraneous independent variables which may influence the behavior of the dependent variable. The easiest method to control for the majority of threats to internal validity is randomization of subjects (Kirlinger, 1986; Cook and Campbell, 1979). The focus of this research, firms employing the IPD strategy in their NPD process, precluded the use of randomization as a feasible alternative. Two other alternatives rely on the manipulation of subjects, matching or homogeneous (Cook and Campbell, 1979). These methods also did not present themselves as feasible solutions for this research design. The final method of controlling extraneous variables is to incorporate the variables into the design. This was the desired method given the nature of the research.

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External validity addresses the generalizability of the results and conclusions. Randomization assures the highest level of external validity, but this was not possible in the present study. Efforts to increase the generalizability was aided through the representation of multiple industries using the IPD strategy, including transportation, electronics, and machinery. The results and conclusions were effort at the beginning of each conference and invited those in attendance to participate in the research. Attendance at the conferences provided the opportunity to present the scope of research project to interested participants and answer any questions directly.

4.6 Data Collection

Once the sample target population had been determined, commitment from individual participants was sought in an effort to improve the response rate. Because of the nature and complexity of the survey, participant commitment was crucial to the successful completion of this research effort. Initial commitment was sought during the conferences and was followed by telephone contact prior to distribution of the survey instrument.

A subset of the target population from the first "Concurrent Engineering" conference in December of 1990 and individuals from industry and academia were used for a pilot test of the survey instrument to determine the clarity of questions, ease of response, and face validity. Input from the group was incorporated in the final survey instrument prior to mass distribution.

The survey, ten pages in length, was composed primarily of scale items with some objective information sought pertaining to the dependent variable IPD Success and descriptive information regarding the firm and industry. Completion of the survey required approximately a two-hour commitment on the part of participants.

The survey was distributed by first class mail. A two page cover letter outlining the research project, the benefits to participants, instructions, and the sponsoring institutions was included along with a return self-addressed, stamped envelope. The surveys were distributed in the second quarter of the 1992. Individuals who did not respond to the initial mailing within one month were issued a second survey to serve as a reminder and to replace any surveys that may have been misplaced.

The objective information regarding the results of the new product development project proved to be the only source of missing data which posed any problem. Every effort was made to contact participants through telephone calls, facsimile, and letters to request their cooperation in providing the missing data.

4.7 Measures

Each of the variables involved in the research (Supplier Involvement, Group Process, Integrative Mechanisms, Resources, IPD Success, and Firm Performance) is multi-faceted, requiring multiple measures of the same construct. The dimensions along which these variables were measured are as follows:

SUPPLIER INVOLVEMENT (SI)

1. Quantity (SI_1)
2. Quality (SI_2)
3. Communication (SI_3)
4. Investment (SI_4)
5. Relationship (SI_5)
6. Expertise (SI_6)

GROUP PROCESS (GP)

1. Structure (GP_1)
2. Communication(GP_2)
3. Leadership (GP_3)
4. Cohesion (GP_4)

INTEGRATIVE MECHANISMS (IM)

1. Structure (IM_1)
2. Support System (IM_2)
3. Information (IM_3)
4. Equity (IM_4)

RESOURCES (R)

1. Accessibility (R_1)
2. Utilization (R_2)

IPD SUCCESS (IPDS)

1. Cost ($IPDS_1$)
2. Quality ($IPDS_2$)
3. Time ($IPDS_3$)
4. Performance ($IPDS_4$)

FIRM PERFORMANCE (FP)

1. Relative (FP_1)
2. Market (FP_2)

The specific survey questions designed to measure each of the dimensions of the constructs listed above are provided in a cross-reference form in Tables 3-1 to 3-6.

4.8 Model Specification

To perform the data analysis, an unweighted summated score was computed for each of the independent constructs and the dependent variable Firm Performance. For example, the six dimensions of Supplier Involvement (Quantity, Quality, Communication, Investment, Relationship, and Expertise) were combined into a single composite score for data analysis.

The dependent measures of project performance (IPDS) were not aggregated in the same fashion as the other constructs. These measures were utilized as individual indicators of team performance. Attempts to aggregate these scores would have obscured the interpretation of the results.

4.8.1 Variable Definitions

The following equations represent the aggregation of the constructs to be utilized to test the research hypotheses.

Supplier Involvement (SI) = $SI_1 + SI_2 + SI_3 + SI_4 + SI_5 + SI_6$
Group Process (GP) = $GP_1 + GP_2 + GP_3 + GP_4$
Resources (R) = $R_1 + R_2$
Integrative Mechanisms (IM) = $IM_1 + IM_2 + IM_3 + IM_4$
Firm Performance (FP) = $FP_1 + FP_2$
Relative Performance (RP) = FP_1
Market Performance (MP) = FP_2

In addition, three control variables were incorporated in the research, Firm Size (S), the degree of Product Innovation (PI), and the level of Competitive Intensity (CI). Firm Size was measured by annual sales and stratified into large, medium, and small based on quartile distributions (25/50/25). Product Innovation was measure as a categorical variable with three levels high, medium, and low, corresponding to the level of innovation achieved. Competitive Intensity was measured on 7-point lickert scale ranging from significantly increased, to significantly decreased, compared to three years ago.

The regression coefficients are indicated as β_1, β_2, β_3, β_4, etc. The unexplained variance and higher order interactions are captured in the error term (ϵ).

4.8.2 Overall Model

The overall model is represented by linear equation developed below. The equation indicates that the project success, IPDS, is a function of the direct contribution of Supplier Involvement (SI), Group Process (GP), Resources (R), and Integrative Mechanisms (IM). The model also includes the three control variables Firm Size (S), degree of Product Innovation (PI), and the level of Competitive Intensity (CI).

$$IPDS = f(SI,GP,R,IM,\gamma_i) = \beta_0 + \beta_1(SI) + \beta_2(GP) + \beta_3(R) + B_4(IM) + \beta_5(S) + \beta_6(PI) + \beta_7(CI) + \epsilon$$

4.8.3 Sub-Models

Given the current organizational structures of most firms, utilizing an integrated product development process requires a significant commitment of resources and changes in standard operating procedures. This research addresses the cost-benefit analysis of utilizing this integrated approach in the product-delivery process through the identification of the impact IPDS has on Firm Performance (FP). In addition, this research identifies which of the IPDS measures are instrumental in improving FP. The Relative Performance (RP) of the firm on key competitive dimensions and the relative Market Performance (MP) were evaluated in the same manner.

$$FP = f(IPDS) = \beta_0 + \beta_1(IPDS),\ldots + \beta_{21}(IPDS) + \epsilon$$
$$MP = f(IPDS) = \beta_0 + \beta_1(IPDS),\ldots + \beta_{21}(IPDS) + \epsilon$$
$$RP = f(IPDS) = \beta_0 + \beta_1(IPDS),\ldots + \beta_{21}(IPDS) + \epsilon$$

Once the individual measures for the construct IPDS which influence FP have been identified, the construct Supplier Involvement will be isolated and evaluated for its relative contribution to the project success.

$$IPDS_1,\ldots IPDS_{21} = f(SI,GP,R,IM,S,PI,CI) = \beta_0 + \beta_1(SI) + \beta_2(GP) + \beta_3(R) + \beta_4(IM) + \beta_5(S) + \beta_6(PI) + \beta_7(CI) + \epsilon$$

4.9 Data Analysis

The initial phase of data analysis involved the use of descriptive statistics including the calculation of means, variances, ranges, and the plotting of frequency distributions. These elementary data analysis techniques provided information about the nature of the sample population and the quality of the data. Specific attention was given to the identification, analysis, and correction of data collection and data entry errors revealed by the presence of missing data, outliers, irregularities, and inconsistent data.

Two methods were employed to evaluate the quality of the measures utilized in this research. Calculation of Coefficient Alpha was the first method utilized. A reliability benchmark of 0.70 was utilized to assess the quality of the measures incorporated in this research. This standard was based on the prescription given by Nunnally (1978: 245) for exploratory research.

The second method utilized to determine the quality of the measurement of the constructs was Exploratory Factor Analysis. This method was chosen to assess the level of convergent and discriminant validity of the four independent variables incorporated in the research--Integrative Mechanisms, Group Process, Resources, and Supplier Involvement. Exploratory Factor Analysis is largely used as a data reduction technique. In this research it was employed to facilitate the development of reliable valid measures of the constructs of interest for the purposes of future research. The analysis of factor loadings provided the ability to select the individual scale items for each construct which contribute the highest level of variance explained.

The preceding section explained the general data analysis techniques employed to prepare the data for hypothesis testing and determine the quality of the data for this research analysis. The following section presents the statistical techniques utilized to test individual hypotheses.

4.9.1 Hypothesis Testing

The first step utilized in testing the research hypotheses was an evaluation of the impact of the control variables on the variable IPDS. This was accomplished through an analysis of each of the control variables respective means for the 21 measures of IPDS. This analysis revealed that the control variables did not significantly influence IPDS. Consequently, these control variables were not included in the regression analysis. Subsequent regression models will focus on the impact of Integrative Mechanisms, Group Process, Resources, and Supplier Involvement.

The second step in testing the research hypotheses involved establishing the relationship between the independent variable IPDS and the dependent variable

FP. Multiple linear regression techniques were utilized to evaluate the 21 objective measures of IPDS to reveal those which significantly impact the success of the firm. Each of the remaining research hypotheses were then evaluated utilizing multiple linear regression techniques to determine the impact of supplier involvement on the attainment of the individual IPDS criteria.

The regression equations incorporated the use of the constructs as defined and reduced through the use of exploratory factor analysis. Evaluation of the research hypotheses involved the overall statistical significance of the model and, more importantly, the significance and direction of the variable, SI.

This chapter began by presenting the hypotheses which were tested in this research. It provides the research design, survey instrument, data collection, and data analysis techniques which were employed to test these research questions. Chapter V presents a discussion of the results of this analysis. Chapter VI then provides the conclusions drawn from this research.

CHAPTER V

ANALYSIS AND FINDINGS

5.0 This chapter begins with a description of the research participants including the demographic information, category of product under development, degree of product innovation, target market for the product, technology requirements, source of benchmark for the product, the primary manufacturing process, and the descriptive statistics regarding the supplying organizations involved in the New Product Development process (NPD). This is followed by the results of the test for normality, reliability, and the exloratory factor analysis. A redefinition of the Integrated Product Development (IPD) conceptual model based on these preliminary findings will be presented, followed by a discussion of the statistical analysis and evaluation of the individual research hypotheses. Chapter VI is dedicated to a discussion of the conclusions and future implications stemming from the findings of this research effort.

5.1 Description of Research Participants

A total of 256 surveys were mailed to interested domestic participants. Completed surveys were returned from 133 research participants for a 51.9 percent response rate. An additional 23 surveys were returned from respondents indicating that the research was not appropriate for their environment due to the nature of their business (non-profit, consulting, software development, etc.), or that they did not have a product which currently met the criteria of full-scale production. Based on this additional information the adjusted response rate is 57.1 percent. The high response rate can be attributable to the personal commitment sought from respondents prior to distribution of the survey, level of interest in the research, and the data collection instrument.

A total of 54 companies and 65 divisions were represented in the sample. Of the 133 respondents, 62.4 percent, or 83 of the respondents indicated that suppliers were a part of the NPD process (see Figure 5-1). This sub-population of the larger sample is the focus of this research representing 36 companies, 60 operating divisions, and 83 unique projects.

Composition of the responding population indicated that the largest industry representation was automotive (38.6 percent), followed by electronic (18.1 percent), defense (10.9 percent), medical (8.4 percent), transportation equipment (8.4 percent), machinery (7.2 percent), office furniture (2.4 percent), and other (2.4 percent) (see Figure 5-2).

The large automotive industry representation was further analyzed to determine if there existed a potential to bias the data from the sample population of 83 respondents. Of the 32 projects which indicated that they competed in the automotive industry, seven firms (8.4 percent) were actually component suppliers and the specific project they were reporting on was intended for an automotive application. One firm was actually an unrelated business unit owned by an automotive manufacturer. Firms considered as part

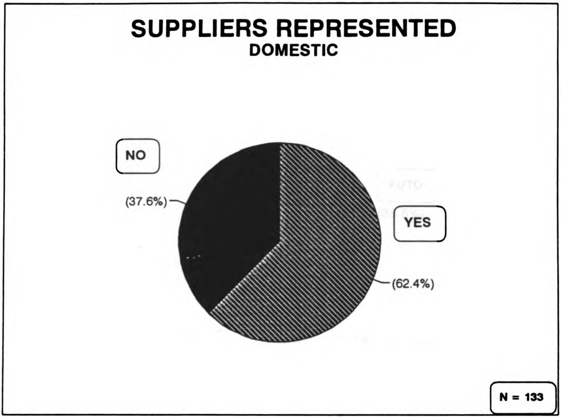


FIGURE 5-1

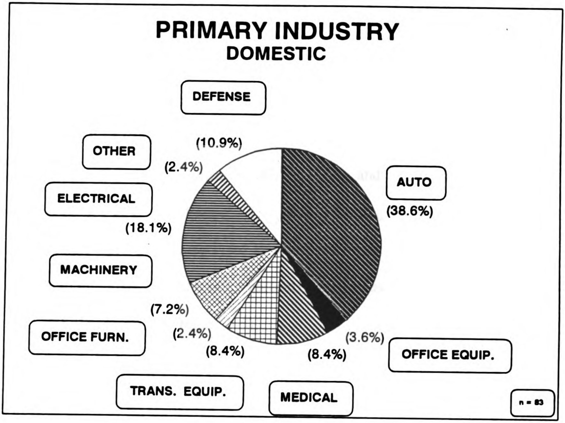

PRIMARY INDUSTRY
DOMESTIC
DEFENSE
OTHER
(10.9%)
(2.4%)
ELECTRICAL
AUTO
(38.6%)
(18.1%)
MACHINERY
(7.2%)
OFFICE FURN.
(2.4%)
(3.6%)
(8.4%)
(8.4%)
OFFICE EQUIP.
TRANS. EQUIP.
MEDICAL
n = 83

FIGURE 5-2

of the automotive supply chain were actually in the electronic, hydraulic, specialty materials, and filtration businesses. Figure 5-3 reflects this further analysis and industry breakdown. The breadth of industry representation facilitates the achievement of one of the research objectives involving the generalizability of the results.

Responding firms were categorized as small, medium, or large, based on the number of employees and annual sales for comparative purposes. Firms with fewer than 1,000 employees were considered small (12.8 percent), between 1,000 to 29,999 employees, medium (47.5 percent), and over 30,000 employees (39.7 percent), large (see Figure 5-4). Firms reporting up to 100 million dollars in annual sales were categorized as small (12.7 percent), from 100 million to 10 billion dollars, medium (49.3 percent), and greater than 10 billion dollars, large (38.0 percent) (see Figure 5-5).

The majority of the respondents (72.2 percent) provided information regarding the development of a finished good (see Figure 5-6). The respondents indicated that the products were considered to be a major enhancement of a previous product (44.6 percent), or an entirely new product (54.2 percent) (see Figure 5-7). Product development was geared primarily to satisfy the needs of existing customers (66.3 percent), with new market segments (25.3 percent) and completely new markets (8.4 percent) commanding less emphasis (see Figure 5-8).

Figure 5-9 illustrates the level of technological complexity involved in the NPD projects. Respondents described the development process as requiring the

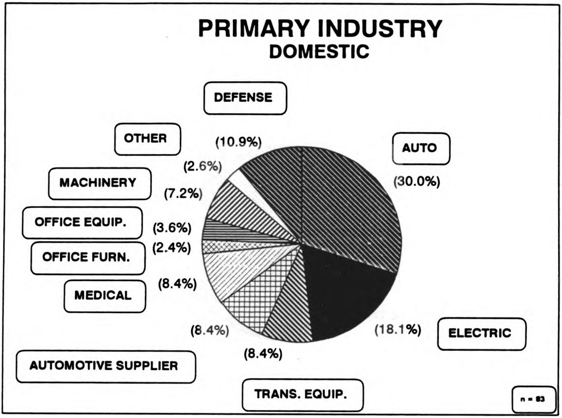
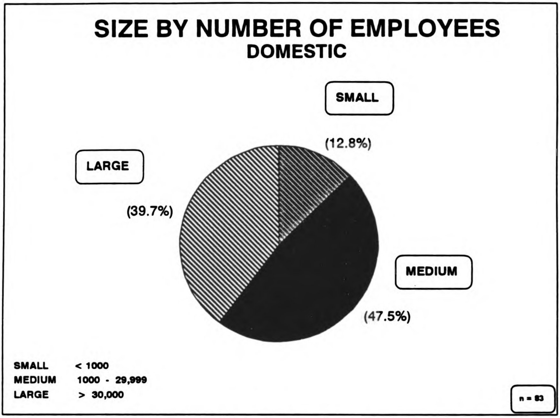

PRIMARY INDUSTRY
DOMESTIC
DEFENSE
OTHER
(10.9%)
AUTO
(2.6%)
MACHINERY
(7.2%)
(30.0%)
OFFICE EQUIP.
(3.6%)
(2.4%)
OFFICE FURN.
(8.4%)
MEDICAL
(8.4%)
(18.1%)
ELECTRIC
(8.4%)
AUTOMOTIVE SUPPLIER
TRANS. EQUIP.
n = 83

FIGURE 5-3



SIZE BY NUMBER OF EMPLOYEES
DOMESTIC
SMALL
(12.8%)
LARGE
(39.7%)
MEDIUM
(47.5%)
SMALL < 1000
MEDIUM 1000 - 29,999
LARGE > 30,000
n = 83

FIGURE 5-4

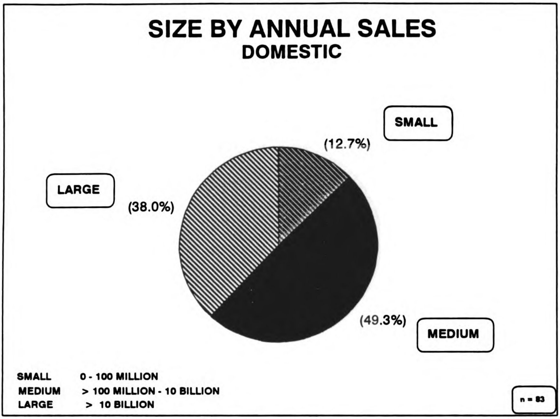

SIZE BY ANNUAL SALES
DOMESTIC
SMALL
(12.7%)
LARGE
(38.0%)
(49.3%)
MEDIUM
SMALL 0 - 100 MILLION
MEDIUM > 100 MILLION - 10 BILLION
LARGE > 10 BILLION
n = 83

FIGURE 5-5

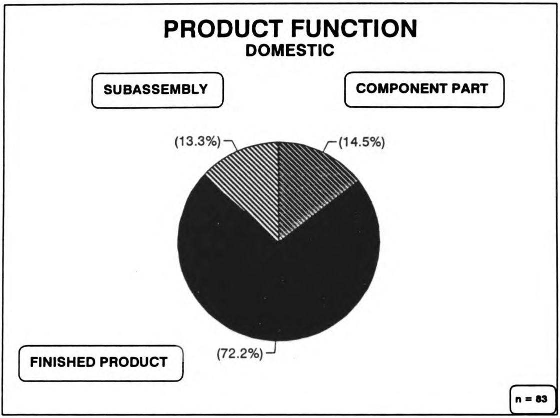

PRODUCT FUNCTION
DOMESTIC
SUBASSEMBLY
COMPONENT PART
(13.3%)
(14.5%)
(72.2%)
FINISHED PRODUCT
n = 83

FIGURE 5-6

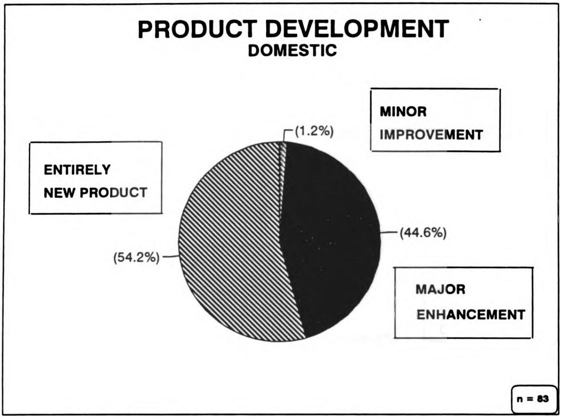

PRODUCT DEVELOPMENT
DOMESTIC
MINOR IMPROVEMENT
(1.2%)
ENTIRELY NEW PRODUCT
(44.6%)
(54.2%)
MAJOR ENHANCEMENT
n = 83

FIGURE 5-7

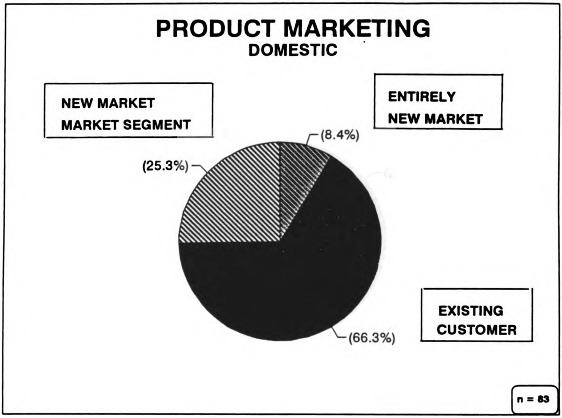

PRODUCT MARKETING
DOMESTIC
NEW MARKET
MARKET SEGMENT
ENTIRELY
NEW MARKET
(8.4%)
(25.3%)
(66.3%)
EXISTING
CUSTOMER
n = 83

FIGURE 5-8

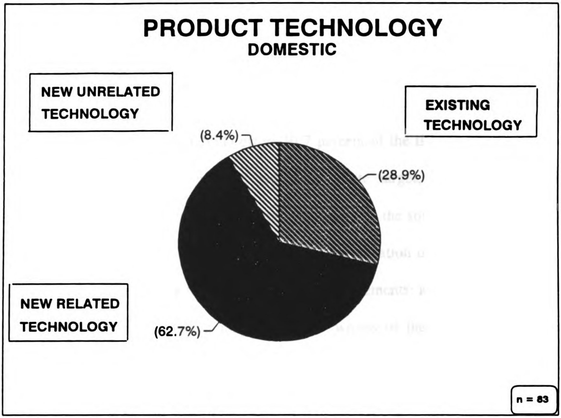

PRODUCT TECHNOLOGY
DOMESTIC
NEW UNRELATED TECHNOLOGY
EXISTING TECHNOLOGY
(8.4%)
(28.9%)
NEW RELATED TECHNOLOGY
(62.7%)
n = 83

FIGURE 5-9

utilization of technology which was related to previously utilized technology as follows: new-related technology 62.7 percent of the time; existing technology, 28.9 percent; entirely new-unrelated technology, 8.4 percent of the projects.

