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Knowledge Integration in Integrated Product Development: The Role of Team Vision, Mutual Trust, and Mutual Influence on Shared Knowledge in Product Development Performance

by

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An Abstract of

KNOWLEDGE INTEGRATION IN INTEGRATED PRODUCT DEVELOPMENT: THE ROLE OF TEAM VISION, MUTUAL TRUST, AND MUTUAL INFLUENCE ON SHARED KNOWLEDGE IN PRODUCT DEVELOPMENT PERFORMANCE

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The first objective of this study is the development of a conceptual model of knowledge integration. A clear understanding of the components of knowledge integration and their outcomes in product development may provide an important missing link in integrated product development (IPD) research. The second objective is to develop valid and reliable instruments of three determinants of knowledge integration (team vision, mutual trust, mutual influence, and shared

knowledge) and product development performance outcomes (process outcomes and product outcomes). The third objective is to explore and test the relationships between knowledge integration and IPD outcomes based on sound theory and standardized measures developed in this research.

The methodology used to derive the instruments (measures) includes in extensive review of literature, interviews with four practitioners and an evaluation with seven experts in the field. A pilot study was conducted with thirty-four product development practitioners to test the instruments. An exploratory data analysis with large sample size was then conducted to test the reliability, validity, and structural relation of the proposed model.

Structural equation modeling (SEM) methodology was used to test the relationship between constructs. Plenty of evidence exists to support the use of SEM in empirical research especially when there is a strong theoretical support about the constructs and variables, when the study involves latent variables, and when there is a possibility of existence of multiple paths among the constructs.

Based upon the results of large-scale study, an alternative model was generated to establish the relationships of the three drivers of shared knowledge in IPD. Further, recommendations for future studies are discussed including: (1) benchmark studies of firms applying the instruments developed in this research to improve actual IPD performances; (2) a combination of work and knowledge integration measures to assess a more comprehensive process and product outcomes of IPD; (3) confirmatory factor analysis, the use of multiple methods of obtaining data, and incorporation of contextual variables (e.g. knowledge environment); (4) study of role of team vision, mutual trust, mutual influence and shared knowledge in the general context of knowledge management.

Given the nature of the research, the purpose of the empirical part of the research is not to test the adequateness of proposed theoretical models and propositions based on these models, but to direct the generation of new theoretical framework for the shared knowledge and in general, knowledge integration model in new product development. All situations examined concern shared knowledge of team member with other members of development team, which in the context of this research is seen as an important consideration for a good product development practice. Yet there may exist several other contextual variables that may have different relationship with shared knowledge. This research pays particular attention to the role of team vision, mutual trust, and mutual influence on shared knowledge.

The dissertation is structured among the following chapters:

Chapter 1 provides introduction to the dissertation.

Chapter 2 identifies salient characteristics of integrated product development that has been discussed by several practitioners and academicians. The research framework proposed for this study is based on these characteristics of IPD.

Chapter 3 is on theory development with the relevant literature reviews on integrated product development, team vision, mutual trust, mutual influence, shared knowledge, and product development performance.

Chapter 4 discusses research methodology for pilot study, and the pilot study results. Recommendations for large-scale study for the research are also included.

Chapter 5 discusses the empirical analysis of large-scale study.

Chapter 6 discusses the results in terms of theoretical significances and practical significances. Recommendations for future research are also provided.

Chapter 7 concludes the dissertation followed by reference lists and appendix.

Dedicated to Our First Born
Aashvi

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There are so many people who have supported me during my academic pursuits and especially during the last two year while writing this dissertation. Because I cannot list them all here, I just want to extend my gratitude for their support and good wishes during my doctoral program.

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Chapter One

Introduction

The central importance of new product development decisions in marketing and business strategy has been recognized by strategy researchers (Penrose, 1959; Levitt, 1960; Conrad, 1963, Simmonds, 1968 etc.) In 1997 alone, 25,261 new products were launched (Fellman, 1998) which comes out to be almost 486 products launched per week or 69-plus per day. In 1998, investment in R&D in the United States climbed $221 billion (Ayers et al, 2001). Industrial R&D investment in the United States has been increasing at double-digit levels over the past five years; this pattern is expected to continue through 2000 and beyond (Larson, 2001). While new product development is vital for any business, many developmental projects fail to meet its strategical and financial objectives.

Although different literatures have defined new product development in different ways, in its basic definition, it is a process of creating and launching products, from identifying the business need to its commercialization. Yang and Yu (2002) state NPD process can be viewed as a series of activities, including idea generation, product development and product commercialization. Handfield et al. (1999) view NPD process as a series of interdependent and often overlapping activities during which a new product is brought from the “idea” stage to preparation for full-scale production or service delivery.

Successful NPD is recognized to be crucial for the companies across the industries, however development of successful NPD remains difficult and challenging, especially for innovative and truly new products. Nearly 50% of the new products that are introduced each year fail (Sivadas and Dwyer, 2000). Organizations thus find themselves in a double blind. On the one hand they must innovate consistently to remain competitive, but on the other hand innovation is risky and expensive. Rapid and successful product development ability as a competitive rationale requires product development projects continuously have to adapt, change, and improve processes and products (Framsyn, 2000).

Individuals working in the context of a business process are essentially engaged in problem-solving activities as they attempt to make sense of some phenomena (Gray and Chan, 2000). Researchers commonly view NPD as a process of problem solving and decision making regarding the developmental product’s target markets and customers, business needs, product goals and objectives, engineering characteristics, functional characteristics, bill of material, project process, production process etc (Figure 1.1). The success of products is measured in terms of their intellectual content and timeliness (Doll and Vonderembse, 1990). An effective problem solving and decision making process requires those who are in charge should be knowledgeable about the issues and the team has a collective wisdom regarding the solution. This ensures that when the solution is implemented, it is congruent with the solution developed by the team as the members have a shared knowledge about the problems, solutions, and the issues in hand. According to Doll and Vonderembse (1990), the current state of post-industrial paradigm requires manufacturing firms to integrate innovation where (1) decisions require trade-offs between multiple performance measures and (2) work groups or task forces have a shared understanding of customer preferences. Information and collective knowledge is crucial to efficient to product development (Eppinger, 2001).

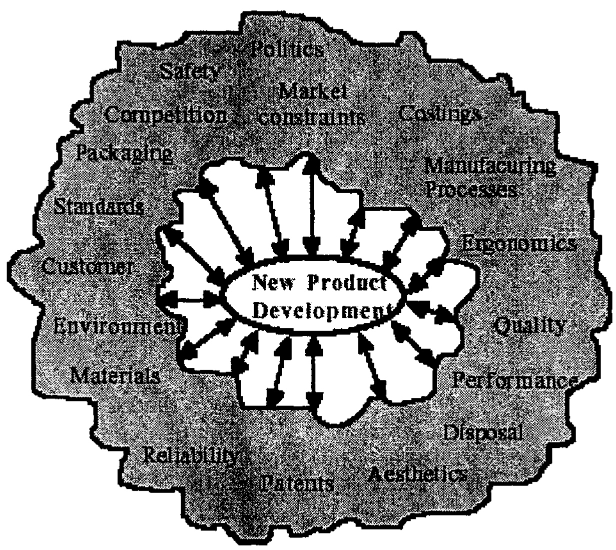

Figure 1.1 Knowledge Areas in NPD (Adapted from Pugh, 1991)

Within product innovation literature, researchers have called for developing and designing new knowledge based paradigms for business processes. The need to implement new paradigms (Deschamps and Nayak, 1995; Wheelright and Clark, 1992; Wind and Mahajan, 1997) in the knowledge economy can be attributed to the increasing complex and volatile environment that is characterized by innovative processes and must be reappraised in a knowledge management perspective. In order to generate new knowledge that is rooted in idea, expertise, information, and knowledge, innovative firms need to improve internal capabilities of exploring and exploiting their knowledge potential and integrate it with external sources of knowledge (Badaracco, 1991; Nonaka and Takeuchi, 1995).

The importance of knowledge in businesses has been attributed to at least two perspectives: *resource based view of firm and information-processing theory.*

There is a growing conviction among company managers, consultants, and scholars that organizational knowledge may constitute a key strategic resource (Boisot, 1998; Spender, 1996; Nanda, 1996). Knowledge can be seen as an intangible asset which is unique, path dependent, causally ambiguous, and hard to imitate or substitute (Cabrera and Cabrera, 2002). These characteristics make knowledge a potential source of competitive advantage, and, consequently, should be a matter of immense interests for business community in building competitive advantages through new product development.

The information processing perspective (Galbraith, 1973, 1977; Tushman and Nadler, 1978; Daft and Macintosh, 1981) implies a focus on uncertainty and what the firm does not know. The exchange of information among employees constitutes a key component in the creation and management of collective wisdom, and, consequently, the availability of tools that support such exchanges facilitates tremendously the implementation of knowledge management systems (Cabrera and Cabrera, 2002).

While manufacturing firms strive to remain competitive with NPD, from above two perspectives it clearly appears that knowledge can be a competitive asset that, if managed properly, can help combat uncertainty, solve problems, and improve overall productivity of the team.

1.1 RESEARCH AGENDA

Past researches have focused on a number of product development models that are based on integrated product development (IPD) ideas (Shyamil, 2000; Zika-Viktorsson et al, 2000 etc.). These ideas admit use of cross-functional team, concurrent engineering, and a continuous integration, which result in a raise in both quality and timesaving (Smith and Reinertsen, 1991; Shyamil. 2000; Zika-Viktorsson et al, 2000 etc.). A knowledge based perspective on product development and innovation suggests that, continuous renewal is dependent on the capacity to constantly combine and re-combine organizational and individual knowledge (Grant, 1996; Ravasi and Verona, 2001). Data, information, skill, know-how, decision making, problem solving and knowledge are key concepts in NPD and it is hardly surprising that many of the prominent researchers in NPD have included them in defining NPD. For example according to Roseanau (1996), NPD as process defines and describes the normal means by which a company can repetitively convert embryonic ideas into salable products or services Clark and Fujimoto (1991) define product development as "a process by which an organization transforms data on market opportunities and technical possibilities into information assets for commercial production".

As highlighted by several studies (Wheelwright and Clark, 1993), the final output of NPD is the result of an iterative process, mainly based on trial and error, on experimentation, failure and learning. In the knowledge view of the firm, the creation of new knowledge to be embodied in the product is a process that requires various cycles starting with the sharing of experience among the team members and ending with the building of prototype which is linked to either to improve upon the outcome of to overcome the shortcomings of the previous cycle (Buratti, 2000). Such sharing of experience and knowledge among the IPD team members should be an ongoing process during the design and developmental phases for both incremental and the innovative new products.

At the heart of realizing superior product performance in the developmental project seems to be developing organizational mechanisms that fuel the knowledge integration process where the development team can effectively utilize a wide variety of sources of knowledge and apply them in many different design and developmental tasks. In NPD, knowledge integration is seen as a process of bringing together all relevant knowledge, deriving from various different internal and external sources (Hong, 2000). The dispersed knowledge on the product and processes during the developmental process needs to be shared and understood by the team members in order to be capitalized on so that it is integrated in the work processes of the project. Such knowledge integrated approach in NPD will support the notion of continuous renewal by promoting individual and organizational learning by enhancing specialized knowledge (Nonaka and Takeuchi, 1994; Ravasi and Verona, 2001) and the periodic knowledge reconfiguration (Henderson and Clark, 1990).

However, to foster the knowledge integration in IPD is complex task, for many reasons. First, as the knowledge is embedded in people, its transfer is often far from simple: its partly tacit nature makes transfer of knowledge slow, costly, and uncertain (Kogut and Zander, 1992). Moreover, the efficiency with which knowledge can be transferred also depends upon potential for aggregation (Grant, 1996). In many cases, researchers have viewed knowledge transfer in a team as a social process. Problem solving and decision making in IPD environment requires the availability of accurate, timely, and relevant knowledge in timely fashion. As knowledge transfer requires both transmission and receipt, the parties involved in knowledge integration should be able to trust one another regarding the value and quality of information. The notion of mutual trust, although been a popular topic of interest among the research community, however has not been studied in the context of IPD.

Empowerment, team participation, and power equalization has been noted as powerful philosophy of high performance team which also seems to be relevant in the context of knowledge integration. Power and authority are relevant and important in the NPD process as team members belong to diverse functional areas. Knowledge integration requires that the team members should share an equal power base so that it ensures knowledge can be freely shared with one another and is not simply dictated upon by the powerful actors of the team. For such open and free sharing of knowledge, knowledge integration should insure that it brings the necessary changes in the perception and attitude of the team members through knowledge sharing participation. With knowledge transferred, team members should be able to reflect in their behavior in response to newly available information. It makes no sense that one party is willing to provide the expertise, but the other party is either not willing to receive it or do not act upon it. Team members should be willing to share knowledge on one hand, and should also be willing to accept and challenge each others idea and knowledge before acting upon such knowledge on the other hand. The absorptive capacity of the sender and recipient of the transferred knowledge is critical (Cohen and Levinthal, 1990) in the knowledge integration. Such participation in knowledge sharing process seems to be embedded in the concepts of mutual trust and mutual influence that can ensure open transmission and reception during knowledge sharing process based upon the notion of mutuality.

Implementing a knowledge-driven approach in the NPD in the post-industrial era may need several new initiatives, affecting the processes and practices:

1. recognizing product development processes as problem solving activities with overlap decision making in an integrated product development (IPD) environment that requires knowledge exploration, knowledge integration, and eventually knowledge exploitation;
2. recognizing that any product development goals, strategies, and targets needs to be understood and accepted by the development team so that the team possess a collective wisdom regarding the project;
3. identifying ways to promote knowledge sharing among the cross-functional teams and sub-teams that leads availability of valuable information to the right person, at the right time;

4. organizing product development teams in non-hierarchical ways where the team members can influence one another which encourage knowledge flows thus enabling learning processes and the transformation of tacit ,embedded knowledge into explicit knowledge embodied in the new product;
5. to integrate dispersed knowledge of customers and suppliers with the knowledge of organizational team members and of the processes to enhance performance.

1.2 PROBLEM IDENTIFICATION

Knowledge integration affects the entire process of product development. Since critical failure occurs at the front-end, effective knowledge integration should start in this early stage of product ideation and its impact on the performance needs to be properly measured. With the absence of good conceptual models of knowledge integration and instruments that test and validate the models, understanding and evaluating the effectiveness of knowledge outcomes in product development teams is still a difficult task (Hong, 2000). Research in knowledge integration area is still in an early stage and defining the contexts of knowledge integration in IPD are still rare (Pisano, 1994; Grant, 1996; Johannessen et al., 1999; Hoopes and Postrel, 1999).

Dan Holdhouse, quoted in Allee (2000), described the new managed knowledge organizations in the following terms “managing for knowledge means creating a thriving work and learning environment that fosters the continuous creation, aggregation, use and reuse of both organizational and personal knowledge in the pursuit of a new business value". Exactly on this argument lies the importance of knowledge integration. *Knowledge is to be shared and as it is shared, it multiplies.* In NPD environment, knowledge may be transferred through interaction and communication between individuals of the development team, or through artifacts, i.e. knowledge embedded in processes, products, or other forms of 'knowledge carriers'. As such, it is widely agreed that knowledge transfer is a social process with clear implications to the behavioral issues in team. In spite of the extensive research on groups and teams, little research has been conducted to explore *what causes team members to* share information or *share knowledge* while they collectively work together toward common objectives in IPD environment.

In order to build a research around the area of knowledge integration in IPD, it is important first to recognize and understand some salient characteristics of IPD that seemed to be embedded in past researches and the best practices. These characteristics are summarized below and discussed in detail in the next chapter.

1. IPD is a *goal driven* project that is based on overall business strategy. Goal formulation is a critical and one of the initial phases of NPD project.
2. IPD activities are based upon the *interdependent relationships* of team members and various stages in the development processes
3. IPD is a *knowledge intensive* process that requires integration of knowledge of the cross-functional team members in order to solve complex problems during the design and development phases.

4. IPD is a performance oriented activities. The final outcomes of NPD should be measured in terms of both product and process outcomes.

Based upon the above important characteristics of IPD, this dissertation explores the field of research in NPD that emerges when the four variables team vision, mutual trust, mutual influence, and shared knowledge are combined. Separately, each of the domains defined by these variables has attracted a substantial if not massive amount of research in various streams and occasionally in the area of NPD. However, these variables have not been studied collectively in the specific context of IPD team. Moreover, the research on shared knowledge in knowledge management field remains limited and the researches on shared knowledge in the specific context of product development remain significantly few.

A combined understanding of how the interaction between team vision, mutual trust, and mutual influence can help in knowledge sharing issue appears a prerequisite for understanding the difference between a successful product development and unsuccessful product development in IPD environment where the work integration mechanisms have been well researched but the issue of knowledge integration remains largely ignored. As such, this dissertation is based upon two current popular research streams of IPD and knowledge integration.

Although the definition and detailed discussion of various concepts are presented in the subsequent chapters, Table 1.1 summarizes the terminologies used in this study.

Table 1.1: Terminologies and Definition

Terms	Definition
Integrated Product Development (IPD)	cross functional product, parallel product development that is used to optimize the design, manufacturing and supporting processes to enhance multiple outcomes of product development
Work Integration	operational optimization of cross-functional workflows for enhancement of multiple product development outcomes
Knowledge Integration	the extent of shared understanding of cross-functional team members through strategic focus and disciplined problem solving to enhance multiple performance outcomes in product development
Team Vision	the extent of a shared understanding of the project mission, strategic fit and the project target for product development
Mutual Trust	mutual expectation among product development team members that everyone will work together in good faith
Mutual Influence	symmetrical power relationships among members of the product development team
Shared Knowledge	shared understanding of customers, suppliers, internal capabilities, and process in cross-functional product development team
IPD Outcomes	performance measurements of IPD in terms of process outcomes and product outcomes

1.3 RESEARCH OBJECTIVES

This dissertation aim to contribute to the understanding the key determinants of knowledge integration in IPD by identifying relevant constructs and measures. As such, this study has several objectives.

The *first objective* of this study is the development of a *theoretical framework* of knowledge integration in IPD environment. An understanding of these relationships may provide an important missing link in IPD research. The theoretical framework of IPD is generally based on fundamental concepts such as total quality management, multi-functional teams, computer-aided tools, process simplification, data standards, enterprise integration, and reengineering (Hunt, 993). The theoretical domain of IPD has been determined by its objectives: reducing time (Paterson, 1993; Gupta and Wilemon, 1990; Blackburn, 1991), cutting costs (Hartley, 1990; Carter and Baker, 1992; Handfield, 1994), enhancing quality (Zairi, 1994), effective design of product and process (Rosenthal, 1992), and manufacturability (Ha and Porteus, 1995; Swink, 1999). Given the large body of relevant theoretical and a few empirical studies concerning the constituent concepts of knowledge integration, and product development performance, the research involves a substantial theoretical exploration stage combined with an investigation of product development teams in practice. A clear understanding of the components of knowledge integration and their outcomes in product development may provide an important missing link in the IPD research (Hong, 2000).

The *second objective* is to develop valid and reliable instruments for: (1) the three determinants of shared knowledge (team vision, mutual trust, and mutual influence, (2) shared knowledge (shared knowledge of internal capabilities, shared knowledge of customers, shared knowledge of suppliers, and shared knowledge of process), and (3) product development performance outcomes.

Knowledge literature usually focuses on a particular aspect of knowledge integration but has not presented a model that captures the complex nature of knowledge integration in IPD. Hong (2000) empirical study in knowledge integration in product development is an exception. Strategy literature has emphasized the importance of integrating strategic goals to project targets (Englund and Graham, 1999; Khurana and Rosenthal, 1998) but it is not clear how to assess the extent of strategic integration at project team level. Empirical evidence for the relationship between trust and learning ranges from Dodgson's (1993) work on trust, showing that trust between people encourages learning, to Kale et al.'s (2000) work on inter-organizational alliance reporting significance positive effect of trust and learning. Role of mutual influence on knowledge sharing also seems to appear in various literatures (Kanter, 1972; Prahalad and Hammel, 1990 etc.) in various streams of studies. However, neither mutual trust nor mutual influence had been studied in the context of IPD or knowledge integration.

The appropriation of relevant shared knowledge is also stressed but exactly what constitute this shared knowledge is not yet-well-defined (Nonaka and Takeuchi, 1995; Singh, et al., 1997; Madhavan and Grover, 1998). Many success factors of IPD have been identified but their interrelationships in the context of knowledge integration have not been explored further (Cooper and Kleinschmidt, 1995; Cooper, 1998; Cooper, 1999). The key assumption is that by bringing people, technology and processes together it is possible to simultaneously achieve the multiple performance requirements mentioned above. In this context, IPD researchers emphasized the importance of the integration of these factors but have not precisely examined the interrelationships of these key components of knowledge integration in terms of team vision, mutual trust, and mutual influence.

The *third objective* of this research is to develop valid and reliable instruments of knowledge integration (i.e., team vision, mutual trust, mutual influence, and shared knowledge). Instrument development is a necessary foundation to test and validate a conceptual model. Many of the instruments used in this study would be borrowed from relevant past researches, for example Hong (2000), Syamil (2000), Koufteros (1996), and in many cases these instruments would be modified to suit more closely this study. These standardized measures intend to be *objective* (e.g., testable with unambiguous procedures for documenting empirical evidences of learning practices of automotive industries in IPD), *quantifiable* (e.g., numerical indices in terms make it possible to report results of knowledge integration practices of different firms in numbers), *communicable* (e.g., the process and product outcomes of learning practices are communicable to other researchers), *economical* (e.g., researchers and firms are able to save time and money in studying and comparing their integrated product development with others), and *scientifically generalizable* (e.g., the instruments may be useful beyond particular industries) (Nunnally, 1978).

The *fourth objective* of this study is to *test the relationships* among the drivers of shared knowledge (i.e., among the constructs of team vision, mutual trust, and mutual influence), the relationship of these drivers with shared knowledge, and the relationship of all these constructs with product development performance outcomes on the sound theory and standardized measures developed in this research. However, since some of these constructs are being studied for the first time in the context of IPD and knowledge integration, the research would take and exploratory mode rather than a confirmatory approach. *Alternative models* could be generated to test for alternative relationships among these proposed constructs.

The *fifth objective* of this dissertation is to advance the theory of knowledge integration. A fruitful research in IPD requires a good understanding of the subject matter based on sound theories, research methodologies, and valid and reliable empirical findings. As of now, this study is one of a few studies in knowledge integration in IPD of manufacturing industries. Many studies in this area have been conceptual and case studies. Bases on the empirical results of this study, future direction of research will focus on methodological, structural and practical dimensions of IPD research. The research findings will be helpful to further promote understanding of this important research topic. Furthermore, it may shed better light on how to enhance IPD performances through knowledge integration.

1.4 CONCLUSION

A knowledge integration perspective in IPD seems to be important to manage complex challenges surrounding product development projects. However researches in this are very few. The primary objective of this study is to develop the theoretical model of knowledge integration in IPD. As a starting point, Chapter 2 identifies and discusses key characteristics of IPD that will provide the foundation for the research model for this study.

Chapter 2

Theory Development

2.1 INTRODUCTION

Manufacturing companies have long recognized that product development activities add value to the business and NPD process is their core business process (Berden et al., 2000). Wheelwright and Clark (1992) commented that firms that can develop products, which can satisfy the needs and expectations of customers, and can, market them much faster and more efficiently, create significant competitive advantages. However, product development operates in a turbulent environment that has stimulated several new challenges for a successful product development. Fast *technology innovation* (Goldhar et al., 1991; Wheelwright and Clark, 1992; Nijssen et al., 1993; Birnbaum, 1998; Minderhoud, 1999; Brombacher and de Graef, 2001), increasing *globalisation and segmentation* (Classen and Lopez, 1998; Murthy et al., 1994; Brombacher and de Graef, 2001), increasing *complexity in customer requirements* and perceptions over product performance (Goldhar et al., 1991; Wheelwright and Clark, 1992; Brombacher and de Graef, 2001), and *increasing pressure on time-to-market* (Stalk and Hout, 1990; Goldhar et al., 1991; Wheelwright and Clark, 1992; Minderhoud, 1999) have created a highly competitive market and challenges for innovation process.