The benchmarking process is deemed useful in establishing performance targets for the NPD projects. It was important for this research to quantify the results of the IPD process which was recorded as the percentage change from benchmark projects. Respondents indicated that competitor's products provided the benchmark for their NPD effort 30.7 percent of the time, a previous model was utilized by 30.7 percent, and a corporate target, 21.3 percent. The remaining respondents (17.3 percent) indicated that the source of the benchmark was derived from one of the following: a combination of the three previously mentioned methods; a function of customer requirements; negotiated by the team; a product of management judgement; the "whims of the CEO"; or, the team operated without any benchmarks (see Figure 5-10).

The majority of the respondents, 65.4 percent, categorized their product-delivery process as mass production. Of the remaining respondents, 25.6 percent indicated that their product-delivery process was characterized as batch production, followed by job-shop environments, 9.0 percent (see Figure 5-11).

The number of different suppliers represented on the NPD teams ranged from one to 99, with a mean of 13, and a mode of one. This distribution reflects the variety of projects involved in the sample in terms of scope and scale. The responses ranged from finished goods automotive manufacturers representing large-scale projects consisting of multiple teams, teams-within-teams, to

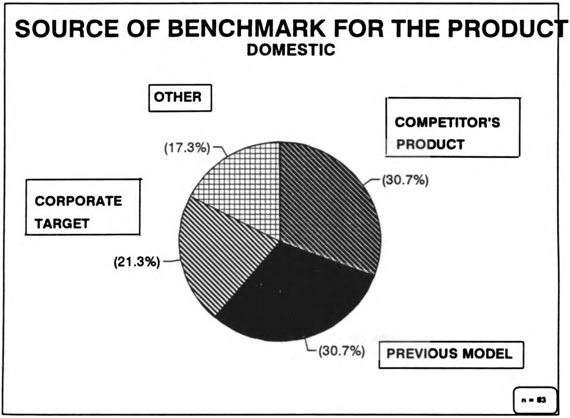

SOURCE OF BENCHMARK FOR THE PRODUCT
DOMESTIC
OTHER
COMPETITOR'S PRODUCT
CORPORATE TARGET
PREVIOUS MODEL
(17.3%)
(30.7%)
(21.3%)
(30.7%)
n = 83

FIGURE 5-10

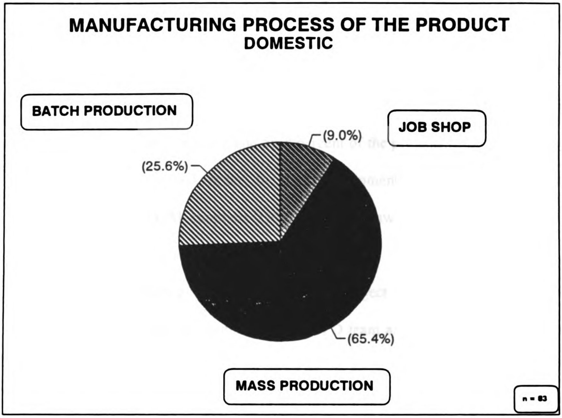

MANUFACTURING PROCESS OF THE PRODUCT
DOMESTIC
BATCH PRODUCTION
JOB SHOP
(9.0%)
(25.6%)
(65.4%)
MASS PRODUCTION
n = 83

FIGURE 5-11

component and subassembly contributors supplying the perspective from more narrowly-defined projects.

Figure 5-12 gives a breakdown of the types of suppliers who were members of a NPD team according to the product or service that they provided. The results are based on the total representation of suppliers on NPD teams as there was often more than one supplier on a given team. Component part and subassembly/assembly suppliers were the most frequently included, with membership on 80.2 percent and 56.8 percent of the projects respectively. They were followed, in rank order, by capital equipment suppliers (34.6 percent), finished goods/OEM suppliers (29.6 percent), raw materials suppliers (25.9 percent), and service providers (14.8 percent).

The technology involved in the NPD project was the primary reason for inviting suppliers to be members of the NPD team as indicated by 32.5 percent of the respondents. This was followed by the suppliers' level of expertise, 19.3 percent, and the type of product or service they provided, 18.1 percent. Of far less importance in the selection criteria were the length of time doing business with the supplier, 9.6 percent, the value of the purchased part or service, 8.4 percent, and the relative proximity of the supplier, 1.2 percent (see Figure 5-13). While the length of the buyer-supplier relationship was not a primary determinant in the supplier selection process, the average life span of the reported relationship was 10 years with a range between 1 to 25.

The total number of supplier personnel reported to be involved in the project ranged from 1 to 99, the mean was 35, the median was 15, with the most

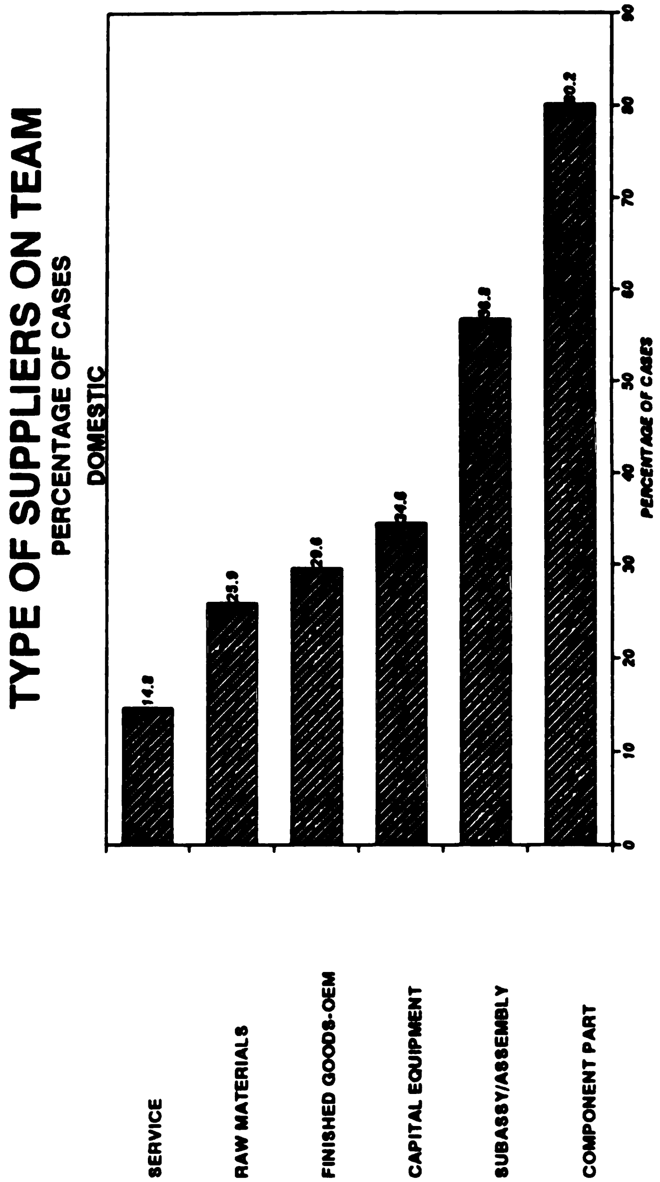

TYPE OF SUPPLIERS ON TEAM
PERCENTAGE OF CASES
DOMESTIC
SERVICE
RAW MATERIALS
FINISHED GOODS-OEM
CAPITAL EQUIPMENT
SUBASSY/ASSEMBLY
COMPONENT PART
14.8
25.9
29.6
34.6
56.8
80.2
0
10
20
30
40
50
60
70
80
90
PERCENTAGE OF CASES

FIGURE 5-12

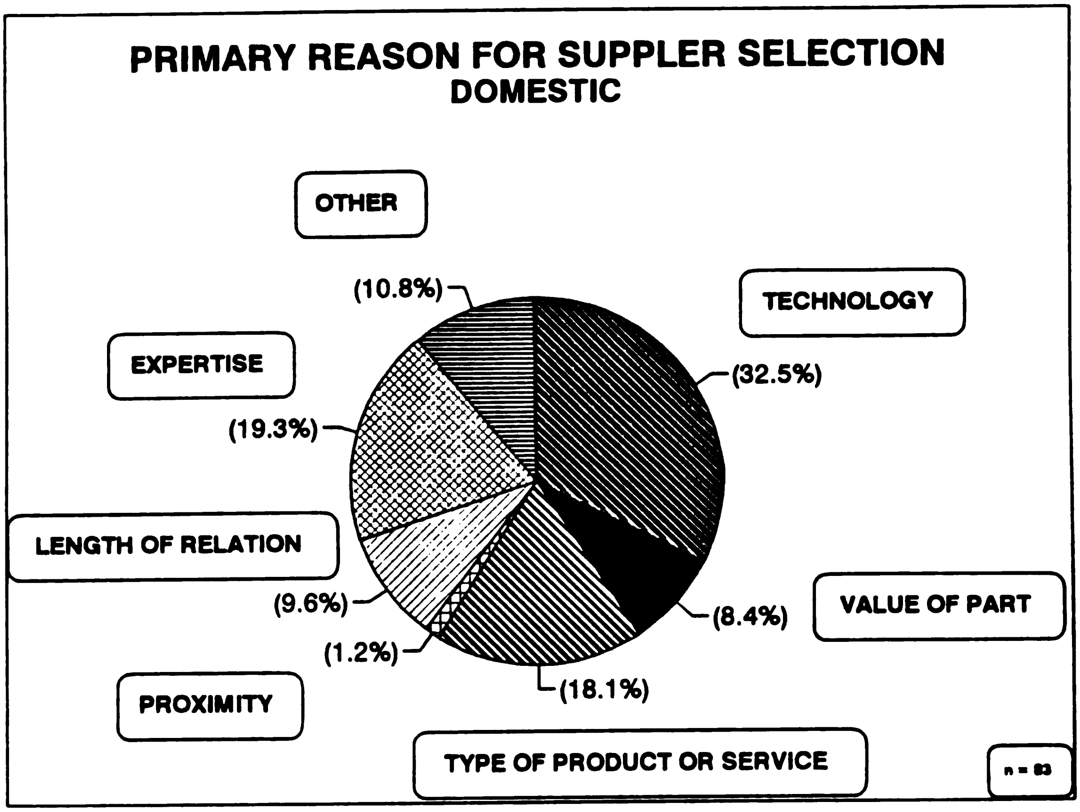

PRIMARY REASON FOR SUPPLER SELECTION
DOMESTIC
OTHER
(10.8%)
TECHNOLOGY
(32.5%)
EXPERTISE
(19.3%)
LENGTH OF RELATION
(9.6%)
(1.2%)
PROXIMITY
(8.4%)
VALUE OF PART
(18.1%)
TYPE OF PRODUCT OR SERVICE

FIGURE 5-13

common responses being two and four. This demonstrates the magnitude of difference in the degree of supplier involvement in the NPD process. Another indicator is the variety of the supplying firms' personnel who were involved in process. Figure 5-14 depicts the frequency of involvement of the suppliers' personnel from a variety of departments including sales, engineering, quality, management and manufacturing. All of the suppliers supporting functions were involved in over two-thirds of the cases, with engineering involved in 91.6 percent of the projects.

5.2 Preliminary Statistics

5.2.1 Normality

A necessary assumption for many statistical procedures including the methods utilized in this research, regression analysis, is a normal distribution of the residuals and independence of the error terms. The first method utilized to confirm the condition of normality was a visual inspection of the distribution of the data for the dependent variables, Firm Performance and IPDS. Casewise plots of the residuals identified outliers which were removed from further analysis.

A more formal procedure, the Kolmogorov-Smirnov Goodness of Fit Test, was then employed for additional verification of a normal distribution. While a normal distribution is not a necessary prerequisite for independent variables in regression analysis, the results of this procedure are presented for both the

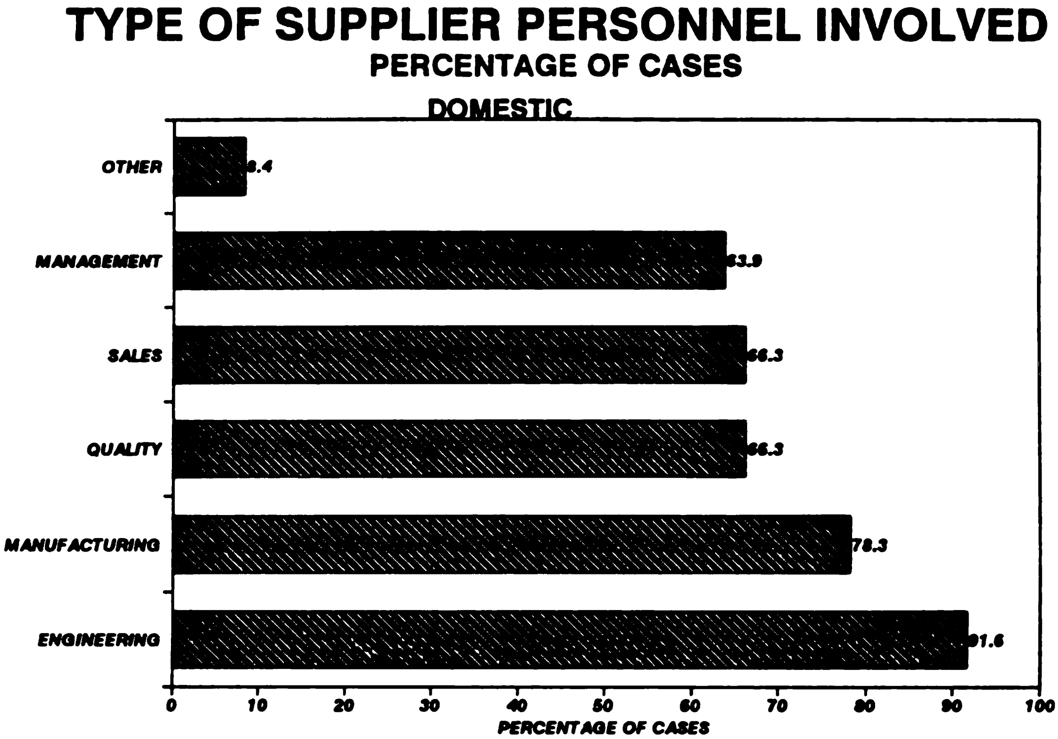

TYPE OF SUPPLIER PERSONNEL INVOLVED
PERCENTAGE OF CASES
DOMESTIC
OTHER
MANAGEMENT
SALES
QUALITY
MANUFACTURING
ENGINEERING
8.4
63.9
66.3
66.3
78.3
91.6
0
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF CASES

FIGURE 5-14

dependent and independent variables. The construct IPDS plays a unique role in this research, acting as the linking-pin between left and right side of the conceptual model. It therefore acts as both a dependent and independent variable.

The Kolmogorov-Smirnov test compares the actual distribution of the data with a normal distribution to determine whether the distributions are statistically different. The desired result is a failure to prove that the distribution of the actual data differs from a normal distribution, a failure to reject the null hypothesis. The results of this analysis are provided in Tables 5-1a for the independent variables and 5-1b for the dependent variables. The results demonstrate that there are no serious deviations from normality. Two of the individual measures of IPDS, improved product quality and product performance, deserve further consideration as the results indicate that the distributions do statistically differ from a normal distribution. The multiple regression techniques, while significantly influenced by the presence of outliers, is fairly robust to deviations from the assumption of normality. This confirmation provided the basis for the remaining statistical procedures which were employed to test the research hypotheses.

Scatterplots of the residuals demonstrated a descending fan-like distribution for the dependent variable IPDS, indicating nonindependence of the error terms. A logarithmic transformation of the dependent variable IPDS was utilized as a remedial measure prior to further data analysis (Neter, Wasserman, and Kunter: 133-137).

Table 5-1 A.

Kolmogorov Smirnov Goodness of Fit Test

Independent Variable

VARIABLE	MEAN	STD. DEV.	K - S Z	2-Tailed P
Supplier Involvement	4.16	0.93	0.56	0.91
Buyer Supplier Relationship	4.98	1.12	0.99	0.28
IM Structure - Culture	4.27	0.79	0.67	0.75
Information Importance	5.51	0.69	0.74	0.64
Information Accessibility	4.94	0.94	0.60	0.85
Group Process	5.53	0.78	0.85	0.46
Resource Utilization	4.45	0.89	0.60	0.86

Table 5-1 B

Kolmogorov - Smirnov Goodness of Fit Test

Dependent Variables

VARIABLE	MEAN	STD.DEV	K-S Z	2-TAIL P.
Firm Performance	4.48	0.89	0.99	.28
Market Performance	4.08	1.23	1.00	.26
IPDS Overall	18.31	12.92	1.31	.06
Relative Performance	4.70	0.92	1.05	.21
Reduce Product Cost	8.87	11.19	1.70	.01
Reduce Start-Up Costs	13.16	13.89	0.65	.80
Reduce Tooling Costs	12.65	11.10	0.74	.64
Improve Product Quality	16.25	21.46	1.88	.00*
Reduce Warranty Costs	19.00	15.73	1.05	.22
Reduce Customer Complaint	26.30	24.30	1.22	.10
Reduce Rejected Material	14.52	14.39	1.15	.14
Reduce Rework Cost	16.89	18.63	1.08	.20
Improve Product Performance	20.55	26.42	1.84	.00*
Improve Market Share	11.18	11.32	1.06	.21
Increase Perceived Value	32.97	28.91	1.23	.10
Increase Perceived Quality	30.86	28.81	1.16	.13
Improve Dollar Sales	21.89	23.65	1.04	.23
Improve Product profitability	19.05	16.78	1.32	.06
Improve Product Capabilities	29.39	26.23	1.41	.04
Reduce Development Time	18.63	18.99	1.75	.01
Improve Communication	34.59	33.76	1.21	.11
Reduce Total Manhours	19.38	17.21	1.11	.17
Reduce Engineering Change Notices	24.17	23.07	0.79	.56
Reduce Manufacturing Cycle Time	24.51	19.90	1.12	.16
Improve White Collar production	23.65	19.13	0.74	.65

5.2.2 Reliability

Due to the exploratory nature of this research, prior to testing the research hypotheses, the reliability of the measures pertaining to the constructs of interest needed to be determined. In order to improve the generalizability of the results the entire sample was utilized to perform this analysis, both the domestic (n=133) and international respondents (n=83) for a total sample population of 216 projects. Coefficient alpha was utilized to test the inter-item reliability of the theoretically-derived constructs with a benchmark value of 0.70, based on standards for exploratory research set by Nunnally (1978: 245). The results of this analysis are provided on the individual dimensions of each construct, as well as the aggregate construct itself, where applicable.

One of the objectives of this research was to develop a reliable measure of the construct Supplier Involvement (SI). The construct was measured along five dimensions: quantity, quality, communication, investment, and caliber of the relationship. The reliability of these individual dimensions ranged from .76 for communication, to .94 for relationship, with the overall measure of Supplier Involvement demonstrating a reliability of .94 (see Table 5-2).

Integrative Mechanisms (IM), the organizational-level variable, was measured along the dimensions of structure/culture, support systems, information, and status. The individual reliabilities of this dimensions were .63, .84, .85, and .81 respectively, with an overall reliability of .87 (see Table 5-3).

The team-level variable labelled Group Process (GP) was composed of a structural dimension (alpha=.74), communication dimension (alpha=.50),

Table 5-2 . Dimensions and Measures of Supplier Involvement

SUPPLIER INVOLVEMENT (SI)		
DIMENSIONS (SI)	QUESTIONS	RELIABILTY
QUANTITY (SI1)	Q 28 Q 31 Q 33,35 Q 37 Q 38	.7819 (11)
QUALITY (SI2)	Q 42.3 Q 42.4 Q 42.2 Q 42.1 Q 50 Q 56	.9306 (22)
COMMUNICATION (SI3)	Q 34 Q 40 Q 45.1-45.6 Q 45.1-45.6 Q 48 Q 51	.7586 (10)
INVESTMENT (SI4)	Q 36 Q 44.1-8	.8104 (9)
EXPERTISE (SI5)	Q 42.5 Q 42.6	N.A.
RELATIONSHIP (SI6)	Q 39 Q 41 Q 43 Q 49 Q 47,52,54,55 Q 53 Q 57	.9306 (22)
Total		**.9434 (60)**

Table 5-3. Dimensions and Measures of Integrative Mechanisms

INTEGRATIVE MECHANISMS		
DIMENSIONS (IM)	QUESTIONS	RELIABILITY
STRUCTURE (IM1)	Q 9.2-9.5 Q 9.8 Q 9.11 Q 9.1,6,7,9,10 Q 10.1-10.5	.6282 (6)
SUPPORT SYSTEM (IM2)	Q 74.1 Q 74.2 Q 74.3 Q 74.4 Q 74.5 Q 74.6 Q 74.7 Q 74.8	.8390 (8)
INFORMATION ACCESSIBILITY (IM3)	Q 79.1-11 Q 79.12-22	.8513 (22)
EQUITY (IM4)	Q 73.1 Q 73.2 Q 73.3 Q 73.4 Q 73.5 Q 73.6	.8095 (6)
Total		**.8723 (42)**

leadership dimension (alpha=.91), and a cohesion dimension (alpha=.87). The overall reliability of the construct Group Process is .90 for the aggregation of the 36 individual items (see Table 5-4).

Specific resources identified in the literature as facilitating the NPD process were evaluated based on their utilization (alpha=.87) and adequacy (alpha=.87). The aggregate measure of the Resource (R) construct demonstrated a reliability of .89 (see Table 5-5).

The first dependent variable included in the theoretical framework is the outcome measure of the team's performance, IPDS. Due to the objective nature of the data utilized to measure this construct, reliabilities are unnecessary. They are provided for the benefit of future research. The composite measure for IPDS is a product of the underlying dimensions of cost (alpha=.7786), quality (alpha=.83), product performance (alpha=.8350), and development time (alpha=.7524). The reliability of the composite measure is .91 (see Table 5-6).

Firm Performance represents the second dependent variable, and the final construct included in this research. Firm Performance was measured along two dimensions including an assessment of the performance relative to competitors on the key competitive priorities (alpha=.76), and market indicators (alpha=.90). The combination of these two dimensions yielded an overall indicator of firm performance with a reliability of .85 (see Table 5-7).

5.2.3 Exploratory Factor Analysis

The exploratory nature of this research required both the verification of the reliability of the constructs and establishment of the validity of the measures.

Table 5-4. Dimensions and Measures of Group Process

GROUP PROCESS (GP)		
DIMENSIONS (GP)	QUESTIONS	RELIABILITY
STRUCTURE (GP1)	Q 60 Q 61 Q 62 Q 63 Q 64-65	.7293 (7)
COMMUNICATION (GP2)	Q 68 Q 75.1-75.5	.4991 (7)
LEADERSHIP (GP3)	Q 59.1 Q 59.2 Q 59.3 Q 59.4 Q 59.5 Q 59.6 Q 59.7 Q 59.8 Q 59.9 Q 59.10	.9076 (10)
COHESION (GP4)	Q 67 Q 69.8 Q 69.1 - 69.7 Q 70 Q 71 Q 72	.8705 (13)
Total		**.9019 (36)**

Table 5-5. Dimensions and Measures of Resources

RESOURCES (R)		
DIMENSIONS (R)	QUESTIONS	RELIABILITY
UTILIZATION (R1)	Q 25.1 Q 25.2 Q 25.3 Q 25.4 Q 25.5 Q 25.6 Q 25.7 Q 25.8 Q 25.9 Q 25.10 Q 25.11 Q 25.12	.8696 (12)
ADEQUACY (R2)	Q 26.1 Q 26.2 Q 26.3 Q 26.4 Q 26.5 Q 26.6 Q 26.7 Q 26.8 Q 26.9 Q 26.10 Q 26.11 Q 26.12	.8665 (12)
Total		**.8932 (24)**

Table 5-6. Dimensions and Measures of IPD Success

INTEGRATED PRODUCT DEVELOPMENT SUCCESS (IPDS)		
DIMENSIONS (IPDS)	QUESTIONS	RELIABILTY
COST (IPDS1)	Q 16A Q 16B Q 16C Q 16R Q 16S	.7786 (5)
QUALITY (IPDS2)	Q 16D Q 16E Q 16F Q 16G Q 16H	.8305 (5)
TIME (IPDS3)	Q 16P Q 16Q Q 16T Q 16U	.7524 (4)
PERFORMANCE (IPDS4)	Q 16I Q 16J Q 16K Q 16L Q 16M Q 16N Q 16O	.8350 (7)
Total		**.9099 (21)**

Table 5-7. Dimensions and Measures of Firm Performance

FIRM PERFORMANCE (FP)		
DIMENSIONS (FP)	QUESTIONS	RELIABILITY
RELATIVE PERFORMANCE (FP1)	Q 8.1 Q 8.2 Q 8.3 Q 8.4 Q 8.5 Q 8.6 Q 8.7	.7649 (7)
MARKET PERFORMANCE (FP2)	Q 8.8 Q 8.9 Q 8.10 Q 8.11	.8974 (4)
Total		**.8472 (11)**

Face validity was established by an intensive review of the literature, through information obtained from interviews and brainstorming sessions with practioners, a pilot test of the survey instrument, and feedback sought from leading academics. Confirmation of the face validity was sought through exploratory factor analytic techniques to determine if the individual measures actually measured the constructs of interest.

Orthogonal solutions provide information regarding the ability of the factors to discriminate among the constructs of interest. Oblique solutions enhance the interpretability of the results but do not guarantee an orthogonal solution. Both orthogonal and oblique solutions were sought for this research effort to assess the discrimanability and interpretability of the constructs.

The conceptual model identified four independent variables which provided the initial specification for the factor analysis (SI, GP, IM, and R). A varimax rotation was selected based on the guidelines provided by Kim and Mueller (1978: 36), which suggest that while each of the rotation methods will provide a slightly different result, the differences are not usually meaningful. Therefore, any of the rotation methods should provide an adequate solution for interpretation while the varimax solution will tend to give a clearer separation among the factors. The results of this initial analysis are provided in Table 5-8a. Guidelines regarding the appropriate selection criteria for factor loadings revealed a range of between .30 to .40. For the purposes of this research, an initial value of .35 was utilized. Both the orthogonal and oblique solutions (Table 5-8b) provided clear indications of the existence of four factors based on the initial measures as specified.

TABLE 5-8 A

VARIMAX 4 FACTOR ANALYSIS

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
RESOURCES	Q 25.1				0.38384
	Q 25.2				0.46040
	Q 25.3				0.50280
	Q 25.4				0.52183
	Q 25.5				0.61104
	Q 25.6				0.58848
	Q 25.7				0.56780
	Q 25.8				0.53880
	Q 25.9				0.56730
	Q 25.10				0.47263
	Q 25.11				0.44012
	Q 25.12	0.34700			0.36305
	Q 26.1	0.45074			
	Q 26.2				0.38433
	Q 26.3				0.38757
	Q 26.4				0.34484
	Q 26.5				0.43880
	Q 26.6				0.42828
	Q 26.7	0.36588			0.44784
	Q 26.8				0.37123
	Q 26.9				0.41867
	Q 26.10				
	Q 26.11	0.42480			0.36483
	Q 26.12	0.51670			
SUPPLIER	Q 29				
INVOLVEMENT	Q 31				
	Q 33.1			0.38222	
	Q 33.2			0.56615	
	Q 33.3			0.37858	
	Q 33.4			0.50297	
	Q 33.5			0.48142	
	Q 33.6			0.38347	
	Q 35			0.47056	
	Q 37			0.52068	
	Q 38			0.50882	
	Q 42.1		0.42553		
	Q 42.2				
	Q 42.3		0.37410	0.38841	
	Q 42.4		0.45361	0.34780	
	Q 50			0.63088	
	Q 56				
	Q 34				
	Q 40			0.61310	
	Q 45.1			0.50307	
	Q 45.2			0.48844	
	Q 45.3			0.53886	
	Q 45.4			0.48867	
	Q 45.5			0.42372	
	Q 45.6			0.44757	
	Q 48			0.52895	
	Q 51			0.58211	
	Q 36				
	Q 44.1			0.43758	
	Q 44.2			0.49586	
	Q 44.3			0.57953	
	Q 44.4			0.62343	
	Q 44.5			0.51068	
	Q 44.6			0.47670	
	Q 44.7			0.61042	
	Q 44.8			0.51255	
	Q 39			0.38640	

VARIMAX 4 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
	Q 41				
	Q 43				
	Q 47			0.54890	
	Q 49			0.50728	
	Q 52		0.41639	0.60618	
	Q 53		0.52032	0.55748	
	Q 54		0.62199		
	Q 56		0.58428		
	Q 57.1		0.75368		
	Q 57.2		0.73921		
	Q 57.3		0.53075		
	Q 57.4		0.80584		
	Q 57.5		0.86027		
	Q 57.6		0.81907		
	Q 57.7		0.79114		
	Q 57.8		0.81369		
	Q 57.9		0.79066		
	Q 57.10		0.75386		
	Q 57.11		0.82601		
	Q 57.12		0.74237		
	Q 57.13		0.76879		
	Q 42.5				
	Q 42.6			0.45259	
GROUP PROCESS	Q 59.1	0.61024			
	Q 59.2	0.67480			
	Q 59.3	0.50738			
	Q 59.4	0.40827			
	Q 59.5	0.48222			
	Q 59.6	0.51207			
	Q 59.7	0.54452			
	Q 59.8	0.56983			
	Q 59.9	0.61986			
	Q 59.10	0.62185			
	Q 60				
	Q 61				
	Q 62				
	Q 63				
	Q 64				
	Q 65				
	Q 66	0.41180			
	Q 67				
	Q 69.1	0.44827			
	Q 69.2	0.66456			
	Q 69.3	0.60713			
	Q 69.4	0.62851			
	Q 69.5	0.57406			
	Q 69.6	0.58632			
	Q 69.7	0.61290			
	Q 69.8	0.59425			
	Q 69.9	0.55039			
	Q 70	0.34607			
	Q 71				
	Q 72				
	Q 68	0.54346			
	Q 75.1				
	Q 75.2				
	Q 75.3				
	Q 75.4				
	Q 75.5	0.36974			
INTEGRATIVE	Q 9.1	0.34745			
MECHANISM	Q 9.2	0.42796			

VARIMAX 4 FACTOR ANALYSIS Contd.

QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
Q 9.3				
Q 9.4				
Q 9.5				
Q 9.6				
Q 9.7				
Q 9.8				
Q 9.9	0.43848			
Q 9.10	0.38657			
Q 10.1				
Q 10.2	0.34580			
Q 10.3				
Q 10.4				
Q 10.5	0.40108			
Q 73.1				
Q 73.2				
Q 73.3				
Q 73.4				
Q 73.5				
Q 73.6				
Q 74.1	0.53144			
Q 74.2	0.47812			
Q 74.3	0.52548			
Q 74.4				
Q 74.5	0.40888			
Q 74.6	0.48046			
Q 74.7	0.51135			
Q 76				
Q 79.1				
Q 79.2				
Q 79.3				
Q 79.4				
Q 79.5				
Q 79.6				
Q 79.7				
Q 79.8				
Q 79.9				
Q 79.10				
Q 79.11				
Q 79.12				
Q 79.13				
Q 79.14				
Q 79.15				
Q 79.16				
Q 79.17				
Q 79.18				
Q 79.19				
Q 79.20				
Q 79.21				
Q 79.22	0.37089			

TABLE 5-8 B

OBLIM 4 FACTOR ANALYSIS

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
RESOURCES	Q 25.1				0.35331
	Q 25.2				0.45007
	Q 25.3				0.49917
	Q 25.4				0.51298
	Q 25.5				0.59904
	Q 25.6				0.58592
	Q 25.7				0.59273
	Q 25.8				0.53123
	Q 25.9				0.60401
	Q 25.10				0.50818
	Q 25.11				0.43904
	Q 25.12				
	Q 26.1	0.45396			
	Q 26.2	0.34538			0.35849
	Q 26.3				0.37263
	Q 26.4				
	Q 26.5				0.41465
	Q 26.6				0.43171
	Q 26.7	0.36056			0.45898
	Q 26.8				0.37538
	Q 26.9				0.46201
	Q 26.10				0.34527
	Q 26.11	0.40382			0.36126
	Q 26.12	0.49604			
SUPPLIER	Q 28				
INVOLVEMENT	Q 31				
	Q 33.1		-0.36617		
	Q 33.2		-0.54841		
	Q 33.3				
	Q 33.4		-0.48465		
	Q 33.5		-0.48177		
	Q 33.6		-0.37212		
	Q 35		-0.45857		
	Q 37		-0.51385		
	Q 38		-0.53091		
	Q 42.1			-0.38996	
	Q 42.2				
	Q 42.3		-0.38228		
	Q 42.4			-0.44867	
	Q 50		-0.62382		
	Q 56				
	Q 34				
	Q 40		-0.62410		
	Q 45.1		-0.50511		
	Q 45.2		-0.49797		
	Q 45.3		-0.52755		
	Q 45.4		-0.47548		
	Q 45.5		-0.42308		
	Q 45.6		-0.43852		
	Q 48		-0.53865		
	Q 51		-0.55868		
	Q 36				
	Q 44.1		-0.44246		
	Q 44.2		-0.49044		
	Q 44.3		0.58595		
	Q 44.4		-0.67176		
	Q 44.5		-0.56110		
	Q 44.6		-0.48518		
	Q 44.7		-0.64550		
	Q 44.8		-0.55751		
	Q 39		-0.36114		

OBLIM 4 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
	Q 41		-0.36934		
	Q 43				
	Q 47		-0.57471		
	Q 49		-0.61170		
	Q 52		-0.56605	-0.36832	
	Q 53		-0.51533	-0.49295	
	Q 54			-0.61778	
	Q 55			-0.56171	
	Q 57.1			0.75000	
	Q 57.2			-0.74047	
	Q 57.3			-0.53257	
	Q 57.4			-0.81535	
	Q 57.5			-0.64076	
	Q 57.6			-0.83052	
	Q 57.7			-0.78112	
	Q 57.8			-0.81723	
	Q 57.9			-0.77583	
	Q 57.10			-0.77440	
	Q 57.11			-0.83662	
	Q 57.12			-0.73762	
	Q 57.13			-0.77683	
	Q 42.5				
	Q 42.6		-0.41889		
GROUP PROCESS	Q 59.1	0.60423			
	Q 59.2	0.68567			
	Q 59.3	0.51931			
	Q 59.4	0.41014			
	Q 59.5	0.49055			
	Q 59.6	0.46645			
	Q 59.7	0.53887			
	Q 59.8	0.58657			
	Q 59.9	0.62280			
	Q 59.10	0.64595			
	Q 60				
	Q 61				
	Q 62				
	Q 63				
	Q 64	0.37620			
	Q 65	0.34538			
	Q 66	0.44843			
	Q 67				
	Q 69.1	0.43834			
	Q 69.2	0.67156			
	Q 69.3	0.59813			
	Q 69.4	0.63946			
	Q 69.5	0.56399			
	Q 69.6	0.58878			
	Q 69.7	0.60605			
	Q 69.8	0.57451			
	Q 69.9	0.54013			
	Q 70	0.35239			
	Q 71				
	Q 72				
	Q 68	0.52832			
	Q 75.1				
	Q 75.2				
	Q 75.3				
	Q 75.4				
	Q 75.5	0.38271			
INTEGRATIVE	Q 9.1				
MECHANISM	Q 9.2	0.41454			

OBLIM 4 FACTOR ANALYSIS contd.

QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
Q 9.3				
Q 9.4				
Q 9.5				
Q 9.6	0.36408			
Q 9.7				
Q 9.8				
Q 9.9	0.43728			
Q 9.10	0.30020			
Q 9.11				
Q 10.1	0.36796			
Q 10.2				
Q 10.3				
Q 10.4	0.34563			
Q 10.5	0.41148			
Q 73.1				
Q 73.2				
Q 73.3				
Q 73.4				
Q 73.5				
Q 73.6				
Q 74.1	0.50557			
Q 74.2	0.45538			
Q 74.3	0.49305			
Q 74.4			0.35583	
Q 74.5	0.30832			
Q 74.6	0.46633			
Q 74.7	0.50172			
Q 76				
Q 79.1				
Q 79.2				
Q 79.3				
Q 79.4				
Q 79.5				
Q 79.6				
Q 79.7				
Q 79.8				
Q 79.9				
Q 79.10				
Q 79.11				
Q 79.12				
Q 79.13				
Q 79.14				
Q 79.15				
Q 79.16				
Q 79.17				
Q 79.18				
Q 79.19				
Q 19.20				
Q 79.21				
Q 79.22	0.36585			

In an effort to improve on this initial finding, iterations of this process continued until an "optimal" solution was derived revealing the existence of seven underlying factors (Table 5-9a). This solution provided the highest level of interpretability while also yielding a consistent oblique solution (Table 5-9b). Appendix II contains the results of the factor analyses. The factor loadings suggest that data reduction is possible through the elimination of certain questions which did not load sufficiently high enough on any one factor. Additional questions were discarded because they demonstrated sufficiently high loadings on more than one factor.

Specifically, the questions regarding resource adequacy tended to load on both the Resource construct, and the Group Process construct so those items were eliminated. In addition, the construct previously identified as Integrative Mechanisms, which was developed to assess the organizational-level impact on the NPD process, was refined into three constructs measuring 1) organizational structure/culture, 2) information importance, and 3) information accessibility.

A significant result of this process was the identification of two clearly identifiable and interpretable factors originally intended to measure one construct associated with the level of supplier involvement in the NPD process. This finding led to the disaggregation of the Supplier Involvement construct into two unique factors. The first factor is consistent with the original model and is designed to measure the quantitative level of supplier involvement in the NPD process. The second factor represents one of the dimensions of the original construct, relationship, which was dedicated to the measurement of the caliber of

TABLE 5-9 A

VARIMAX 7 FACTOR ANALYSIS

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
RESOURCES	Q 25.1				0.38647			
	Q 25.2				0.50220			
	Q 25.3				0.57903			
	Q 25.4				0.61536			
	Q 25.5				0.67083			
	Q 25.6				0.68626			
	Q 25.7				0.73458			
	Q 25.8				0.68300			
	Q 25.9				0.68061			
	Q 25.10				0.41043			
	Q 25.11				0.35860			
	Q 25.12	0.36208			0.41706			
	Q 26.1	0.38806						
	Q 26.2							
	Q 26.3							
	Q 26.4							
	Q 26.5							
	Q 26.6							
	Q 26.7	0.30108			0.38677			
	Q 26.8							
	Q 26.9							
	Q 26.10							
	Q 26.11	0.42307			0.36573			
	Q 26.12	0.49037						
SUPPLIER	Q 28							
INVOLVEMENT	Q 31			0.36045				
	Q 33.1			0.33080				
	Q 33.2			0.50730				
	Q 33.3							
	Q 33.4			0.45408				
	Q 33.5			0.48061				
	Q 33.6			0.37112				
	Q 35			0.43022				
	Q 37			0.48086				
	Q 38			0.54120				
	Q 42.1		0.41580					
	Q 42.2							
	Q 42.3		0.38612	0.37176				
	Q 42.4		0.43308					
	Q 50			0.61732				
	Q 56							
	Q 34							
	Q 40			0.62840				
	Q 45.1			0.52178				
	Q 45.2			0.50790				
	Q 45.3			0.52217				
	Q 45.4			0.48142				
	Q 45.5			0.43441				
	Q 45.6			0.47824				
	Q 48			0.52873				
	Q 51			0.57804				
	Q 36							
	Q 44.1			0.48886				
	Q 44.2			0.52882				
	Q 44.3			0.57829				
	Q 44.4			0.64841				
	Q 44.5			0.54071				
	Q 44.6			0.48013				
	Q 44.7			0.64447				
	Q 44.8			0.54882				
	Q 39			0.38793				

VARIMAX 7 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
	Q 41			0.35060				
	Q 43							
	Q 47			0.53040				
	Q 49			0.62948				
BUYER SUPPLIER	Q 52		0.40725	0.59050				
RELATIONSHIP	Q 53		0.51904	0.55014				
	Q 54		0.62573					
	Q 56		0.58621					
	Q 57.1		0.73067					
	Q 57.2		0.72971					
	Q 57.3		0.51763					
	Q 57.4		0.80182					
	Q 57.5		0.88029					
	Q 57.6		0.83608					
	Q 57.7		0.78107					
	Q 57.8		0.81469					
	Q 57.9		0.78282					
	Q 57.10		0.77086					
	Q 57.11		0.83783					
	Q 57.12		0.73087					
	Q 57.13		0.76408					
	Q 42.5							
	Q 42.6			0.30726				
GROUP PROCESS	Q 59.1	0.62808						
	Q 59.2	0.67121						
	Q 59.3	0.47472						
	Q 59.4	0.41086						
	Q 59.5	0.40873						
	Q 59.6	0.53108						
	Q 59.7	0.61040						
	Q 59.8	0.61918						
	Q 59.9	0.68176						
	Q 59.10	0.66728						
	Q 60							0.30066
	Q 61							0.37730
	Q 62							0.30041
	Q 63							
	Q 64							
	Q 65							
	Q 66	0.36456						
	Q 67	0.40087						
	Q 69.1	0.43736						
	Q 69.2	0.60066						
	Q 69.3	0.57208						
	Q 69.4	0.57823						
	Q 69.5	0.53640						
	Q 69.6	0.56717						
	Q 69.7	0.56771						
	Q 69.8	0.57042						
	Q 69.9	0.40480						
	Q 70							
	Q 71							
	Q 72	0.30637						
	Q 68	0.57065						
	Q 75.1							
	Q 75.2							
	Q 75.3							
	Q 75.4							
	Q 75.5	0.36244						
INTEGRATIVE	Q 9.1							
MECHANISM	Q 9.2	0.36207						0.42955

VARIMAX 7 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
	Q 9.3							0.42656
	Q 9.4							0.40401
	Q 9.5							0.38141
	Q 9.6							
	Q 9.7							
	Q 9.8							
	Q 9.9	0.39126						
	Q 9.10							0.38307
	Q 9.11							
	Q 10.1							
	Q 10.2							
	Q 10.3							
	Q 10.4							
	Q 10.5							0.39410
	Q 73.1							
	Q 73.2							
	Q 73.3							
	Q 73.4							
	Q 73.5							
	Q 73.6							
	Q 74.1	0.54218						
	Q 74.2	0.40642						
	Q 74.3	0.58645						
	Q 74.4	0.39482						
	Q 74.5	0.41821						
	Q 74.6	0.48114						
	Q 74.7	0.50296						
	Q 76							
INFORMATION	Q 79.1						0.48338	
IMPORTANCE	Q 79.2						0.47163	
	Q 79.3						0.43613	
	Q 79.4						0.41819	
	Q 79.5						0.36778	
	Q 79.6						0.62304	
	Q 79.7						0.48818	
	Q 79.8						0.57191	
	Q 79.9						0.58804	
	Q 79.10						0.72421	
	Q 79.11							
INFORMATION	Q 79.12					0.47419		
ACCESSIBILITY	Q 79.13					0.49036		
	Q 79.14					0.40234		
	Q 79.15					0.32061		
	Q 79.16					0.40622		
	Q 79.17					0.28772		
	Q 79.18					0.48017		
	Q 79.19					0.57007		
	Q 79.20					0.61042		
	Q 79.21					0.65560		
	Q 79.22					0.54307		

TABLE 5-9 B

OBLIM 7 FACTOR ANALYSIS

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
RESOURCES	Q 25.1				0.39832			
	Q 25.2				0.61028			
	Q 25.3				0.58733			
	Q 25.4				0.62863			
	Q 25.5				0.68773			
	Q 25.6				0.70213			
	Q 25.7				0.75119			
	Q 25.8				0.69039			
	Q 25.9				0.66721			
	Q 25.10				0.39997			
	Q 25.11				0.35209			
	Q 25.12				0.43101			
	Q 26.1							
	Q 26.2							
	Q 26.3							
	Q 26.4							
	Q 26.5							
	Q 26.6							
	Q 26.7							
	Q 26.8				0.36951			
	Q 26.9							
	Q 26.10							
	Q 26.11							
	Q 26.12	0.38554						
SUPPLIER	Q 28							
INVOLVEMENT	Q 31		-0.36628					
	Q 33.1							
	Q 33.2		-0.44952					
	Q 33.3							
	Q 33.4		-0.40699					
	Q 33.5		-0.42723					
	Q 33.6		-0.36335					
	Q 35		-0.39005					
	Q 37		-0.47028					
	Q 38		0.54891					
	Q 42.1			-0.38411				
	Q 42.2							
	Q 42.3							
	Q 42.4			-0.39909				
	Q 50		-0.58234					
	Q 56							
	Q 34							
	Q 40		-0.61101					
	Q 45.1		-0.53100					
	Q 45.2		-0.52205					
	Q 45.3		-0.49430					
	Q 45.4		-0.47275					
	Q 45.5		-0.48396					
	Q 45.6		-0.49280					
	Q 48		-0.51760					
	Q 51		-0.54063					
	Q 36							
	Q 44.1		-0.46353					
	Q 44.2		-0.51897					
	Q 44.3		-0.56840					
	Q 44.4		-0.65246					
	Q 44.5		-0.58067					
	Q 44.6		0.49357					
	Q 44.7		-0.66516					
	Q 44.8		-0.57783					
	Q 39		-0.37639					

OBLIM 7 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
	Q 41		-0.36495					
	Q 43							
	Q 47		-0.90106					
	Q 49		-0.64473					
BUYER-SUPPLIER	Q 52		-0.53484	-0.36880				
RELATIONSHIP	Q 53		-0.49138	-0.40812				
	Q 54			-0.62139				
	Q 55			-0.57217				
	Q 57.1			-0.72903				
	Q 57.2			-0.72741				
	Q 57.3			-0.90644				
	Q 57.4			-0.81805				
	Q 57.5			-0.69957				
	Q 57.6			-0.86103				
	Q 57.7			-0.78212				
	Q 57.8			-0.83196				
	Q 57.9			-0.80878				
	Q 57.10			-0.79082				
	Q 57.11			-0.85736				
	Q 57.12			-0.73478				
	Q 57.13			-0.77945				
	Q 42.5							
	Q 42.6							
GROUP PROCESS	Q 59.1	0.61963						
	Q 59.2	0.62669						
	Q 59.3	0.42287						
	Q 59.4	0.35543						
	Q 59.5	0.47675						
	Q 59.6	0.49911						
	Q 59.7	0.63770						
	Q 59.8	0.65612						
	Q 59.9	0.71924						
	Q 59.10	0.67266						
	Q 60					0.36330		
	Q 61					0.37621		
	Q 62					0.36878		
	Q 63							
	Q 64							
	Q 65					0.40541		
	Q 66							
	Q 67	0.39497						
	Q 69.1	0.42070						
	Q 69.2	0.55407						
	Q 69.3	0.51766						
	Q 69.4	0.52016						
	Q 69.5	0.47247						
	Q 69.6	0.53018						
	Q 69.7	0.50672						
	Q 69.8	0.52499						
	Q 69.9	0.44254						
	Q 70							
	Q 71							
	Q 72	0.37170						
	Q 68	0.57822						
	Q 75.1							
	Q 75.2							
	Q 75.3							
	Q 75.4	0.36029						
	Q 75.5							
INTEGRATIVE	Q 9.1							
MECHANISM	Q 9.2							

OBLIM 7 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7
	Q 9.3					0.42764		
	Q 9.4					0.42327		
	Q 9.5					0.47095		
	Q 9.6					0.38357		
	Q 9.7							
	Q 9.8							
	Q 9.9							
	Q 9.10							
	Q 9.11					0.38175		
	Q 10.1							
	Q 10.2							
	Q 10.3							
	Q 10.4							
	Q 10.5					0.40340		
	Q 73.1							
	Q 73.2							
	Q 73.3							
	Q 73.4							
	Q 73.5							
	Q 73.6							
	Q 74.1	0.40866						
	Q 74.2	0.43816						
	Q 74.3	0.54756						
	Q 74.4	0.37374						
	Q 74.5	0.36834						
	Q 74.6	0.39795						
	Q 74.7	0.42101						
	Q 76							
INFORMATION	Q 79.1						0.48903	
IMPORTANCE	Q 79.2						0.47053	
	Q 79.3						0.43881	
	Q 79.4						0.42212	
	Q 79.5						0.36087	
	Q 79.6						0.63448	
	Q 79.7						0.49369	
	Q 79.8						0.50685	
	Q 79.9						0.60559	
	Q 79.10						0.73774	
	Q 79.11							
INFORMATION	Q 79.12							0.49035
ACCESSIBILITY	Q 79.13							0.47019
	Q 79.14							0.42426
	Q 79.15							
	Q 79.16							0.50482
	Q 79.17							
	Q 79.18							0.41994
	Q 79.19							0.60330
	Q 19.20							0.64303
	Q 79.21							0.69054
	Q 79.22							0.57700

the buyer-supplier relationship.