2.2 NPD PROCESS

There are several definitions of NPD in the literature (Andreasen and Hein, 1987; Clausing, 1994; Mcgrath, 1996; Hanssen, 2000; PDMA, 2001). Hanssen (2000) uses a general NPD process that starts with a perception of market needs and ends with the market introduction of a new or improved product without taking into account the many differences between each product development project. Product Development and Management Association (PDMA) defined NPD process as a disciplined and defined set of tasks and steps, which describe the normal means by which a company repetitively converts embryonic ideas into saleable products or services (PDMA, 2001). Clausing (1994) gave a more specified definition of a NPD process: a process to develop products through the phases of concept, design and production. Other definitions sometimes gave more details of a PDP by breaking the three phases defined by Clausing (1994) further into more detailed development activities.

Based on the degree of technical changes in products as well as their applications, two major types of NPD processes can be distinguished (Andreasen and Hein, 1987, Wheelwright and Clark, 1992) in literatures.

- *Radical NPD*: Radical products are new products, which generally contain new technologies and significantly change behaviors and consumption patterns in the marketplace. The first MP3 player is an example of radical product.
- *Derivative NPD*: Proven technologies are used to create products based on mature building blocks from existing products. Some product features

are modified, refined, or improved without affecting the basic product architecture or platform. Such processes usually require substantially fewer resources than processes that develop totally new products. Intel's Pentium (III) processors are example of derivative products.

The following stages are the most common stages in a product development processes (Bingham and Quigley, 1990).

Stage 1: Idea generation: Information from existing or potential markets is obtained by marketing research and directed for evaluation. Members of development team review this information, focusing upon product/service ideas to meet competitive offerings.

Stage 2: Idea Screening: The idea-screening stage focuses upon narrowing the range of ideas into subgroups based upon their probability of success and the time horizon for implementation. To accelerate this stage of the process, it is accomplished in conjunction with idea generation.

Stage 3: Conceptual Development and Testing: During this stage, the product ideas that form the new product implementation list must be precisely defined. The ideas must emerge into well-formulated sets of attribute designed to appeal to specific sets of consumers.

Stage 4: Business Analysis: An idea that seems appropriate to company mission and strategy thrust is forwarded to research and development, where the new product concept is translated into a concrete, tangible entity.

Stage 5: Product Development: At this stage, the idea has completed its transformation into a physical product. Technical and design problems are resolved and consumer reaction is gauged in order to develop entry strategies.

Stage 6: Test Market: Prototypes that survive the product development stage but do not yet meet the criteria to proceed to commercialization enter the test market stage

Stage 7: Product Introduction: The idea generated once regarding the new product has reached its final stage. A full scale production and commercialization of the new product takes place.

Figure 2.1 exhibits the NPD process typical among the firms (Hertenstein and Platt, 2000) that is based upon popular and commonly used stage-gate model.

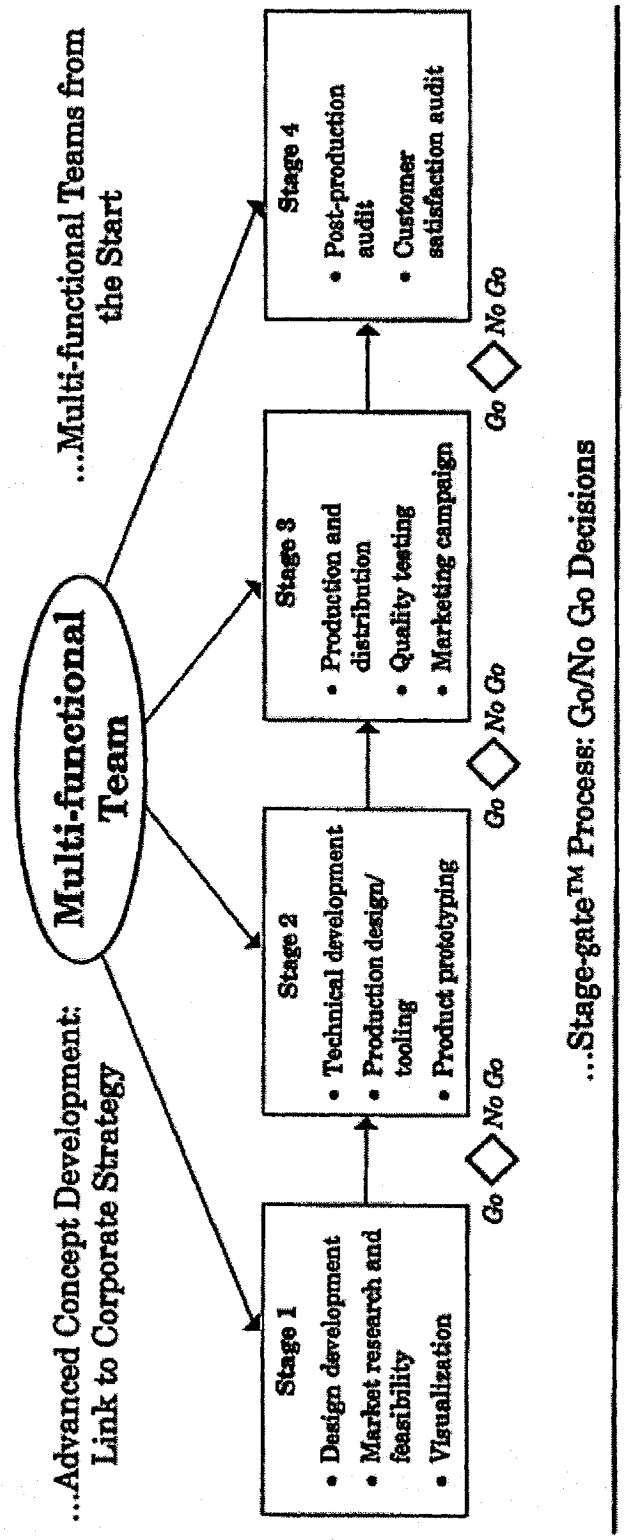

Figure 2.1 A Typical Stage-Gate NPD Process with Go/No Go Decisions

(Adapted from Hertenstein and Platt, 2000)

As shown in Figure 2.1, advanced concept discussions informed by strategy generate product concepts that cross-functional teams design and develop into the final product prototype in stages. At stage-gates between the stages, senior managers re-evaluate the project and decide whether to proceed with the development (Hertenstein and Platt, 2000). Throughout the development process, knowledge sharing plays an important role to ensure high team productivity, on time product development, improved quality, and lowered product cost. Shared knowledge among the functional expertise helps team in solving problems at each stages and evaluating the work at each gates during the course of the project. It has thus been well discussed and accepted that the core of any NPD lies in problem solving and information processing.

The importance and criticality of information and knowledge in the context of NPD has been identified and discussed in past few researches. For example,

1. NPD is a *problem-solving* activity. Wheelright and Clark (1992) state "...in the final analysis, when we search for an understanding of truly outstanding development, we must eventually get down to the working level where individual designers, marketer and engineers work together to make detailed decisions and solve specific problems. The magic of an outstanding product is in the details. Thus, detailed problem solving is at the core of outstanding development."
2. NPD is *complex* problem-solving activity. In Clausing's (1994) words, "..in developing a complex-product, there maybe 10 million decisions. Although individuals can make most decisions, the most critical decisions (roughly

1,000 to 10,000 for large, complex products) require more attention, and most of them do not lie entirely within the experience of any individual or group." Ulrich and Eppinger (1995) state that "... very few products can be developed in less than a year, many require three to five years, and some take as long as ten years."

3. Decisions made in different sub-problems have to be *checked for consistency*; and earlier decisions have to be checked for consistency with later decisions (Vassilakis, 1997). Lack of consistency implies revision of decisions already made, i.e. rework.
4. NPD is a *knowledge-intensive* activity (Eder, 1997; Iansiti and MacCormack, 1997; Nonanka and Takeuchi, 1995; Song and Weiss, 1998, Hong; 2000).
5. Fast product developers use the *degree of interaction among decisions,* not membership in a skill category, as the criterion of assigning decisions into sub-problems (Vassilakis, 1997). Sub-problems are usually identified with teams, because each sub-problem is the responsibility of a dedicated team. In Clausing's (1994) words, "many critical interfaces have a dedicated team. Teams are formed whenever they are needed to achieve an integrated approach to the development of the new product. The formation of the best interlocking structure of teams is a key success factor."

Ulrich and Eppinger (2000) suggested that a NPD process could be described as an information processing system. It begins with input such as the corporate objectives and capabilities of available technologies, product platforms, and production systems. This requires shared knowledge by NPD team regarding various functionalities and processes. Then it moves on processing the development information, formulating specifications, concepts, and design details by conducting various activities. Finally, it ends when all the information required supporting production and sales have been created and communicated. Information and knowledge should be shared and members should be ready to act upon such shared knowledge by trusting and influencing one another. The core of the NPD process, the information transformation process consists of a number of interconnected development activities that transform information inputs into information outputs. Output information from one activity becomes input information for one or more other activities regardless if the product development is sequential or the tasks are being executed in parallel using concurrent engineering.

From above it becomes clear that various functional knowledge are embedded in processes of IPD and team members in the product development. The major challenge in IPD thus becomes in determining ways to integrate this dispersed knowledge into shared knowledge for successful product development.

This thesis focuses on the importance of knowledge transformation or more specifically, knowledge sharing among the NPD team members and explores the determinants of knowledge integration.

According to Jassawalla and Sashittal (1999), the most difficult yet important challenges facing product development teams are "integration of markets, products, and technologies". Developing highly successful new products is possible through the integration of the abilities of both upstream (e.g. design engineers) and downstream knowledge workers (e.g. manufacturing engineers). Such knowledge integration of cross-functional teams is a key aspect of integrated product development (IPD). In this study, *integrated product development (IPD) is defined as "cross functional product, parallel product development that is used to optimize the design, manufacturing and supporting processes to enhance multiple outcomes of product development"* (Hong, 2000; Ettlie, 1995; Moffat 1998; Magrab, 1997; DoD, 1998). In reality however, in such IPD environment that uses cross functional team approach, each function (R &D, marketing, engineering and manufacturing) operates in a fragmented and separated manner, barriers of communication exist, knowledge is not properly transferred and complex problems are not resolved in a timely manner. As a consequence, firms are less able to focus in multiple performance goals (e.g., time, quality, cost and delivery) and to achieve strategic goals (Hong, 2000).

According to Kim (1993) the team learning process goes through Kofman's OADI cycle (observe, assess, design and implement). In his model, conceptual (i.e., assess and design) and operational (i.e., implement and observe) learning is distinguished. Work integration in IPD has the cycle of implement and observes (Hong, 2000). The implementation cycle of product development is devising optimum workflows. The observation cycle of product development is evaluating actual enhancement of multiple product development outcomes. In this thesis, *work integration in IPD is defined as "operational* *optimization of cross-functional workflows for enhancement of multiple product development outcomes".* In brief, the IPD cycle has both knowledge and work integration. The focus of study in this thesis is on knowledge integration in new product development that improves development performances.

Knowledge integration in IPD has the cycle of assess and design (Hong, 2000). The assessment cycle of a product development team is to explore and process knowledge through sharing information and data. The design phase is the transformation of these idea and information into specific instructions that is agreed and understood by the NPD team members. In this thesis, *knowledge integration in IPD is defined as "the extent of shared understanding of cross-functional team members through strategic focus and disciplined problem solving to enhance multiple performance outcomes in product development".*

On a team level, the conceptual aspect of learning is knowledge integration (i.e., know-why learning by planning or modeling) and the operational aspect of learning is work integration (i.e., know-how or learning by doing). By focusing on knowledge integration, the objective of this study is to find the determinants of shared knowledge that can lead to a superior performance of NPD.

2.3 CHARACTERISTICS OF IPD

In past, researches in the area of knowledge integration have been largely ignored. The seminal work of Brown and Eisenhardt (1995) provides important insight for developing the research framework of knowledge integration in IPD, the focus of this study.

In their literature review of NPD, Brown and Eisenhardt (1995) identified three perspectives: product development as rational plan, communication web, and disciplined problem solving.

The *rational plan* body of research is characteristically exploratory and non-theoretical, and it typically serves to identify the factors that influence the financial performance of the product. The premise of the rational plan perspective is that new product success virtually depends on good planning, implementation, and management support, and the objective of its research is to identify specifically the critical factors from these areas. Cooper's body of work (Cooper, 1980, 1984, 1984b, 1999 etc.) is a good example of the rational plan school.

In the *communication web* model, team group process external communication and internal communication factors mediate project leadership and process performance, and team composition directly affects process performance. An important result from the communication web research is the validation of the value of cross-functional teams and the importance of how they synthesize their diverse *thought worlds* interactively and iteratively, collaborating on concrete tasks, and violating routines and existing organizational barriers (Dougherty and Heller, 1994). Communication web research clarifies the role and value of external task and political communication; the interaction of the NPD team with its environment through *gatekeepers* and *heavyweight project managers*.

For the *disciplined problem-solving* model, NPD process performance directly depends on R&D and supplier networks and cross-functional team composition. Process performance is affected by team process and the team organization of work. Heavyweight project leadership and senior management provide *subtle control* allowing the team to work autonomously and providing a clear guiding vision of the product, intended image that directly influence product concept effectiveness.

In their synthesis of these perspectives, Brown and Eisenhardt (1995) recognized that the financial success of a new product depends on the outputs of the communication web and disciplined problem-solving models

From IPD perspective, NPD as rational plan can fall into work integration, where as knowledge integration research seems to be more suitable to be categorized in the other two streams; i.e. communication web and disciplined problem solving.

The knowledge generated (on the product, process, organization of the project) during product development must then be capitalized by the IPD team and it is to be integrated across projects over the time. Developing organizational mechanisms that fuel the *knowledge integration process* becomes a key factor for successful innovators. In NPD, knowledge integration is seen as a process of bringing together all relevant knowledge, deriving from different sources, either internal (company employees) or external (suppliers and customers).

In order to develop the research model for knowledge integration, a review and understanding of some salient characteristics of product development seems to be a pre-requisite. The next section highlights some important features of IPD which will then help to conceptualize key variables of the research model of knowledge integration in IPD.

2.3.1 Characteristic 1: Strategic Orientation and Goal Driven

An organization's process for NPD should serve to improve its performance as it innovates with new products or services, repositions existing products and services, and extends lines to expand into new market segments (Hustad, 1996). Product strategy and planning involve decisions about the firm's target market, product mix, project prioritization, resource allocation, and technology selection. Mansfield and Wagner (1975) show that these factors have a significant influence on the probability of economic success.

An investment in NPD projects are strategic undertaking, defining the business strategy in terms of cost, quality, and speed and aligning it with the business opportunities (and threats) created by the new product. The starting point of NPD is the alignment of the new product with the overall business objectives. According to Cooper et. al. (1999), those who optimize their R&D and marketing investments define the right new product strategy for the firm, select the winning new product projects, and achieve the ideal balance of projects and will win in the long run. Companies should critically consider the portfolio management (of NPD) whereby decision processes regarding list of active products is constantly evaluated, selected and prioritized (Cooper et. al. 1999). Strategically, business portfolios of best projects and products should be aligned with the business strategy and objectives. Based on Wheelright and Clark (1992), product and process development leads to bottom line performances for rich financial rewards such as improved return on investment, higher margins, expanded sales volume, increased value added, lower costs, and improved productivity.

Fitzsimmons, Kouvelis and Mallick (1991) emphasized the need for a fit between a product design task and strategy. An idea that seems appropriate to company mission and strategy thrust is forwarded to research and development, where the new product concept is translated into a concrete, tangible entity. Cooper (1988) describes the early stage as a four step process in which ideas are generated (1), subjected to a preliminary technical and market assessment (2), and merged to coherent product concepts, (3) which are finally judged for their fit with existing product strategies and portfolios (4). A cross functional team along with customers and suppliers may be involved to collect relevant information during this early stage for developing new product concept, functions and characteristics. Accordingly, as Hustad (1996) puts, the strategic orientation of NPD should facilitate: the explicit identification opportunities, explicit formulation of goals for NPD, aid in idea and concept development, product design, and reduce uncertainty and risk.

For highly uncertain NPD situations, prototyping, rapid iteration, and direct customer contact work better than rigorously applied project management. Groups learn in the early stages of NPD projects through chaotic, non-goal-directed interactions. As the product approaches commercialization, the group depends more on clear goals and formal management. Reducing the cognitive load of making sense of the uncertain situation in the beginning of an NPD project by imposing clear metrics, goals, and responsibilities, reduces learning by inhibiting the variety of information the group processes and creates. Through integrated knowledge, the group applies its understanding, and a framework for the interpretation of new information develops and goals emerge. These goals further reduce the field from which new information is sought and accepted. In the NPD process, the product concept materializes. Knowledge integration of knowledge provider and bearer, open communication, clear understanding of product goals, open participation at this stage ensures a good product development practice. Based upon this interchange of information, the team compiles a new product idea array, each idea being defined by a measure of probable success and a time dimension for implementation.

In essence, the starting point of NPD process defines the downstream effort of the future and it is important that the development team has a clear understanding of the goals, objectives, and mission of the new project in order to secure cooperation and commitment. Establishing a clear and stable vision for the project, securing team and management support for the vision, and installing a system for documenting, filing, and reviewing team information, specifications, and notes lead to the efficient acquisition of information and its effective implementation (Lynn, 2000). All of the steps in the NPD process, upstream and downstream, need to be integrated with the design and development of the process that will minimize the total cost of providing and communicating its value.

The entire life cycle of the product needs to be considered throughout the NPD process as well. In their seminal article, From Experience: Linking Projects to Strategy, Enguland and Graham (1999) report the formation of a top management team (project managers, high level functional managers, and customers) to identify and select sets of projects that achieve organizational goals. The team clarifies or develops the goals expected from each project in terms of purpose, vision, and mission. Team vision is, in a sense, a focus on innovative problem definition. Team vision directs team members to set broad and specific goals that lead to desirable IPD performance outcomes. Sharp et al. (2000) purpose that shared vision, purpose, goals and direction are among the key enablers for a high performance team.

Use of cross-functional team in the IPD environment provides several challenges and opportunities for managing NPD as each functional member has different expertise, different priorities, and different motivation. Issues like establishing objectives, processes, and procedures for directing the involvement and the establishment of organizational coordination mechanisms (Bruce et al, 1995; Ragatz et al, 1997) are considered as critical success factors to overcome major differences in style, priorities, and motivation (Tabrizi and Walleigh, 1997). Takeishi (2001) refers in this context to integrative capabilities, like architectural knowledge, integrated problem solving, and internal coordination as critical factors determining the quality of the design outcome of joint development effort. The starting point of such integrated effort should begin with the goal formulation. Early participation of marketing, R&D, and manufacturing in the early stages of the NPD process, such as strategy formulation, new product idea generation, and new product project selection leads the three functions to share commitment and responsibility for projects (Pinto, Pinto, and Prescott, 1993) which is consistent with the goal-setting theory of goal formulation, goal acceptance and goal commitment being important variables of highly successful team. NPD being a highly knowledge intensive process, the notion of collective ambition seems highly appropriate for a cross-functional team.

Weggeman (1995) describes the development of an intervention technique designed for knowledge intensive organizations as '*collective ambition development*'. The term collective ambition refers to an organization's mission, its goals and its strategy when they are widely shared. The development of a collective ambition, which can be either an explicit or a more implicit process, is mainly aimed at the development of commitment of the members of an organization. When a collective ambition is widely shared, the members of an organization have internalized the same set of goals. Such a strong collective ambition therefore enhances the chance that two colleagues have congruent goals. In addition to offering employees the opportunity to learn about each other's value structure, a participative collective ambition development offers them also the opportunity to see each others behavior in an important decision making process. Participation in strategic decision making will increase the feeling of procedural justice (Korsgaard, Schweiger & Sapienza, 1995; Kim & Mauborgne, 1998). Procedural justice is the extent to which the dynamics of the decision process are judged to be fair (Kim & Mauborgne, 1998).

Empirical studies by Pinto, Pinto, and Prescott (1993) have shown that goal incongruity causes inter-group conflict that may be reduced by the introduction of super ordinate goals. *Goal incongruity* is defined as the basic difference within the firm between marketing's goals and values and those of the R&D and manufacturing departments. A high level of goal incongruity generally leads to a high level of cross-functional conflict and open hostility (Pinto, Pinto, and Prescott 1993; Rahim 1986). When marketing's goals differ greatly from those of R&D and manufacturing, marketing may presume that the others' progress interferes with its own, and therefore it has little incentive to cooperate (Dyer and Song 1997; Tjosvold 1991).

In order to secure cooperation among the IPD team members, and have a high level of commitment to the objectives of the new project, the NPD process should begin with a joint goal development for the project. Defining NPD strategy, clarifying roles and responsibilities, defining targets, the development of collective ambition or shared team vision seems to be a pre-requisite of integrated effort in IPD environment. Involvement and engagement in formulating team vision by the team members who eventually are going to execute the NPD process will lead to a higher level of cooperation and commitment and lower the goal incongruity. A lack of shared vision is a major reason for disappointing performance (Lynn, 1998). According to Leonard-Barton et al. (1994), a clear vision that is shared and agreed upon by others on the team (i.e., coherent vision) was recurring themes for successful innovation.

The strategic orientation of NPD reflects the strategic directions implemented by a firm to create the proper behavior for the continuous superior performance of the business (Gatignon and Xuereb, 1997). The strategic orientation involves clarity of directions, and is generally articulated through vision and mission statements of the firm manifested through the selection of ideas and allocation of the resources. Bart (1998) found that portions of strategic process, including the statement of competitive strategy and the articulation of goal, have significant effects on innovativeness of the firm.

This initial step and inherent characteristic of a NPD process, i.e. strategic orientation and goals is clearly an important characteristic for a successful product development.

2.3.2 Characteristic 2: Relationship Orientation

IPD processes involve two major practices:

- *Parallel or concurrent processing* of the development process steps (Takeuchi and Nonaka, 1986; Karagozoglu and Brown, 1993; Murmann, 1994)
- Improving the R&D–marketing–manufacturing interface by establishing *cross-functional teams* (Griffin, 1992; Towner, 1994)

The traditional product development process is sequential, with each stage following in logical order (Sommers, 1982). The screening of idea follows from the development of ideas; business analysis follows from concept testing, and so forth which are illustrated in Figure 2.1. Depending upon a number of factors certain stages may be leap-frogged or partially omitted (Hertenstein and Platt, 2000). Cooper (1993) identifies 13 distinct NPD stages of what is popularly known as the *stage-gate* process with senior management making go or no-go decisions between each stage. Griffin (1997) reports that over 60 percent of surveyed manufacturing firms use a cross-functional stage-gate NPD process. As opposed to the sequential approach, concurrent engineering is often considered as a *rugby race* (Meyer, 1997). It emphasizes the parallel consideration of all aspects of product introduction rather than the more traditional sequential approach. It requires considerably ongoing interaction between the various business functions involved and is at all times a team effort. Many researchers concluded that concurrent engineering offers companies a better approach to significantly reduce the time it takes to bring products to their customers as well as to substantially improve quality and reduce cost (Takeuchi and Nonaka, 1986; Cleetus, 1992; Dicesare, 1993; Handfield, 1994; Minderhoud, 1999).

Regardless a firm uses sequential approach or concurrent engineering, developing and implementing an NPD process is a formidable task that presents many complex technical and organizational problems to resolve. It involves the application of new technologies and the resolution of tradeoffs among challenging technical requirements (Brown & Eisenhardt, 1995). Typically, the process contains significant levels of technological uncertainty, and integrating knowledge from a diverse set of technical specialties requires creativity. The process also requires the effective coordination of persons from a variety of functional and occupational backgrounds (Denison, Hart, & Kahn, 1996) generally achieved through the use of cross-functional teams in IPD environment. The complexity of new product and its cross-functional character create many problems for planning, communicating, coordinating, and sharing understanding among members of the innovation team, particularly when the team is developing a product that is relatively new or groundbreaking for the product development organization.

A firm that can solve such problems rapidly and quickly when developing an innovative product has an important capability for competing in highly dynamic and competitive markets. For instance, in a study of product innovation in the global computer industry, Eisenhardt & Tabrizi (1995) found an association between an "*experiential*" problem-solving strategy and rapid innovation in highly dynamic markets. They argue that when the product innovation process is highly uncertain, the key to quick innovation is "rapidly building intuition and flexible options in order to learn quickly about and shift with uncertain environments." Their study shows that project mechanisms such as multiple design iterations, extensive testing and frequent project milestones are practices that are linked to rapid innovation. The authors' proposition is that these activities help product team members acquire the concrete information and joint experience necessary to build intuition and respond quickly to problems encountered during development.

The study of groups within the framework of Social and Organizational Psychology has led to the development of various theoretical models that attempt to identify critical factors affecting the functioning and effectiveness of work groups (structural, ecological and motivational models) (Hackman and Morris 1975; Hackman 1987; Sundstrom, De Meuse and Futrell, 1990 and Guzzo, Yost, Campbell and Shea, 1993). All of these aim to analyze and explain group functioning on the basis of different types of variables (contextual, process and result). Moreover, they share the idea that group effectiveness is explained not solely by the final result obtained by the group, but also by the process followed in order to arrive at that result. McGrath (1984) defines group processes as "the behavior pattern of its members". This refers to the patterns of communication that emerge between the group members, interpersonal actions, influences and contacts.

Even though cross- functional team members work together to achieve shared project goals, people from different disciplines often have different functional objectives, priorities, and agendas (Jasswalla and Sashittal, 1999). These functional goals often are in conflict and require a "give and take" type of problem solving to arrive at a solution that will satisfy the project goals and the goals of each discipline.

In order to resolve problems during each stages or activities, cross-functional integration, communication, cooperation and coordination seems to be a pre-requisite and have been topics of interests in several researches in NPD. It is widely accepted that integration across functional specialties derives superior product development performances in multiple areas. This conclusion is consistent across industries: automobiles (Clark and Fujimoto, 1991; Clark and

Wheelwright, 1993, Syamil, 2000), mainframe computers (Iansiti, 1997), and pharmaceuticals (Henderson, 1994; Pisano, 1994). Numerous other studies confirm this point as well (Clark and Fujimoto, 1991; Leonard Barton, et al., 1994; Adler, 1995; Cooper and Kleinschmidt, 1995; Cooper, 1998a, Hong, 2000).

Functional diversity through the use of cross-functional team has been found to enhance effectiveness and timeliness of NPD when the product being developed is highly innovative and the coordination mechanism is participative (Keller, 2001). Each stages or activities in any NPD process are inter-related with one another. From a system perspective, the output of one stage or activity becomes the input to the subsequent stage or objective. Following the view of Simon (1965), task dependencies are inherent to organizations under the assumption that people work together in order to achieve the organization's goals (Simon, 1965), it is less argument that NPD process is task dependent. The product composition and its underlying linkages between components determine to an important extent the choice for a coordination approach (Sanchez, 1995) which in IPD environment requires the coordination among the members belonging not only to the various functions, but also from the supplier and customer communities.

Several authors refer to the need for co-ordination and integration for the various specialist disciplines and functions with an organization (Dyerson and Mueller, 1999; Grant, 1996 etc.). Following the literature, a team has been defined as a social system of three or more people which is embedded in an organization (context), whose members perceive themselves as such and are perceived as members by others (identity), and who collaborates on a common task (teamwork) (Alderfer, 1987; Wiendieck, 1992; Guzzo and Shea, 1992). Many working definitions of "team working" encompass team-to-team co-ordination and integration (Hoegl et al., 2000). Work teams are theorized to solve problems at multiple levels of a firm (Cohen and Bailey, 1997), process information (Hinsz, Tindale and Vollrath, 1997), and combine disparate resources to address complex decision scenarios (Denison, Hart and Kahn, 1996) which seems to be particularly relevant in the case of IPD. The criticality of cross-functional coordination in NPD comes through clearly in Zirger and Maidique's (1990) research. They rely on strategic management theory in their propositions that strong R&D and marketing-manufacturing prowess and coordination are essential for NPD success.

Holland et al. (2000) review shows that inter-functional communication and transparency was correlated or associated with successful NPD projects. Souder (1981) contends that a spirit of candor, teamwork, and reliance among members of different units is vital to the NPD process; Song, Montoya-Weiss, and Schmidt (1997) contend that, to enable successful NPD, companies must break down the walls between the various departments. They point out that cross-functional cooperation is perceived as critical to NPD success by various departments, including research and development (R&D), marketing, and manufacturing. One key to achieving co-ordinated action in the face of dispersed knowledge is to develop ways of interrelating and connecting the knowledge each individual has (Tsoukas, 1996). In addition to the availability of a communication channel, willingness and motivation, as well as the competencies to use it, are also required. The notion of 'absorptive capacity' (Cohen and Levinthal, 1990) is particularly important here, i.e. being able to receive, interpret and apply knowledge. Conflict can arise from differences in departmental cultures, differing responsibilities, and reward structures. Vested interests can prevent effective progress on a good project (Urban and Hauser 1980). Therefore, trust is a critical ingredient for inter-functional cooperation, which is critical for NPD success.

Interdependence is the extent to which the IPD members perceive the need for their relationship, value each other's contribution of skills, resources, or value added to the relationship, and perceive that the relationship cannot be readily replaced. This conceptualization is rooted in Thompson's (1967) concept of task interdependence and is concerned with the extent cross-functional team members rely on each other to realize joint opportunities. The notion of interdependence is consistent with Anderson and Narus's (1990) discussion of relational construct that reflects the interaction of individual perceptions of dependence and Kumar, Scheer, and Steenkamp's (1995) concepts of total dependence and symmetry of dependence to reflect mutual or joint dependence. The interdependency of tasks in IPD establishes the interdependency relationships of the cross-functional team members who execute these tasks. Interdependence is critical in achieving goals for novel, important, and complex NPD projects (cf. Adler 1995, Pfeffer and Salancik 1978). There had been some interesting researches to differentiate between symmetrical and asymmetrical dependency. As McAlister, Bazerman, and Fader (1986) explain, asymmetrical dependence interferes with joint problem solving because the weaker party guards against exploitation while the stronger tends to probe the boundaries of exploitation or guard against the appearance of intentions to exploit. This combination of pressures on the relationship severely taxes the ability of the parties to cooperate in unbalanced power contexts. Parties that do not depend on each other have little motivation to cooperate (Harrigan 1988). In cross-functional teams, disciplinary differences may be particularly salient because of the importance people place on their own specialization (e.g. Schunn, Crowley and Okada, 1998). Both Harrigan (1988) and Brouthers, Brouthers, and Wilkinson (1995) suggest that symmetrical partnerships tend to foster a cooperative culture and that alliances without cooperative cultures tend to fail.

Cooper (1993) has noted that, as companies strive to bridge the barriers between functional areas, information critical to the product's formation and function can get withheld, misunderstood, or lost. Sometimes participants may even withhold information because of a lack of trust. These communication difficulties must be resolved for successful NPD. Good communication has long been viewed as a critical element in NPD success (Barclay 1992; Cooper 1993; Rothwell 1992).

While interdependency among the cross-functional team members is an important characteristic of NPD, from knowledge integration perspective, it is important to identify key issues surrounding the team members' relationship that can prevent or promote knowledge transfer of these experts to solve complex problems of the project. From research perspective of this thesis, the challenge is to integrate knowledge of the team members for superior NPD outcomes.

As Brouthers, Brouthers, and Wilkinson (1995) point out, alliances without cooperative cultures tend to fail. It is not surprising to find that the same factors are identified as requisites to NPD success because, whether or not NPD is undertaken jointly with another organization, it is a cooperative enterprise with other functional units – R&D, marketing, and manufacturing (Song, Montoya-Weiss, and Schmidt 1997). Moreover, as Dyer and Singh (1998) point out, alliance partners must generate and enhance their knowledge-absorbing capacities and generate routines that facilitate sharing of information. Argyle (1991) concludes that cooperation enhances effectiveness under the conditions of small groups, interdependent tasks, problem-solving tasks, and resource dependency – which are conditions of IPD.

Resource-dependency theory (e.g., Pfeffer and Salancik 1978) suggests that mutually dependent parties, being interested in sustaining their relationship, will be more accommodating, open to influence, and willing to make adaptations than asymmetrically dependent parties who will either coerce or be coerced. From an exchange theory perspective, it is the extent to which *both* partners voluntarily make adaptations in their strategies or behaviors to accommodate each other's needs or interests, restrain from the use of power, share information, and jointly solve problems (Heide and Miner 1992).

When the distribution of power, influence, and control in a relationship results in an asymmetric relationship, the advantage party may be motivated to assert their will on the other to affect outcomes that favor that party. This is likely to create feelings of animosity, resistance, or revenge that motivate the other to be uncooperative, feud, or retaliate in ways that undermine the relationship (Homans 1961; Zand 1972). Similar logic led Anderson and Weitz (1989) to suggest that asymmetric power relationships are less stable. When the ability to use power and influence is balanced conflict is discouraged because both parties know the other can inflict meaningful damage to their own interests. Such balance encourages cooperation by focusing the attention of the parties on their joint interests. Each party has a vested interest in sharing information and being flexible, which when reciprocated, supports further cooperation and strong relational behavior (Dwyer, Schurr, and Oh 1987).

Scholars call into question the effect of participation on decision outcomes in NPD (Li and Atuahene-Gima, 1996) and in organization studies (Wagner 1994), arguing that influence is a more critical factor. Influence is germane in NPD because at its core NPD is about risk, ambiguity, and uncertainty, and is replete with functional conflicts caused by difference in perceptions and self-interest (Frost and Egri 1991, Ruekert and Walker 1987).

Within the knowledge management literature, trust is often discussed as an important element for successful knowledge management ventures (e.g., Bukowitz & Williams, 1999; Rolland & Chauvel, 2000; Roberts, 2000). For example, statements such as, “Trust is, after all, the single most important precondition for knowledge exchange” (Rolland & Chauvel, 2000) is a common occurrence, particularly in practitioner oriented literature.

The problem in IPD is to determine what can lead to a coordinated set of actions aimed at strengthening the joint problem solving skills of IPD team on the one hand, and to ensure the link with internal process optimization capabilities on the other hand. To summarize the literature reviews, it is widely agreed that successful alliances of customers, suppliers, and cross-functional team hinge on the ability of the partners to trust, communicate, integrate and coordinate task and information in the interdependent task of NPD. To reach these targets involves a focus and orientation of the NPD process towards the attainment of project goals; the presence of a mutual relationships among the team members; full sharing of power among the team members in the IPD, making available of all the information necessary to take correct decisions at the right time, thus greatly reducing hierarchical levels and increasing the mutual relationships of the NPD team. Furthermore, because truly cooperative relations are based upon intensive and effective two-way exchanges of information and joint problem-solving, a key factor for successful NPD is close cross-functional coordination and collaboration, with a significant impact on power sharing and trust. Mutual trust and mutual influence is about collectively and cohesively able to identify the problem and able to provide mutual support for exploring problem solutions through knowledge sharing. The element of mutuality brings a sense of flexibility, respect, assistance, and support among the NPD team members to encourage and develop new ideas and contributions rather than trying to outdo each other in such functionally diversified intense information processing system.

2.3.3 Characteristic 3: Knowledge Intensive

Product design is a complex and uncertain process. The process is complex because product design often involves large number of activities that are interrelated to each other. The process is uncertain because these activities and their relationships are difficult to define in advance for a new product design project. Thus, management of complexity and uncertainty are the key challenges in managing product design (Simon 1964, Galbraith 1973, Meyers and Roberts 1986, Clark 1989, Clark and Fujimoto 1991, Fitzsimmons, Kouvelis, and Mallick 1991, Wheelwright and Clark 1992, Griffin 1997, Mallick 2000, Tatikonda and Rosenthal 2000a, 2000b, Eppinger 2001, Ramdas and Sawhney 2001, Krishnan and Bhattacharya 2002, Micheal, Rochford, and Wotruba 2003).

NPD teams are information-processing subsystems of the organization designed to reduce customer, market, and technology uncertainty in the NPD process (Moenaert and Souder 1990). Such a system involves individuals or functions that create and disseminate information and act on shared meanings (Moorman 1995). Krishnan and Ulrich (2001) focused on the decisions that need to be made during the NPD process, adopting a perspective on NPD complementary to the traditional functional view in which decisions are delegated to the departments that claim them (Figure 2.2). Krishnan and Ulrich (2001), from their observations of industrial practice and review of the marketing, organization, engineering design, and operations management academic literature, identified approximately 35 decisions that need to be made in NPD.

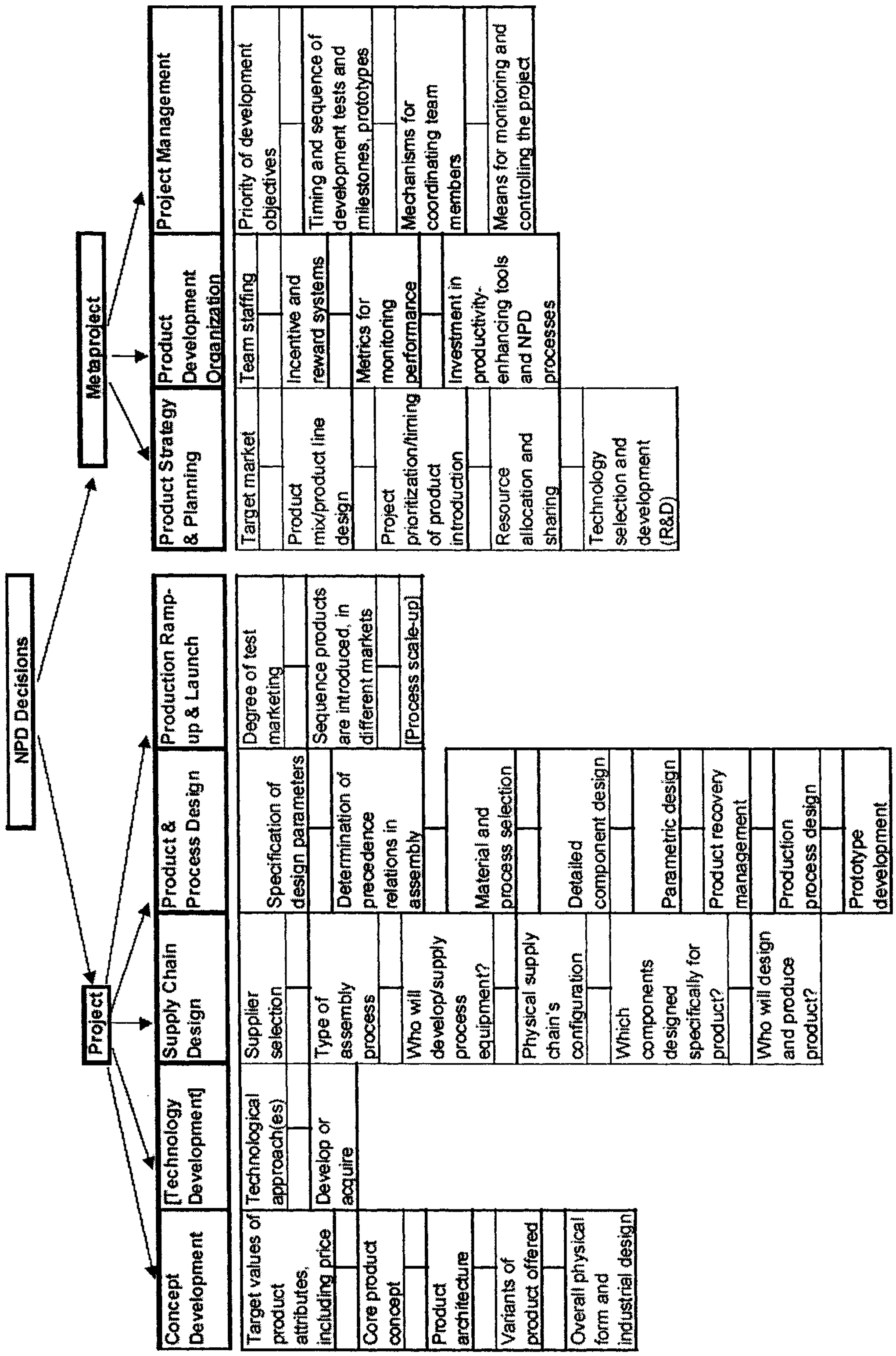
NPD Decisions
Project
Metaproject
Concept Development
Target values of product attributes, including price
Core product concept
Product architecture
Variants of product offered
Overall physical form and industrial design
[Technology Development]
Technological approach(es)
Develop or acquire
Supply Chain Design
Supplier selection
Type of assembly process
Who will develop/supply process equipment?
Physical supply chain's configuration
Which components designed specifically for product?
Who will design and produce product?
Product & Process Design
Specification of design parameters
Determination of precedence relations in assembly
Material and process selection
Detailed component design
Parametric design
Product recovery management
Production process design
Prototype development
Production Ramp-up & Launch
Degree of test marketing
Sequence products are introduced, in different markets
[Process scale-up]
Product Strategy & Planning
Target market
Product mix/product line design
Project prioritization/timing of product introduction
Resource allocation and sharing
Technology selection and development (R&D)
Product Development Organization
Team staffing
Incentive and reward systems
Metrics for monitoring performance
Investment in productivity-enhancing tools and NPD processes
Project Management
Priority of development objectives
Timing and sequence of development tests and milestones, prototypes
Mechanisms for coordinating team members
Means for monitoring and controlling the project

Figure 2.2: NPD Decisions (Adapted from Krishnan and Ulrich, 2001)

People who work together accumulate a shared set of information and know-how, and this proximity enablesthem to understand who possesses what type of expertise (Asanuma 1989; Dyer and Singh 1998). Consequently, this enhances the quality of communication and cooperation and enables superior performance on innovation projects (von Hippel 1988).

According to how well it can be articulated, knowledge in organization can be classified as *tacit or explicit*. Tacit knowledge includes hard-to-communicate skills, know-how or practical knowledge (e.g. build excellent automobiles). Explicit knowledge, on the contrary, refers to forms of knowledge that can be easily communicated to others (e.g. physical dimensions of the new product). Both tacit and explicit knowledge are considered not to be in dichotomous states of knowledge, but mutually dependent and reinforcing qualities of knowledge: tacit knowledge forms the background necessary for assigning the structure to develop and interpret explicit knowledge (Polyani, 1975). The inextricable linkage of tacit and explicit knowledge suggests that only individuals with a requisite level of shared knowledge can truly exchange knowledge: if tacit knowledge is necessary to the understanding of explicit knowledge, then in order for Individual B to understand individual A's knowledge, there must be some overlap in their underlying knowledge bases or a shared knowledge space (Ivari and Linger, 1999;Tuomi, 1999).

New knowledge in firms is created through a combination of individuals' tacit and objective knowledge (Tucker, Meyer, and Westerman 1996). Although objective knowledge is observable and explicit, tacit knowledge, "the unexpected knowing that precedes and underpins" (Spender 1993) any communication, is based on the shared set of experiences of the individuals for which, in IPD, shared team vision seems to an important driver. Tacit knowledge is communicated through a set of roles and interaction patterns specific to an organization. To enable that, from earlier discussion of NPD characteristics, relationships based upon mutuality seems to be yet another important driver. Thus, effective and efficient tacit knowledge integration results from a communication system that facilitates shared experience among individuals that could be driven by shared vision and mutuality.

There is several other classification of knowledge in the literature. A summary of these classifications is presented in Table 2.1.

Table 2.1 Different Knowledge Types (Adapted and modified from Alavi and Leidner, 2002)

Knowledge Types	Definition	Examples
Tacit	Knowledge is rooted in actions, experience, and involvement in product development	Best means of dealing with specific supplier
Cognitive tacit	Mental models	Individual's belief on cause-effect relationship
Technical tacit	Know-how applicable to specific work	CAD skill
Explicit	Articulated, generalized knowledge	Knowledge of production/technological constraints
Individual	Created by and inherent in the individual	Insights gained from completed project
Social	Created by and inherent in collective actions of a group	Mutual trust for knowledge sharing in cross functional team
Declarative	Know-about	What materials are appropriate for production
Procedural	Know-how	How to administer product testing
Causal	Know-why	Understanding why the new product works
Conditional	Know-when	Understanding when to commercialize the product
Relational	Know-with	Understanding how the part components interact with other components
Pragmatic	Useful knowledge for an organization	Best practices, project experiences, engineering drawings, reports

Nonaka and Konno (1998) conceptualize that *ba* is a shared space that serves as a foundation for knowledge creation and provides a platform for advancing individual and/or collective knowledge. Knowledge is embedded in *ba*, where it is then acquired through one's own experience or reflections on the experiences of others. Knowledge resides in *ba*, and it is intangible. Individuals share their tacit work experiences with their coworkers in a knowledge sharing and creation space *ba*, then conceptualize the experiences into explicit form, and together combine this knowledge into innovative solutions. In the scope of integrated product development the designers, assembly planners and production planners, as well as the persons responsible for quality or testing not only consult themselves while they are working simultaneously on their tasks, but exchange interconnected intermediate results in a continuous interplay (Lindemann et al. 1999).

Several scholars and consultants (Davenport et al., 1998; Davenport and Prusak, 1998; Nevis et al., 1995; DeLong and Fahey, 2000; Gupta and Govindarajan, 2000) have argued that creating a culture that values creativity, continuous improvement and the sharing of ideas is necessary for knowledge management initiatives to succeed. For an organization to manage its knowledge assets effectively, it needs to have employees who are motivated to explore new market opportunities, new work procedures or new products, and who are willing to apply new ideas to their own work; it needs structures and work systems that are flexible enough to admit innovative changes, and job definitions that grant employees a fair level of autonomy; and, very importantly, it needs to set up mechanisms by which new ideas are shared (Gupta and Govindarajan, 2000). The sharing of ideas among employees is not only one of several processes underlying collective knowledge within an organization, but it is the key process without which a company may not be able to leverage its most valuable asset (Wasko and Faraj, 2000; Jarvenpaa and Staples, 2000; Nahapiet and Ghoshal, 1998).

Team working and knowledge management fields are increasingly converging. Grant (1996), a proponent of knowledge-based view of firm, argues that knowledge is the pre-eminent resource for competitive advantage in the current era, and stresses the role of co-ordination mechanisms to integrate the specialist knowledge of multiple individuals in an organization. Nonaka and Takeuchi (1995) emphasize the importance of teamwork in the conversion process of personal, tacit knowledge into organizational knowledge. Dialogues, discussion and dynamic interaction enabled by teamwork are argued to play a vital role in the knowledge creation process. The ideas of individuals are articulated, challenged, refined and once converted into organizational knowledge, embodied into new products, processes, or services (Sapsed et al., 2002).

Team knowledge comprises shared mental models of the task domain, its procedures and conceptual apparatus as well as the team situation; the specific knowledge of behaviors involved in working with the other team members in the dynamic environment (Cooke et al., 2000). Cannon-Bowers et al. (1993) hypothesize that team performance is directly related to the compatibility of expectations derived from the individual team members' mental models. Team leaders and team members must not only share compatible knowledge of the project, they must use the shared knowledge to develop share expectations for the task and the team in order to be effective. By acquiring shared mental models, teams allow themselves to develop a framework for conducting the required work (Weick, 1993) without a continuous process of interpretation and re-interpretation of meanings (Smircich, 1983), which can be operational when team members can mutually influence one another.