The clarity of this solution demonstrated a need to redefine the original constructs. Tables 5-10 to 5-16 present the adaptations of the original constructs which now include, Supplier Involvement (SI), Buyer-Supplier Relationship (BSR), Integrative Mechanisms Structural/Cultural (IMSC), Information Importance (II), Information Accessibility (IA), Group Process (GP), and Resource Utilization (RU). The reliability of these new constructs are .92, .96, .71, .84, .85, .93, .87 respectively and are reported for comparison with the original reliability results. The reliability of the measures has improved slightly overall with a corresponding reduction in the item measures, a desirable outcome of a factor analysis.

5.3 Re-specification of the IPDS Conceptual Model

Based on the initial interpretation of the data, it was apparent that the original conceptual model needed to be revised. It is therefore necessary to re-specify the model prior to further analysis of the data.

The new model incorporates the seven constructs as re-defined according to the findings of the factor analysis (SI, BSR, IMSC, II, IA, GP, RU), and the dependent variables Integrated Product Development Success (IPDS) and Firm Performance (FP). The new IPD model suggested by this research is depicted in Figure 5-15. The model suggests that each of the independent variables has a direct influence on the dependent variable IPDS and an indirect influence on FP.

Table 5-10

SUPPLIER INVOLVEMENT		
QUESTION	DESCRIPTION	
Q 38	Percentage total hours committed by suppliers	
Q 50	How influential suppliers were	
Q 40	Percentage total meetings suppliers attended	
Q 48	Extent supplier updated on product design	
Q 51	Amount of two-way communication with supplier	
Q 44.1	How much invested in training	
Q 44.2	How much invested in research development	
Q 44.3	How much invested in tooling/equipment	
Q 44.4	How much invested in technology	
Q 44.5	How much invested in structural/reorganization	
Q 44.6	How much invested in material/prototypes	
Q 44.7	How much invested in labor hours	
Q 44.8	How much invested in co-location of supplier	
Q 47	Extent supplier supported design	
Q 49	Level of risk supplier assumed	
RELIABILITY	COEFFICIENT ALPHA	0.92

Table 5-11

BUYER - SUPPLIER RELATIONSHIP		
QUESTION	DESCRIPTION	
Q 57.1	Supplier encouraged open expression of ideas	
Q 57.2	Supplier handled criticism well	
Q 57.3	Supplier encouraged divergent thinking	
Q 57.4	Supplier communicated honestly	
Q 57.5	Supplier did not force views on others	
Q 57.6	Supplier believed in cooperation	
Q 57.7	Supplier demonstrated confidence in others	
Q 57.8	Supplier understood other view points	
Q 57.9	Supplier was trustworthy	
Q 57.10	Supplier kept commitments	
Q 57.11	Supplier was easy to work with	
Q 57.12	Supplier equitably shared credit	
Q 57.13	Supplier did not blame others for project difficulties	
RELIABILITY	COEFFICIENT ALPHA	0.96

Table 5-12

INTEGRATIVE MECHANISMS STRUCTURAL/CULTURAL		
QUESTION	**DESCRIPTION**	
Q 9.3	Extent agree - highly structured communication channels	
Q 9.4	Extent agree - insistence on uniform managerial style	
Q 9.5	Extent agree - emphasis on uniform managerial style	
Q 9.6	Extent agree - informal style of dealing each other	
Q 9.11	Results are more important than procedures	
Q 10.5	In uncertainty, adopts "wait and see" policy to minimize mistakes	
Q 60	Structure used for task fulfillment	
Q 61	Structure used for task accomplishment	
Q 62	Structure used for task developments	
Q 65	Process design tasks were sequential/concurrent	
RELIABILITY	COEFFICIENT ALPHA	0.71

Table 5-13

INFORMATION IMPORTANCE		
QUESTION	DESCRIPTION	
Q 79.1	Degree of importance on materials reliability	
Q 79.2	Degree of importance on materials availability	
Q 79.3	Degree of importance on material quality (ppm)	
Q 79.4	Degree of importance on labor cost	
Q 79.5	Degree of importance on machining tolerances	
Q 79.6	Degree of importance on parts cost	
Q 79.7	Degree of importance on parts configuration	
Q 79.8	Degree of importance on assembly time	
Q 79.9	Degree of importance on ease of fabrication	
Q 79.10	Degree of importance on ease of assembly	
Q 79.11	Degree of importance on ease of test	
RELIABILITY	COEFFICIENT ALPHA	0.84

Table 5-14

INFORMATION ACCESSIBILITY		
QUESTION	DESCRIPTION	
Q 79.12	How accessible information on material reliability	
Q 79.13	How accessible information on material availability	
Q 79.14	How accessible information on material quality	
Q 79.15	How accessible information on labor cost	
Q 79.16	How accessible information on machining tolerances	
Q 79.17	How accessible information on parts cost	
Q 79.18	How accessible information on parts configuration	
Q 79.19	How accessible information on assembly time	
Q 79.20	How accessible information on ease of fabrication	
Q 79.21	How accessible information on ease of assembly	
Q 79.22	How accessible information on ease of test	
RELIABILITY	COEFFICIENT ALPHA	0.85

Table 5-15

GROUP PROCESS (GP)		
QUESTION	DESCRIPTION	
	LEADERSHIP	
Q 59.1	Manager ability to recognize and mediate conflict	
Q 59.2	Manager influence useful for obtaining resources	
Q 59.3	Manager had important and useful contacts with R&D	
Q 59.4	Manager disseminated important relevant information	
Q 59.5	Manager well informed of professional activities	
Q 59.6	Manager prepared environment for change	
Q 59.7	Manager empowered members of the project team	
Q 59.8	Manager had vision of project goals	
Q 59.9	Manager able to secure upper management support	
Q 59.10	Extent team members like each other	
	COHESION	
Q 69.1	Extent help each other to get the job done	
Q 69.2	Extent members take interest in each other	
Q 69.3	Extent members trust each other	
Q 69.4	Extent members like being with each other	
Q 69.5	Extent members respect each other	
Q 69.6	Extent members share information	
Q 69.7	Extent members agree on project goals	
Q 69.8	Extent members influence design process	
Q 69.9	Communication between group members was continuous	
Q 68		
RELIABILITY	COEFFICIENT ALPHA	0.93

Table 5-16

RESOURCE UTILIZATION		
QUESTION	DESCRIPTION	
Q 25.1	Utilization of job-related information	
Q 25.2	Utilization of tools	
Q 25.3	Utilization of materials-supplies	
Q 25.4	Utilization of administrative support/services	
Q 25.5	Utilization of budgetary support	
Q 25.6	Utilization of facilities	
Q 25.7	Utilization of equipment	
Q 25.8	Utilization of engineering support	
Q 25.9	Utilization of total person hours	
Q 25.10	Utilization of development time	
Q 25.11	Utilization of education and training	
Q 25.12	Utilization of upper management support	
RELIABILITY	COEFFICIENT ALPHA	0.87

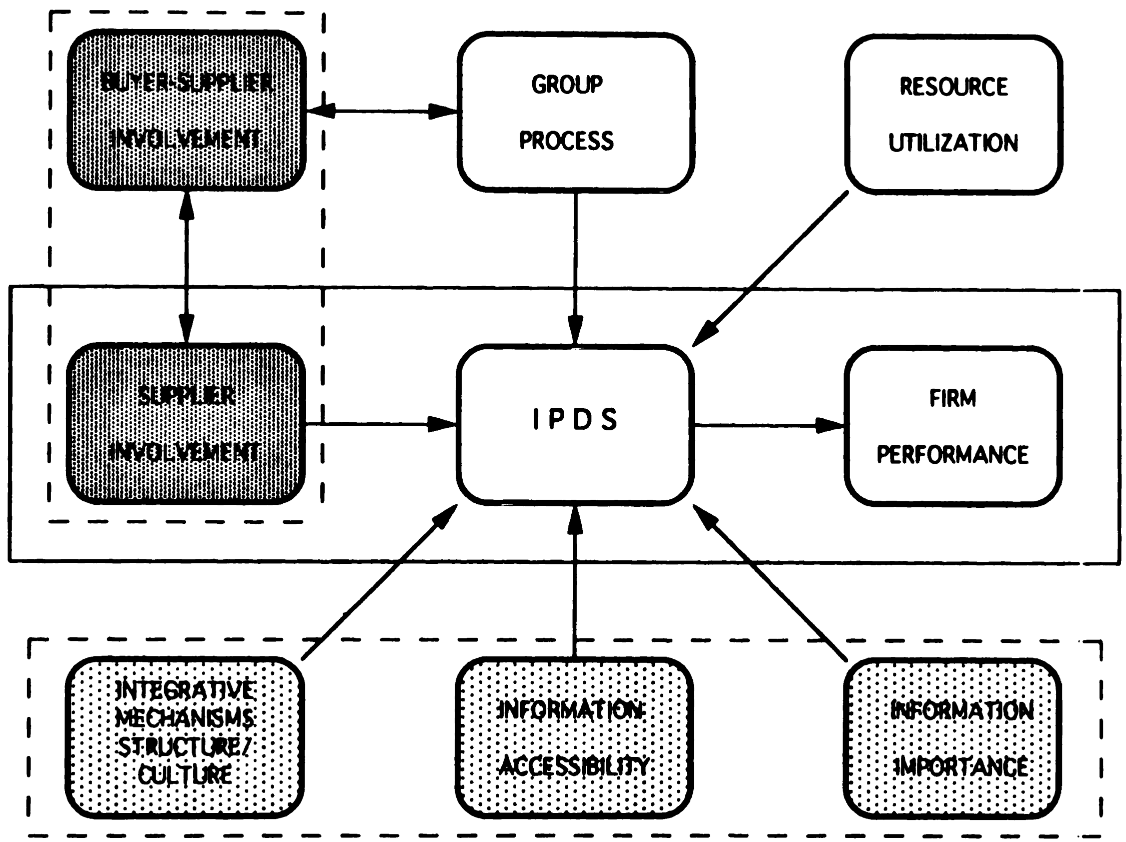


FIGURE 5-15

INTEGRATED PRODUCT DEVELOPMENT
RE-DEFINED

Linear Model

The equation indicates that the project success, IPDS, is a function of the direct contribution of Supplier Involvement (SI), Buyer-Supplier Relationship (BSR), Group Process (GP), Resource Utilization (RU), Integrative Mechanisms Structure-Culture (IMSC), Information Importance (II), Information Accessibility (IA), and the interaction of these independent variables.

$$\text{IPDS} = f(\text{SI},\text{BSR},\text{GP},\text{RU},\text{IMSC},\text{II},\text{IA},\gamma_i)$$

$$= \beta_0 + \beta_1(\text{SI}) + \beta_2(\text{BSR}) + \beta_3(\text{GP}) + \beta_4(\text{RU}) + \beta_5(\text{IMSC}) + \beta_6(\text{II}) + \beta_7(\text{IA}) + \epsilon$$

The regression coefficients are indicated as β_1, β_2, β_3, β_4, β_5, β_6, β_7. The unexplained variance and higher order interactions are captured in the error term (ϵ).

5.4 Hypothesis Testing

The exploratory nature of this research focused on identifying statistically significant relationships among the variables of interest to develop a parsimonious model of the IPD environment. This research effort was not interested in the predictive cababilities of the variables, but rather the development of the "best" model to explain variations in the success of NPD efforts.

5.4.1 Firm Performance

Current convention maintains that there are many benefits to be gained by utilizing teams to solve complex corporate problems. The team approach also requires an investment by the firm to facilitate this strategy including changes in corporate structures, management, culture, etc. One of the goals of this research was to provide evidence to support the current paradigm by establishing the direction and magnitude of the relationship between the performance of the firm, and the team approach to new product development. Utilizing an integrated product development strategy was expected to have a positive impact on the performance of the firm. To establish this relationship, the objective measures of IPDS were utilized as the independent variables in the regression equation.

Hypothesis 1:

H_o: Firm performance is unrelated to IPD Success.
H_1: Firm performance is related to IPD Success.

Linear Model:

$$FP = f(IPDS) = \beta_0 + \beta_1(IPDS),\ldots + \beta_{21}(IPDS) + \epsilon$$

Table 5-17
Regression Results for Firm Performance

Multiple R = .669
R Squared = .448 F-Statistic = 12.524
Adjusted R Squared = .413 Statistical Significance = .0000

Variables Included in the Equation	Beta	Sig T
Reduce Manufacturing Cycle Time	.193	.047*
Improve Product Profitability	.323	.000*
Improve White Collar Productivity	.231	.012*
Improve Market Share	.312	.002*
Reduce Customer Complaints	-.242	.009*
(constant)		.0000

* = statistically significant

The results, Table 5-17, indicate that 44.8 percent of the variance in a firm's performance can be explained by five of the IPDS measures. It can be concluded that there exists a positive, significant relationship (p=.0000) between IPDS and overall FP. This finding supports the utilization of an IPD approach to NPD and provides practioners with the individual elements of project success which significantly impact the performance of the firm.

5.4.2 Market Performance

A component of the aggregate measure of Firm Performance (FP) is the dimension of Market Performance (MP). The individual measures of the MP were designed to capture the objective indicators of success in the marketplace relative to competitors. Relative growth rate in the areas of market share, sales, and earnings along with return on assets were utilized for this purpose. A firm's position and success in the marketplace was expected to be positively influenced by the utilization of IPD process. By establishing this vital linkage this research provides the verification of the long-term tangible rewards derived by firms employing this strategy in their NPD efforts. The objective measures of IPDS act as the independent variable in the regression equation. The results serve to highlight any differences that may occur between the determinants of overall FP and MP.

Hypothesis 2:

H_o: Market performance of the firm is unrelated to IPD Success.
H_1: Market performance of the firm is related to IPD Success.

Linear Model:

$$MP = f(IPDS) = \beta_0 + \beta_1(IPDS),\ldots + \beta_{21}(IPDS) + \epsilon$$

Table 5-18
Regression Results for Market Performance

Multiple R = .552		
R Squared = .305	F-Statistic = 8.567	
Adjusted R Squared = .270	Statistical Significance = .0000	

Variables	Beta	Sig T
Improve Product Profitability	.290	.004*
Reduce Start-up Costs	.338	.001*
Reduce Customer Complaints	-.216	.029*
Reduce Manufacturing Cycle Time	.183	.071
(constant)		.0000

* = statistically significant

A positive, statistically significant (p=.0000) relationship is demonstrated to exist between the dependent variable MP and four of the elements of IPDS with a total of 30.5 percent of the variance in MP explained (Table 5-18). Three of the variables improve product profitability, reduce start-up costs, and reduce customer complaints--demonstrate statistically significant T-statistics at the .05 level or better. Reductions in manufacturing cycle time is marginally significant.

An interesting result is the difference in the individual variables of IPDS which were selected as yielding the most explanatory power. Reductions in manufacturing cycle time fell from first in predicting FP (p=.047), to fourth in the amount of explained variation in MP (p=.071). Another interesting result is that start-up costs is statistically significant ($p=.001$) variable in the regression equation for MP, and was not a determinant of FP. The relationship between a reduction in start-up costs and improvement in product profitability may be a possible explanation for this result. The direction of the relationship, negative, between a reduction in customer complaints and improvements in MP is consistent with previous finding but defies further interpretation.

5.4.3 Relative Performance

Another prerequisite to long-term success in the market is the establishment of a core competence in the areas of strategic competitive priorities. To gain a sustainable competitive advantage over competitors it is necessary to differentiate a firm's product offering in the product-delivery process through superior performance along the competitive dimensions of responsiveness, service, innovation, cost, performance, quality, or process innovation. Where the MP dimension of the overall construct FP was developed to assess a more quantitative measure of success, it does not measure the overall quality of the product-delivery process. Relative Performance (RP) serves to determine the viability and success of an enterprise based on superior performance along these competitive dimensions. An IPD strategy was expected to support the attainment of a competitive advantage due to the RP of the firm in the market. This analysis serves to identify the dimensions of an integrated approach which are the most influential in this goal.

Hypothesis 3:

H_o: Relative firm performance is unrelated to IPD Success.
H_1: Relative firm performance is related to IPD Success.

Linear Model:

$$RP = f(IPDS) = \beta_0 + \beta_1(IPDS),\ldots + \beta_{21}(IPDS) + \epsilon$$

Table 5-19
Regression Results for Relative Performance

Multiple R = .655
R Squared = .429 F-Statistic = 9.539
Adjusted R Squared = .384 Statistical Significance = .0000

Variables	Beta	Sig T
Improve Market Share	.290	.005*
Improve Product Profitability	.306	.001*
Improve White Collar Productivity	.248	.008*
Improve Communication	.186	.037*
Reduce Customer Complaints	-.230	.016*
Reduce Rejected Material	.183	.062
(constant)		.0000

* = statistically significant

The explanatory power of this regression equation, R squared equal to 42.9 percent (p=.0000), included six of the IPDS measures (Table 5-19). Five of the variables demonstrating a statistically significant t-statistic of .05 or better, with reductions in rejected material demonstrating marginal statistical significance (p=.062). A noticeable change in the regression equation is the relative contribution of improvement in market share, and the absence of manufacturing cycle time. The remaining variables are consistent with the indicators of overall

FP with the additions of two measures, reduction in rejected material and improved communication.

Of the two quality measures included in the regression equation, only the reduction in rejected material, an internal cost of poor quality, demonstrated a positive relationship with RP. The inverse relationship revealed by this research between the dependent variable RP, and reduction in customer complaints is inconsistent with current management theory regarding the importance of quality and performance of the firm on both market and relative criteria. While this variable is an objective measure of the construct of quality, it relates to external costs of quality rather than the internal costs which may provide some indication for the direction of these relationships.

The results from Tables 5-17 through 5-19 demonstrate that the overall measure of FP (R squared=.448) is enhanced through the aggregation of MP (R squared=.305), and RP (R squared=.429) as the amount of explained variation in performance of the firm improves. In addition, these results firmly demonstrate the positive impact of utilizing an IPD strategy in the development of new products. This evidence serves to promote the utilization of this strategy and also indicates the dimensions of IPDS which are of primary importance to the overall performance of the firm. This information is beneficial in setting meaningful targets by establishing a linking mechanism between the performance criteria for the project to the strategic corporate goals.

Establishing this critical linkage provides meaning to the remainder of the research which focuses on identifying the determinants of IPDS. The focus will be primarily on the role of the supplier in the NPD process associated with an IPD strategy with additional insight gained regarding the impact of the remaining independent variables (IMSC, II, IA, GP, RU).

5.4.4 Supplier Involvement

The team approach utilized in conjunction with an IPD strategy strives to involve all the elements of the product-delivery process as valuable resources to the NPD project. Inclusion of suppliers in the process has been advocated as a method of facilitating inter-organizational coupling, and improving the success of the product through the advantages gained by utilizing this previously untapped resource. This prescription for success has been the by-product of individual case studies from firms utilizing the IPD approach (for more detail refer to Chapter II). This research serves to empirically identify and test the relationship between IPDS, Supplier Involvement (SI) and Buyer-Supplier Relationship (BSR) in the process.

Supplier Involvement (SI) and BSR were expected to have a positive, significant relationship with the individual measures of IPDS. The analysis is presented based on the aggregate dimensions of IPDS--cost, quality, time, and performance. Each of the individual measures of the four dimensions is evaluated to provide for the highest level of interpretability.

Table 5-20 presents a summary of the research findings. The individual IPDS success measure is listed in the left-hand column. The number in parentheses next to the IPDS success measure is the sample size. The seven independent variables, Supplier Involvement (SI), Buyer-Supplier Relationship (BSR), Group Process (GP), Integrative Mechanisms Structure/Culture (IMSC), Information Importance (II), Information Accessibility (IA), and Resource Utilization (RU) are located across the top with their corresponding Beta weights located in the columns below. This is followed by the R-squared value, F-statistic and significance level associated with each linear equation. Table 5-21 highlights only those independent variables which demonstrated a significant T-statistic of .05 or better. These results will be interpreted individual to test the research hypotheses.

5.4.4.1 Cost

Early supplier involvement in Integrated Product Development is expected to result in lower product cost due to a compatible design, increased visibility, and simplicity of design. The individual measures which serve to measure the aggregate concept of overall cost include, product cost, start-up cost, tooling and equipment cost, manhours, and engineering change notices (ECN).