As highlighted by several studies (Takeuchi and Nonaka, 1986; Wheelright and Clark, 1993), the final output of NPD is the result of an *iterative process*, mainly based on trial and error, on experimentation, failure and learning. For this reason, it is a time consuming process. And in fact, in the knowledge view of the firm, the creation of new knowledge to be embodied in the product is a process which requires various cycles. Each cycle, starts with the sharing of experience among the team members and ends with the building of a prototype. Knowledge creation is crucial to innovation and knowledge is created in a social context, which is also the fundament of problem solving, especially in dynamic and complex business environment in which NPD process have to operate. A knowledge-based perspective on product development and innovation suggests that, continuous renewal is dependent on the capacity to constantly combine and recombine organizational and individual knowledge (e.g. Grant 1996, Spender 1996, Ravasi and Verona, 2001). Successful IPD requires the creation and utilization of new knowledge, because ultimately the new products and services are the outcome of creation utilization and embodiment of the knowledge. Integration has to occur on a conceptual level-beyond operational work because knowledge is embedded in people and products. This knowledge needs to be continuously explored and used. Sustaining knowledge exploitation and exploration are essential elements of successful product development (McNamara and Baedn-Fiuller, 1999).

March (1991) discusses the necessity of having a balance between exploitation, i.e. the re-use of existing knowledge, and exploration, i.e. the development of new knowledge. Björkegren and Anderson (2000) illustrate the different characteristics knowledge exploitation and exploration (Figure 2.3).

EXPLOITATION ⟷	EXPLORATION
adaptation	discovery
habit formation	frame breaking
preservation	innovation
refinements	experimentation
positive returns	often negative returns
predictable outcomes	unpredictable outcomes

Figure 2.3: Knowledge exploration and knowledge exploitation

Knowledge exploitation has to do with utilizing existing knowledge of identify problems. The knowledge exploitation stream primarily focuses on goal-integration and innovative problem definition based on existing knowledge. Innovative problem includes the firm's capacity to assimilate and exploit knowledge (Cohen and Levinthal, 1990), the value of information (Von Hippel, 1994), inter-functional information transfers (Soulder and Moerhart, 1992), factors affecting the success of product development (Brown and Eisenhart, 1995), product innovation determinant (Romano 1990), interpretative barriers to successful product development (Doughty 1992), factors of organizational and technical innovation for product development (Dougherty and Heller, 1994), and factors of developing products quickly (Ettlie, 1995, Eisenhardt and Tabrizi, 1995).

Knowledge exploration occurs when existing knowledge is not sufficient to solve the problems identified. Successful product development depends on how quickly projects team capture, share and utilize relevant knowledge components (i.e., shared knowledge) and integrate them to derive innovative solutions for new products (Iansiti and MacCormack, 1997). Knowledge exploration research focuses on finding innovative solutions through cooperation and collaboration among firms (Shan et al. 1995), identifying processes and methods of knowledge diffusion (Abrahmson, 1991; Abrahamson and Fombrun, 1994), knowledge creation for new products (Dougherty 1990), methods creation for capturing the value from process innovation (Ettlie and Reza, 1992), utilizing product knowledge embedded in culture and information processing systems (McCrimmon and Wagner, 1994), and computer-based idea generation (Henderson and Clark, 1990). Knowledge exploration is directed to create new knowledge while utilizing existing knowledge as a base for expansion.

Fiol (1996) urged the researchers to integrate both streams of knowledge exploitation and exploration. The knowledge exploitation research stream focuses on problem definition (i.e., *what is the problem and solution based on the existing mental models and perspectives*). Knowledge exploration research streams deal with problem solution (i.e., *what to do about the problem*) with expanded perspectives and shared mental models. In this sense, knowledge integration includes both knowledge exploitation and exploration to achieve multiple product performance outcomes.

Shared knowledge is about finding innovative problem solving through sharing relevant knowledge and cross-functional teams. Shared knowledge of customers, suppliers, processes and internal capabilities will not only utilizes existing knowledge but will also enhance a greater level of knowledge exploration.

If knowledge sharing is vital for IPD success, what motivates individuals to share the knowledge with other? Clearly, there seems to be behavioral implications when it comes to sharing of information and knowledge. Within the knowledge management literature, trust is often discussed as an important element for successful knowledge management ventures (e.g., Bukowitz and Williams, 1999; Rolland and Chauvel, 2000; Roberts, 2000). For example, statements such as, "Trust is, after all, the single most important precondition for knowledge exchange" (Rolland & Chauvel, 2000) is a common occurrence, particularly in practitioner oriented literatures. In another study, respondents noted that they would only be willing to share knowledge in contexts where they trusted the recipient of the knowledge (Connelly and Kelloway, 2000). Similarly, from the discussions made in section 2.3.2, power seems to be another important variable that affects the interdependency, cooperation, co-ordination and integration. However, both trust and power has not been a subject of study in the context of IPD.

2.3.4 Characteristic 4: Performance Oriented

Performance measures are common control mechanism. They communicate desired outcomes or behavior of a system, and are used to evaluate success in achieving goals. It is generally believed that the best performance measures are those linked to a firm's strategy (Kaplan and Norton, 1992; Langfield-Smith, 1997). Several studies report that about half of surveyed firms measure NPD performance (Griffin, 1997).

In managing NPD project, decisions are made about the relative priority of development objectives, the planned timing and sequence of development activities, the major project milestones and prototypes, mechanisms for coordination among team members, and means of monitoring and controlling the project. At the end of the project, performance measurement of the NPD ensures what was planned and what was realized.

In IPD, product development performance is generally measured by the lead time to develop the product, the cost of the development effort, the manufacturing cost of the product, and the product's quality or attractiveness in the market (Clark and Fujimoto 1991, Griffin 1997, Iansiti and Clark 1994). Foster et al. (1985a, 1985b) provide an excellent discussion on how metrics can be used to clarify the link between research and development and corporate profits. Cohen et al. (1996) have shown that these performance measures are often traded off against each other. Other research studies indicate that these measures may have different effects on firm's profit in different markets, so it may not always be appropriate to force-fit one approach (such as lead-time minimization) to all development situations.

Formal project-scheduling techniques such as PERT and CPM enjoy widespread use in development projects for planning the timing and sequence of activities; however product development processes are not as easily modeled with these techniques (Eppinger et al. 1994). The exchange of information among product development professionals can be modeled using a tool called the Design Structure Matrix (DSM), introduced by Steward (1981) and further developed for large projects by Eppinger and his colleagues.

The best-practices firms identified by Griffin (1997) by their performance in the three dimensions of NPD performance: customer, financial, and technical performance success were found to be more likely to use formal NPD processes and to use a number of NPD practices simultaneously. Griffin and Page (1996) proposed that the best measures of NPD success at the project level depend on the strategy for the project, and that the best measures of NPD success at the program level depend on the *firm's* strategy for innovation. In previous work, they had found more than 75 measures of product development success used commercially and academically for individual NPD projects and for NPD project portfolios. The authors noted that financial success is not necessarily a principal goal for a product within a firm's portfolio of products, though it would be for the portfolio overall. Griffin and Page found that companies typically use two customer-based, one financial, and one technical performance success measure, but, while these general classes were useful, the specific measures available within companies for NPD expressly did not meet the needs of product developers. Table 2.2 illustrates commonly used NPD success measures which have been found to be generally used in various IPD research for performance measurement.

Newness to the Market
(project's market strategy)

Newness to the Firm
(project market, technological uncertainty)

Newness to the Firm \ Newness to the Market	Low		High
High	New-to-the-Company 1. Market share 2. Revenue or Satisfaction 3. Met profit goal 4. Competitive advantage		New-to-the-World 1. Customer acceptance 2. Customer satisfaction 3. Met profit goal or IRR/ROI 4. Competitive advantage
	Product improvements 1. Customer satisfaction 2. Market share or Revenue growth 3. Met profit goal 4. Competitive advantage	Add to existing lines 1. Market share 2. Revenue, Revenue growth, Customer satisfaction, Customer acceptance 3. Met profit goal 4. Competitive advantage	LEGEND:
Low	Cost reductions 1. Customer satisfaction 2. Customer acceptance or Revenue 3. Met margin goal 4. Performance or Quality	Repositionings 1. Customer acceptance 2. Customer satisfaction or Market share 3. Met profit goal 4. Competitive advantage	Product strategy 1. Customer measure 2. Customer measure 3. Financial measure 4. Performance measure

Table 2.2 Most useful NPD project success measures
(Adapted from Griffin and Page, 1996).

Another recent but important research on NPD performance measurement has been conducted by Driva, Pawar, and Menon (2000). They presented their Performance Measurement for Product Development (PMPD) project to develop a measurement system for NPD. Their methodology is based on their review of the literature, analysis of documents from industry, structured-question interviews with NPD managers and academics, and an 18-month longitudinal case study. The PMPD tool focuses on the time, quality, and cost aspects of NDP measurement, as opposed to the long-term commercial success of new products. Driva et al. (2000) surveyed 580 United Kingdom, United States, and European Community companies. Their findings are summarized in Table 2.3.

Measures used by companies		Measures recommended by academics	
% Who Use	Measure	Rank as Very Useful Now	Measure
71	Total cost of project	1	Total time to market (from concept through launch)
61	On-time delivery of development project	2	Accuracy of prediction of customer requirements
60	Actual project cost compared to budget	3	Accuracy of interpretation of customer requirements
58	Actual vs. target time for project completion	4	Total product development time
57	Lead time to market	5	Actual vs. target time for project completion
54	Field trials prior to production	6	Actual product quality performance vs. predicted
51	Projected profitability analysis	7	% on-time delivery of specification to manufacturing
50	Product failure rates	8	No. of customer-detected design faults
49	Supplier lead time	9	Total cost of each product development project
46	Reasons for failures on the market	10	Response time to customer requests for "specials"
45	Product prototype passed safety tests	11	Ability to use a common design platform
43	R&D budget as % of turnover	12	Reasons for failures of previously released products
42	Time spent on each stage of product development	13	Delivery of product to cost (as quoted)
39	Product met quality guidelines	14	Rate of successful product development projects
35	Actual-to-predicted profit on products	15	Time spent on changes to original product specification

Table 2.3 NPD success measures used by business and academics

(Adapted from Driva et. al., 2000)

IPD being a goal-oriented effort, performance measurement is common in literatures. In their seminal article, Gerwin and Barrowman (2002) argue that in IPD, a project's performance reflects integrative intermediate objectives such as development time, development cost, product quality, product cost, and overall product performance.

IPD outcomes are the final measurement of the efforts and resources used during the project. Final outcome of such process measurement should include not only the measurement of the final tangible product of the project but also the measurements of the development process through which product was developed. The performance measurement of knowledge integration in IPD therefore should include measures for both process outcomes and product outcomes.

2.4 CONCLUSION

This dissertation focuses on what leads to sharing of valuable information and ideas among individuals in a new product development team realizing that IPD is a knowledge intensive process and requires both knowledge exploration and exploitation that is embedded in team members. IPD is goal oriented effort and to enhance "collective ambition", shared team vision clearly seems to be important variable. Product development is about task interdependency. Cooperation, co-ordination, communication and integration of specialist knowledge require team member trust one another to develop the shared mental model for which empowerment and trust seems to be critical.

Next, the conceptual research model of knowledge integration for IPD is presented and the specific variables are discussed in detail. In particular, the research framework will help to understand the socio-psychological processes governing exchanges among employees and that may guide the design interventions to successfully manage organizational knowledge. The framework borrows sociological and business researches on mutual trust and mutual influence, team vision, and shared knowledge. Theory development to the specific objectives of this dissertation is presented in the next chapter.

Chapter 3

Research Model of Knowledge Integration in IPD

3.1 INTRODUCTION

Knowledge integration in IPD in this research is based on developing a collective wisdom or shared mental model of cross-functional team members to solve problems and make decisions during the NPD project. By examining several previous literatures in the area of NPD, IPD, knowledge management, and team behavior, this chapter is based on integrating important research streams to present the research model.

The first important research stream on knowledge integration focuses on the importance of integration of product design and manufacturing processes. Successful product development involves integration of product design and manufacturing process design (Ettlie and Reza, 1992; Ettlie, 1995, Hong, 2000). Based on an extensive case study of the Toyota Company, Sobek (1997) emphasized the knowledge leadership of engineers, especially that of chief engineers, for effective integrated product development effort. Broad integration of product design and manufacturing process design is a key aspect of knowledge integration and this requires active involvement of design and manufacturing engineers in IPD.

The second aspect of knowledge integration is the importance of strategic focus in IPD (Hong, 2000). In chapter 2, one of the important characteristics of IPD was discussed and presented in terms of strategic and goal orientation. Successful product development is possible when the IPD teams of companies maintain a strategic focus (Ettlie, 1995). Because of resource constraints, firms expand their product lines within reasonable boundaries, stay in touch with changing customer needs and utilize their internal capabilities (Madique and Hayes, 1984, Crawford, 1991). Such focus has to occur in the very early part of the product development processes. Khurana and Rosenthal (1997, 1998) stressed the importance of front-end activities in product development. Front-end activities involve clear definitions of product concepts, careful planning of projects and clear assessments of customers' needs. All these front-end activities require a high level of focused work by cross-functional teams.

The third aspect of knowledge integration is disciplined problem solving (Hong, 2000). Successful firms concentrate effort on a few, high priority issues (Ettlie and Stoll, 1990; Ettlie, 1995; Clark, 1989). Problems that IPD teams face are complex and their implications are multiple. New knowledge is constantly created in the course of the product development processes. The amount of available knowledge is in many cases more than enough for team members to handle. In this context, effective sharing of relevant knowledge is what matters (Zander and Kogut, 1995; Henderson and Clark, 1990; Pissano, 1994; Simonin, 1997). This requires a high level of discipline among the project team members so that team members may have shared mental models and adequate understanding of key issues and problems but not be overloaded with unnecessary information (Nelson and Cooprider, 1996; Hoopes and Postrel, 1999).

The fourth aspect of knowledge integration is reason that motivates individuals to share timely information with one another that facilitates knowledge sharing among the IPD member. In chapter 2, another important characteristic of IPD was discussed in terms of relationship orientation. Knowledge transfer takes place in social setting such as team work and clearly such social process should have behavioral implications. Based upon the social exchange theories, transaction cost theory, and role theory this thesis posits that mutual trust (Shapiro et al., 1992; Lewicki and Bunker, 1996), mutual influence (Sollner, 1998; Dougherty, 1987), and team vision (Hong, 2000) are the positive drivers of shared knowledge and hence key variables for knowledge integration.

3.2 KNOWLEDGE INTEGRATION IN IPD: PROPOSED RESEARCH MODEL

Business relationships are typically addressed from either of two theoretical perspectives, the IMP (Industrial, Marketing, and Purchasing) approach (Ford, 2002) or the social network theory (Scott, 1992; Wasserman and Faust, 1994). The recent upsurge of industrial network and relationship theories from both the Industrial Marketing and Purchasing project (IMP) and social network theory (SNT) carry important questions like, *why do firms engage in inter-organizational cooperation and when? With whom are firms likely to ally and why? How do firms organize and control their cooperation* (Ebers,1999)? As a collection of various departmental units' representative, suppliers, and customers, these theories can be extended to the kind of relationship that is mandated in the cross-functional team that leads to a productive performance behavior in IPD. Such questions posed by these two theories can be nicely explained in terms of mutual trust and mutual influence.

Bradach and Eccles (1989) mention three different mechanisms to deal with others' behavior. In addition to trust they mention price and authority. The sharing of knowledge co-coordinated by the price mechanism implies selling knowledge. Co-ordination by authority means using hierarchical power to force someone to share his knowledge. Co-ordination by trust means that someone shares his knowledge because he expects that the recipient will not harm his interests.

According to Liebeskind et al. (1996), knowledge sharing within an organization is co-coordinated by authority. This would imply that all knowledge-sharing activities within an organization are hierarchically enforced. But that should be considered impossible within a knowledge intensive organization. Within such an organization of professionals, the professionals themselves are the experts who know which knowledge could be of use, and not solely their superiors (Weggeman, 1996). Therefore, an existence of mutual influence, or the symmetrical power relation, can ensure that both the parties in knowledge exchange are willing to change one-another's opinion on a development issues rather than taking a hierarchical authorative approach. Mutual influence then can be considered an important driver for knowledge sharing in the knowledge-intensive activities, such as new product development.

In addition, the knowledge workers should play an initiating role too. Taking an initiating action, under conditions of vulnerability to and ignorance about responding actions, requires trust (Gambetta, 1988; Hosmer, 1995) and mutual influence. Assuming that the conditions of vulnerability and ignorance exist, this means that both authority and trust are necessary as co-coordinating mechanisms for knowledge sharing. This is in line with Bradach and Eccles' main argument, namely that the co-ordination mechanisms are not mutually exclusive, but are able to function concurrently (Bradach & Eccles, 1989). The existence of mutual trust, which will allow truthful, accurate, timely, and important knowledge exchange, seems to be yet another important driver for knowledge sharing.

The use of the third mechanism, price, can be considered improbable between colleagues within one organization but maybe argued in terms of rewards and incentives but it is not considered in this dissertation.

The value of product development performance measures has been emphasized in several studies (Calantone, et al., 1995; Cooper and Kleinschmidt, 1995; Cooper, 1998a, Hong, 2000; Syamil, 2000). In the subsequent section, the detailed aspects of these constructs will be examined further.

Figure 3.1 presents the research model of this study, which shows the components of knowledge integration and their interrelationships in IPD. This model indicates the critical importance of team vision, mutual trust, mutual influence, shared knowledge on product performance. The dotted left area identifies the four components of knowledge integration (i.e., team vision, mutual trust, mutual influence and shared knowledge). The dotted rectangular area on right denotes product and process performance outcome of knowledge integration in IPD. Table 3.1 provides the operational definition of each constructs used in the research framework.

However, since little is known about the relationships among these constructs in the knowledge intensive team such as IPD team, the results from the empirical study may motivate to examine alternative relationships among these constructs in this study.

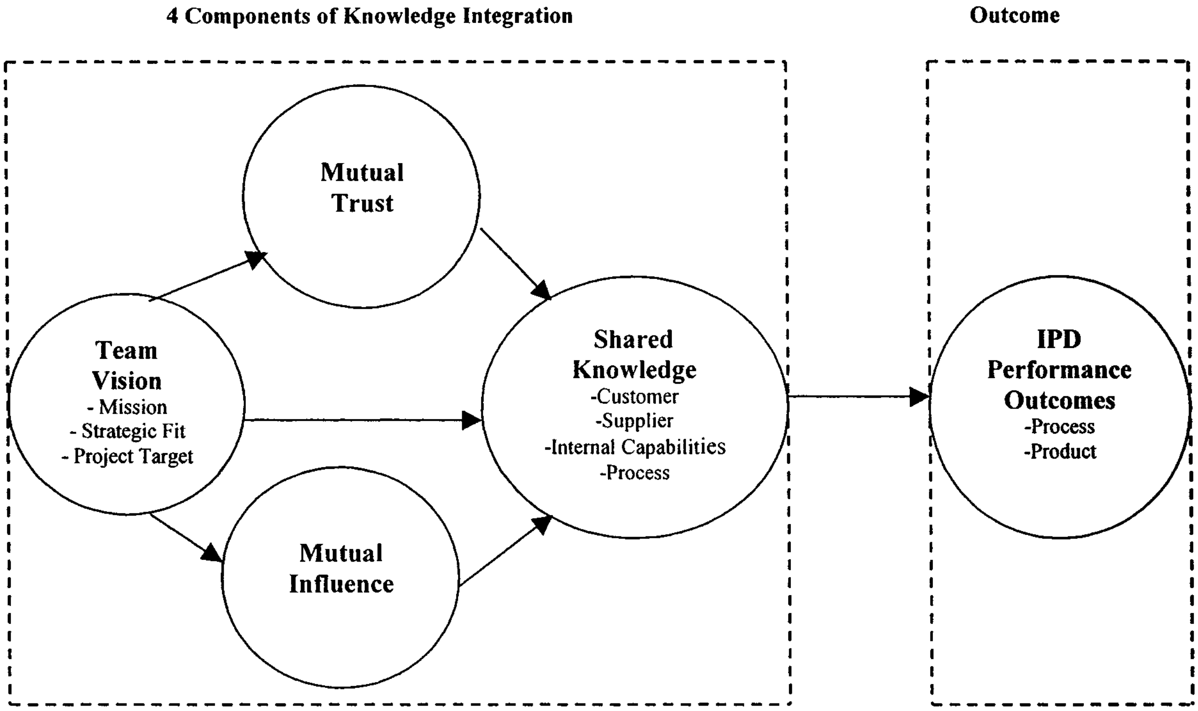

Figure 3.1 Research Framework of Knowledge Integration in IPD

Table 3.1 Constructs and Definition

Constructs	Definition
Team Vision	Team Vision is the extent of a shared understanding of the project mission, strategic fit and the project target for product development.
Mutual Trust	Mutual Trust is the mutual expectation among product development team members that everyone will work together in good faith.
Mutual Influence	Mutual Influence is the symmetrical power relationships among members of the product development team.
Shared Knowledge	Shared Knowledge is the shared understanding of customers, suppliers, internal capabilities, and process in cross-functional product development team.
IPD Outcomes	IPD Outcomes are product outcomes and process outcomes.

3.3 LITERATURE REVIEW

The proposed research model for knowledge integration consists of five variables: team vision, mutual trust, mutual influence, shared knowledge, and IPD outcomes. A comprehensive literature review for these variables is presented next.

3.3.1 Team Vision

Growth in organizations typically results from successful projects that generate new products, services or procedures. Project managers are increasingly concerned about getting better results from the projects that are under way in their organizations and in getting better cross-functional cooperation. Katzenbach and Smith (1993) argue that "a team is a small group of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable". Sharp et al. (2000) purpose that shared vision, purpose, goals and direction are among the key enablers for a high performance team. Importance of team purpose and objectives are also discussed by Colenso (2000). Team fails because of confused goals and unresolved roles (Robbins and Finley, 1996). According to Katzenbach and Smith (1993), in jointly developing clear goals and approaches, teams establish communications that support real-time problem solving and initiative.

Developing cooperation across projects requires that upper managers take a strategic and systematic approach to projects. This means that they need to look at projects as a system of interrelated activities and carefully examine each project's contribution for the overall strategic objectives (Graham and Englund, 1997; Englund and Graham, 1999).

Use of cross-functional team in the IPD environment provides several challenges and opportunities for managing NPD as each functional member has different expertise, different priorities, and different motivation. Issues like establishing objectives, processes, and procedures for directing the involvement and the establishment of organizational coordination mechanisms (Bruce et al, 1995; Ragatz et al, 1997) are considered as critical success factors to overcome major differences in style, priorities, and motivation (Tabrizi and Walleigh, 1997). Takeishi (2001) refers in this context to integrative capabilities, like architectural knowledge, integrated problem solving, and internal coordination as critical factors determining the quality of the design outcome of joint development effort. The starting point of such integrated effort should begin with the goal formulation. Early participation of marketing, R&D, and manufacturing in the early stages of the NPD process, such as strategy formulation, new product idea generation, and new product project selection leads the three functions to share commitment and responsibility for projects (Pinto, Pinto, and Prescott, 1993) which is consistent with the goal-setting theory of goal formulation, goal acceptance and goal commitment being important variables of highly successful team. NPD being a highly knowledge intensive process, the notion of collective ambition seems highly appropriate for a cross-functional team.

Weggeman (1995) describes the development of an intervention technique designed for knowledge intensive organizations as '*collective ambition development*'. The term collective ambition refers to an organization's mission, its goals and its strategy when they are widely shared. The development of a collective ambition, which can be either an explicit or a more implicit process, is mainly aimed at the development of commitment of the members of an organization. When a collective ambition is widely shared, the members of an organization have internalized the same set of goals. Such a strong collective ambition therefore enhances the chance that two colleagues have congruent goals. In addition to offering employees the opportunity to learn about each other's value structure, a participative collective ambition development offers them also the opportunity to see each others behavior in an important decision making process. Participation in strategic decision making will increase the feeling of procedural justice (Korsgaard, Schweiger & Sapienza, 1995; Kim & Mauborgne, 1998). Procedural justice is the extent to which the dynamics of the decision process are judged to be fair (Kim & Mauborgne, 1998:325).