Hypothesis 4:

H_o: Costs are unrelated to the level of supplier involvement in IPD.
H_1: Costs are related to the level of supplier involvement in IPD.

Linear Model:

$IPDS_1 = f(SI, BSR, GP, RU, IMSC, II, IA)$

$$= \beta_0 + \beta_1(SI) + \beta_2(BSR) + \beta_3(GP) + \beta_4(RU) + \beta_5(IMSC) + \beta_6(II) + \beta_7(IA) + \epsilon$$

Individual regression equations were run for each of the elements of cost. While all of the linear relationships proved to be statistically significant at the .05 level or better (Table 5-20), SI and/or BSR were only significant variables in the reduction in product cost, start-up cost, and tooling and equipment cost (Table 5-21). The detailed results of these individual linear equations is presented in Tables 5-22 through 5-26.

Table 5-22
Reduction in Product Cost

Multiple R = .566
R Squared = .321 F-Statistic = 3.169
Adjusted R Squared = .220 Statistical Significance = .008

Variables	Beta	Semi-Partial	Sig T
SI	-.384	-.342	.007*
BSR	-.072	-.059	.623
GP	-.046	-.035	.770
IMSC	.313	.273	.028*
II	.090	.070	.565
IA	.121	.097	.426
RU	.074	.067	.579
(constant)			.114

* = statistically significant

The results reveal that 32.1 percent of the variance in reductions in product cost can be explained by the seven predictor variables. The overall model (p=.008) and the individual variables SI (p=.007) and IMSC (p=.028) are statistically significant. Squaring the semi-partial correlation coefficients provides the absolute percent of the explained variance attributable to the individual independent variable, controlling for the influence of the other

Table 5-20

IPDS MEASURE	S I	B S R	G P	I M S C	I I	I A	R U	R^2	F STATS.	SIGNIF.
Reduce Cost (54)	--.384 ^^	--.072	--.046	.313 ^	.090	.121	.074	.321	3.169	.008
Reduction in Start-up Cost (70)	--.060	--.340 *	.296 *	.021	.429 **	.133	--.046	.407	6.180	.000
Reduction in Tool/Equip Cost (71)	.111	--.365 *	.144	--.114	.354 ^^	.039	.051	.268	3.349	.004
Improve Product Quality (52)										
Reduce Warranty Cost (72)	.114	--.328 ^^	.327 ^	--.091	.279 ^	--.105	--.119	.234	2.842	.012
Reduce Customer Complaints (73)	--.035	--.336 ^^	.295 ^	--.060	.168	.107	--.275	.238	2.902	.011
Reduce Rejected Material (72)	--.040	--.101	--.235	.410 ***	.250	.109	.193	.239	2.922	.010
Reduce Rework Cost (70)										
Improve Product Performance (60)	--.368 ^^					.231	.342 ^^	.188	4.410	.000
Improve Market Share (73)	--.518 ***	.010	--.261 ^	.247 ^	.260 ^	.048	.227 ^	.325	4.538	.000
Increase perceived value by Customer (77)	--.192		.205				.331 *	.143	4.100	.010
Increase perceived Quality by Customer (73)						.233 ^		.055	4.151	.045
Improve Dollar Sales (76)	--.226	.345 ^^	.006	.335 *	--.175	--.090	.307 ^^	.278	3.800	.002
Improve Product Profitability (72)	--.260 ^	.212	--.013	.280 ^	--.113	.225	.032	.235	2.845	.012
Improve Product Capabilities (74)	--.154	.306 ^	--.419 *	.179	.011	.018	.253 ^	.192	2.279	.038
Reduce Project Development Time (57)		--.162	.257	.238				.136	2.828	.047
Improved Communication (72)	--.219	.110	.336 ^^	.103	.114	.070	.097	.258	3.232	.005
Reduce Total Manhours (73)	--.055	--.050	.184	.324 ^^	.053	.098	--.241 ^	.264	3.376	.004
Reduction in Engineering Change Notices(74)	--.192	--.149	--.034	--.084	.320 ^	.229	.086	.196	2.330	.034
Reduction in Mfg.Cycle Time/Lead Time(72)	--.241	.060	.095	.120	.341 ^	.050	--.149	.242	2.972	.009
Improve White Collar Productivity (72)			.206	.175	.182				3.770	.014

Statistical Significance

^ .05 ^^ .01 * .005 ** .001 *** .000

Table 5-21

IPDS MEASURE	S I	B S R	G P	I M S C	I I	I A	R U	R^2	F STATS.	SIGNIF.
Reduce Cost (54)	–.384 ^^			.313 ^				.321	3.169	.008
Reduction in Start-up Cost (70)		–.340 *	.296 *		.429 **			.407	6.180	.000
Reduction in Tool/Equip Cost (71)		–.365 *			.354 ^^			.268	3.349	.004
Improve Product Quality (52)										
Reduce Warranty Cost (72)		–.328 ^^	.327 ^		.279 ^			.234	2.842	.012
Reduce Customer Complaints (73)		–.336 ^^	.295 ^				–.275 ^	.238	2.902	.011
Reduce Rejected Material (72)				.410 ***				.239	2.922	.010
Reduce Rework Cost (70)										
Improve Product Performance (60)	–.368 ^^						.342 ^^	.188	4.410	.000
Improve Market Share (73)	–.518 ***		–.261 ^	.247 ^	.260 ^		.227 ^	.325	4.538	.000
Increase perceived value by Customer (77)							.331 *	.143	4.100	.010
Increase perceived Quality by Customer (73)						.233 ^		.055	4.151	.045
Improve Dollar Sales (76)		.345 ^^		.335 *			.307 ^^	.278	3.800	.002
Improve Product Profitability (72)	–.260 ^			.280 ^				.235	2.845	.012
Improve Product Capabilities (74)		.306 ^	–.419 *				.253 ^	.192	2.279	.038
Reduce Project Development Time (57)								.136	2.828	.047
Improved Communication (72)			.336 ^^					.258	3.232	.005
Reduce Total Manhours (73)				.324 ^^			–.241 ^	.264	3.376	.004
Reduction in Engineering Change Notices(74)					.320 ^			.196	2.330	.034
Reduction in Mfg.Cycle Time/Lead Time(72)	–.241 ^				.341 ^			.242	2.972	.009
Improve White Collar Productivity (72)									3.770	.014

Statistical Significance

^ .05 ^^ .01 * .005 ** .001 *** .000

independent variables (Cohen and Cohen, 1983: 101; Nie, et.al., 1975: 333) . Supplier Involvement (SI) contributes 11.7 percent of the total variance explained by this regression equation. The Beta coefficient demonstrates that the direction of this relationship is negative. This indicates that higher levels of supplier involvement in the NPD process will result in higher product cost.

Table 5-23
Reduction in Start-up Cost

Multiple R = .638
R Squared = .407 F-Statistic = 6.180
Adjusted R Squared = .341 Statistical Significance = .0000

Variables	Beta	Semi-Partial	Sig T
SI	-.060	-.051	.601
BSR	-.340	-.286	.005*
GP	.296	.217	.029*
IMSC	.021	.019	.842
II	.429	.336	.001*
IA	.133	.109	.266
RU	-.046	-.043	.579
(constant)			.343

* = statistically significant

The explanatory power of the linear regression regarding changes in start-up costs is highly statistically significant (p=.0000) with the ability to predict 40.7 percent of the total explained variance. In this model the independent variables BSR, GP, and II were all statistically significant at the .05 level or better. For this research, the construct BSR is of interest. The direction of the relationship is negative with the individual contribution to the total explained variance amounting to 8.2 percent (p=.005). Hence, the more integrated and cohesive the relationship is between the buyer and the supplier in the NPD process, the higher the relative start-up costs.

Table 5-24
Reduction in Tooling and Equipment Cost

Multiple R = .518
R Squared = .268 F-Statistic = 3.349
Adjusted R Squared = .188 Statistical Significance = .0042

Variables	Beta	Semi-Partial	Sig T
SI	.111	.098	.364
BSR	-.365	-.315	.004*
GP	.144	.113	.296
IMSC	-.114	-.105	.328
II	.354	.280	.011*
IA	.039	.032	.764
RU	.051	.048	.658
(constant)			.756

* = statistically significant

Reductions in tooling and equipment costs are inversely related to the strength of the buyer-supplier relationship (Beta= -.365). This relationship is statistically significant (p=.004).

Table 5-25
Reduction in Total Manhours

Multiple R = .513	
R Squared = .264	F-Statistic = 3.376
Adjusted R Squared = .186	Statistical Significance = .0039

Variables	Beta	Semi-Partial	Sig T
SI	-.055	-.049	.644
BSR	-.050	-.044	.680
GP	.184	.149	.162
IMSC	.324	.294	.007*
II	.053	.042	.692
IA	.098	.080	.454
RU	-.241	-.226	.036*
(constant)			.435

* = statistically significant

While the overall model is statistically significant (p=.0039) as demonstrated by the results of this regression equation, SI and BSR are not statistically significant.

Table 5-26
Reduction in Engineering Change Notices

Multiple R = .442	
R Squared = .196	F-Statistic = 2.330
Adjusted R Squared = .112	Statistical Significance = .0344

Variables	Beta	Semi-Partial	Sig T
SI	-.192	-.170	.126
BSR	-.149	-.129	.242
GP	-.034	-.027	.808
IMSC	-.084	-.076	.490
II	.320	.252	.025*
IA	.229	.186	.094
RU	.086	.080	.471
(constant)			.426

* = statistically significant

Supplier Involvement (SI) and BSR are not significant variables contributing to the 19.6 percent explanatory power of the regression equation (p=.0344) predicting reductions in Engineering Change Notices (ECN). The majority of the explanatory power stems from the utilization of Important Information (II) accounting for 6.4 of the 19.6 percent of the variance explained by this regression model (p=.025).

Individual analysis of the five measures of product cost reveal that the direction of the relationship between SI and BSR, and the cost element of IPDS is negative as indicated by the negative Beta coefficients. The only exception to this generalization is the relationship between SI and reductions in tooling and equipment costs which was positive, but not statistically significant.

In addition, the influence of the supplier was significant in three of the five regression analyses with SI the primary determinant of reductions in product cost, and BSR a significant determinant of reductions in start-up and tooling and equipment costs. The results demonstrate that the influence of the supplier in the NPD process in an integrated product development environment is negative with respect to the performance measures associated with product cost. The evidence suggests that the null hypothesis should be rejected, and that supplier involvement in the process actually increases overall product cost.

5.4.4.2 Quality

Supplier involvement in the IPD process was expected to be associated with higher levels of product quality. Overall quality was measured by the percent improvement in quality, and reduction in warranty costs, customer complaints, rejected material, and rework costs.

Hypothesis 5:

H_o: Quality is unrelated to the level of supplier involvement in IPD.

H_1: Quality is related to the level of supplier involvement in IPD.

Linear Model:

$$IPDS_2 = f(SI, BSR, GP, RU, IMSC, II, IA)$$

$$= \beta_0 + \beta_1(SI) + \beta_2(BSR) + \beta_3(GP) + \beta_4(RU) + \beta_5(IMSC) + \beta_6(II) + \beta_7(IA) + \epsilon$$

Two of the independent measures of quality, overall improvements in product quality and reductions in rework costs, did not prove to be statistically significant. The analysis will focus on the remaining three measures which were all statistically significant at the .01 level (Table 5-20). The impact of the supplier (BSR) proved to be significant with regard to reductions in warranty costs and customer complaints. Reductions in rejected material were not significantly influenced by the involvement of the supplier in the process (Tables 5-27, 5-28, 5-29).

Table 5-27
Reduction in Warranty Costs

Multiple R = .484
R Squared = .234 F-Statistic = 2.842
Adjusted R Squared = .112 Statistical Significance = .0120

Variables	Beta	Semi-Partial	Sig T
SI	.114	.100	.361
BSR	-.328	-.281	.011*
GP	.327	.263	.018*
IMSC	-.091	-.083	.448
II	.279	.223	.044*
IA	-.105	-.085	.435
RU	-.119	-.112	.306
(constant)			.756

* = statistically significant

The seven independent variables incorporated in this linear regression determine 23.4 percent of the explained variation associated with the quality measure, reductions in warranty costs, with a statistical significance of p=.0120. The relationship between the buyer and the supplier as captured by the construct BSR, demonstrates a negative (Beta= -.328), statistically significant (p=.001) contribution of 7.9 percent of the explained variance. This inverse relationship means that warranty costs actually rise as the caliber of the relationship between the buyer and the supplier becomes more cohesive and integrated.

Table 5-28
Reduction in Customer Complaints

Multiple R = .488
R Squared = .238 F-Statistic = 2.902
Adjusted R Squared = .156 Statistical Significance = .0106

Variables	Beta	Semi-Partial	Sig T
SI	-.035	-.030	.784
BSR	-.336	-.294	.009*
GP	.295	.238	.032*
IMSC	-.060	-.055	.615
II	.168	.134	.222
IA	.107	.085	.434
RU	-.275	-.256	.021*
(constant)			.022

* = statistically significant

The regression results for reductions in customer complaints display a similar pattern to the findings regarding reductions in warranty costs. The BSR construct is statistically significant (p=.009) in the regression model contributing 8.6 percent of the explained variation. The R^2 value is .238 and the regression equation is statistically significant at the .01 level. The relationship between this independent variable and the dependent variable, reductions in customer complaints, is negative indicated by the Beta coefficient (-.336) for BSR. This finding indicates that reductions in customer complaints are achieved through less tightly integrated buyer-supplier relationships in the NPD process.

Table 5-29
Reduction in Rejected Material

Multiple R = .489
R Squared = .239 F-Statistic = 2.921
Adjusted R Squared = .157 Statistical Significance = .0101

Variables	Beta	Semi-Partial	Sig T
SI	-.040	-.036	.744
BSR	-.101	-.089	.412
GP	-.235	-.188	.086
IMSC	.410	.381	.001*
II	.250	.201	.067
IA	.109	.091	.405
RU	.193	.184	.094
(constant)			.365

* = statistically significant

Reduction in the amount of rejected material is highly related to the integrative structure and culture of the firm (IMSC, p=.001) accounting for 14.5 percent, of the total explained variation of 23.9 percent, in the dependent variable. While the regression equation demonstrated a statistical significance of .0101, SI and BSR did not prove to be statistically significant (p=.744 and .412 respectively).

The results of the three independent analyses determined that the relationship with the supplier (BSR) is a significant influence IPDS measures of quality, reductions in warranty costs and customer complaints, and is negatively related to the attainment of these goals. The quantitative measure of supplier involvement in the IPD process, SI, was not statistically significantly related to the attainment of these goals.

In evaluating the null hypothesis, which postulates that the IPDS quality dimension is not influenced by the level of supplier involvement in the process, the results are mixed. The quantitative component of supplier involvement (SI) does not demonstrate a significant influence with regard to any of the individual measures of quality. The qualitative measure of supplier involvement in the IPD process (BSR) does demonstrate a statistically significant, albeit negative influence on the attainment of these goals. These findings support the rejection of the null hypothesis, recognizing the important influence of the relationship between the buyer and the supplier in the pursuit of quality.

5.4.4.3 Development Time

Supplier involvement in the process was expected to reduce the product development time. Project development time, communication, manufacturing cycle time/lead time, and white collar productivity were utilized to evaluate the aggregate dimension of time.

Hypothesis 6:

H_o: Time is unrelated to the level of supplier involvement in IPD.
H_1: Time is related to the level of supplier involvement in IPD.

Linear Model:

$$IPDS_3 = f(SI, BSR, GP, RU, IMSC, II, IA)$$

$$= \beta_0 + \beta_1(SI) + \beta_2(BSR) + \beta_3(GP) + \beta_4(RU) + \beta_5(IMSC) + \beta_6(II) + \beta_7(IA) + \epsilon$$

The results for the individual regression equations regarding the measures of development time are provided in Tables 5-30 through 5-34. All of the regression equations proved to be statistically significant, reductions in product development time (p=.047), improvements in communication (p=.0053), reductions in manufacturing cycle time/lead time (p=.0091), and improvements in white collar productivity (p=.0144). Supplier Involvement (SI) in the IPD process demonstrated significant influence (p=.051) only with regard to the reductions in the manufacturing cycle time/lead time (Table 5-32).

Table 5-30
Reduction in Project Development Time

Multiple R = .368	
R Squared = .136	F-Statistic = 2.828
Adjusted R Squared = .088	Statistical Significance = .0470

Variables	Beta	Semi-Partial	Sig T
BSR	-.162	-.151	.237
GP	.257	.238	.065
IMSC	.238	.235	.068
(constant)			.000

* = statistically significant

Reductions in the amount of time required to develop the product was regressed on three of the independent variables, BSR, GP, and IMSC. The regression equation is significant at the .05 level accounting for 13.6 percent of the variation in reductions in project development time. None of the independent variables are statistically significant at the .05 level. However, GP and IMSC are close to the conventional significance level.

Table 5-31
Improvement in Communication

Multiple R = .508
R Squared = .258 F-Statistic = 3.232
Adjusted R Squared = .178 Statistical Significance = .0053

Variables	Beta	Semi-Partial	Sig T
SI	-.219	-.193	.075
BSR	.110	.096	.371
GP	.336	.269	.014*
IMSC	.103	.095	.378
II	.114	.090	.403
IA	.070	.057	.597
RU	.097	.089	.409
(constant)			.401

* = statistically significant

The full linear model explains 25.8 percent (p=.0053) of the variance associated with improvement in communication. Group Process (GP) is the only statistically significant independent variable (p=.041) accounting for 7.2 percent of the variance explained. Neither quantitative (SI), or qualitative (BSR), measures of supplier involvement in the IPD process proved to be statistically significant in this regression equation.

Table 5-32
Reduction in Manufacturing Cycle Time/Lead Time

Multiple R = .492
R Squared = .242 F-Statistic = 2.972
Adjusted R Squared = .161 Statistical Significance = .0091

Variables	Beta	Semi-Partial	Sig T
SI	-.241	-.215	.051*
BSR	.060	.052	.633
GP	.095	.077	.478
IMSC	.120	.108	.319
II	.341	.268	.016*
IA	.050	.039	.720
RU	-.149	-.142	.194
(constant)			.262

* = statistically significant

Supplier Involvement (SI) in the regression model utilized to predict reductions in manufacturing cycle time is statistically significant at the .05 level. The SI construct demonstrates a negative relationship to the dependent variable (Beta = -.241), while accounting for 4.6 percent of the explained variation in the reductions in manufacturing cycle time.

Table 5-34
Improvement in White Collar Productivity

Multiple R = .375
R Squared = .141 F-Statistic = 3.771
Adjusted R Squared = .104 Statistical Significance = .0144

Variables	Beta	Semi-Partial	Sig T
GP	.206	.174	.124
IMSC	.175	.172	.129
II	.182	.152	.177
(constant)			.144

* = statistically significant

The results of the regression equation indicate that none of the independent variables are statistically significant in predicting white collar productivity.

The aggregate results of the individual measures of the time dimension of IPDS indicate that overall, supplier involvement in the process plays an insignificant role in the attainment of improvements in project development time, communication, and white collar productivity. Supplier Involvement is significant in the efforts to reduce manufacturing cycle time/lead time. This requires the rejection of the null hypothesis which postulated that time is unrelated to the level of supplier involvement in the IPD process.

5.4.4.4 Product Performance

Supplier involvement in the NPD process was expected to have a positive impact on quality and cost, two of the components of IPD Success. This relationship was expected to transfer into the subjective evaluations of the customer's perceptions of quality and value and the capabilities of the product. Overall product performance was measured based on the improvement in tangible product performance, market share, perceived value, perceived quality, sales, profitability, and product capabilities.

Hypothesis 7:

H_o: Product performance is unrelated to the level of supplier involvement in IPD.

H_1: Product performance is related to the level of supplier involvement in IPD.

Linear Model:

$IPDS_4 = f(SI,BSR,GP,RU,IMSC,II,IA)$

$= \beta_0 + \beta_1(SI) + \beta_2(BSR) + \beta_3(GP) + \beta_4(RU) + \beta_5(IMSC) + \beta_6(II) + \beta_7(IA) + \epsilon$

The seven individual regression analyses related to the IPDS product performance dimension are presented in Tables 5-35 through 5-41. All of the regression models proved to be statistically significant, improvements in product performance (p=.0074), improvements in market share (p=.0004), increases in perceived value (p=.0101), improvements in dollar sales (p=.0015), improvements in product profitability (p=.0119), and improvements in product capabilities (p=.0383). Each of the dependent variables, and the influence of supplier involvement, will be discussed following the presentation of their individual regression results.

Table 5-35
Improvement in Product Performance

Multiple R = .434
R Squared = .188 — F-Statistic = 4.410
Adjusted R Squared = .146 — Statistical Significance = .0074

Variables	Beta	Semi-Partial	Sig T
SI	-.368	-.329	.008*
IA	.231	.225	.064
RU	.342	.309	.012*
(constant)			.068

* = statistically significant

Improvements in the tangible performance characteristics of the product (speed, strength, weight, etc) can be predicted (R^2=.188) by the level of Supplier Involvement (SI), Information Accessibility (IA), and Resource Utilization (RU) (p=.0074), Table 5-35. The supplier's influence in the achievement of tangible product performance improvements is negative (Beta= -.368). SI is a significant determinant of the changes in product performance demonstrating the highest individual explained variation (10.8 percent) and statistical significance (p=.008).

Table 5-36
Improvement in Market Share

Multiple R = .570
R Squared = .325 F-Statistic = 4.538
Adjusted R Squared = .253 Statistical Significance = .0004

Variables	Beta	Semi-Partial	Sig T
SI	-.518	-.448	.000*
BSR	.010	.084	.411
GP	-.261	-.210	.042*
IMSC	.247	.225	.029*
II	.260	.207	.045*
IA	.048	.041	.688
RU	.227	.205	.047*
(constant)			.400

* = statistically significant

The seven independent variables which were included in the linear model for explaining improvements in market share account for 32.5 percent of the observed variation in this dependent variable (Table 5-36). This model is statistically significant (p=.0004) with five of the independent variables SI (p=.000), GP (p=.042), IMSC (p=.029), II (p=.045), and RU (p=.047) having significant T-statistics. Supplier Involvement (SI) in the IPD process demonstrates a strong inverse relationship to the IPDS goal of improvements in market share indicated by the high negative Beta coefficient of -.518. The individual contribution of the independent variable SI to the explained variation is 20.1 percent.

Table 5-37
Increase in Perceived Value

Multiple R = .489
R Squared = .239 F-Statistic = 2.921
Adjusted R Squared = .157 Statistical Significance = .0101

Variables	Beta	Semi-Partial	Sig T
SI	-.192	-.174	.110
GP	.205	.195	.075
RU	.331	.312	.005*
(constant)			.374

* = statistically significant

Three of the independent variables (SI, GP, RU) were selected for inclusion in the predictive model relating to increasing the perceived value of the product (Table 5-37). The role of SI in increasing the perceived value of the product is not statistically significant (p=.110).