In IPD, team vision is a shared purpose and plan of action that clarifies mission, strategic fit, and sets of project targets and priorities that are consistent with the firm's internal capabilities and the market place realities (Rosenthal and Tatikonda, 1990; Rosenthal and March, 1986, Clark and Wheelwright, 1993; Marquart and Reynolds, 1996). Team vision is a critical linkage to shared knowledge to bring positive product development outcomes.

Empirical studies by Pinto, Pinto, and Prescott (1993) have shown that goal incongruity causes inter-group conflict that may be reduced by the introduction of super ordinate goals. *Goal incongruity* is defined as the basic difference within the firm between marketing's goals and values and those of the R&D and manufacturing departments. A high level of goal incongruity generally leads to a high level of cross-functional conflict and open hostility (Pinto, Pinto, and Prescott 1993; Rahim 1986). When marketing's goals differ greatly from those of R&D and manufacturing, marketing may presume that the others' progress interferes with its own, and therefore it has little incentive to cooperate (Dyer and Song 1997; Tjosvold 1991). In such environment, where goal incongruency exists, there is less motivation of sharing knowledge to develop collective wisdom.

A lack of shared vision is a major reason for disappointing performance (Lynn, 1998). According to Leonard-Barton et al. (1994), a clear vision that is shared and agreed upon by others on the team (i.e., coherent vision) was recurring themes for successful innovation. Successful teams were committed to the vision of the project, while unsuccessful teams were misdirected with blurred vision or a vision conflict among team members (Bowen, et al., 1994; Lynn, 1998).

For the purpose of this study, team vision is thus operationalized as:

Team Vision is the extent of a shared understanding of the project mission, strategic fit and the project target for product development.

Table 3.2 shows the three variables of team vision i.e., mission, strategic fit, and project targets, their definitions and each corresponding literature base. Mission describes the future state associated with project success. Strategic fit identifies and confirms important factors that assesses and compare a project's ability to achieve overall strategic goals. Project's target is for use in evaluating alternatives among existing and potential projects and deciding exactly what the project is to accomplish among the set of targets (cost and benefits). The first two variables (i.e., mission and strategic fit) relate project characteristics to broad organization or program goals, while the last variable (i.e., project targets) examine project specific characteristics (Hong, 2000).

Table 3.2 Team Vision in IPD

Variables	Definition	Literature
Mission	The extent of plan of action for product development.	Hong, 2000; Rosenthal, 1992; McComb, Green and Compton, 1999 etc.
Strategic Fit	The extent of alignment between team's mission and overall business, technology, and product strategy.	Hong, 2000; Cooper, 1983; Cooper and Kleinschimidt 1987; Engulund and Graham, 1999 etc.
Project Targets	The extent of project targets specification and the extent of communication and understanding of project goals.	Hong, 2000; Schein, 1996; Clark and Wheelright, 1993; Gupta and Klaus, 1992; Prabuddha et al, 1995; Rosenau, 1989 etc.

3.3.1.1 Mission

Shared sense of organizational identity is emphasized as a key element of normative control –usually with reference to Ouchi's (1979) thought on "clan control" which may be summarized as employees being more likely to engage in behavior compatible with the interests of the overall organization when the degree of shared goals, visions, values and beliefs are high. According to Drucker (1998) in innovation, as in any other endeavor, there is talent, there is ingenuity, and there is knowledge; but when all is said and done, what innovation requires is hard, focused purposeful work.

Team vision is the extent of a shared understanding of the project purpose, the project mission, the project goals, work plan, and the product concept for product development (Hong, 2000). Project purpose is used to answer the fundamental question of why the project is important. Project mission is used to define what the project is really about (Tjosvold, 1989; Rosenthal, 1992). Project goals are what the project intends to accomplish (Rosenthal and Tatikonda, 1992, 1993). Project work plan is the sequence of how the project is to be implemented. Product concept is an elaborated version of the idea expressed in meaningful consumer terms (Khurana and Rosenthal, 1997; Kotler, 1999). A weak sense of direction has also been attributed for team failure by Katzenbach and Smith (1993).

3.3.1.2 Strategic Fit

Strategic fit is the extent of alignment between the team's mission and overall business, technology and product strategy (Hong, 2000). Strategic fit is the extent to which a firm's overall business, product, and technology guide the product development contents and processes (Cooper, 1983, 1985; Cooper and

Kleinschmidt, 1987; Wheelwright and Clark, 1992b). The team members need to understand the linkage of what they specifically do (e.g., design of new products, setting project targets) with the overall firm's policy directions. Senior management's role is to support overall direction and assist necessary resource allocation (Rosenthal and Tatikonda, 1992, 1993).

If a particular product concept fits the overall strategic direction, it has a better chance of being selected (i.e., the product moves faster), accepted (i.e., better team coordination) and executed (i.e., less cost) among team members (Crawford, 1991, 1992; Song and Parry, 1997). Project targets that have a high degree of strategic fit tend to receive quicker top management support and get easier access to internal resources. It would also accelerate the project process to attain strategic advantages in the marketplace. Therefore, a project that has a high level of strategic fit may enhance teamwork (Trygg, 1993), time to market (Mabert et al.,1992), and manufacturing cost (Cusumano and Nobeoka, 1992).

3.3.1.3 Project Targets

Project targets in the case of IPD can have two dimensions; (1) clarity, and (2) trade-offs (Hong, 2000).

Clarity of project targets relates to the extent of communication and understanding of a set of project goals that guide development efforts (Hong, 2000 Clarity of project targets requires unambiguous definition, rich communication, and common understanding of project targets among team members (Gupta and Klaus, 1992; Schein, 1996; Marquardt and Reynolds, 1996). Effective project targets are based on realistic customer requirements (Rosenau, 1989), and good understanding of competitive situations and technical risks (Clark and Wheelwright, 1993). Sound team members strive to set project objectives that are consistent with manufacturing capabilities, suppliers' capabilities, and resources (Clark and Wheelwright, 1993; Schein, 1996). Having clear project targets may be critical in improving cycle time (i.e., time to market), teamwork and overall process productivity because knowing clear project targets enable members to focus the resources faster and more effectively (Murmann, 1994).

Contingent theories have long held that performances are contingent on the fit between the organization's strategy and its product development practices (Gupta et al., 1986; Dougherty, 1990, 1992). For firms that compete by being able to develop products faster than competitors, this supports the organization's strategy by enabling quicker response to changing technologies and customer demands. In contrast, firms competing on the basis of low cost or mature products or with products that have long life cycles or high switching costs and barriers to entry may see little gain from quicker product development (Crawford, 1992; Ittner and Larcker, 1997).

Tradeoffs of project targets refer to the extent of project targets specifications in terms of performance, cost, quality, and time (Hong, 2000). Time-cost tradeoff analyses were well developed in the project management literature (Robinson, 1975; Moder, et al., 1995). Larger and more complex projects take more time. Accelerated product development incurs higher hidden costs (Crawford, 1992). In IPD, time-cost tradeoff is about the overall product development time and its associated cost. Technologically more advanced products take longer to develop than less advanced products (Karisson and Ahistrom, 1999). Cost-quality tradeoff is about comparing the cost in terms of resources for producing particular products and the equality of the products received by customers (Bolo, 1996).

As more firms engage in time-based competition, defining, communicating and understanding the tradeoff between time and cost, time and quality, and quality and cost become more critical. Timely determination of tradeoffs may facilitate and enhance development productivity.

3.3.2 Mutual Trust

Knowledge sharing is about transfer of both tacit and explicit knowledge. While researches and practices recognize that explicit knowledge is easy to communicate, tacit knowledge in particular poses specific challenges in knowledge transfer. Tacit knowledge resides in individuals through personal experiences and know-how that is difficult to codify. As such, shared knowledge should have behavioral implications, especially for the transfer of tacit knowledge. Trust has been a subject of interest for many years. In the recent years, lots of arguments and research work has been published regarding trust and knowledge management. Some of the behavioral implications of trust is provided in Table 3.3. These behavioral implications seem mostly relevant in the context of information sharing and knowledge sharing characteristics.

Table 3.3 Behavioral Examples of Trust

Implications	Literature
Information Sharing	Clarke and Payne, 1997; Weber, 1998
Expectation	Hagen & Choe (1998)
Belief	Uzzi (1997)
Willingness	Mishra (1996); Doney et al. (1998)
Confidence	McAllister (1995); Webb (1996)
Dynamism	Blakeney (1986)
Predictability (Consistency)	Gabarro (1978)
Morality	Giffin (1967)
Goodwill	Husted (1990)
Responsiveness	Holmes (1991)
Honesty (Integrity, Sincerity)	Gabarro (1978)
Credibility	Bonoma (1976)
Openness	Blakeney (1986)
Personal Attraction	Giffin (1967)
Safe (Careful, Confidence)	Blakeney (1986)
Dependability	Bonoma (1976)
Benevolent (Caring, Concern)	Giffin (1967)
Experterness	Blakeney (1986)
Competence(Ability, Capability)	Gabarro (1978)
Attitude	Whitener et al.(1998)
Reliance	Curral & Judge (1995)
Acceptance/Incorporation of risk/vulnerability	Sheppard & Sherman (1998)
Psychological state	Rousseau et al. (1998)
Perception	Doney & Cannon (1997).
Subjective probability	Nooteboom (1996)
Feeling	Tyler & Degoley (1996)
Assumption	Robinson (1996)
Judgment	Webb (1996)
Anticipated cooperation	Burt & Knetz (1996)

One of the most salient factors in the effectiveness of complex IPD social system is the willingness of one or more individuals in a social unit is to be trusted and to trust – or the issue of mutual trust. The efficiency, adjustment, and even survival of any social group depend upon the presence or absence of such trust (Rotter, 1967). Lindskold, Han, and Betz (1986) found greater cooperation, higher effectiveness, and fewer wasted resources in high trusting dyads than in low trusting dyads. Mutual trust is necessary in cross-functional IPD work because the higher interdependence between disciplines means that team members must rely and relied upon the functional expertise of each other for timely and accurate information, view points, and decisions.

Trust has been classified in several ways by researchers. An aggregate classification of trust is present in Table 3.4.

Table 3.4: Some Classification of Trust: A Synthesis (Adapted from Castaldo, 2003)

Criteria	Typologies
Trust dimensions	- Ideological, cognitive, emotional & routine trust (Lewis & Wiegert, 1985) - Affective, cognitive & behavioral trust (Cummings & Bromiley, 1996) - Behavioral & intentional trust (Nooteboom et al., 1997) - Affect-based & cognition-based trust (McAllister, 1995) - Reliableness & emotional trust (Johnson-George & Swap, 1982) - Values, attitude and mood & emotions (Jones & George, 1998) - Institutionalization & habitualization (Nooteboom et al. 1997) - Competence- & goodwill-based dimensions (Nooteboom, 1996)
Relational layer	- Calculative, institutional ('hyphenated') & personal trust (Williamson, 1993) - Insititutional-based, system-based & societal trust (Lane, 1998) - Individual, inter-personal, institutional trust (Lewicki & Bunker, 1995) - Calculative, relational & institutional trust (Rousseau et al. 1998) - Dispositional, personal/interpersonal & system trust (McKnight & Chervany)
Contents and antecedents	- Calculative, knowledge-based & institutional (Lewicki & Bunker, 1996) - Deterrence-based, knowledge-based & identification-based trust (Sheppard & Tuckinski, 1996) - Calculative, cognitive & normative trust (Lane,1998; Child, 1998) - Contractual trust, competence trust & goodwill trust (Sako & Helper, 1998) - Predictability-based & value-based trust (Sitkin & Roth, 1993) - Predictability & explorative trust (Huemer, 2000)
Strength/Quality	- Full, instable & hopeful trust (Andaleeb, 1992) - Thick or thin, weak or strong, fragile or resilient trust (Meyerson et al.1996) - Weak, semi-strong & strong trust (Barney & Hansen, 1994) - Tust vs. distrust (many authors, e.g. Andaleeb, 1992)
Development processes	- Characteristic-based, process-based, institutionally-based (Zucker, 1986) - Calculative processes, predictive processes, intention-based processes, knowledge-based processes, transfer-based processes (Doney et al. 1998)
Other classifications	- Basic trust, guarded trust & extended trust (Brenkert, 1998) - Deterrence, obligation, discovery & internalization (Sheppard & Sherman, 1998) - Task-focused, fiduciary & relational forms of trust (Barber, 1983)
Contiguous concepts	- Spontaneus trust, generated trust, manipulation & capitulation (Hardy et al. 1998) - Trust, faith, confidence & reputation (Luhmann, 1989; Hart, 1989) - Trust, power & commitment (Morgan & Hunt, 1994) - Rational prediction, probable anticipation, uncertainty, panic, fate, faith (Lewis & Wiegert, 1985)

Trust has been defined in several different ways by different researchers. For example, Moorman et al. (1993) define trust as willingness to rely on an exchange partner in whom one has confidence. According to Rogger's (1967) classic view of trust, " trust is a generalized *expectancy* held by an individual that the word of another...can be relied on", which highlights on confidence. Trust exists when "one party has *confidence* in an exchange partner's *reliability and integrity* (Morgan and Hunt, 1994). Trust has been also defined as the willingness to *risk* increasing "one's vulnerability to another whose behavior is not under one's control" (Zand, 1972). *Predictability, dependability, and faith* are three components according to Andaleeb (1992). Mishra (1996) identifies *competence, openness, concern and reliability* as the dimensions of trust. *Persistence, technical competence, and fiduciary responsibility* are Barber's dimension (Barber, 1983). Rempel (1985) uses *predictability, dependability and faith.*

In the extant literature, trust has been treated as either a feature or an aspect of relationship quality (Dwyer et al., 1987) or as a determinant of relationship quality (Anderson and Narus, 1990). Anderson et al. (1987), for example, view trust as a feature of relationships, in addition to power, communications, and goal compatibility. Anderson and Narus, on the other hand, view trust as determinant of the amount of cooperation and the functionality of conflict between parties. Mohr and Nevin (1990) model trust as determinant of communication between parties.

Trust has been viewed as intention or 'goodwill' to perform according to the best of one's ability, and not engage in opportunistic behavior. Bradach and Eccles (1989) defined trust as 'a type of expectation that alleviates the fear that one's exchange partner will act opportunistically'. This definition embraces all possible bases of trustworthiness, including control (hierarchical control, contractual enforcement, self-interest based on dependence, reputation or protection of hostages), social sources (norms of reciprocity), personal sources (affect, identification), a preference or taste for trust-based dealings, and routinized behavior. Mayer et al. (1995) defined trust as 'the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustier, irrespective of the ability to monitor or control that other party'. According to Hardy et al. (1998) trust can be defined as *predictability* which points to that trust ensures that you can count on knowledge produced in specific context by specific people or as Bachman (2001) emphasizes, "trust reduces uncertainty in that it allows for specific (rather than arbitrary) assumptions about other social actors' future behavior." Further arguments draws that trust is *more than predictability: it also includes goodwill*, the existence of common values that can be translated into common goals (Hardy et al. 1998).

However considering trust in terms of both predictability and goodwill presupposes that predictability arises from shared meaning, while goodwill arises from the participation of all partners in the communication process whereby this shared meaning is created. Accordingly, trust can be considered a continuous process of sense making and negotiating that bridges heterogeneous groups. NPD is about problem solving in a complex uncertain environment that requires continuous stream of information and knowledge. In that way can trust play a role where rational prediction ends as trust possess the power of bridging information uncertainty" (Lane, 1998). Mohr and Nevin (1990) model trust as a *determinant* of communication between parties. Scholars have linked trust to knowledge ambiguity (Simonin, 1999) and knowledge embeddedness (Nielsen, 2001) in the pursuit of effective knowledge transfer, synergies and learning. Empirical evidence for the relationship between trust and learning ranges from Dodgson's (1993) work on trust, showing that trust between people encourages learning to Kale et al.'s (2000) work on inter-organizational alliances, reporting a significant positive effect of relational capital (of which trust is a major part) on learning. Uzzi (1996) reported from his field study that trust acted as the governance mechanisms of embedded relationships and as such facilitated the exchange of especially tacit knowledge related capabilities and information. Tacit knowledge, as opposed to explicit knowledge resides in the individual and in order to share such information, individuals must be able to trust another. Trust promotes voluntary, non-obligating exchanges of assets and services between actors.

Cooper (1993) has noted that, as companies strive to bridge the gap between functional areas, information critical to the product's formation and function can get withheld, misunderstood, or lost. Members of IPD team can withhold information because of a lack of trust among the various cross-functional team members, suppliers and customers. Development team members need some mechanism to connect departmental "thought worlds" so that insights possessed by individual departments can be combined to develop new products that harness collective wisdom of all involved. These communication difficulties must be resolved for successful NPD. Vested interests can prevent effective progress on a good project (Urban and Hauser, 1980).

Therefore, trust is a critical ingredient for inter-functional cooperation, which is critical for NPD success. Mutuality is a critical characteristic, which implies that there is a measure of equality between the parties to a relationship. Common goals and interests (Ford et al., 1986) will bind the firms in a common interest or shared purpose and influence interactions by encouraging either party to make sacrifices for the sake of the relationship. Trust based on mutuality among the IPD team members ensure that knowledge could be openly shared in good faith. Without mutual trust among the IPD team members, there can be little sharing of information, only minimal regard for system requirements, weak follow-through, and low goal attainment. Trust may be based on knowledge and inference (attribution) of the partner's abilities, traits, goals, norms, values, and circumstances. This knowledge may be based on one's own experience (Burt, 1992), the partner's reputation (Monsted, 1998), or institutional indicators like certificates, membership of family, clan or associations (Zucker, 1986) which provides mutual trust as a good indicator as a driver for knowledge sharing in IPD.

For this study, mutual trust is operationalized as:

Mutual trust is the mutual expectation among product development team members that everyone will work together in good faith.

From social exchange perspective, community relationship between the team (e.g. IPD team) as a whole, and the individual with knowledge, are typically marked by identification-based trust, which according to (Shapiro et al., 1992) is developed among those sharing parties who start identify themselves strongly with one another and share common goals and needs. IPD team members being a knowledge worker means being involved in learning and the creation of new knowledge through becoming an 'insider' in the community (Brown and Duguid, 1991), that is, they are acquiring not explicit, formal 'expert knowledge', but the embodied ability to behave as community members. Knowledge-based trust is created if the sharing parties generally demonstrate trustworthiness (Lewicki and Bunker, 1996).

Product development process guides members how to organize their work processes. In addition, it provides team members the understanding of knowledge structure of other members (Nonaka and Takeuchi, 1995), facilitates social integration thorough trust building (Roth and Kleiner, 1996), and replaces individual goal differences with the collective goal (Klimoski and Mohammed, 1994) of the project. This sense of shared goal and trust encourages communication for accomplishing the project (Madhaven and Grover, 1998). Although the knowledge may be provided by the members in knowledge exchange, with the lack of trust among the exchange parties, the knowledge may not be received and accepted in good faith. In addition, during the routine task in the product development, information maybe shared to tackle specific problems, because of lack of good faith no knowledge sharing may take place that can lead to effective problem solving. Lack of mutual trust on the other hand will also add-up the internal uncertainty created by the NPD team members in addition to the existence of regular high uncertainty in any product development environment.

Thus, for knowledge to be shared, both the exchanging parties needs to trust one another.

3.3.3 Mutual Influence

Sharing of tacit knowledge that resides in various team members will have strong behavioral implication on what leads to member to share knowledge. Besides team vision and mutual trust, another such determinant of shared knowledge in product development could be mutual influence. As discussed earlier, knowledge sharing is about both knowledge exploration, and once useful knowledge is located, it is also about knowledge exploitation. The perspective on shared knowledge must see individuals as knowledge creators and bearers, admitting learning in interaction with others as a major tool (Nonaka and Takeuchi, 1995), and keep a creative environment for individual, exemplified by Franken's (1994) ideas on stimulation, communication, and problem solving.

An interesting argument that has been made in the past is that although trust has been seen as an effective and efficient means of coordinating organizational and trans-organizational relations, trust operates through a fragile mechanism. An intrinsic feature of trust is that it can turn out to be misplaced and the danger of a sudden breakdown of trust thus can never be excluded. Fortunately, trust is not the only way to reduce complexity and uncertainty. Another mechanism to control the dynamics of a social relationship is power. While the heavyweight product manager of a product development team holds a formal, authorative power, which is an efficient and robust mechanism of controlling certain exchange activities, such as conflict resolution, symmetrical power distribution, on the other hand, among the team members ensures that development team members can influence one another's activities and behavior. If knowledge is to be exchanged to solve complex problems amidst the uncertainty, mutual influence will ensure that the exchanging parties appreciates and understands the knowledge offered by others. Knowledge sharing would seem to be hazardous or at best silly to rely on the mechanism of asymmetrical power, or unequal power distribution where one can pressurize another party to act on his or her own knowledge-base; just as it would be the case when exchanging parties offer blind trust to another team member.

French and Raven (1968) describe five bases of power: referent, expert, legitimate, reward, and coercive. An additional base of power that is generally recognized is information power, which refers to the ability of an individual to influence another because of information processed or controlled (Kohli, 1989; Raven et al., 1998). Information power is analogous to the gate-keeping ability of an individual (Kohli, 1989). Sharing knowledge among the team members will require no gatekeepers of the information in the team or in other words, there should not exist any power structure within the IPD group that can become barrier of knowledge exchange. Knowledge workers prefer autonomy to any other job characteristics (Cheney, 1984; Goldstein and Rockart, 1984). Autonomy and interdependence have been common leverage points for motivating teams, and are consequently included in most models of team effectiveness (Campion et al., 1993; Gladstein, 1984). In the literatures, team autonomy has been found to mean that the team is empowered to make decisions. Also, such functionally diversified team in IPD environment requires frequent feedbacks and information from each other that can help the team to deal with uncertainty and evolving new product-process goals. Interdependence is critical in achieving goals for novel, important, and complex NPD projects (Adler, 1995; Pfeffer and Salancik, 1978). New product characteristics should have implications for influence because of high level of uncertainty, resource, and power distribution associated with NPD project (Adler, 1995; Moenaert and Souder, 1996).

A distinction between *power and influence* is commonly made in power literature (Venkatesh et al., 1995; Yukl et al., 1996). Power is often seen as the potential to have influence, whereas influence is viewed as actual effect of that power to change the behavior of a group. Individual behavior is made up of elements such as individual personality, attitude, perception, and creativity (Moorhead and Griffin, 2003). Influence is viewed as actual the actual effect of that power to change the behavior of a group. An individual will require power to influence a group to become more aligned with his or her point of view.

Various types of powers are also discussed in the literature in terms of authority and domination. *Authorative power* entails issuing of power, with an expected compliance, though through use of force (Hall, 1999, Powell and Smith-Doer, 1994). Hardy and Phillips (1998) define *formal authority* as the "recognized, legitimate right to make a decision". This is also called the legitimate power, as it is built into the hierarchical structure (Hardy and Clegg, 1996).

Domination involves control (Hall, 1999; Hardy and Clegg, 1996). Powell and Smith-Doer (1994) define domination: it entails the control of the behavior of one individual by another who can offer or restrict benefit or inflict. Finally, Hardy and Phillips (1998) present another version of domination that relies on control of scarce resources: "when one organization or group relies on another for a critical resource, such as expertise, money, equipment, information etc. the dependent organization is at a power disadvantage". As oppose to authority and domination, *influence* is exhibited when a decision is made because of an assumed pressure to satisfy the power holder's wishes (Hall, 1999; Powell and Smith-Doer, 1994). Unlike authority and domination, which are explicit, influence can be subtle. According to Hardy and Phillips (1998), "...such actors are understood to be speaking legitimately for issues and organizations affected by the domain". In knowledge intensive environment such as IPD, it is clearly important that knowledge exchanging functional experts hold such influence with the fellow team members, and simply is not exercising authorative or dominating behavior. In that case, although the knowledge may be transferred, the receiving party may not absorb it in team spirit. Use of authority and domination is definitely not the way of exchanging knowledge.

Influence refers to the degree to which information offered by participants in the NPD process leads to change in behavior, attitudes, and / or actions of the recipient (Kohli, 1989). Influence ensures the legitimacy of the team member in knowledge exchange process. Influence is germane in NPD because at its core NPD is about risk, ambiguity, and uncertainty, and is replete with functional conflicts caused by differences in perceptions and self-interest (Frost and Egri, 1991; Ruekert and Walker, 1987).

Agreement on the understanding of a particular knowledge base will depend upon the agreement among the development team members, or in other word the level of influence individuals may have on the group. If there exist an equal power, each members of the IPD will have an equal opportunity to change other's view on a specific knowledge domain and vice versa. Influence of a power has two components: a type of influence (based on the power attempted) and a level that range from low to high (Kohli, 1989; Venkatesh et al., 1995). A logic extension would be that if in the absent of power of low to high, and if there exists an equal power, the influence will be bi-directional. If then, the knowledge exchange process would be bi-directional, or shared knowledge will emerge among the IPD team members. Thus, such information-processing subsystem of NPD involves individuals and functions that create and disseminate information and act on shared meanings (Moorman, 1995) creating shared knowledge for the team.

As discussed earlier, knowledge sharing is about both sharing explicit knowledge and tacit knowledge. Behavioral implication of mutual influence between the exchanging parties provides answer to why and how the knowledge is shared among the IPD team members. Some of the behavioral examples of influence were captured in Zand (1972) domain of accepting influence (or mutual influence) and interdependence and has been a subject of interest in several studies, some of which are presented in Table 3.5.

Table 3.5 Behavioral Examples of Acceptance of Influence

Implications	Literature
Reliance on Others	Clark and Payne, 1997; Gabarro, 1978
Delegation	Meyers et al., 1995; Rosen and Jerdee, 1977; Schoorman et al., 1996
Informal agreements and Task Coordination	Curall and Judge, 1995; Mayer and Davis, 1999
Promoting interdependece, pursuing joint opportunities and new joint initiatives	Lewicki et al., 1998
Accepting interdependence	Gabarro, 1978; Roberts and O'Reilly, 1974; Mayer et al., 1995

NPD teams are information-processing subsystems of the organization designed to reduce customer, market, and technology uncertainty in the NPD process (Moenaert and Souder, 1990). IPD teams, as problem-solver or knowledge workers, require constant streams of information to gain knowledge from each other about complex tasks demands. Characterized by high level of uncertainty and as information processing system, IPD situation involves “reciprocal interdependence” in which each member involved depends on the other for accurate and truthful information. Interdependence can be considered a defining characteristic of all teams (Sundstorm et al., 1990). Naturally, the information negotiation behavior should involve that each party in information transaction are open to give and accept information with proper feedback. Thompson (1967) argues that mutuality in situations of reciprocal interdependence reduces uncertainty for the parties. Information is exchanged and accepted in an open, mutual environment and provides a basis for joint decision making thus bridling opportunistic behavior of the NPD team members, suppliers and customers. Thus, there is the basis of developing knowledge that is shared among the IPD team members with the existence of mutual influence. It is difficult to imagine meaningful information exchange without proper feedback and any bona fide adjustment by either party in exchange, regardless who initiated such information exchange. As Dyer and Singh (1998) point out, alliance partners must generate and enhance their knowledge-absorbing capacities and generate routines that facilitate sharing of information. Thus, the parties involved in IPD must share, digest, and act on information that created or made available. It is the transfer and recombination of information that is accepted, appreciated, and made to use that allows knowledge sharing among suppliers, various functional team representatives, and customers.

Empirical studies (Griffin and Hauser, 1992; Dougherty, 1987) have shown that communication frequency among project team members influences their performance. The higher the frequency of information exchange, the more knowledge is being created and the better for innovation (Griffin and Hauser, 1992; Dougherty, 1987). Innovation is more successful if individuals in R&D and engineering understand customer needs, individuals in marketing understand technological constraints and capabilities, and both understand the implications for manufacturing and competitive strategy (Workman, 1995). Innovation requires the mobilization and integration of different types of functional knowledge (Dougherty, 1992). Kogut and Zander (1992) propose that in developing the "*combinative capability*" communication codes that facilitate knowledge mobilization between design and manufacturing are necessary. Prahalad and Hammel (1990) suggests that firms that have the "core competence" provide mechanisms whereby individuals who are "carriers of core competence" are encouraged to communicate across functional and business boundaries to share knowledge to create knowledge for innovation. This requires that in communication exchange process, both the sender and receivers are open to each other's perspective on design and development issues of new product.

Social exchange is primarily a voluntary relationship that is based on the general expectation of reciprocity (Blau, 1964; Gouldner, 1960; Bouty, 2000). It occurs naturally if not recognized by hierarchy or power structure. In IPD environment, team members are interdependent on each other for work process and information. The interaction between sharing parties is primarily lateral in social exchange. It may, however, become vertical if receiving exceeds giving (Blau, 1964). That is, if reciprocity becomes unbalanced, a hierarchy of individuals with "expert status" evolves. Individuals in IPD will engage in knowledge sharing only if they have calculated that a potential sharing party would be willing and able to reciprocate by sharing knowledge of equal or higher value. In contrast to social exchange, knowledge sharing is not perceived just as individual-to-individual but between individual and the community (Kanter, 1972). The community is expected to provide its members with the knowledge they need (Kanter, 1972). The member share a common identity, consider each other to be equals, and perceive competition for status as incompatible with the community purpose (Rothschild-Whitt, 1979; Bouty, 2000). Thus knowledge would be shared among the IPD team members if there exists equal power structure among the team members.

For this study, mutual influence is operationalized as:

Mutual Influence is the symmetrical power relationships among members of the product development team.

According to Gates (1993), alliances that are dominated by a single partner (or single function, such as design engineers or marketing) typically have a high rate of failure. Asymmetrical dependence in NPD interferes with joint problem solving because the weaker party guard against exploitation while the stronger tends to probe the boundaries of exploitation or guard against the appearance of intentions to exploit (McAlister, Bazerman, and Fader, 1986). This combination of pressures on the relationship severely taxes the ability of the parties to cooperate in unbalanced power context. Parties that do not depend on each other have little motivation to cooperate (Harrigan, 1988). Brouthers et al. (1995) suggest that symmetrical partnership tends to foster a cooperative culture and that alliance without cooperative cultures tend to fail. The terms ‘asymmetrical’ and ‘symmetrical’ have tended to be used in industrial marketing literature to refer to the asymmetrical nature of one or a few characteristics such as commitment, power or dependence (e.g. Gundlachet et al., 1995; Sollner, 1998). Ford et al. (1986) describe the nature of companies’ interactions according to the other dimensions, including *mutuality*. Ford (1980) states that long–term relationships will be characterized by the companies’ “mutual importance to each other”. In IPD team, individuals who have a high degree of access to information or knowledge tend to have a higher level of power and influence (Blau and Aba, 1982; Spreitrzer, 1996). NPD is a political process fraught with self-interests and struggles for power (Frost and Egri, 1991; Markham, 1998, Maute and Locander, 1994). It thus suggests that participations unlikely to enhance one's impact on the outcomes of decision making without an accompanying influence (Frost and Egri, 1991). Self-interest or stake (which can be minimized through shared team vision) in the NPD outcomes seems an important factor because NPD participants face personal risks in undertaking NPD projects. To the extent that the outcomes affect their interests, they attempt to influence process (Frost and Egri, 1991). Power imbalance between NPD team members will likely lead toward one party to use influence attempts as countervailing power (Atuahene-Gima and Evangelista, 2000). Where power is unbalanced, communication frequency is reduced as the powerful member ignores requests and ideas from the weaker one, and merely dictates its ideas (Mohr and Nevin, 1990) and it that situation knowledge cannot be considered shared. In an asymmetrical power condition, the less powerful person may feel reluctant to communicate directly with more powerful person. The team member may even actively withhold information to counter the power of the more powerful person (Mohr and Nevin, 1990). Naturally, with the implementation of IPD with members from focal product development company, suppliers, and customers, the power and influence of certain functional members could increase because of their deeper understanding in specific matter at some specific stage of product development process. Therefore, it is logical to conclude, if the power is equal, where each member has influence over the other, knowledge of one specific domain is shared equally compared to the other domains.

Lawrence and Lorsch (1986) found that the characteristics of effective knowledge integration is, among other factors, influence (i.e. influence derived from knowledge and expertise valued by all team members, not just positional authority) and rich exchange (i.e. mutuality) of formal and informal information and knowledge to solve problems.

An existence in the sense of equality of power can only insure that members in knowledge exchange process in IPD are willing to share and ready to accept the knowledge from one another. This thesis posit that presence of equal power structure and guided by common vision will help the knowledge sharing among the team members of IPD.

3.3.4 Shared Knowledge

Uzzi (1996) found that joint problem-solving arrangements that enable actors to coordinate functions and work out problems provide more rapid explicit feedback than do market-based mechanisms. These coordinating arrangements enable firms to work through problems and to accelerate learning and problem correction. Along the same lines, Kale and Dyer (2000) found that firms that invest in creating a dedicated alliance function (with the intent of strategically coordinating alliance activity and capturing/disseminating alliance related knowledge) realize greater success with alliances. This suggests that setting up an explicit organizing mechanism for coordinating alliance related activities might increase the level of trust and learning by developing significant tacit knowledge about alliance management, thereby providing a focal point for knowledge sharing and learning.

Effective communication between team members is essential for product development team. Communication refers to "the formal as well as informal sharing of meaningful and timely information", (Anderson and Narus, 1994). In the product development literature, the argument is often made that close and frequent interactions between R&D and other functions, teams, and operational sub-units lead to project effectiveness because of the timely integration or knowledge across organizational boundaries (e.g. Clark and Fujimoto, 1991; Leonard-Barton and Sinha, 1993; Henderson and Cockburn, 1994; Eisenhardt and Tabrizi, 1995; Szulanski, 1996 etc.).

Sharing knowledge is both about combining existing knowledge differently with the purpose of creating new knowledge (Grant, 1996), and securing that existing knowledge is distributed within or across organizational boundaries to prevent "reinventing" the wheel. In recent cognitive models of the mind, knowledge is often conceived in terms of cognitive scripts and schemata. The objective is to develop general models of how meaning is organized, processed and communicated among the team members that hold these dispersed knowledge. Scripts and schemata act as selection mechanisms that specify how certain elements of knowledge relate to one another, and these scripts or specific parts of them are invoked in context. Collaborative learning community concerns how *shared knowledge* is developed and sustained in human activity (Baker et al, 1999, Dillenbourg, 1999). In the context of product development, the development community is the team members representing various departments with functional knowledge, suppliers, and customers. The possibility of developing abstract theoretical models of the communicative processes involved, as a guide for technological systems design, has also been keenly discussed in Computer Supported Cooperative Work or CSCW communities (Nardi, 1996, Dourish and Button, 1998; Arias et al., 2000).

Knowledge sharing is an ongoing concern in all types of organization whether they are what Blackler (1995) refers to as either knowledge-routinized or communication-intensive. The discussion of knowledge sharing is very much influenced and dominated by two “models”: (1) the SRMC (source, recipient, message, and channel) derived from the communication theory and, (2) the distinction between explicit and tacit knowledge (see chapter 2). These two models or perspectives highlight a lot of barriers and problems for sharing knowledge that has been identified and discussed in other literatures, such as the stickiness of knowledge (Szulanski, 2003), where to find the knowledge (O’Dell and Grayson, 1998), the tacit dimension of knowledge (Nonaka and Takeuchi, 1995), the relationship between the sender and receiver of knowledge (Osterloh and Frey, 2000), organizational units that hinder or enables knowledge sharing (Brown and Duguid, 2001), and identification of knowledge worth sharing (Gupta and Govindarajan, 2000).

Knowing that knowledge exists and identifying where it exists among the product development team members is not sufficient in itself for knowledge sharing. From the SRMC model, sharing of information would require both (1) a sender and a receiver of knowledge, (2) knowledge, and (3) some kind of "more than friendly" relationship between the two. A much discussed barrier for sharing knowledge is the assumption that knowledge equals power, and sharing knowledge, hence, means sharing or losing power. There is a certain kind of knowledge hegemony (von Krogh, 1998) that is difficult to overcome.

Clark and Fujimoto (1991) and others observe the importance to superior product development capabilities of thick communication across functional departments. The main value of this communication is in building up a stock of "trans-specialist understanding" (Postrel, 2002) that enables each functional area to avoid presenting unsolvable problems to the other, that is, to avoid "glitches" (Hoopes and Postrel, 1999). Mohamed (1991) state that much knowledge is generated as business partners commit to the relationship by adapting to each other. One partner's adaptation of product and production process is reciprocated by the other partner, so these adaptations are a mutual process. As the business partners commit to the relationship they learn about each other (Fiol and Lyles, 1985), and further knowledge is generated, from within the relationship, as the partners adapt to each other (Hallen et al., 1994; Grabher, 1993). The adaptations may be small scale, and therefore will have smaller learning effects, or may be major such as when a new product is developed for a specific customer (von Hippel, 1978). According to Penrose (1980) and Madhok (1997), Networks provide access to various sources of information thus offering more opportunities to learn than relying on knowledge from within the firm (Grabher, 1993). Larson (1992) found that companies and individuals consider themselves as members of a network within a broad industry framework. Through this industry framework members acquire ideas, influences, or information about the surrounding network that would otherwise be unobtainable (Granovetter, 1973). The very importance of using a cross-functional team long with suppliers and customers is that a network of knowledge domain is formed and related knowledge for new product is shared among the nodes of this network.

Companies are adopting integrated approaches to identify, manage, share, and capitalize on the know-how, experience, and intellectual capital of employees (Steyn, 2002; Martensson, 2000). Early empirical research efforts have begun to shed light on factors involved in knowledge sharing, which some have defined as a set of behaviors involved in exchange of knowledge to others (Connelly).

Dougherty and Heller (1994) argue that the activities that constitute product innovation may be grouped into three sets of linkages. The first set of linkages is the one that innovators make between market and technological possibilities. The second set of linkages is made between the expertise of different functions or departments with the organization. The third set of linkages is made between the product and the firm's strategy and resources (i.e., strategy and goals). The first linkage is about external knowledge components, which are, in IPD context, knowledge of customers and suppliers. The second linkage is about the internal knowledge components, which are knowledge of internal capabilities and process. The third linkage is about linking a particular project with overall strategic goals and objectives (i.e., team vision) and how it can be realized (team vision, mutual trust, and mutual influence). Therefore, for knowledge integration components (i.e., team vision, mutual trust, mutual influence and shared knowledge) are a part of vital knowledge linkages. Recently, some researchers have explored the importance of shared knowledge for the success of a firm's product development efforts (Nonaka and Takeuchi, 1995). However, studies of shared knowledge are limited in a particular industry: information systems (Nelson and Cooprider, 1996). At present, little is known about the impact of knowledge in IPD for manufacturing firms (Hong, 2000). Also, little is known about whether, or under what conditions, a particular aspect of shared knowledge enhances a firm's product development outcomes.

Shared knowledge is one of the unique, valuable and critical resources that is central to having a competitive advantage (Nonaka and Takeuchi, 1994, 1995; Prahlad and Hamel, 1990). Firms increasingly rely on building and creating a shared knowledge base as an important resources capability (Huber, 1991, 1996; Nonaka, 1994; Matusik and Hill, 1998). On a project level, teams share knowledge of individuals in order to solve problems and find innovative solutions (Davenport et al., 1996; Drucker, 1991; Kogut and Zander; 1992; Winter, 1987). Shared knowledge is viewed as as an understanding and appreciation among different functions and effective shared knowledge is viewed as a synergy between team members (Bostrom, 1989; Hoopes and Postreal, 1999).

In this study, shared knowledge is operationalized as:

Shared Knowledge is the shared understanding of customers, suppliers, internal capabilities, and process in cross-functional product development teams.

Empirical studies by Madhavan and Grover (1998), Li and Calanton (1998), and Zander and Kogut (1995) have helped to identify and measure underlying variables of shared knowledge. This research model builds on the pioneering works of Khurana and Rosenthal (1997, 1998), Kim (1993), Paashuis (1998), Hoopes and Postrel, (1999) and Hong (2000) in regard to the importance of shared learning and knowledge. Table 3.6 identifies four variables of shared knowledge, their definition and their relevant literature base of each variable. Shared knowledge affects product development performance outcomes (Zack, 1999).

Table 3.6 Shared Knowledge in IPD

Variables	**Definition**	**Literature**
Shared Knowledge of Customers	The extent of a shared understanding of current customer needs and future value to customer creation opportunities among IPD team members.	Hong, 2000; Clark and Wheelright, 1993; Dolan, 1993; Day, 1990; Cordell, 1997 etc.
Shared Knowledge of Suppliers	The extent of a shared understanding of supplier's design, process, manufacturing capabilities among IPD team members.	Hong, 2000; Evans and Lindsay, 1996; Hartley, 1997, Slade 1993; Hahn, Watts and Kim, 1990 etc.
Shared Knowledge of Internal Capabilities	The extent of a shared understanding of firm's internal design, process, and manufacturing capabilities among IPD team members.	Hong, 2000; Adler et al., 1996; Moorman, 1997; Kim and Mauborgne, 1997 etc.
Shared Knowledge of Process	The extent of a shared understanding of firm's product development process among IPD team members.	Krishnan and Ulrich, 2001; Haho et al., 2000; PMBOK, 2002 etc.

Companies are adopting integrated approaches to identify, manage, share, and capitalize on the know-how, experience, and intellectual capital of employees (Steyn, 2002; Martensson, 2000). Early empirical research efforts have begun to shed light on factors involved in knowledge sharing, which some have defined as a set of behaviors involved in exchange of knowledge to others (Connelly).

3.3.4.1 Shared Knowledge of Customers

Several studies show that a firm can acquire knowledge from its customers, which can be used for further market entry and expansion (Hertz, 1993; Lee, 1991). Shared knowledge of customer refers to the extent of a shared understanding of current customers' needs and future value to customer creation opportunities among product development team members (Hong, 2000, Narver and Slater, 1990; Griffin and Hauser, 1991; Calantone et al., 1995, 1996). The extent of shared knowledge is an indication of a continuous, proactive disposition toward creating high customer values across the functions of an organization and; therefore, it is regarded as the most fundamental aspect of product development (Deshpande et al., 1993).

Those who have a high level of contact with customers (e.g. product manager or marketing manager) may have high degrees of understanding the changing needs of customers (Slater and Narver, 1994, 1995), the value to customer attributes (Slater and Narver, 1994) and levels of satisfaction with customers to the products (Gatignon and Robertson, 1991; Day, 1993; Gale, 1994). A key of product development success is how much other product development team members understand the customer needs, requirements, use, and value attributes in the early stage of product development process (Clark and Wheelright, 1993). Instead of relying on the experience or insight particular functional team members, when cross-functional team members meet with customers directly in focus groups, common experience may improve the quality and knowledge content of customers (Dougherty, 1992; Brown and Eisenhardt, 1995; Jaworski and Kohli, 1993). Shared understanding of customer knowledge also enhances the chances of meeting changing needs of customers, coping with internal dynamics on how customers make their purchase decisions (Holak and Lehmann, 1990) and assessing characteristics of target customers, in broad viewpoints (Cooper, 1983, 1984, 1992; Wheelright and Clark, 1992).

A tool utilized commonly in practice to involve customer requirements in development project has been Quality Function Deployment (QFD). QFD is a multifunctional group technique for identifying and operationalizing customer needs, translating them into product attributes and design specifications, and deriving strategic and operational direction. QFD requires members of marketing, engineering, R&D, and operations to actively interpret the marketing research and the *voice of the customer* (VOC). In a study of 35 U.S. QFD projects, Griffin (1992) found QFD increased customer satisfaction in 27% of the cases and improved the NPD process in 83%, and reduced NPD cost and development time.

Gruner and Homburg (2000) found a positive effect on new product success of the intensity of customer interaction in the first two stages of NPD, idea generation and product concept development, with some indication that customer interaction is more valuable during the more concrete stage of concept development. With shared knowledge of the customers' need, requirements, and expectation, the IPD team will be able to develop a closer customer-product fit. Such shared knowledge of customers in product development also provides a basis of creating greater value for customers and there exists a better chance for product success in the market place.

3.3.4.2 Shared Knowledge of Suppliers

The business network may overlap other structures such as a value-added chain or a distribution channel (Hakansson and Snehota, 1995). According to Sharma and Johanson (1987) the firm's relationships with these various actors are the most important assets of the firm. Being part of a business network is of strategic importance as firms are exposed to opportunities in new markets (Axelsson and Johanson, 1992; Coviello and Munro, 1997).

Suppliers may deliver valuable insights into the integration of the NPD and production phases ensuring a higher overlap between the stages in the product development process as stressed earlier on e.g. by testing the innovation and developing prototypes in collaboration. Croom (2001) and Nesheim (2001) both pointed to the boundaries for supplier involvement. Nesheim found that external suppliers are in fact involved in core activities within the firms, which was supported by Croom. Wynstra and Pierick (2000) argue that supplier involvement rests in effectiveness and efficiency arguments and a natural step is therefore to include suppliers into the later stages of NPD, whereas inputs at earlier stages may not support these arguments. Nevertheless, supplier involvement may be viewed as a preliminary step towards outsourcing of the development efforts (Fischer et al., 2002), which may lead to increased supplier involvement

The firm combines its existing knowledge with knowledge from other partners to create new knowledge (Hakansson and Snehota, 1995; Grabher, 1993). Since this new knowledge has developed within the relationship it means that the knowledge of the two parties is connected. The open-ended character of networks encourages new knowledge to be created which cannot easily be traded in markets (Grabher, 1993), for example, a relationship can result in exchange of sophisticated technology which is knowledge of a tacit nature (Nelson and Winter, 1982). Dowlatshahi (1998) developed a framework for implementing early supplier involvement (ESI), which addressed the stages and interactions among procurement, manufacturing, marketing, and design during the product development process for qualified suppliers.

Shared knowledge of suppliers refers to the extent of the shared understanding (i.e., know-why) of suppliers' design, process and manufacturing capabilities among product development team members (Maas, 1988; Hahn et al., 1990, Slade, 1993). Since suppliers are actively involved in key processes of

IPD, the knowledge of suppliers' capabilities is essential for timely and cost-effective decision making in IPD (Evans and Lindsay, 1996).

Shared knowledge of suppliers allows product development members to improve product performance (e.g., its technical and overall performance) and reduce manufacturing costs (e.g., cost of raw materials of the product supplied by the suppliers) because a substantial portion or part of their final product depends on suppliers' work.

3.3.4.3 Shared Knowledge of Internal Capabilities

Knowledge of internal capabilities refers to the extent of a shared understanding (i.e., know-why) of the firm's internal design, process and manufacturing capabilities among product development members (Hong, 2000; Clark and Wheelwright, 1993; Garvin, 1993; Adler, et al., 1996).

Knowledge of internal capabilities resides usually among design and manufacturing team members. They key is how many different functional specialists (e.g., product design engineers, marketing managers) are aware of the strengths and weaknesses of various aspects of design capabilities, manufacturing processes, facilities and other manufacturing capabilities. Standard work processes (e.g., standard forms and procedures that are simple, devised by the people who use them, and updated as needed) are an important element of process technologies (Sobek et al., 1998).

The more knowledge of internal capabilities is shared among product development members, the faster they start working on their project targets and increase development productivity (e.g., reducing engineering hours). IPD decisions may be a particular function (e.g., that of a design engineer) may affect other functions (e.g., that of a manufacturing engineer). Knowledge what other team members can do would enable team members to make better quality decisions that affect the different outcomes. Therefore, shared knowledge of internal capabilities might affect almost all performance outcomes because ultimately effective problem solving in IPD is the result of the effective decision making of all team members. Effective decision making in all aspects of IPD requires a good understanding of what other functions can do and their limitations because knowledge and work is highly interdependent in and integrated product development environment.