Table 5-38
Increase in Perceived Quality

Multiple R = .233
R Squared = .055 F-Statistic = 4.151
Adjusted R Squared = .041 Statistical Significance = .0453

Variables	Beta	Semi-Partial	Sig T
IA	.233	.233	.045*
(constant)			.000

* = statistically significant

A simple linear regression proved to yield the highest explanatory power for the dependent variable increasing the perceived quality of the product (Table 5-38). The accessibility of information (IA) explained 5.5 percent of the variance in this product performance measure with a statistical significance at the .05 level. Neither SI or BSR were included in this regression equation which means they have no influence on increasing the perception of quality.

Table 5-39
Improvement in Dollar Sales

Multiple R = .528
R Squared = .278 F-Statistic = 3.800
Adjusted R Squared = .205 Statistical Significance = .0015

Variables	Beta	Semi-Partial	Sig T
SI	-.226	-.198	.057
BSR	.345	.281	.008*
GP	.006	.005	.963
IMSC	.335	.304	.004*
II	-.175	-.140	.175
IA	-.090	-.074	.473
RU	.307	.285	.007*
(constant)			.876

* = statistically significant

Another indicator of product performance is the increase in sales associated with the development of a new product (Table 5-39). The overall regression model served to explain 27.8 percent of the variation in sales, measured in dollars, with a statistical significance of .0015. The relationship between the buyer and the supplier in the IPD process (BSR) is positively correlated with improvements in dollar sales (Beta=.345) offering 7.9 percent of the explanatory power of the regression equation. This relationship demonstrated a statistical significance of .008. The influence of SI in the process, reporting borderline significance of .057, is negative with the direction and magnitude of the relationship indicated by the Beta coefficient of -.226.

Table 5-40
Improvement in Product Profitability

Multiple R = .484	
R Squared = .235	F-Statistic = 2.845
Adjusted R Squared = .152	Statistical Significance = .0119

Variables	Beta	Semi-Partial	Sig T
SI	-.260	-.229	.039*
BSR	.212	.186	.092
GP	-.013	-.010	.926
IMSC	.280	.255	.022*
II	-.113	-.090	.410
IA	.225	.181	.101
RU	.032	.030	.782
(constant)			.284

* = statistically significant

A related measure to sales, and an indicator of product performance, is the relative improvement in the profitability of the product (Table 5-40). Two of the independent variables demonstrated significant T-statistics, SI and IMSC, at the .05 level or better (p=.039 and p=.022, respectively). In conjunction with the remaining five independent variables, the model accounts for 23.5 percent of the variance in the improvements in product profitability (p=.0119). The level of SI is inversely related to the improvement in product profitability, Beta equal to -.260, with an absolute contribution to the variance explained of 5.2 percent.

Table 5-41
Improvement in Product Capabilities

Multiple R = .439
R Squared = .192 F-Statistic = 2.279
Adjusted R Squared = .108 Statistical Significance = .0383

Variables	Beta	Semi-Partial	Sig T
SI	-.154	-.134	.225
BSR	.306	.240	.032*
GP	-.419	-.325	.004*
IMSC	.179	.163	.143
II	.011	.009	.935
IA	.018	.014	.897
RU	.253	.234	.037*
(constant)			.029

* = statistically significant

Improvements in product capabilities measured the percent change in the functionality of the product for its intended use (Table 5-41). The seven independent variables reported a predictive capability of 19.2 percent with a significance level of .0383. The BSR construct is positively and significantly correlated (p=.032) with improvements in a products capabilities (Beta=.306), providing 5.8 percent of the explained variation. The SI construct demonstrated a negative relationship with the dependent variable but did not demonstrate a statistically significant individual T-statistic (p=.225).

The results clearly support the rejection of the null hypothesis which postulates that product performance is unrelated to the level of supplier involvement in the IPD process. The construct SI consistently displays a negative relationship with the individual measures of product performance. This relationship was statistically significant in the determination of improvements in product performance (Table 5-35), improvements in market share (Table 5-36), improvements in product profitability (Table 5-40), and marginally significant with regard to improvements in dollar sales (Table 5-39).

These findings are polar to the results attributed to BSR in the determination of the independent variables measuring the IPDS goal of product performance. The relationship between the buyer and the supplier in an IPD environment is consistently positively correlated with the seven independent measures of product performance. This relationship is statistically significant in the regression results associated with improvement in dollar sales (Table 5-39) and product capabilities (Table 5-41).

The discrepancies in the results of the two constructs, depicting the suppliers involvement in the IPD process (SI and BSR), make the determination as to whether this involvement is a positive or negative influence on the performance aspect of the IPDS variable difficult to determine. The results are best interpreted on the disaggregated individual measures of product performance than an aggregated score for the purpose of parsimony.

5.5 Controlling for Exogenous Variables

In the development of the research design, three exogenous variables were identified as potentially having an important influencing role in the regression results. The size of the firm (S), measured by annual sales, the degree of product innovation (PI), routine/incremental versus radical/quantum, and the competitive intensity (CI), measured by the rate of change and growth in the competitive marketplace.

In order to assess the impact of these exogenous variables the sample was stratified into large, medium, and small for the exogenous variable firm size, and high medium, and low for product innovation and competitive intensity/environmental uncertainty. T-tests for a difference between means were run for the independent and dependent variables.

A summary of the results of this analysis is located in Appendix III. The findings indicated that very few of the 24 dependent variables incorporated in this research demonstrated a statistically significant difference in the means between the groups. This result held true for the seven independent variables as well. Based on these results, it was concluded that the influence of the exogenous variables was negligible, and that further analysis would not provide significant additional information pertinent to the regression results.

5.6 Impact of Supplier Involvement on an IPD Environment

Table 5-42 presents a summary of the research findings based on the data provided in Table 5-21, and the results of the individual hypothesis testing. The focus of the hypothesis is located in the left column and corresponds to the discussions of product cost (Hypothesis 4), product quality (Hypothesis 5), development time (Hypothesis 6), and product performance (Hypothesis 7). The columns devoted to SI and BSR indicate the direction to the relationship between the independent variable, positive (+) or negative (-), and whether the relationship was statistically significant (*).

Table 5-42
Summary of Hypothesis Testing for Supplier Involvement

Hypothesis	SI	BSR	Decision
Costs	− *	− *	Reject H_o
Quality		− *	Reject H_o
Time	− *		Reject H_o
Product Performance	− *	+ *	Reject H_o

* = statistically significant

The results demonstrate that the impact of the supplier in the NPD process utilizing an IPD strategy is significant. The direction of the relationship between the independent and dependent variables (negative), with the exception of BSR and Product Performance, is counter to the expectations of the research. The implications of this finding will be addressed in Chapter VI.

This chapter has been devoted to a detailed description of the sample population, presentation of the statistical analysis, development of a new IPDS conceptual model, and the results of the hypotheses testing. Chapter VI addresses the conclusions that can be drawn from this research, the contributions stemming from this research, and the implications for future research.

CHAPTER VI

CONTRIBUTIONS and CONCLUSIONS

6.0 Previous chapters have addressed the relevance of this research problem, focus of this research project, supporting literature, the conceptual model, the research design and methodology, and the data analysis and research findings. This chapter presents the contributions and conclusions which can be drawn from this research, the limitations of the study, and the implications for future research.

6.1 Contributions

This study represents the first large-scale empirical study of the Integrated Product Development (IPD) strategy being utilized in the New Product Development (NPD) process investigating the role of the supplier in this process. In addition to the size of the sample, the research was strengthened by the purposive diversity of the population which was incorporated in the research design to increase the generalizability of the research findings.

The scope of the investigation, incorporating organizational, project, and interorganizational variables in the analysis, was designed to build on previous research by taking the conclusions drawn from other fragmented research, and synthesizing them into one cohesive study. The purpose of this effort was to try and develop an understanding of the inter-play between the variables postulated by previous research, and capture the dynamics associated with the NPD process.

The focus of the research was to isolate and measure the impact of supplier utilization in the IPD strategy in the NPD process. The nature of supplier involvement was evaluated along two dimensions. The first dimension representing the quantitative evaluation of the volume of supplier involvement (SI) on the project level. The second dimension involved the evaluation of the interorganizational dynamics, and character, of the buyer-supplier relationship (BSR). By incorporating the project and organizational level environments in the same study, the influence and contribution of supplier involvement was assessed in a holistic context, rather than in a piecemeal fashion.

Incorporated in the research design was the utilization of the Susman and Dean framework (1991), Figure 1-3, as the foundation for testing the relationships postulated by the literature. This facilitated the objective of building on previous research in the development of a theory regarding an integrated approach to the NPD process. Based on the findings of this research, the initial framework has been refined and a new conceptual model proposed which attempts to capture the dynamic nature of an IPD process, Figure 5-17.

The model includes the incorporation of seven independent variables, Supplier Involvement (SI), Buyer-Supplier Relationship (BSR), Integrative Mechanisms Structure/Culture (IMSC), Information Importance (II), Information Accessibility (IA), Group Process (GP), and Resource Utilization (RU), and two dependent variables, Integrated Product Development Success (IPDS), and Firm

Performance (FP). The research served to identify the direction and magnitude of the relationships between the variables proposed by this new model.

Another contribution of this research has been the development of reliable, validated scales to foster the measurement of those constructs which were identified in the literature, and utilized in this research. The results of this analysis are provided in Tables 5-10 through 5-16 for the seven independent variables, SI, BSR, IM, II, IA, GP and RU. Secondary measures which were developed in this process, and are of significant interest to researchers and practioners, are two dimensions of the GP construct, Leadership and Group Cohesion.

The two dependent variables incorporated in this research, FP and IPDS, were scrutinized, validated, and tested in the same fashion (see Tables 5-6 and 5-7). Establishment of reliable measures of firm performance based on market performance and competitive position will serve to facilitate research of a strategic nature. This research also incorporated an innovative method at collecting objective information of a sensitive nature in the measurement of the IPDS. Each dimension of IPDS was measured as a percent change from a benchmark. This facilitated the aggregation of objective data across industries and projects.

These research findings lay the foundation for future research in the specific area of integrated approaches to new product development, and at the more global level of product development and innovation in general. They also facilitate any future research efforts targeting the assessment of supplier involvement in an interorganizational context across a wide variety of applications. The research served to identify the importance of two dimensions of supplier involvement, the quantitative component which focused on the measurement of the quantity of involvement across a wide variety of criteria (SI) and the quality or caliber of the buyer-supplier relationship (BSR), which focused on the assessment of the nature of the interaction between the two parties.

An important contribution of this research is the verification of a positive, significant relationship between the utilization and success of an IPD process to developing new products and firm performance. This insight supports the utilization of teams in this problem context, and rationalizes the initial costs which may be incurred to establish this structure in an organization. Identification of the market-based (Market Performance-MP) and competitor-based (Relative Performance-RP) criteria which are influenced by the individual measures of Integrated Product Development Success (IPDS) in the assessment of Firm Performance (FP) provides project managers key performance criteria to evaluate the success of their development efforts.

This information provides the linking-pin between the achievement of corporate strategic objectives and the success of individual NPD projects. Managers will be able to focus on the criteria relevant to specific corporate goals whether they be market penetration, growth, profitability, etc. Establishing these criteria, and the significance of the relationship, can help facilitate the deployment and utilization of critical resources in the development of new products.

6.2 Conclusions

Based on this study,. supplier involvement, as determined by the joint assessment of the constructs SI and BSR, in the NPD process appears to have a significant impact on the cost, quality, development time, and product performance dimensions of IPDS (see Tables 5-21 and 5-41). The importance of supplier involvement in the process as a determinant of project success is equal to, or greater than, the impact of the other independent variables incorporated in this research [GP, IMSC, II, IA, RU (Table 5-21)].

A priori expectations were that supplier involvement would be significant, and a positive influence on the attainment of the strategic initiatives incorporated in the IPDS construct. The results support the initial conclusion that supplier involvement is, in fact, significant. Unfortunately, the results also indicate that the nature of the influence is predominately negative, with nine out of the eleven statistically significant correlations reporting a negative Beta coefficient (Table 5-21). The magnitude of this result is acute when a comparison is drawn with the remaining relationships, between the independent and dependent variables which were found to be statistically significant, 26 in all (Table 5-21). Of these, only four demonstrate a negative correlation, with the relationship between RU and a reduction in total manhours (Beta = -.241) being negative as expected.

This result defies conventional wisdom and the current paradigm concerning the inclusion of the supplier in the NPD process. Interpreting this result serves to raise more questions than it provides answers. Evidence which has led to the development of the current paradigm has been the product of case studies of individual projects, hearesy, and common sense. Empirical testing of this relationship across a variety of projects (in scope and scale), industries, firms, cultures, competitive environments, technologies, levels of innovation, etc., indicates that this previous paradigm does not hold true.

One possible explanation is the potential for the presence of sample bias in other studies, which may have led to the erroneous conclusion that supplier involvement is a positive influence in the NPD process. Other research in this area has been restricted in scope to primarily two industries, automotive and electronic. In addition, the sample population for these research efforts has predominately focused on executives in the purchasing and materials management function. Respondents have often been requested to provide information regarding the key success variables, as well as gauging the degree of success of the NPD project. Due to the difficulty in collecting objective data, these studies have primarily relied on the utilization of perceptual measures to capture information for both the independent and dependent variables. The results are therefore speculative due to the threat of mono-operational bias.

In this research, a wide variety of industries were represented. The respondents were also from a wide spectrum of functional backgrounds including, engineering, marketing, production, materials management, purchasing, and sales. The threat of mono-operational bias was minimized in the research design by utilizing objective and perceptual measures for both the dependent and independent variables.

Another possible explanation for the discrepancy between the current research findings, and the conclusions drawn from the literature, lies with the potential to bias the data by disclosing the focus of the research to the research participants. To protect against this form of data contamination, participants were told that the research was an investigation of the NPD process utilizing a team approach. Respondents were not given any further insight as to the focus of the research, supplier involvement in the process. In fact, the questions on the survey regarding supplier involvement in the process were addressed in the last section of the ten page survey to minimize the potential for biasing the results.

A final explanation is the influence of the learning curve associated with the team approach to the development of new products. The unit of analysis for this research effort was the individual NPD project. As such, the results are based on the aggregation of individual events representing a given point in time. The data collected did not differentiate the projects based on the level of experience the firm, team, and/or supplier demonstrated with an IPD strategy.

There is reason to believe that experience with an IPD approach would yield more effective utilization of both internal and external resources. This assumption is based on the organizational and interorganizational initial cultural inertia demonstrated by firms utilizing the IPD strategy. Adoption of this approach requires the development of a new system to facilitate the process including the appropriate culture, structure, information channels, rewards, etc.

While the current research did not directly measure the learning/experience curve of the respondents, information was sought regarding the degree of innovation as a control variable to provide some additional insight. The T-test for a difference between means indicated that there was no substantial difference in the levels of supplier involvement (SI, BSR), or project performance (IPDS) based on the degree of innovation (Appendix III) with one exception, reductions in warranty costs.

6.3 Limitations

The research is limited by the purposive, convenience sampling technique employed to insure that respondents were utilizing an IPD approach in the NPD process. The data were provided almost exclusively by manufacturing firms reporting on the experience in developing a tangible product for delivery to the market. Consequently, the majority of the suppliers involved were also the providers of tangible products. The results are therefore only representative of the manufacturing sectors of the economy and can not be generalized to the service sectors.

The primary limitation of this study is a function of the research design, and was done intentionally to improve the generalizability of the results across industries. The sample population selected for this research consisted of a variety of industries, nine including the "other" categorization (Figure 5-2), for a sample size of 83 projects. While the sample size is more than adequate to provide meaningful results across industries, it is inadequate for comparative purposes between industries.

A question which therefore remains to be answered is if these findings are consistent within each industry. The number of independent variables incorporated in this research does not facilitate an in-depth analysis by industry, given the sample size for each industry represented. The large automotive industry representation did allow for this investigation, and the results were consistent with the overall research findings.

Additional information regarding the experience of the firm and individual team with the IPD approach to NPD and specifically, the incorporation of the supplier in this process, would have provided some valuable insight. Another improvement would have involved the inclusion of perceptual measures of project success to use in conjunction with the objective measures incorporated in the research. This information would have facilitated the bi-polar examination of the impact of supplier involvement in projects that were considered to be a success, versus those that were considered to be a failure, as a measure to normalize the data across industries.

In addition, the findings of this research are based on the information provided by the buying organization. The research would have been strengthened by a research design which incorporated the supplying organizations input. Valuable information could have been obtained with case comparisons between the buying and supplying organizations based on the level of supplier involvement and the degree of project success.

6.4 Implications for Future Research

The results of this research are a well-spring of opportunities for many future research endeavors through an incremental step in the advancement of a theory regarding an integrated approach to the innovation process involving new product development. The development of a conceptual framework and reliable, valid constructs provides researchers with a foundation and some additional tools to facilitate future research.

In addition, the findings serve to provoke the development of more questions and plausible explanations for the conclusions drawn from this research which need further investigation. A logical extension of this research is the development of a path model which specifies the order and interactions among the variables. In addition, specific research to identify the influence of intervening variables such as international differences, organizational culture, leadership, industry, and group dynamics needs to be conducted.

The present research calls for parallel studies utilizing a different sample to determine if these results are an anomaly or demonstrate the need for a paradigm shift regarding the buyer-supplier relationship in the realm of NPD. Specifically, in-depth comparison studies by industry would be beneficial. This would require the commitment of enough participants by industry to facilitate comparative statistics. Given the growth and importance of the service sector in the overall economy, and the significant differences between manufacturing and services in the product development and delivery process, a thorough investigation regarding the utilization and effectiveness of an IPD strategy in the services industries is needed.

Another approach involves the use of a stratified sample based on the point of supplier involvement in the NPD process. This methodology would offer insight as to what point in the process the supplier's involvement is the most beneficial and facilitate the optimal integration of the supplier in the IPD environment.

Two additional methodological contributions include a follow-up longitudinal study to determine the impact of the experience/learning curve, and a paired case study approach including input from the supplier and buyer in the analysis. The longitudinal study would serve to identify if the role of the supplier changes over time as the organizational barriers to the IPD approach are minimized or eliminated, and if the overall process also becomes more effective. The paired approach would validate the contributions of the supplier and eliminate the threat of mono-operational bias in the analysis.

6.5 Concluding Remarks

Based on this research, inclusion of the supplier in the NPD process as a member of an integrated product development team is seen as detrimental to the success of the project. The only exception to this finding is that the quality of the interaction between the buyer and the supplier positively impacts the improvement in the sales (dollar) and capabilities of the product. These results serve as an indication that current purchasing practices advocating a high level of supplier involvement in the NPD process be revisited. In addition, the results call into question current purchasing strategic practices such as strategic alliances, partnering, joint ventures, long-term contracts, sole sourcing, etc., which are based on the premises of collaboration. A far-reaching conclusion is that the research supports a reinstitution of competitive market conditions in the buyer-supplier relationship to achieve a competitive advantage in the introduction of new products to the market place.

APPENDIX I

MICHIGAN STATE UNIVERSITY

GRADUATE SCHOOL OF BUSINESS ADMINISTRATION
DEPARTMENT OF MANAGEMENT • (517) 353-5415
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Dear Research Participant:

First of all, I would like to thank you for your commitment and support of this research project investigating new product development. Your participation is critical to the success of this project. Your contribution will serve to facilitate the development of a knowledge-base regarding the intricate process associated with new product development as well as, allowing me to complete my doctoral degree at Michigan State University. Therefore, you can view your involvement as a contribution to the advancement of science and a humanitarian gesture. The purpose of this letter is to provide you with more detail regarding the nature and scope of this research project, the benefits you will derive from participating in this study, and some basic instructions.

This research addresses contemporary manufacturing concerns regarding the area of new product development and the challenge to rapidly develop and introduce new products in the marketplace, a concept known as Time-Based Competition. Traditionally, product and process designs have been done sequentially, effectively ignoring the interaction between the two sources of innovation. A departure from the traditional approach involves the use of teams in the new product development effort. This research seeks to understand, measure and explain the impact of individual, organizational, and inter-organizational factors which effect the success of new product development efforts. The results of this research will serve to identify which variables impact the process and their relative order of magnitude. This will provide firms with the tangible data necessary to effectively allocate resources.

The research findings will be a product of a large scale empirical investigation involving many firms from across a wide distribution of industries both domestic and abroad. Data will be gathered through the use of a survey and supported by in-depth case studies of firms from each of the representative industries. The results will be shared with participants on the aggregate level (involving all the firms/project), by industry, and a international versus domestic analysis. For those firms utilizing this research as a corporate initiative (providing multiple responses), a confidential statistical analysis of the firm's results will also be provided. Participating in this research will effectively provide you with benchmarking information within your own firm, your industry, across industries, and internationally.

The survey is designed to gather information regarding a specific new product development project which has made it through the design phases, and is actually into production. The survey should be completed by an individual who was actively involved with the project since conception, a core team member, project leader, or manager. The survey was pilot tested and took about two hours to complete. The survey provided to you is number___________. This number can be found on the lower right-hand portion of the last page. You can utilize this number for your own internal tracking and control purposes.

I suggest that you make a copy of the completed questionnaire for your own use prior to returning the original. Please return all the questionnaires, both completed and uncompleted, as I need this information for the statistical analysis, and the reporting of results. If you have questions, or require additional questionnaires, please feel free to call.

Another related issue came up in a discussion with Rick Malecki from Navistar International. Rick asked me if I would help him facilitate the formation of a "roundtable" discussion group devoted to new product development. The purpose of the group would be the "transfer of technology" or sharing of information and experiences involving product development in an integrated environment. The idea is to provide a low-key, low-cost environment for learning from each other. No formal presentations, but rather an exchange of information and ideas from all participants. If you are interested, please call Rick Malecki (219-461-1438), or myself (517-339-4651), and help us to determine the appropriate time and location.

Lastly, I would like to thank the International Quality & Productivity Center, Productivity Inc., The Society of Computer-Aided Engineering, The National Association of Purchasing Management, and The Michigan State University Purchasing Development Fund for their support of this research effort. As we all know, the product is only as good as the team!

Highest Regards,

Laura M. Birou

Survey of New Product Development Strategies And Processes

This research is being funded by the National Association of Purchasing Management and the Michigan State University Purchasing Development Fund.

Information

The information provided about your company will be held strictly confidential.

Please fill in the following or attach a business card. (Optional)

Name: ______________________________

Position/Title: ______________________________

Company: ______________________________

Address: ______________________________

____

Telephone/Extension: ______________________________

Please return the completed survey to:

Laura M. Birou
Michigan State University
Management Department
232 Eppley Center East Lansing, MI 48824-1121
517-339-4651 (Direct)
517-353-5415 (Main Office)
517-336-1111 (Fax)

The success of this research is highly dependent on your participation. Therefore, I would like to thank you for your time, energy, and thoughtfulness. Your assistance is greatly appreciated.

General Instructions

1. This questionnaire should be filled out with respect to a new product development project which has made it through the design phase and is in production.
2. The individual completing this survey should have a high level of familiarity with the project identified for this research.
3. Some questions ask you to check a box, circle a number, or provide specific data. There are no "right" or "wrong" answers. Different projects are expected to have different responses. The purpose of this research is to understand the differences.
4. Please answer all questions, as incomplete questionnaires create serious problems in data analysis.
5. Please answer the questions as accurately as you can. The success of the study depends on your frankness and care in answering questions.
6. Please return all questionnaires in the enclosed envelope within 2 weeks.

I. General Information

1. The primary industry in which your products compete. (Check one)

☐ Automotive ☐ Machinery, except Electric ☐ Defense
☐ Electronic/Electric ☐ Transportation Equipment ☐ Other (Please Specify) ________________

2. Indicate the size of your firm/business by the number of employees. ____________ employees

3. Indicate the size of your firm/business unit by the annual sales. ____________ dollars

4. Indicate the relative importance of the alternatives below to your firm's ability to compete.

	Not Important					Extremely Important	
Product Cost	1	2	3	4	5	6	7
Product Quality	1	2	3	4	5	6	7
Dependability/Delivery/Due Date Performance	1	2	3	4	5	6	7
Flexibility/Responsiveness	1	2	3	4	5	6	7
Rapid New Product Introduction/Innovation	1	2	3	4	5	6	7

5. Indicate the relative importance of each characteristic to your firm's business strategy.

	Not Important					Extremely Important	
New Product Development	1	2	3	4	5	6	7
Brand Identification	1	2	3	4	5	6	7
Innovation in Marketing Techniques	1	2	3	4	5	6	7
Advertising	1	2	3	4	5	6	7
Operating Efficiency	1	2	3	4	5	6	7
Competitive Pricing	1	2	3	4	5	6	7
Procurement of Raw Materials	1	2	3	4	5	6	7
Innovation in Manufacturing Processes	1	2	3	4	5	6	7

6. Compared to 3 years ago, what has been the trend in your industry?

	Significantly Decreased						Significantly Increased
Market growth (domestic)	1	2	3	4	5	6	7
Market growth (internationally)	1	2	3	4	5	6	7
Rate of technological changes in products	1	2	3	4	5	6	7
Rate of technological changes in processes	1	2	3	4	5	6	7
Competition	1	2	3	4	5	6	7

7. Describe your firm's competitive environment.

	Strongly Agree					Strongly Disagree	
Our firm rarely changes its marketing practices.	1	2	3	4	5	6	7
The rate of product obsolescence is slow.	1	2	3	4	5	6	7
Actions of competitors are easy to predict.	1	2	3	4	5	6	7
Demand and consumer tastes are easy to forecast.	1	2	3	4	5	6	7
The rate of process obsolescence is slow.	1	2	3	4	5	6	7

8. *Relative to your leading competitors*, indicate your firm's position on the following dimensions.

	Significantly Lower						Significantly Higher
Responsiveness/flexibility	1	2	3	4	5	6	7
Customer Service	1	2	3	4	5	6	7
Innovation/rate of new product introduction	1	2	3	4	5	6	7
Product cost	1	2	3	4	5	6	7
Product performance	1	2	3	4	5	6	7
Product quality/customer perception	1	2	3	4	5	6	7
Process innovation	1	2	3	4	5	6	7
Market share growth	1	2	3	4	5	6	7
Sales growth	1	2	3	4	5	6	7
Earnings growth	1	2	3	4	5	6	7
Return on assets	1	2	3	4	5	6	7

9. Indicate the extent to which you agree with the following statements regarding your firm's internal environment.

	Strongly Agree						Strongly Disagree
Innovation and change are encouraged	1	2	3	4	5	6	7
Authority and responsibility are decentralized	1	2	3	4	5	6	7
Highly structured channels of communication	1	2	3	4	5	6	7
A strong insistence on uniform managerial style	1	2	3	4	5	6	7
A strong emphasis on formal procedures	1	2	3	4	5	6	7
Informal style of dealing with each other	1	2	3	4	5	6	7
Mistakes are tolerated	1	2	3	4	5	6	7
Important decisions are made by individuals	1	2	3	4	5	6	7
Cooperation and trust exists between departments	1	2	3	4	5	6	7
The organization and people are closed and secretive	1	2	3	4	5	6	7
Results are more important than procedures	1	2	3	4	5	6	7

10. Indicate what you believe most accurately describes your firm's innovative environment.

	Strongly Agree						Strongly Disagree
The rate of new product introduction by the firm has decreased compared to leading competitors.	1	2	3	4	5	6	7
The rate of change in your methods of production has declined compared to leading competitors.	1	2	3	4	5	6	7
Risk taking by key executives of the firm in seizing and exploring a "risky" growth opportunity has decreased.	1	2	3	4	5	6	7
Seeking unusual, novel solutions by senior executives to problems via the use of "idea men," brainstorming, etc. has declined.	1	2	3	4	5	6	7
When confronted with decision-making situations involving uncertainty, my firm typically adopts a cautious, "wait and see" posture in order to minimize the probability of making a mistake.	1	2	3	4	5	6	7

II. Project Specific Information

Please answer the following questions with respect to a *specific* new product development effort you were personally involved in.

11. What is the name of this project/product? ________________________ *(To be held strictly confidential).*

12. Was this product: (Check one)

☐ A minor improvement of an existing product ☐ A major enhancement of an existing product ☐ An entirely new product

13. This project required the utilization of: (Check one)

☐ Existing technology ☐ New-related technology ☐ New-unrelated technology

14. This project was designed to satisfy the needs of: (Check one)

☐ Existing customers ☐ A new market segment/niche ☐ A new market

15. This product represents: (Check one)

☐ A finished product ☐ A subassembly ☐ A component part

16. For the following project goals, indicate the targeted change in performance improvement and the actual change in performance improvement on this project as a percentage (*i.e.*, 0%, 35%, 100%, etc.) . Then provide the unit of measure utilized to monitor this goal achievement (hours, dollars, people, etc.).

Example: In the development of the new ABC widget, the new product development team targeted a 10% cost reduction. They were able to achieve a 12% cost reduction, and the unit of measure was dollars.

Project Goal	Target	Actual	Unit of Measure
Example: Reduce Product Cost	10%	12%	Dollars
Reduce Product Cost			
Reduction in Start-Up Cost			
Reduce Tooling Costs/Equipment Cost			
Improve Product Quality			
Reduce Warranty Cost			
Reduce Customer Complaints			
Reduce Rejected Material			
Reduce Rework Cost			
Improve Product Performance (*e.g.*, speed, weight)			
Improve Market Share			
Increase Perceived Value By Customer			
Increase Perceived Quality By Customer			
Improve Dollar Sales			
Improve Product Profitability			
Improve Product Capabilities			
Reduce Project Development Time			
Improved Communication			
Reduce Total Manhours			
Reduction in Total Engineering Change Notices			
Reduction in Manufacturing Cycle Time/Lead Time			
Improved White-Collar Productivity			

17. The answer to the previous project performance goals is based on the establishment of a project benchmark or target. Please indicate the source of this benchmark. (Check only one).

________ A competitor's product ________ A corporate target

________ A previous model ________ Other, please specify________________

18. The manufacturing process to produce this product is:

☐ Mass production ☐ Batch production ☐ Job shop

On this project:

	Low Risk						High Risk
19. Degree of ***product*** technical risk?	1	2	3	4	5	6	7
20. Degree of ***process*** technical risk?	1	2	3	4	5	6	7

21. The new product development process on this project:

	Strongly Agree						Strongly Disagree
was characterized by the simultaneous consideration of product and process design opportunities and constraints	1	2	3	4	5	6	7
led to the development of a product in the shortest amount of development time	1	2	3	4	5	6	7
provided superior value to the customer	1	2	3	4	5	6	7
provided the lowest possible cost of ownership	1	2	3	4	5	6	7
provided superior quality	1	2	3	4	5	6	7
provided a competitive advantage for the firm	1	2	3	4	5	6	7
provided the firm adequate returns and growth	1	2	3	4	5	6	7

22. How many core team members were involved, from the beginning to the completion, on this new product development team?

________________ employees

23. How many total people were involved, from the beginning to the completion, on this new product development team?

________________ employees

24. Indicate which departments were represented on this new product development team.? **(Check all that apply)**

☐ Manufacturing ☐ Suppliers ☐ Product Development

☐ Quality ☐ Customers ☐ Other (Identify Below)

☐ Purchasing ☐ Marketing ☐ ________________

☐ Customer Service ☐ Accounting ☐ ________________

☐ Finance ☐ Process Development ☐ ________________

25. Compared to previous product development projects of the same magnitude and scope, indicate the level of resource utilization on this project.

	Significantly Less			Same			Significantly Greater
Job-related information	1	2	3	4	5	6	7
Tools	1	2	3	4	5	6	7
Materials and supplies	1	2	3	4	5	6	7
Administrative support/services	1	2	3	4	5	6	7
Budgetary support	1	2	3	4	5	6	7
Facilities	1	2	3	4	5	6	7
Equipment	1	2	3	4	5	6	7
Engineering support (person hours)	1	2	3	4	5	6	7
Total person hours	1	2	3	4	5	6	7
Development time	1	2	3	4	5	6	7
Education and training	1	2	3	4	5	6	7
Upper management support	1	2	3	4	5	6	7

26. Indicate the adequacy of the following internal resources during the project.

	Significantly Inadequate			Sufficiently Adequate			More Than Adequate
Job-related information	1	2	3	4	5	6	7
Tools	1	2	3	4	5	6	7
Materials and supplies	1	2	3	4	5	6	7
Administrative support/services	1	2	3	4	5	6	7
Budgetary support	1	2	3	4	5	6	7
Facilities	1	2	3	4	5	6	7
Equipment	1	2	3	4	5	6	7
Engineering support (person hours)	1	2	3	4	5	6	7
Total person hours	1	2	3	4	5	6	7
Development time	1	2	3	4	5	6	7
Education and training	1	2	3	4	5	6	7
Upper management support	1	2	3	4	5	6	7

27. **Were suppliers' representatives members of the new product development team?** **Yes** **or** **No**
If *NO* go to Question number 58.

28. **How many *different* suppliers were represented on the new product development team?** ______________ Suppliers

29. **What type of supplier(s) were on the team : (Check all that apply)**

- ☐ **Raw Materials**
- ☐ **Componen: /Part**
- ☐ **Subassembly/Assembly**
- ☐ **Capital Equipment**
- ☐ **Service, Type** ______________________
- ☐ **Finished Goods/OEM**

30. **What was the *primary* reason the supplier(s) was selected? (Select one)**

- ☐ **Technology**
- ☐ **Dollar value of purchased part**
- ☐ **Type of product/service provided**
- ☐ **Proximity**
- ☐ **Length of existing relationship**
- ☐ **Expertise**
- ☐ **Other** __________
  ____
  ____

31. **How many total supplier personnel were involved in the project?** ______________________________

32. **Please indicate the type of supplier personnel who were involved in the project. (Check all that apply)**

- ☐ **Sales**
- ☐ **Engineering**
- ☐ **Quality**
- ☐ **Management**
- ☐ **Manufacturing**
- ☐ **Other,** ______________________________

33. **Indicate the supplier's involvement at each stage.**

	Not Involved			Supplier Involvement			Highly Involved
Product Conception	1	2	3	4	5	6	7
Product Design	1	2	3	4	5	6	7
Prototype	1	2	3	4	5	6	7
Tooling and Facilities	1	2	3	4	5	6	7
Ramp-up	1	2	3	4	5	6	7
Full-Scale Production	1	2	3	4	5	6	7

	Flying Distance			Driving Distance			Walking Distance
34. On average, the distance between your site and the supplier's location.	1	2	3	4	5	6	7
	0%			50%			100%
35. How complete was the project when the supplier(s) began to make comments on the product design?	1	2	3	4	5	6	7
36. How complete was the project when the supplier(s) started making commitments to purchase tools and equipment?	1	2	3	4	5	6	7
37. Length of time the supplier(s) were involved as a percentage of the total time (concept-to-market).	1	2	3	4	5	6	7
38. Number of hours committed by the supplier(s) as a percentage of total development hours on the project.	1	2	3	4	5	6	7
39. Degree of commitment made by your firm to the supplier(s) for future business.	1	2	3	4	5	6	7
40. Attendance rate by the supplier(s) as a percentage of the total meetings involved?	1	2	3	4	5	6	7
41. The percentage of business your account represents of the supplier's total business	1	2	3	4	5	6	7

42. Indicate the level of supplier's:

	Low						High
creativity	1	2	3	4	5	6	7
autonomous contributions	1	2	3	4	5	6	7
ideas generated by the supplier	1	2	3	4	5	6	7
ideas generated which were implemented	1	2	3	4	5	6	7
expertise in process technology	1	2	3	4	5	6	7
expertise in product technology	1	2	3	4	5	6	7

43. Average length of time you have been doing business with the supplier(s). ____________ years

44. How much of each of the following types of support did the supplier(s) provide in order to improve the way that the supplier and manufacturer work together?

Investment in:	No Investment			Average Investment			High Investment
Training	1	2	3	4	5	6	7
Research and Development	1	2	3	4	5	6	7
Tooling/Equipment	1	2	3	4	5	6	7
Technology (EDI, CAD, CMI, JIT, etc.)	1	2	3	4	5	6	7
Structural/Reorganization	1	2	3	4	5	6	7
Material/Prototypes	1	2	3	4	5	6	7
Labor Hours	1	2	3	4	5	6	7
Co-location of supplier	1	2	3	4	5	6	7

45. How frequently did the supplier initiate the following methods of communication with the manufacturer?

	Never			Sometimes			Very Frequently
Written Letter/Memos	1	2	3	4	5	6	7
Electronic Transfer	1	2	3	4	5	6	7
Telephone	1	2	3	4	5	6	7
Teleconferencing/Videoconferencing	1	2	3	4	5	6	7
Face-to-face/Direct meetings	1	2	3	4	5	6	7
On-site supplier representative/Co-location	1	2	3	4	5	6	7

46. When evaluating supplier(s)' performance, how much weight is placed on the following areas?

	None			Some			High
Product Cost	1	2	3	4	5	6	7
Product Quality	1	2	3	4	5	6	7
Dependability/Delivery/Due Date Performance	1	2	3	4	5	6	7
Flexibility/Responsiveness	1	2	3	4	5	6	7
Concept-to-Market Time	1	2	3	4	5	6	7
Development Cost	1	2	3	4	5	6	7

	Low						High
47. To what extent did the supplier support a design for ease of manufacturing?	1	2	3	4	5	6	7
48. To what extent did the supplier(s) update your firm's manufacturing personnel on the product design?	1	2	3	4	5	6	7
49. Indicate the level of risk the supplier(s) assumed in the project development.	1	2	3	4	5	6	7
50. How influential were suppliers in decision-making?	1	2	3	4	5	6	7
51. Indicate the amount of two-way communication with the supplier(s).	1	2	3	4	5	6	7
52. Indicate the level of supplier's agreement on project goals and priorities.	1	2	3	4	5	6	7
53. To what extent was the supplier(s) committed to the goals and priorities established by the team?	1	2	3	4	5	6	7
54. To what extent was the supplier(s) willing to share incomplete or tentative information?	1	2	3	4	5	6	7
55. To what extent was the supplier(s) willing to revise his/her decisions in light of information provided by other team members?	1	2	3	4	5	6	7

	Primarily Administrative						Primarily Technical
56. The type of support given by the supplier(s) was	1	2	3	4	5	6	7

57. The supplier(s):

	Strongly Agree						Strongly Disagree
Encouraged open expression of ideas.	1	2	3	4	5	6	7
Handled criticism well.	1	2	3	4	5	6	7
Encouraged divergent thinking.	1	2	3	4	5	6	7
Communicated honestly.	1	2	3	4	5	6	7
Did not force views on others.	1	2	3	4	5	6	7
Believed in cooperation.	1	2	3	4	5	6	7
Demonstrated confidence in others.	1	2	3	4	5	6	7
Understood other viewpoints.	1	2	3	4	5	6	7
Was trustworthy.	1	2	3	4	5	6	7
Kept commitments.	1	2	3	4	5	6	7
Was easy to work with.	1	2	3	4	5	6	7
Equitably shared credit for success.	1	2	3	4	5	6	7
Did not blame others for project difficulties.	1	2	3	4	5	6	7

58. Were you the project manager or team leader? Yes ________ No ________.

59. The project manager:

	Strongly Agree						Strongly Disagree
had the ability to recognize and mediate conflicts between groups or individuals.	1	2	3	4	5	6	7
had considerable influence which was useful in obtaining the various resources necessary to complete the project effectively.	1	2	3	4	5	6	7
had important and useful contact with other R&D professionals *within* this organization.	1	2	3	4	5	6	7
disseminated important and relevant information concerning state-of-the-art technical advances.	1	2	3	4	5	6	7
kept current and was well informed about the latest professional activities/technology.	1	2	3	4	5	6	7
prepared the environment for change.	1	2	3	4	5	6	7
empowered members of project team.	1	2	3	4	5	6	7
had a vision of project goals.	1	2	3	4	5	6	7
had the ability to communicate the vision to the team members.	1	2	3	4	5	6	7
was able to secure upper management support.	1	2	3	4	5	6	7

The following describe organizational structures associated with the new product development process. Indicate by circling the number which most closely describes the structure utilized for this project.

60.
1 — 2 — 3 — 4 — 5 — 6 — 7

1	4	7
Formal groups organized by functional specialty.	Informal groups.	No groups, each member contributed to task fulfillment.

61.
1 — 2 — 3 — 4 — 5 — 6 — 7

1	4	7
Formal groups did predefined functionally-related tasks.	Informal groups continually redefined tasks to meet project needs.	No groups, focus on task accomplishment.

62.
1 — 2 — 3 — 4 — 5 — 6 — 7

1	4	7
Process was described in terms of members' responsibilities.	Process was described in terms of interactions between team members.	Process was described in terms of tasks for developing the end product.

63.
1 — 2 — 3 — 4 — 5 — 6 — 7

1	4	7
Formal transfer points between functional groups. Extensive paper work at transfer points.	No formal transfer points – little paper work.	No formal transfer points. Continuous, overlapping of communication channels.

	Completely Sequential						Completely Concurrent
64. Product design tasks were	1	2	3	4	5	6	7
65. Process design tasks were	1	2	3	4	5	6	7
65. Product and process design tasks were	1	2	3	4	5	6	7

	Strongly Agree						Strongly Disagree
67. Establishing project goals was a team effort.	1	2	3	4	5	6	7
68. Communication between group members was continous..	1	2	3	4	5	6	7

69. To what extent do the members of the new product development team:

	Very Little						A Great Deal
like each other?	1	2	3	4	5	6	7
help each other to get the job done?	1	2	3	4	5	6	7
take a personal interest in each other?	1	2	3	4	5	6	7
trust each other?	1	2	3	4	5	6	7
look forward to being with other team members?	1	2	3	4	5	6	7
respect each other?	1	2	3	4	5	6	7
share information?	1	2	3	4	5	6	7
agree on project goals and priorities?	1	2	3	4	5	6	7
influence the design process?	1	2	3	4	5	6	7

	0%			50%			100%
70. What was the average attendance rate at project meetings by project team members?	1	2	3	4	5	6	7
71. What was the percentage of turnover by project team members?	1	2	3	4	5	6	7
72. During early meetings, what percentage of time was devoted to "team-building?"	1	2	3	4	5	6	7

73. How much *difference* existed among team members on the following dimensions?

	Great Difference						No Difference
Seniority	1	2	3	4	5	6	7
Budget authority	1	2	3	4	5	6	7
Pay	1	2	3	4	5	6	7
Facilities	1	2	3	4	5	6	7
Status in organization	1	2	3	4	5	6	7
Decision-making authority	1	2	3	4	5	6	7

74. To what extent *did your company* undertake the following initiatives to improve team effectiveness?

	Not At All						A Great Deal
Promoted Awareness/Visibility	1	2	3	4	5	6	7
Education/Training	1	2	3	4	5	6	7
Improved Communication	1	2	3	4	5	6	7
Reorganized	1	2	3	4	5	6	7
Increased Decision-making Authority	1	2	3	4	5	6	7
Provided Sufficient Resources	1	2	3	4	5	6	7
The Support of Top Management	1	2	3	4	5	6	7

75. How frequently did team members use the following methods to communicate?

	Never						Very Frequently
a. Written Letters/Memos	1	2	3	4	5	6	7
b. Electronic Mail/Electronic Bulletin Board	1	2	3	4	5	6	7
c. Telephone	1	2	3	4	5	6	7
d. Teleconferencing/Video Conferencing	1	2	3	4	5	6	7
e. Face-to-face meetings	1	2	3	4	5	6	7

	Never						Very Frequently
76. How often does your company give project members any special recognition or reward if a project is a success?	1	2	3	4	5	6	7

77. Indicate the importance of the following new product development issues to the ***manufacturing function.***

	None			Some			High
Product Cost	1	2	3	4	5	6	7
Product Quality	1	2	3	4	5	6	7
Dependability/Delivery/Due Date Performance	1	2	3	4	5	6	7
Flexibility/Responsiveness	1	2	3	4	5	6	7
Concept-to-Market Time	1	2	3	4	5	6	7
Development Cost	1	2	3	4	5	6	7

78. Indicate the importance of the following new product development issues to the ***engineering function.***

	None			Some			High
Product Cost	1	2	3	4	5	6	7
Product Quality	1	2	3	4	5	6	7
Dependability/Delivery/Due Date Performance	1	2	3	4	5	6	7
Flexibility/Responsiveness	1	2	3	4	5	6	7
Concept-to-Market Time	1	2	3	4	5	6	7
Development Cost	1	2	3	4	5	6	7

79. Indicate the importance and accessibility of the following types of information.

Type of Information	Indicate the degree of importance.							Indicate how accessible this information is to you.						
	Low						High	Difficult						Easy
Materials Reliability	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Materials Availability	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Material Quality (PPM)	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Labor Cost	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Machining Tolerances	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Parts Cost	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Parts Configuration	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Assembly Time	1	2	3	4	5	6	7	1	2	3	4	5	6	7
East of Fabrication	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Ease of Assembly	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Ease of Test	1	2	3	4	5	6	7	1	2	3	4	5	6	7

APPENDIX II

T - TEST FOR SIZE BY ANNUAL SALES

DOMESTIC SUPPLIER SAMPLE

VARIABLE	GROUP	NUMBER OF CASES	MEAN	T - VALUE	DEGREES OF FREEDOM	2 - TAIL P.
MARKET SHARE	SMALL LARGE	9 27	14.044 6.435	3.13	34	.004
DOLLAR SALES	SMALL LARGE	9 27	17.566 8.714	2.27	34	.030
REDUCE TOOL-EQUIP COST	MEDIUM LARGE	35 27	13.098 6.826	2.01	60	.049
SUPPLIER-BUYER RELATION	SMALL MEDIUM	9 35	4.051 5.090	-2.34	42	.024
SUPPLIER-BUYER RELATION	SMALL LARGE	9 27	4.051 5.251	-3.54	34	.001
GROUP PROCESS	SMALL LARGE	9 27	4.900 5.719	-3.44	34	.002