3.3.4.4 Shared Knowledge of Process

The project management principles in business process development are crucial to implement the process innovations (Haho et al., 2000). In managing a development project, decisions are made about the relative priority of development objectives, the planned timing and sequence of development activities, the major project milestones and prototypes, mechanisms for coordination among team members, and means of monitoring and controlling project (PMBOK, 2002; Krishnan and Ulrich, 2001). All the steps of NPD process, upstream and downstream, need to be integrated with the design and development of the development process that will make the product to minimize the development cost (both schedule and dollar cost) and communicate these processes, their interdependencies and the decision points to the IPD team. Krishnan and Ulrich (2001) focused on the decisions that need to be made during the NPD process. The final product is the outcome of the development team's decisions and innovative ideas (Nonaka and Takeuchi, 1995; Oliver and Orgote, 1999).

NPD typically follows a well-defined process where new product concept evolves through several stages before product reach commercial production. Cooper (1993) identifies 13 distinct NPD stages of what is popularly known in the industry as stage-gate process where the management makes go or no-go decisions between each stage. Griffin (1997) reports that just over 60% of surveyed manufacturing firms use a cross functional stage-gate NPD process. Montoya-Weiss and Calantone (1994) conducted research on new product projects and classified the identified influencing factors in project process development. Similarly, Deschamp and Nayak (1995) identified six basic management process in product innovation, namely intelligence development process, idea management, resource management, technology and product development and planning, project or program management, and product support management. Several studies have shown that use of repeatable NPD process to successful new production outcomes (Cooper and Edgett, 1996; Cooper and Kleinschmidt, 1995; Rochford and Rudelius, 1997). Repeating task enables the executers of task to learn and gain insight about the task that could be improved upon in the future and has been center of many articles in management dealing with the issue of learning by doing.

Formal project planning tools, such as Work Breakdown Structures, Gantt chart and project-scheduling techniques such as PERT and CPM enjoy widespread use in planning the resources and timing sequences of various development activities and processes (Project Management Book of Knowledge, 2002; Eppinger et al., 1994). Careful management of overlapped activities in product development requires the detailed representation of information exchange between individual tasks a deeper understanding of the properties of information (Krishnan et al., 1997; Loch and Terwiesch 1998). Insights about the nature on nature of development tasks offer the promise of fostering communication where it is most valuable (Moenaert and Souder, 1996; Griffin, 1992).

Shared knowledge of process it the extent of a shared understanding of firm's product development process among IPD team members. A clear understanding of various stages, activities, and milestones enables IPD team to co-ordinate task and realize the task interdependencies among various tasks and team members. Team member will thus have a clear knowledge of timing and sequence of development activities (Aitsahlia et al., 1995; Krishnan et al., 1997), project milestones and planned prototypes (Tarwiesch and Loch, 1998; Milson et al., 1992), and the relative priority of development objectives (Ittner and Larcker, 1997; Cohen et al., 1996).

3.3.5 IPD Performance Outcomes

Performance measures are common control mechanism. They communicate desired outcomes or behavior of a system, and are used to evaluate success in achieving goals. It is generally believed that the best performance measures are those linked to a firm's strategy (Kaplan and Norton, 1992; Langfield-Smith, 1997). Several studies report that about half of surveyed firms measure NPD performance (Griffin, 1997). Most firms that measure performance use a combination of financial and non-financial measures (Griffin and Page, 1996). Their research has shown that NPD success can be measured by factors that are customer-based, financial, and technical performance-based. These measures focused on efficiency, effectiveness, and growth (Griffin and Page, 1996). A project's performance reflects integrative intermediate objectives, such as cost, time, productivity, customer satisfaction and overall product performance. These objectives are integrative since they demand that a various partners work together rather than separately follow their own goal. Thus the integrated mechanism exists not only during the project execution, but the end results are also integrative.

Syamil (2000) research work on IPD measures the performance using 11 measurement factors; teamwork performance, engineering change time, product cost reduction, team productivity, manufacturing cost reduction, product integrity, suppliers' on-time performance, suppliers' quality performance, suppliers' cost performance, product development time, and customer satisfaction. Hong (2000) used teamwork, development productivity, time to market, manufacturabilty, manufacturing cost, value to customer and product performance in his research on knowledge integration in new product development. Since the effectiveness of IPD processes can be measured only in relation to the performance measures, proper identification of these measures is important. Since this study focuses on knowledge integration in an IPD environment, performance measures used here is a combination performance measures used in these two areas of IPD (Syamil, 2000) and knowledge integration (Hong, 2000). Based upon their measurements, in this study, IPD performance measures are classified into two broad categories of (1) Process outcomes, and (2) Product outcomes.

Process outcomes measure the effectiveness of product development process (Hong, 2000). Accordingly in the study, process outcome is measured in terms of engineering change time, teamwork, and productivity. Product outcomes in this study are measures related with the product development characteristics and are measured using four factors: product cost reduction, manufacturing cost reduction, product development time, and customer satisfaction. Table 3.7 shows these 7 variables of process and product outcomes, their definition, and relative literatures base for each.

3.3.5.1 Engineering Change Time

Engineering change of an existing product is the modification of some aspect of the product's definition or documentation (Blackburn, 1991). The time required to modify it is called engineering change time (Syamil, 2000). Engineering change can occur through some medium such as an engineering drawing or a bill of material (Heizer and Render, 1999). Engineering changes are very common in product development. Boeing faced 12,000 engineering changes on its first 767 aircraft (Garvin, 1991). Engineering change can be attractive in some perspectives, such as matching competitors innovation (Syamil, 2000), incorporating new features in the product that were not considered earlier, new technology, new technique or for any other reasons. However, engineering change may cause disruption in manufacturing such as obsolesce of certain components, inventory fluctuation, schedule changes, and production delay (Balakrishnan and Chakravarty, 1996). Therefore successfully managing engineering changes are critical for managing product development process efficiently. Fujimoto (1989), Clark and Fujimoto (1991) suggest that US auto manufacturers are slower in engineering change than their German counterparts.

Table 3.7 IPD Performance Outcomes

Variables	Definition	Literature
Process Outcome		
Engineering Change Time	The time required to modify product definition or documentation.	Syamil, 2000; Blackburn 1991; Balakrishnan and Chakravarty, 199, Fujimoto, 1989; Clark and Fujimoto, 1991 etc.
Teamwork	Degree of collaborative behavior of IPD team.	Hong, 2000; Clark and Fujimoto, 1991; Zirger and Maidique, 1990; Mabert et al., 1992 etc.
Productivity	Effectiveness of new product development –from product concept to commercialization.	Syamil, 2000; Hong, 2000; Clark and Fujimoto, 1991; Crawford, 1992; Adler, 1995 etc.
Product Outcome		
Product Cost Reduction	Success level of the development team to reduce product costs.	Syamil, 2000; Gupta et al., 1992; Clark, 1989 etc.
Manufacturing Cost Reduction	Cost of materials, labor, and overhead for the product.	Syamil, 2000; Hong, 2000; Gersbach et al., 1994; Mercer, 1994; Garrison and Noreen, 1997 etc.
Product Development Time	Time required from product concept to product introduction.	Syamil, 2000; Hong, 2000; Stalk, 1988; Clark, Chew and Fujimoto, 1987; Bonnaccorsi and Lapparini, 1994; Murmann, 1994 etc.
Customer Satisfaction	Satisfaction of the customer for the product designed in a certain target market	Syamil, 2000; Cooper and Kleinschmidt, 1987; Clark and Fujimoto, 1991; Koen and Kohli, 1998 etc.

Project hampered by too many design changes will be an indicator of weak development process, which will eventually delay the product launch and commercialization target dates.

3.3.5.2 Teamwork

Teamwork is the performance of individuals as a group when working toward common goal (Leonard-Barton, 1992; Pinto et al., 1993). It refers to degree of collaborative behavior of IPD team. The indicators of high level of teamwork are: timely conflict resolution (Zirger and Maidique, 1990; Clark and Fujimoto, 1991), effective decision implementation (Mabert et al., 1992), creative problem solving (Guftafson, 1994), effective communication (Brown and Eisenhardt, 1995; Fisher et al., 1997), and good coordination of activities (Heany, 1989; Griffin, 1993). Susman and Dean (1992) and Emmanuelides (1993) argue that the cross-functional nature of concurrent engineering improves the decision making effectiveness of the product development team by considering a problem from various perspectives.

IPD team guided by shared team vision and existence of mutual trust and mutual influence will bring a collaborative problem-solving work environment. This will help the team members to work closely during the development processes.

3.3.5.3 Team Productivity

Team productivity measures the amount of work that can be done considering the resources used (Sheriff, 1988). Clark and Fujimoto (1991) used engineering hours and lead-time to measure team productivity. Productivity is the effectiveness of new product development –from product concept to commercialization (Hong, 2000). IPD members with high level of development productivity would complete work quickly, reduce cost, and engineering hours and will have a general sense of productivity (Crawford, 1992; Ali Krapfel and LaBahan, 1995; Tersine and Hummingbird, 1995; Adler, 1995). Although development productivity is affected by the time element, it is different from time to market (Hong, 2000). It is measured by overall technical and team performance in terms of efficiency, budget, schedule, and innovation (Cooper and Kleinschmidt, 1987, 1995; Ancona and Caldwell, 1990, 1992; Cooper, 1999).

3.3.5.4 Product Cost Reduction

Product cost reduction measures the success level of the development team to reduce product costs (Clark, 1989). Product cost can be reduced if all the team carefully monitors and controls all the direct and indirect costs in every stages of the project. Low cost of product signifies efficiency in development of the product. In Germany, R&D department fosters product cost reduction, while in the US, it is fostered by marketing department (Gupta et al., 1992). Project or part complexity can be a proxy of product cost (Syamil, 2000). Higher complexity leads to a potentially higher product cost. Product development is efficient handling of uncertainty and efficient problem solving by the IPD team members. Shared knowledge of customer, supplier, internal capabilities, and process will enable the team members to breakdown complex problems into simpler solutions, and thereby reduce the product cost.

3.3.5.5 Manufacturing Cost Reduction

A typical auto manufacturing process consists of five operations – stamping, welding, painting, assembly, and final testing (Gersbach, 1994). The first three operations may represent 20% of total employees in a plant and the last two operations may account for 80% of the total employees. Added together, these five manufacturing operations may take about 25% of the total car cost excluding development cost (Mercer, 1994). Because of such high proportion of cost distribution to manufacturing, manufacturing cost reduction is important to achieve a cost advantage in the auto industry (Syamil, 2000).

Manufacturing cost is the cost of materials, labor, and overhead for the product (Garrison and Noreen, 1997). Manufacturing cost thus reflects the company's competitive position with the industry performance. Changes in the later stage of development are quite high than the changes made during the earlier stages. Such changes and its impact on manufacturing cost can be reduced with better shared knowledge of customer requirements and supplier and internal capabilities. To increase suppliers' capabilities, firms are willing to empower suppliers with expert knowledge as long as such arrangement does not create long term dependence (MacDuffle and Helper, 1998). Low manufacturing cost is highly related to the early involvement of manufacturing people in the product development process (Walleigh, 1989).

3.3.5.6 Product Development Time

Product development time is the time required from product concept to product introduction (Stalk, 1988; Gupta, Brockhoff and Weisendfeld, 1992). The time to market refers to how fast a firm completes product development projects from concept to market introduction (Takeuchi and Nonaka, 1986; Clark and Fujimoto, 1991; Gupta and Wilemon, 1990; Dyer et al., 1999). A product development team that values time to market would strive to get products to market ahead of competitors (Lieberman and Montgomery, 1988; Stalk and Hout, 1990; Blackburn, 1991; Yossef, 1995), develop products on schedule (Cohen, 1996; Ziger, 1996) and keep improving on the previous time to market (Mabert et al., 1992; Haddad, 1996).

Clark et al. (1987) indicate that each day of delay in introducing a new $10, 000 car may reduce the profitability of a company by $1 million. Reducing product development time and hence the time to the introduction of a new product can create relative advantages in market share, profit, and long-term competitive advantage (Mc Donoug and Spital, 1984; Lieberman and Montgomery, 1988; Brown and Karagozoglu, 1993; Sanchez, 1995; Ward et al., 1995; Ali et al., 1995).

Technologically more advanced products take longer to develop than less advanced products. When shortening product development cycle time, the challenge is no to cut corners, but to carry out the development task faster without sacrificing quality of eliminating steps (Gupta and Wilemon, 1990; Karlsson and Ahlstrom, 1999).

Although the success of an individual project may not be indicative of a systematic relationship between time to market and overall organizational performance (Clark and Fujimoto, 1991; Cusamano and Nobeoka, 1992; Smith and Reinertsen, 1991), the extent of shared knowledge is related to the project's time to market (Hong, 2000). Stalk and Webber (1993) argue that one of the biggest problem with time to market reduction programs is that firms often pursue speed without considering how faster product development or increased product turnover contribute to the fulfillment of their customer requirements. The extent of shared knowledge of customers, therefore, is critical to ensure that the resulting products satisfy customer needs (Cicacntelli and Magidson, 1993). Reducing time to market requires adequate knowledge of customers earlier in the process (Mabert et al., 1992). Substantial work in accelerating time to market (e.g., understanding the earlier availability of prototypes, increased standardization of parts, consistency between designs and suppliers' process capabilities, and reduced engineering changes) is based on the proper understanding of suppliers and internal capabilities (Bonaccorsi and Lapparini, 1994). Understanding internal capabilities is significant in reducing time to market.

Having a shared understanding of vision, purpose of the project and strategic intent substantially affects the time to market (Mabert et al., 1992). Clear project targets are also another critical factor in reducing time to market (Murmann, 1994).

3.3.5.7 Customer Satisfaction

Customer satisfaction measures the satisfaction of the customer for the product designed in a certain target market (Cooper and Kleinschmidt, 1987). Customer satisfaction is important for many companies for several reasons. First, attracting new customers is more expensive than retaining existing customers. Satisfied customers mean lower handling cost in managing customer complaints, lower warranty cost, and it can help the company to attract new customers (Syamil, 2000). The transaction cost can also be lowered if a company can take advantage of the economic of scale of the current customer base (Sharma et al., 1999).

Value to customer is measured in terms of the value of new products in meeting customer needs and expectations in the market place (Clark and Fujimoto, 1991; Clark & Wheelwright, 1993; Cordell, 1997). It is also reflected in the product success in the marketplace (Slater and Narver, 1995), its creation of value to customers in terms of highly perceived product quality (Clark and Wheelwright, 1992), customer's perceived value in terms of uniqueness (Zirger and Maidique, 1990), and the key commonalities in what customer's value (Kim and Mauborgne, 1997). Value to customers is enhanced through shared knowledge of customers (Koen and Kohli, 1998).

3.4 HYPOTHESIS

The nature of relationships among components of knowledge integration, i.e. team vision, mutual trust, mutual influence, and shared knowledge, and product performance outcomes is described in terms of hypothesis. This study does not examine the detailed relationship of each variable (e.g., shared knowledge of supplier and manufacturing cost reduction). These hypotheses examine the relationships among partially aggregated models. Figure 3.3. shows how the four components of knowledge integration (i.e. team vision, mutual trust, mutual influence and shared knowledge) are related. It also depicts how these components affect product development performances.

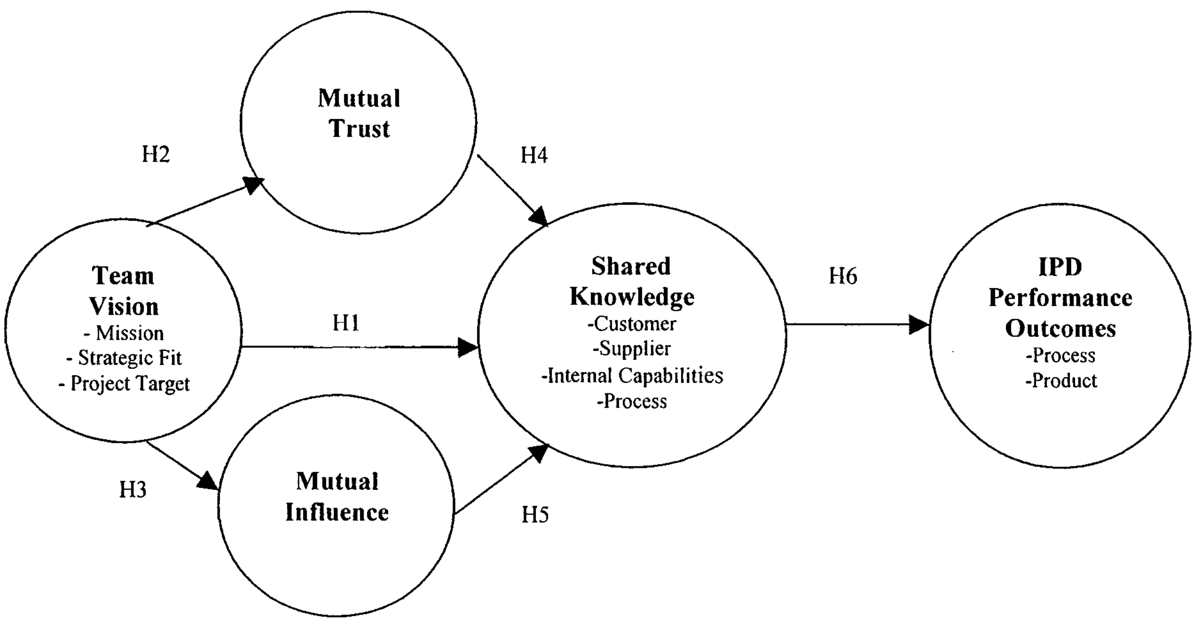

Figure 3.2 Hypotheses of Key Relationships

3.4.1 Development of Hypothesis 1

The failure to integrate a product strategy, a well-planned portfolio, and a facilitating organizational structure with clearly identified customer needs, a well-defined product concept, and a project plan can severely hamper product development whereas improving the entire product development process depends on improving the effectiveness of front-end process (Khurana and Rosenthal, 1997). Hong (2000) concluded a positive relationship between the team vision and shared knowledge. A shared vision embodies common goals and aspiration of the team members and ensures a common interest and objective for knowledge sharing geared toward a IPD goals. With share purpose and vision, team members would avoid possible misunderstandings and share more information through open communication. A common team vision will provide opportunities to exchange ideas and resource more freely. The common goals that the IPD team members share will help the team to see the potential value of each others view points and benefit cooperation. Team members who share a vision will be more likely to share or exchange their critical knowledge resources (Orton and Weick, 1990; Tsai and Ghoshal, 1998). Therefore, teams with a greater level of team vision will achieve higher levels of shared knowledge. In that sense, there is a positive relationship between team vision and shared knowledge in knowledge integration of IPD.

Hypothesis 1: The greater the extent of the team vision, the greater the extent of the shared knowledge.

3.4.2 Development of Hypothesis 2

Trusting negotiators have a confidence that their opponents will not use the information to take advantage of their vulnerability (Butler, 1991; Zand, 1972).

This can be further elaborated in the context if IPD. With a shared common goal that has strategic value to the company, team members driven by the common team members will share information in their possession with other team members so that collectively, as a team can realize the objectives. This regular exchange of cross-functional information in routine problem solving environment aided by uncertainty but powered by mutual trust among the team members will help on sharing knowledge otherwise isolated with a member or a small sub-unit. A mutual trust relationship enables the informer to open with their knowledge, thoughts, information, and perspectives and encourages both the recipient and the sender to be receptive to each other, further increasing information dialogues and exchange. In the regard of IPD, team vision provides further thrust in improving mutual trust among the team members. Fisher and Brown (1988) and Zand (1972) argued that demonstrating concern and benevolence toward each other's interest develops trust. The apparent benevolence frees the other from the fear that one will exploit their vulnerability. Thus the team develops a sense of mutual trust that, in turn, allows then focusing even more on each other's interest. And in the shared team vision driven IPD team, the sense of common objective will drive mutual trust. Lynn et al. (2000) also sought support for the value of vision clarity, or the precision and detail of the objective, and the relationship of the stability of vision to trust within the team and the concomitant development of interdependence, commitment, and focused work toward objectives.

By repeatedly working together to obtain mutual goals, group develops a mutual trust (Sherif and Sherif, 1953). By sharing expectations and reducing individual dissonance inducing fears among group members, mutual trust brings groups closer. The investment of trust between different groups can be viewed as a leap of cognitive faith and understanding (Lewis and Weigert, 1985). A common objective, common goal, brought by the IPD team vision will ensure elimination of self-interest goal among the IPD team members. Team members can thus share information and develop shared knowledge in good faith.

From research, it is suggested that teams can better apply the information they acquire implement what they learn when team members and their management support the vision of the project, and that the implementation of what they learn contributes to NPD success (Lynn at al., 2000). Thus, we hypothesize that there is a positive relationship between team vision and mutual trust in knowledge integration of IPD.

Hypothesis 2: Understanding and acceptance of team vision leads to increased level of mutual trust among the NPD team members.

3.4.3 Development of Hypothesis 3

The concept of opportunistic behavior from the transaction cost analysis literature is defines as, “self-interest seeking with guile” (Williamson, 1975). As such, “the essence of opportunistic behavior is deceit-oriented violation ... of required role behavior” (Donaldson, 1990). Thus, if there is an equal power structure among the IPD and if everyone has a common and agreed upon objective, there will be an absence of self-interest reasons. The distribution of power in varying level among the team members may lead the members in knowledge exchange not to share the knowledge completely or not to accept the knowledge from one another. All parties in business relationships face varying degrees of conflict and co-operation in their interactions with other parties including sharing the knowledge base of individual parties. Conflict may arise through competition between parties in horizontal relationships (between the internal functional departments) or vertical relationships (between supplier and the company's functional personnel and customers) (Mallen, 1964; Araujo and Mouzas, 1998). Role theory, applied at the level of organizational groups, highlights the dynamic interaction between interdependent dyadic groups in organizations, providing a conceptual framework to examine the nature of mutual influence and regulation (Katz and Kahn, 1966). In sharing knowledge during product development analysis the primary area of concern is vertical conflict between customers and suppliers and various functions. The aim of influencing relationships in the direction of one's own goals and requirements may underlie any mutual relation relationship (Araujo and Mouzas, 1998). Thus team vision plays an important role in defining and maintaining mutual influence in knowledge exchange. Although power and dependence will ebb and flow in the cross-functional relationship, with different parties taking the lead on different developments or innovations, agreement on strategic direction– tacit or explicit-is an important consideration in a mutual relationship to ensure that no party is exploited or overruled.

Without mutual influence, mutually interdependent tasks of IPD can become decoupled and as noted for in terms of general group behavior, decoupling and conflict can result (House, 1991). The ability of group to accomplish its goals can be limited by its ability to influence others in the group (Kanter, 1983; Pfeffer and Salakcik, 1978). Thus, the study posits that there is a positive relationship between team vision and mutual influence in knowledge integration in IPD.

Hypothesis 3: Understanding and acceptance of team vision leads to increased level of mutual influence among the NPD team members.

3.4.4 Development of Hypothesis 4

The attainment of mutual trust leads to shared knowledge. Repeated inter-group exchange communication builds trust leading to increased communication and the eventual sharing of knowledge (Anderson and Narus, 1990). By alleviating the fear of the unexpected and facilitating interactions and involvement (Bradach and Eccles, 1989), trust encourages a climate conductive to the sharing knowledge (Nelson and Cooprider, 1996). By sharing expectations and reducing individual dissonance inducing fears among group members, mutual trust brings groups closer together. Although it may also seem reasonable that that sharing knowledge might lead to trust, Sherif's (1966) work demonstrates that repeated episodes of joint effort and communication leads to trust, which then leads to the sharing of methods and ideas. Trust also leads to appreciation through the common manifold belief in the performance of groups involved (Swanson, 1974). Mutual trust developed through repeated communication and sharing information is thus hypothesized to have a positive impact on shared knowledge.