T - TEST FOR LEVEL OF INNOVATION

DOMESTIC SUPPLIER SAMPLE

VARIABLE	GROUP	NUMBER OF CASES	MEAN	T - VALUE	DEGREES OF FREEDOM	2 - TAIL P.
REDUCE WARRANTY COST	LOW MEDIUM	13 52	6.766 16.271	-2.04	63	.046
REDUCE WARRANTY COST	LOW HIGH	13 18	6.766 18.552	-2.83	29	.008
REDUCE REJECTED MATERIAL	MEDIUM HIGH	52 18	7.701 16.888	-2.75	68	.008

T - TEST FOR COMPETITIVE INTENSITY

DOMESTIC SUPPLIER SAMPLE

VARIABLE	GROUP	NUMBER OF CASES	MEAN	T - VALUE	DEGREES OF FREEDOM	2 - TAIL P.
REDUCE PROJECT DEVELOPMENT TIME	LOW	21	8.266	-2.30	39	.027
	HIGH	20	29.842			
REDUCE TOTAL MANHOURS	LOW	21	8.961	-2.63	39	.012
	HIGH	20	21.635			
INCREASE PERCEIVED VALUE	MEDIUM	42	21.074	-2.59	60	.012
	HIGH	20	56.737			
IMPROVE PRODUCT CAPABILITIES	MEDIUM	42	25.862	-2.19	60	.033
	HIGH	20	62.366			

APPENDIX III

VARIMAX5 FACTOR ANALYSIS

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
RESOURCES	Q 25.1				0.39943	
	Q 25.2				0.52271	
	Q 25.3				0.53659	
	Q 25.4				0.55027	
	Q 25.5				0.64543	
	Q 25.6				0.61575	
	Q 25.7				0.65989	
	Q 25.8				0.63476	
	Q 25.9				0.60786	
	Q 25.10				0.44789	
	Q 25.11				0.41197	
	Q 25.12				0.40303	
	Q 26.1	0.46722				
	Q 26.2				0.37908	
	Q 26.3				0.41382	
	Q 26.4					
	Q 26.5				0.43483	
	Q 26.6				0.39058	
	Q 26.7				0.41858	
	Q 26.8				0.37080	
	Q 26.9				0.37996	
	Q 26.10					
	Q 26.11	0.45465				
	Q 26.12	0.51230				
SUPPLIER	Q 28					
INVOLVEMENT	Q 31					
	Q 33.1			0.38870		
	Q 33.2			0.56323		
	Q 33.3			0.37820		
	Q 33.4			0.50607		
	Q 33.5			0.49480		
	Q 33.6			0.38708		
	Q 35			0.46827		
	Q 37			0.51763		
	Q 38			0.50676		
	Q 42.1		0.42485			
	Q 42.2					
	Q 42.3		0.37243	0.40155		
	Q 42.4		0.44947	0.34824		
	Q 50			0.63335		
	Q 56					
	Q 34					
	Q 40			0.60993		
	Q 45.1			0.50225		
	Q 45.2			0.50008		
	Q 45.3			0.53981		
	Q 45.4			0.48486		
	Q 45.5			0.42276		
	Q 45.6			0.44417		
	Q 48			0.53183		
	Q 51			0.58296		
	Q 36					
	Q 44.1			0.43728		
	Q 44.2			0.49566		
	Q 44.3			0.58543		
	Q 44.4			0.62256		
	Q 44.5			0.50650		
	Q 44.6			0.48020		
	Q 44.7			0.61432		
	Q 44.8			0.50757		
	Q 39			0.39867		

VARIMAX 5 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
	Q 41					
	Q 43					
	Q 47			0.55339		
	Q 49			0.59756		
	Q 52		0.41064	0.60568		
	Q 53		0.51506	0.55984		
	Q 54		0.61994			
	Q 56		0.58352			
	Q 57.1		0.75088			
	Q 57.2		0.73798			
	Q 57.3		0.53020			
	Q 57.4		0.80525			
	Q 57.5		0.65907			
	Q 57.6		0.81983			
	Q 57.7		0.79111			
	Q 57.8		0.81170			
	Q 57.9		0.78012			
	Q 57.10		0.75316			
	Q 57.11		0.82463			
	Q 57.12		0.74131			
	Q 57.13		0.76820			
	Q 42.5					
	Q 42.6			0.45049		
GROUP PROCESS	Q 58.1	0.63537				
	Q 58.2	0.68679				
	Q 58.3	0.50013				
	Q 58.4	0.40649				
	Q 58.5	0.47879				
	Q 58.6	0.52310				
	Q 58.7	0.57464				
	Q 58.8	0.58011				
	Q 58.9	0.65568				
	Q 58.10	0.64454				
	Q 60					0.38134
	Q 61					0.38541
	Q 62					0.34260
	Q 63					0.32829
	Q 64					
	Q 65					
	Q 66	0.38752				
	Q 67	0.37781				
	Q 69.1	0.44700				
	Q 69.2	0.65948				
	Q 69.3	0.61596				
	Q 69.4	0.61704				
	Q 69.5	0.58240				
	Q 69.6	0.58483				
	Q 69.7	0.60661				
	Q 69.8	0.60322				
	Q 69.9	0.55042				
	Q 70	0.34874				
	Q 71					
	Q 72					
	Q 68	0.56523				
	Q 75.1					
	Q 75.2					
	Q 75.3					
	Q 75.4					
	Q 75.5	0.37568				
INTEGRATIVE	Q 9.1					
MECHANISMS	Q 9.2	0.38965				

VARIMAX5 FACTOR ANALYSIS contd.

QUESTION	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
Q 9.3					0.43348
Q 9.4					0.37757
Q 9.5					0.50421
Q 9.6					0.40105
Q 9.7					
Q 9.8					
Q 9.9	0.40519				
Q 9.10					0.35832
Q 9.11					0.39201
Q 10.1					
Q 10.2					
Q 10.3					
Q 10.4					
Q 10.5					
Q 73.1					0.43480
Q 73.2					
Q 73.3					
Q 73.4					
Q 73.5					
Q 73.6					
Q 74.1	0.54658				
Q 74.2	0.50574				
Q 74.3	0.57643				
Q 74.4	0.34630				
Q 74.5	0.42810				
Q 74.6	0.48293				
Q 74.7	0.46718				
Q 76					
Q 79.1					
Q 79.2					
Q 79.3					
Q 79.4					
Q 79.5					
Q 79.6					
Q 79.7					
Q 79.8					
Q 79.9					
Q 79.10					
Q 79.11					
Q 79.12					
Q 79.13					
Q 79.14					
Q 79.15					
Q 79.16					
Q 79.17					
Q 79.18					
Q 79.19					
Q 79.20					
Q 79.21					
Q 79.22	0.36322				

OBLIMS FACTOR ANALYSIS

	QUESTION	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5
RESOURCES	Q 25 1				0 40894	
	Q 25.2				0.54611	
	Q 25.3				0.54827	
	Q 25.4				0.57232	
	Q 25.5				0.66199	
	Q 25.6				0.63400	
	Q 25.7				0.67991	
	Q 25.8	-0.35915			0.64447	
	Q 25.9	-0.35584			0.61439	
	Q 25.10	-0.37051			0.45063	
	Q 25.11				0.42209	
	Q 25.12				0.42124	
	Q 26.1	0.41632				
	Q 26.2				0.38568	
	Q 26.3				0.41723	
	Q 26.4					
	Q 26.5				0.44554	
	Q 26.6				0.40195	
	Q 26.7				0.43299	
	Q 26.8				0.38024	
	Q 26.9				0.39021	
	Q 26.10					
	Q 26.11	0.41399				
	Q 26.12	0.44182				
SUPPLIER	C 28					
INVOLVEMENT	C 31					
	Q 33.1		-0.38463			
	Q 33.2		-0.54617			
	Q 33.3		-0.34971			
	Q 33.4		-0.49365			
	Q 33.5		-0.48754			
	Q 33.6		-0.38236			
	Q 35		-0.44553			
	Q 37		-0.51453			
	Q 38		-0.50875			
	Q 42.1					
	Q 42.2					
	Q 42.3		-0.37723	-0.35224		
	Q 42.4			-0.43403		
	Q 50		-0.62041			
	Q 56					
	Q 34					
	Q 40		-0.60013			
	Q 45.1		-0.51142			
	Q 45.2		-0.51968			
	Q 46.3		-0.53207			
	Q 45.4		-0.47199			
	Q 45.5		-0.39474			
	Q 45.6		-0.45071			
	Q 48		-0.53231			
	Q 51		-0.55089			
	Q 36					
	Q 44.1		-0.43787			
	Q 44.2		-0.49190			
	Q 44.3		-0.59208			
	Q 44.4		-0.62710			
	Q 44.5		-0.52890			
	Q 44.6		-0.48686			
	Q 44.7		-0.63259			
	Q 44.8		-0.52810			
	Q 39		-0.39393			

OBLIM 5 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
	Q 41		-0.34745			
	Q 43					
	Q 47		-0.53500			
	Q 49		-0.60861			
	Q 52		-0.57004	-0.37649		
	Q 53		-0.51828	-0.48732		
	Q 54			-0.61068		
	Q 55			-0.56444		
	Q 57.1			-0.74911		
	Q 57.2			0.73509		
	Q 57.3			-0.52160		
	Q 57.4			-0.81762		
	Q 57.5			-0.65816		
	Q 57.6			-0.82466		
	Q 57.7			-0.79479		
	Q 57.8			-0.82352		
	Q 57.9			-0.70668		
	Q 57.10			-0.76341		
	Q 57.11			-0.83096		
	Q 57.12			-0.74063		
	Q 57.13			-0.78020		
	Q 42.5					
	Q 42.6		-0.42907			
GROUP PROCESS	Q 59.1	0.65007				
	Q 59.2	0.67411				
	Q 59.3	0.48407				
	Q 59.4	0.37643				
	Q 59.5	0.46373				
	Q 59.6	0.50035				
	Q 59.7	0.59685				
	Q 59.8	0.60725				
	Q 59.9	0.69732				
	Q 59.10	0.65740				
	Q 60					0.37610
	Q 61					0.38203
	Q 62					0.34550
	Q 63					0.33409
	Q 64					
	Q 65					0.35397
	Q 66	0.38340				
	Q 67	0.36329				
	Q 69.1	0.43465				
	Q 69.2	0.64159				
	Q 69.3	0.59631				
	Q 69.4	0.60387				
	Q 69.5	0.56309				
	Q 69.6	0.57020				
	Q 69.7	0.57771				
	Q 69.8	0.57708				
	Q 69.9	0.53320				
	Q 70					
	Q 71					
	Q 72					
	Q 68	0.57203				
	Q 75.1					
	Q 75.2					
	Q 75.3					
	Q 75.4					
	Q 75.5	0.36330				
INTEGRATIVE	Q 9.1					
MECHANISM	Q 9.2					

OBLIM 5 FACTOR ANALYSIS contd.

QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
Q 9.3					0.42849
Q 9.4					0.37436
Q 9.5					0.49938
Q 9.6					0.40914
Q 9.7					
Q 9.8					
Q 9.9	0.37982				
Q 9.10					0.36862
Q 9.11					0.38862
Q 10.1					0.34577
Q 10.2					
Q 10.3					
Q 10.4					
Q 10.5					0.45056
Q 73.1					
Q 73.2					
Q 73.3					
Q 73.4					
Q 73.5					
Q 73.6					
Q 74.1	0.52656				
Q 74.2	0.49543				
Q 74.3	0.55804				
Q 74.4			0.36769		
Q 74.5	0.40558				
Q 74.6	0.43392				
Q 74.7	0.41220				
Q 76					
Q 79.1					
Q 79.2					
Q 79.3					
Q 79.4					
Q 79.5					
Q 79.6					
Q 79.7					
Q 79.8					
Q 79.9					
Q 79.10					
Q 79.11					
Q 79.12					
Q 79.13					
Q 79.14					
Q 79.15					
Q 79.16					
Q 79.17					
Q 79.18					
Q 79.19					
Q 19.20					
Q 79.21					
Q 79.22					

VARIMAX 6 FACTOR ANALYSIS

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
RESOURCES	Q 25.1				0.39172		
	Q 25.2				0.52079		
	Q 25.3				0.53655		
	Q 25.4				0.55758		
	Q 25.5				0.63706		
	Q 25.6				0.60865		
	Q 25.7				0.65809		
	Q 25.8				0.64254		
	Q 25.9				0.62336		
	Q 25.10				0.46119		
	Q 25.11				0.36889		
	Q 25.12	0.34915			0.36773		
	Q 26.1	0.43939					
	Q 26.2	0.35923			0.36153		
	Q 26.3				0.39680		
	Q 26.4						
	Q 26.5	0.36346			0.42080		
	Q 26.6				0.37336		
	Q 26.7	0.41056			0.39800		
	Q 26.8				0.35395		
	Q 26.9				0.37075		
	Q 26.10						
	Q 26.11	0.48844					
	Q 26.12	0.52071					
SUPPLIER	Q 28						
INVOLVEMENT	Q 31			0.35095			
	Q 33.1						
	Q 33.2			0.51017			
	Q 33.3						
	Q 33.4			0.45571			
	Q 33.5			0.46346			
	Q 33.6			0.37389			
	Q 35			0.44005			
	Q 37			0.49618			
	Q 38			0.53698			
	Q 42.1		0.43015				
	Q 42.2						
	Q 42.3		0.37920				
	Q 42.4		0.45177				
	Q 50			0.61567			
	Q 56						
	Q 34						
	Q 40			0.62257			
	Q 45.1			0.52762			
	Q 45.2			0.51337			
	Q 45.3			0.52207			
	Q 45.4			0.49600			
	Q 45.5			0.42968			
	Q 45.6			0.47757			
	Q 48			0.53523			
	Q 51			0.58100			
	Q 36						
	Q 44.1			0.45532			
	Q 44.2			0.52184			
	Q 44.3			0.57058			
	Q 44.4			0.65035			
	Q 44.5			0.54909			
	Q 44.6			0.49254			
	Q 44.7			0.64318			
	Q 44.8			0.54440			
	Q 39			0.38105			

VARIMAX 6 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
	Q 41			0.35674			
	Q 43						
	Q 47			0.54190			
	Q 49			0.62787			
	Q 52		0.41578	0.58037			
	Q 53		0.52019	0.54940			
	Q 54		0.62290				
	Q 55		0.58653				
	Q 57.1		0.75101				
	Q 57.2		0.73884				
	Q 57.3		0.53077				
	Q 57.4		0.80444				
	Q 57.5		0.65845				
	Q 57.6		0.81932				
	Q 57.7		0.79116				
	Q 57.8		0.80858				
	Q 57.9		0.77928				
	Q 57.10		0.74861				
	Q 57.11		0.82245				
	Q 57.12		0.74240				
	Q 57.13		0.76475				
	Q 42.5						
	Q 42.6			0.39088			
GROUP PROCESS	Q 58.1	0.62813					
	Q 58.2	0.66002					
	Q 58.3	0.40856					
	Q 58.4	0.44808					
	Q 58.5	0.51057					
	Q 58.6	0.53482					
	Q 58.7	0.58912					
	Q 58.8	0.58551					
	Q 58.9	0.66204					
	Q 58.10	0.65237					
	Q 60						0.37386
	Q 61						0.37120
	Q 62						0.35783
	Q 63						0.33724
	Q 64						
	Q 65						0.37334
	Q 66						
	Q 67	0.41899					
	Q 69.1	0.41440					
	Q 69.2	0.60295					
	Q 69.3	0.57282					
	Q 69.4	0.58181					
	Q 69.5	0.54906					
	Q 69.6	0.55751					
	Q 69.7	0.56883					
	Q 69.8	0.57821					
	Q 69.9	0.49084					
	Q 70						
	Q 71						
	Q 72	0.38883					
	Q 68	0.56565					
	Q 75.1						
	Q 75.2						
	Q 75.3						
	Q 75.4						
	Q 75.5	0.37746					
INTEGRATIVE	Q 9.1						
MECHANISM	Q 9.2	0.38589					

VARIMAX 6 FACTOR ANALYSIS contd.

QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
Q 9.3						
Q 9.4						0.42854
Q 9.5						0.38877
Q 9.6						0.50934
Q 9.7						0.38380
Q 9.8						
Q 9.9	0.41432					
Q 9.10						0.35451
Q 9.11						0.37579
Q 10.1						
Q 10.2						
Q 10.3						
Q 10.4						
Q 10.5						
Q 73.1						0.42777
Q 73.2						
Q 73.3						
Q 73.4						
Q 73.5						
Q 73.6						
Q 74.1	0.56062					
Q 74.2	0.53586					
Q 74.3	0.60290					
Q 74.4	0.37505					
Q 74.5	0.43140					
Q 74.6	0.51669					
Q 74.7	0.50758					
Q 76						
Q 79.1					0.48457	
Q 79.2					0.47647	
Q 79.3					0.45050	
Q 79.4					0.41515	
Q 79.5					0.36807	
Q 79.6					0.60705	
Q 79.7					0.47005	
Q 79.8					0.58511	
Q 79.9					0.60529	
Q 79.10					0.72954	
Q 79.11						
Q 79.12						
Q 79.13						
Q 79.14						
Q 79.15						
Q 79.16						
Q 79.17						
Q 79.18						
Q 79.19						
Q 79.20						
Q 79.21						
Q 79.22						

OBLIM 6 FACTOR ANALYSIS

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
RESOURCES	Q 25.1				0.40391		
	Q 25.2				0.52426		
	Q 25.3				0.54345		
	Q 25.4				0.55036		
	Q 25.5				0.64040		
	Q 25.6				0.61230		
	Q 25.7				0.66178		
	Q 25.8				0.64295		
	Q 25.9				0.63102		
	Q 25.10				0.48221		
	Q 25.11				0.40369		
	Q 25.12				0.38790		
	Q 26.1	0.40292					
	Q 26.2						
	Q 26.3				0.37618		
	Q 26.4						
	Q 26.5				0.40832		
	Q 26.6				0.38084		
	Q 26.7				0.40215		
	Q 26.8				0.35752		
	Q 26.9				0.41309		
	Q 26.10						
	Q 26.11	0.48548					
	Q 26.12	0.43422					
SUPPLIER	Q 28						
INVOLVEMENT	Q 31		-0.38350				
	Q 33.1						
	Q 33.2		-0.46518				
	Q 33.3						
	Q 33.4		-0.40983				
	Q 33.5		-0.42957				
	Q 33.6		-0.35036				
	Q 35		-0.40416				
	Q 37		-0.47139				
	Q 38		-0.56279				
	Q 42.1			-0.39783			
	Q 42.2						
	Q 42.3			-0.35115			
	Q 42.4			-0.45385			
	Q 50		-0.58419				
	Q 56						
	Q 34						
	Q 40		-0.62794				
	Q 45.1		-0.53084				
	Q 45.2		-0.51708				
	Q 45.3		-0.49197				
	Q 45.4		-0.48474				
	Q 45.5		-0.41835				
	Q 45.6		-0.40958				
	Q 48		-0.53266				
	Q 51		-0.54152				
	Q 36						
	Q 44.1		-0.46874				
	Q 44.2		-0.51979				
	Q 44.3		-0.56760				
	Q 44.4		-0.68660				
	Q 44.5		-0.61316				
	Q 44.6		-0.49817				
	Q 44.7		-0.67804				
	Q 44.8		-0.60044				
	Q 39		-0.35795				

OBLIM 6 FACTOR ANALYSIS contd.

	QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
	Q 41		-0.37541				
	Q 43						
	Q 47		-0.53427				
	Q 49		-0.64472				
	Q 52		-0.53683	-0.38077			
	Q 53		-0.48976	-0.50082			
	Q 54			-0.63360			
	Q 55			-0.57961			
	Q 57.1			0.75998			
	Q 57.2			0.75103			
	Q 57.3			-0.54856			
	Q 57.4			-0.82951			
	Q 57.5			-0.65112			
	Q 57.6			-0.84614			
	Q 57.7			-0.79541			
	Q 57.8			-0.82260			
	Q 57.9			-0.78631			
	Q 57.10			-0.78091			
	Q 57.11			-0.84391			
	Q 57.12			-0.75245			
	Q 57.13			-0.78183			
	Q 42.5						
	Q 42.6						
GROUP PROCESS	Q 59.1	0.61812					
	Q 59.2	0.65906					
	Q 59.3	0.48048					
	Q 59.4	0.45213					
	Q 59.5	0.52750					
	Q 59.6	0.47744					
	Q 59.7	0.60259					
	Q 59.8	0.60271					
	Q 59.9	0.70675					
	Q 59.10	0.69233					
	Q 60					0.37688	
	Q 61					0.37367	
	Q 62					0.36552	
	Q 63					0.36612	
	Q 64						
	Q 65					0.39094	
	Q 66						
	Q 67	0.41507					
	Q 69.1	0.35653					
	Q 69.2	0.53760					
	Q 69.3	0.50616					
	Q 69.4	0.53194					
	Q 69.5	0.48990					
	Q 69.6	0.50857					
	Q 69.7	0.49265					
	Q 69.8	0.51890					
	Q 69.9	0.48876					
	Q 70						
	Q 71						
	Q 72	0.38313					
	Q 68	0.55270					
	Q 75.1						
	Q 75.2						
	Q 75.3						
	Q 75.4						
	Q 75.5	0.37908					
INTEGRATIVE	Q 9.1						
MECHANISM	Q 9.2					0.37466	

OBLIM 6 FACTOR ANALYSIS contd.

QUESTION	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
Q 9.3					0.44879	
Q 9.4					0.42997	
Q 9.5					0.55181	
Q 9.6					0.45227	
Q 9.7						
Q 9.8						
Q 9.9						
Q 9.10					0.41441	
Q 9.11					0.38008	
Q 10.1					0.38553	
Q 10.2						
Q 10.3					0.36845	
Q 10.4					0.37134	
Q 10.5					0.51685	
Q 73.1						
Q 73.2						
Q 73.3						
Q 73.4						
Q 73.5						
Q 73.6						
Q 74.1	0.49837					
Q 74.2	0.51868					
Q 74.3	0.58689					
Q 74.4			0.35913			
Q 74.5	0.38317					
Q 74.6	0.44142					
Q 74.7	0.39488					
Q 76						
Q 79.1						0.48849
Q 79.2						0.47699
Q 79.3						0.44254
Q 79.4						0.42721
Q 79.5						0.36792
Q 79.6						0.65838
Q 79.7						0.49646
Q 79.8						0.62409
Q 79.9						0.62487
Q 79.10						0.74163
Q 79.11						
Q 79.12						
Q 79.13						
Q 79.14						
Q 79.15						
Q 79.16						
Q 79.17						
Q 79.18						
Q 79.19						
Q 19.20						
Q 79.21						
Q 79.22						

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