Hypothesis 4: Higher the level of mutual trusts between NPD team members, higher the level of shared knowledge.

3.4.5 Development of Hypothesis 5

Social communication and social influence process are interwoven with the process of knowledge creation and dissonance reduction (Festinger, 1957). By seeking support for ideas, individuals and teams in the IPD environment seek either influence others into accepting these ideas or be influenced by others' ideas and attitudes. This influence process is necessary for achieving mutual understanding between groups (Churchman and Schainblatt, 1965). Through this social influence process in the IPD, cognitive elements are exchanged among the group member; various team members share information, understanding, expertise, experiences and create shared knowledge of customers, suppliers, internal capabilities and the product development processes. The exchange of information exchange between buyer-seller group is positively related to the level of group influence (Boyle et al., 1992). IPD team member routine involvement in the development process will be characterized by exchange of information, the NPD process is affected only when the received information is used and leads to changes in behavior or action by the recipient (Frost and Egri, 1991; Li and Atuahene-Gima, 1996). In a low-influence condition, influence target may ignore the information given by the influence source (Atuahene-Gima and Evangelista, 2000). The sharing of knowledge is not limited to simple information exchange, but is related to the influence developed between groups as result of more frequent and in-depth communications. By depending on each other for the joint accomplishment of goals, expectations, needs, knowledge about customers, suppliers, internal capabilities, and project process is thus shared among the IPD group members. Thus, it is hypothesized that the there is a positive relationship between mutual influence and shared knowledge in knowledge integration in IPD.

Hypothesis 5: Higher the level of mutual influences between NPD team members, higher the level of shared knowledge.

3.4.6 Development of Hypothesis 6

In the context of multiple groups, shared knowledge must be expressed in words and or symbols that are common to the social domain of both groups (Zeleny, 1989). Such a shared language can facilitate knowledge transfer as well as create positive social influence process (Pondy, 1978). Effective shared knowledge can be viewed as a synergy between groups (Bostrom, 1989). The synergy can be defined as mutual understanding and respect between groups. Shared understanding of customer, suppliers, product development processes and internal capability not only means the awareness of or the details of each other's activities, knowledge, skill bases, but also of the other's needs, constraints, contribution, and importance during the product development. A deeper level of knowledge must be shared to achieve mutual understanding. This deeper level of knowledge is often characterized as organizational knowledge (Nelson and Cooprider, 1996). If the knowledge base, expectations, and realities of each group become more distant from that of the other, lack of cooperation and conflicts begin to appear (Sherif, 1962). What then occurs is the in-group/out-group phenomenon (Sherif et al., 1965), which can exhibit itself as an "us against them" group attitude (Bettenhausen, 1991). The attainment of product development goals and product performance outcomes can become an almost impossible task in the face of cross-functional conflicts in IPD. The absence of knowledge integration may lead to poor IPD performance, while the presence of knowledge integration may lead to better performance. Hong (2000), in his empirical study, found a positive relationship between shared knowledge and product performance outcomes. Thus an environment of shared knowledge driven by shared team vision, mutual trust, and mutual influence will ensure knowledge integration that will have a positive relationship with the product performance outcomes.

Hypothesis 6: Knowledge integration in IPD through shared knowledge among the team members of IPD will have a positive impact on product performance outcomes.

3.5 CONCLUSION

Literature review on team, mutual trust, and mutual influence provided initial theoretical rationale for being possible drivers for shared knowledge in an IPD environment. Based upon earlier research works, there seemed to be evidences that knowledge share can lead to improved product development performance. The next step was to develop and test the valid and reliable instruments for these constructs and their respective variables. Once establishing such instruments, the research could then proceed to analyze the structural relationships of the proposed model.

Chapter Four presents the research methods and results for the pilot study.

Chapter Five presents the research methods and results for the large scale study.

Chapter Four

Research Methodology and Pilot Study

4.1 INTRODUCTION

This chapter describes the development and subsequent pilot testing of the measures of shared knowledge in new product development projects. The location of this exploratory study in the overall methodological approach used by the research described in this dissertation is presented in Figure 4.1.

After careful review of the various exploratory research techniques available, a pilot study was selected for use within this research. The objective was to collect data to serve as a guide for the subsequent larger study. Consideration was given to the fact that there was no secondary data available. An experience survey, in which individuals who are knowledgeable about this particular research problem, was not available within the boundaries of this research. Preliminary case study research would have been difficult due to the confidentiality of the research subject working in the strategical and confidential nature of new product development.

Therefore, a pilot study was conducted involving several of the companies. The pilot sample is not representative and the ability to generalize results from it is limited. Pilot study results were used to improve the relevancy and accuracy of the survey instrument and to identify any conceptual gaps in the research process and design. The pilot was also used for purposes of estimating the population parameters, for the subsequent final survey samples.

The details of the pilot survey are presented in the next section.

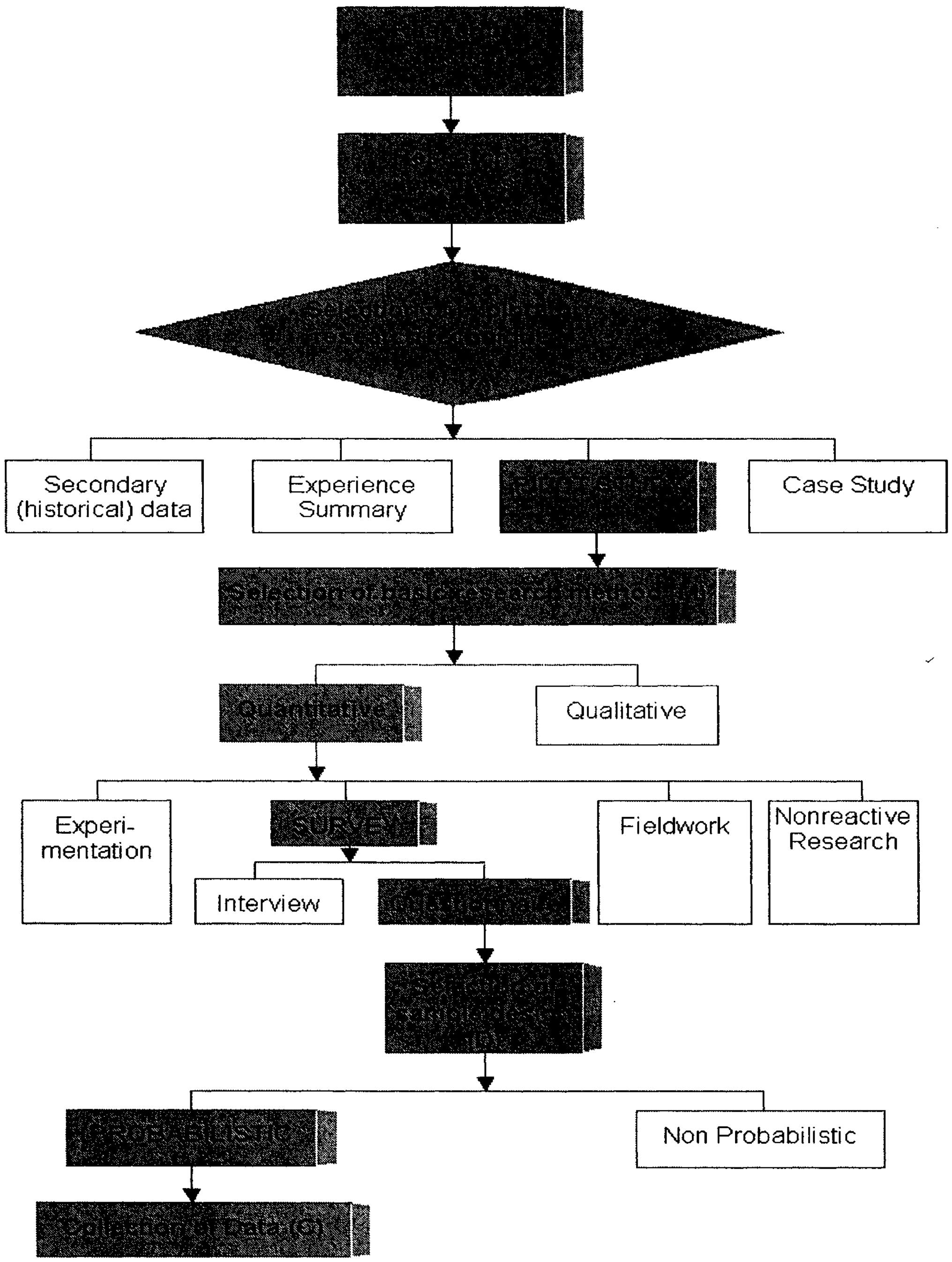

Figure 4.1 Data collection process *(Adapted from Zikmund, 1994; Brewer and Hunter 1989)*

4.2 RESEARCH OBJECTIVE

The primary goal of this study is to determine the role of team vision, mutual trust and mutual influence on shared knowledge in the product development team. To achieve this goal, first this study aims to develop valid and reliable measurements of mutual trust, and mutual influence, and to re-establish the validity and reliability of the measurements of team vision, shared knowledge and product development performance researched earlier. Additionally, relationships between team vision, mutual trust, mutual influence, shared knowledge and NPD performance would be determined to conclude that team vision, mutual trust and mutual influence are the drivers of shared knowledge and collectively they represent knowledge integration. These valid and reliable measures (i.e. instruments) are useful for benchmarking knowledge integration practices in product development against competitors. These instruments develop may provide quick feedback mechanisms for intervening in organizations to improve product development performance. Additionally, these instruments will provide drivers for shared knowledge in knowledge integration of product development effort in conjunction with work integration.

These effective instruments are useful only when they contain several measurement characteristics: construct validity, content validity, convergent validity, discriminant validity, predictive validity, and reliability. Construct validity refers to an effective instrument that covers the content domain of each construct (Nunnally, 1978). Convergent validity is concerned with the extent to which multiple measures of the same construct agree with each other (Campbell and

Fisk, 1959). Content validity establishes that measure provides adequate coverage of the concepts which is generally achieved through extensive literature reviews and soliciting expert opinion on the domain of interest (Gregory, 1996; Zikmund, 1994).

Predictive validity refers to the extent to which scores of one construct are empirically related to scores of other conceptually related constructs (Bagozzi, et al. 1992). Discriminant validity is evident if items underlying each dimension loads as different factors (i.e. discriminate with measures of the other constructs) (Pitt, et al. 1995). Each construct should have a reliability of 0.80 (Cronbach's alpha) or more (Nunnally, 1978), and the instrument should be short and easy to use. To increase the usefulness of this instrument for basic research, it should be generalizable across industries and firms of varying sizes (Koufteros et al. 1998; Hong, 2000).

To achieve these goals, the process of developing measures was based on commonly accepted methods for developing standardized instruments (Nunnaly, 1978; Churchill, 1979). An extensive literature review ensured that the proposed research model was grounded in theory. In addition, case studies and structured interviews with product development practitioners helped to define the domain of the constructs and facilitated item generation. A pre-test was conducted utilizing completed to enhance content validity or face validity. A pilot study was conducted utilizing respondents similar to the target respondents. These steps were taken to insure the above mentioned measurement characteristics.

4.3 ITEM GENERATION

The unit of analysis was the cross-functional product development team since all items pertain to the practices for the product development team. The following steps were taken to insure the content validity of each variable. First, possible items were adapted from articles published in major journals in the fields of marketing, product development, manufacturing management, strategy, teamwork, organizational learning, team learning, individual learning, psychology, organizational behavior, knowledge, and project management. In addition, previous doctoral dissertations in the field of work integration (Concurrent Engineering) and shared knowledge (Knowledge Integration) in the specific context of product development were studied and the authors were consulted. Questions were then developed to measure a particular variable (e.g. team Mission) of an individual construct (e.g. team vision).

The goal of the literature review in Chapter 3 was to generate a comprehensive list of items to match the domain of team vision (3 variables), mutual trust, mutual influence, shared knowledge (4 variables), process outcomes (3 variables), and product outcomes (4 variables). A five-point Likert scale was used to solicit responses for each items where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. Figure 4.2 provides an example on one of the item used in the web-based survey for this pilot study.

Section 2. The following questions enable you to describe factors that encourage team members to share their knowledge/expertise with other members of their cross-functional team. For each item, please choose the response that best describes the focal project you named above.

1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree

	1	2	3	4	5
The team members trusted each other to share accurate information.	○	○	○	○	○

Figure 4.2 : An example of item used in Pilot Study

To provide additional support for the content validity, the items were grouped according to their theoretical construct and presented to three researchers and four product development project managers during structured interviews. For each construct, the researchers and the managers were asked to discuss the knowledge integration theories and practices. Their responses were then compared with the proposed constructs and items for this study. The key questions were: (1) what did they think about the importance shared knowledge in product development; (2) what aspects of knowledge were critical in the product development from their personal standpoint of views; (3) if they perceive importance of promoting trust among the focal project team members and its relationship with team and/or product performance; (4) if they perceive importance of equal power among the focal project team members; and finally, (5) whether they could answer all the questions based on their personal experiences in a recent product development project. Their qualitative comments from the structured interviews were compared with the responses to items measuring each construct. This was done to verify that they understood the questions. Based on suggestions by these researchers and practitioners, items were added, modified, or even deleted for a reviewed instrument. Finally the revised items were grouped into 17 variables as shown in Table 4.1.

Table 4.1 Constructs and Variables of the Proposed Research Model

Construct	Variables	Code
Team Vision		
	Mission (5 Items)	TM
	Strategic Fit (4 Items)	SF
	Project Target (4 Items)	PTT
Mutual Trust	(10 Items)	TR
Mutual Influence	(9 Items)	MI
Shared Knowledge (of)		
	Customers (4 Items)	CT
	Internal Capabilities (4 Items)	IT
	Suppliers (6 Items)	ST
	Process (5 Items)	TP
Process Outcome (NPD Performance)		
	Engineering Change Time (3 Items)	EC
	Team Work (3-Items)	TW
	Team Productivity (3 Items)	XTP
Product Outcome (NPD Performance)		
	Product Cost Reduction (4 Items)	PC
	Manufacturing Cost Reduction (5 Items)	MC
	Product Development Time (5 Items)	YPT
	Customer Satisfaction (6 Items)	CS

4.4 PRETEST

In assessing the extent of shared knowledge in teams, it was important to get a broad section of responses. Four individuals (one program manager, two team leaders, and one team member) from the field of product development were selected as key informants for the pretest of this study. All these four individuals worked in automobile industry. These members worked in product development areas with OEM, tier-1 and tier-2 auto parts suppliers.

The first criterion for selecting these participants was position. All four individuals represented diverse team positions of product development team. The participants were all involved in the cross-functional product development projects. They identified their project. Their responses were based on the particular project they experienced with the other team members. The key question was, "Was the informant in a position knowledgeable to answer regarding the extent of shared knowledge in the team?" (Seidler,1974). All the individuals in the position mentioned above were active participants in product development work so that they were able to share their perception about the level of the shared knowledge of their project teams.

Next, a knowledge ability test assessed the content of inquiry (Kumar et al., 1993). The potential informants were asked about how knowledgeable they were about the content of inquiry after answering the questionnaire. All the respondents reported comfortable and confident in answering the questions. This ensures that the respondent with appropriate positions and knowledge answered the questionnaire. The very first page of the questionnaire clearly stated as follows:

"A person who has been a project manager or team leader for a new product development project should answer the questionnaire below. The questions enable you to describe the extent that the focal project utilized key best practices in integrated product development."

The next procedure to promote content validity involved presenting the entire list of potential items to five academics experts and two doctoral level students who had taken advance courses in new product development and organizational behavior and were given opportunity to keep, modify, and/or drop items. They were also encouraged to provide suggestions for additional items if they perceived them important in order to cover the intended domain of the variable. Representatives from organizational behavior and manufacturing management were included because the research constructs and variables involved both disciplines. Of total previously developed and borrowed 122 items, 27 items were dropped. Where any experts suggested that the domain of a construct should be more adequately covered, or the previous study did not capture the constructs appropriately, modification and generation of new items were carried out through further literature review and group discussions. The total number of items after the expert evaluation and revision for the pilot study was 85.

4.5 PILOT STUDY METHODS

The pilot questionnaire was compiled and finalized after the industry and academic experts suggested a number of modifications. Next, construction of web page for the internet-based survey was carried out. Researchers with experience in internet based survey were consulted for proper format and color combination to increase the attractiveness and responses of this survey. The final version of the survey questionnaire for pilot study was posted at http://www.wjdoll.utoledo.edu/pdpsurvey/PDPPilot.html . Multiple test runs were conducted by two doctoral students for two weeks to ensure all the responses for each items were technically functioning. Once a respondent completes the survey and click on the "Submit" button at the end of the questionnaire, the web page creates and e-mails a text file capturing item codes and corresponding answers to the item.

Once the technical performance of the web questionnaires were established, 20 members of Product Development Management Association (PDMA) working in automobile industry in the USA were chosen randomly and contacted through e-mail requesting them to participate in the pilot study. After one week of the original e-mail sent date, an e-mail reminder was sent requesting their participation. After failing to solicit any responses in the first phase, a list 40-product development practitioner from automobile industry was generated randomly. These individuals were selected from their membership with parameters such as: product development managers, product development team members, position titles, functional diversity, product complexity and industry position (OEM versus suppliers). These companies are under the standard industrial classification (SIC) codes 3231, 3251, 3253, 3254 and 3259. They were primarily drawn from the Midwest (Ohio, Michigan, Indiana and Illinois) and West Coast region (California). The pilot study responses will later be excluded in the large-scale study.

The items were grouped according to the constructs. The first group was team vision (i.e. mission, strategic fit, and project targets). The second and third group was mutual trust and mutual influence respectively. The fourth group was shared knowledge (i.e. knowledge of customers, suppliers, internal capabilities, and process). The fifth group was process outcomes (engineering change time, team work, and team productivity). The sixth group was product outcome (product cost reduction, manufacturing cost reduction, product development time, and customer satisfaction). Both process outcomes and product Outcomes represented measures for NPD performance outcomes.

Within each constructs (e.g. team vision), items measuring different variables (e.g. mission, strategic fit, and project targets) were mixed randomly. Items for mutual trust and mutual influence were also mixed randomly when the survey was presented to the respondents. This was done to ensure that respondents paid close attention reading each items before filling the responses.

The entire pilot study questionnaire could be divided into 3 broad sections. The first section provided respondents about the information on the goal and purpose of the research, the name and background of researchers, and the requirements for a respondent to participate in this study. This was important to ensure that the sample respondents represented the target population in the field of product development and thus can help to generalize the findings of this research. Also included in this section was the length of time the respondent required to complete the survey. This was of importance when considering the costs and convenience with data collection.

The second section of pilot study questionnaire consisted of items for each of the variables of the research model measured in the five-point Likert-scale as discussed earlier.

The final section of pilot questionnaire consisted questions on demographic. These questions were about specific information about the type of industry, size of the firm, knowledge intensity of product development, product complexity, process complexity and position in the supply chain (OEM or suppliers).

Participation by the target sample was voluntary and anonymity was provided.

As discussed by Churchill (1979), the instrument was purified by examining the corrected-item total correlations (CITC, each item's correlation with the sum of the other items in its category) of the items with respect to a particular variable (e.g. mission) of a specific construct (e.g. team vision). The item inter-correlation matrices provided by SPSS 11.0 were utilized to drop items if they did not strongly contribute to Cronbach's alpha for the variable under consideration (Flynn et al., 1995; Hong, 2000). Item purification was also considered through reliability analysis using SPSS 11.0. Reliability analysis allows studying the properties of measurement scales and the items that make them up. The Reliability Analysis procedure calculates a number of commonly used measures of scale reliability and also provides information about the relationships between individual items in the scale. Intra-class correlation coefficients can be used to compute inter-rater reliability estimates. Using reliability analysis, one can determine the extent to which the items are related to each other; one can get an overall index of the repeatability or internal consistency of the scale as a whole, and identify problem items that should be excluded from the scale. Cronbach's alpha is a model of internal consistency, based on the average inter-item correlation. Items were to be eliminated if Cronbach's alpha was less than 0.80. The reported alpha for each variable (e.g. shared knowledge of customers) was assessed and compared with the alpha value of each item if it was to be deleted. Modification or addition of items is necessary for the variables and items, which showed reliabilities near the minimum standard of 0.80 (Hong, 2000). For example, when reliability analysis for Mission was conducted, the alpha value reported was 0.9651. This was compared with individual alpha if the item was deleted of the five items used to measure Mission to investigate if it could lead to any statistically significant improvement in the measurement. However, care was taken to assess practical significance of any item if it failed to meet minimum statistical criterion suggested in the literature by previous researchers.

Next, exploratory factor analysis was conducted to assess the internal consistency (i.e. dimensionality) of the remaining items of each variable (e.g. Mission) and, where appropriate, was used to eliminate items that were not factorally pure (Koufteros et al., 1998).

One of the table in factor analysis, called the pattern matrix reports the factor loadings for each items of variable on the components or factors after rotation. It allows specifying the method of factor extraction. Available methods are principal components, are unweighted least squares, generalized least squares, maximum likelihood, principal axis factoring, alpha factoring, and image factoring. Extractions methods in a factor analysis includes either retaining all factors whose Eigen values exceed a specified value or retain a specific number of factors. Different methods of factor rotation includes varimax, direct oblimin, quartimax, equamax, or promax. In the SPSS 11.0 factor analysis result, the "Total" column gives the amount of variance in the observed variables accounted for by each component or factor. The "% of Variance" column gives the percent of variance accounted for by each specific factor or component, relative to the total variance in all the variables. The "Cumulative %" column gives the percent of variance accounted for by all factors or components up to and including the current one. In a good factor analysis, there are a few factors that explain a lot of the variance and the rest of the factors explain relatively small amounts of variance.

Literature recommends the use of Principal Component Analysis (PCA) as a first step in factor analysis as it reveals more about the probable number and nature of the factors than other extraction procedure (Kima and Mueller, 1978; Pedhazur and Schmelkin, 1991; Tabachnick and Fidell 1996). PCA and oblimin were used as the means of extraction and rotation respectively. Items, which load below 0.60, were generally to be eliminated at this stage. However, any item for elimination was not to be based solely on this criterion. Rather, an item's importance to the research objective was to be carefully considered as suggested by Dillon and Goldstein (1985). Some items (e.g. Shared Knowledge of Internal Capabilities, IT2), which showed weaker loadings, were selected for modification for the large-scale study instead of being eliminated. To streamline the factor interpretation process, loadings below 0.30 were not reported. Each variable was expected to have a simple factor structure and a minimum factor loading of 0.75.

The number of factors to be extracted in this study was to be based on Kaiser's Eigen values greater than 1 (Nunnally, 1978, 1995). This rule suggests that only factors that explain more variance than the average amount explained by one of the original items should be retained.

The external consistency of all the variables in a construct (3 variables for team vision, 4 for shared knowledge, 3 for process outcomes and 4 for product outcomes) was appraised separately by submitting all the items of all the variables in each construct to exploratory factor analysis to uncover any significant cross-loadings. Next, all the items for mutual trust and mutual influence were submitted for exploratory factor analysis. Similarly, all the items for process outcomes (with initially 3 variables) and product outcomes (with initially 4 variables) were submitted to factor analysis to uncover any significant cross-loadings. Again, principal components and oblimin were used as the means of extraction and method of rotation respectively. Loadings below 0.30 were not reported.

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy is a statistic which indicates the proportion of variance in the variables which is common variance, i.e. which might be caused by underlying factors. High values (close to 1.0) generally indicate that a factor analysis may be useful with the data. If the value is in the 0.90's it is considered as outstanding, in the 0.80's as very good, in the 0.70's as average, in the 0.60's as tolerable, in the 0.50's as miserable, and below 0.50 as unacceptable.

Bartlett's test of sphericity indicates whether the correlation matrix is an identity matrix, which would indicate that the variables are unrelated. The significance level gives the result of the test. Very small values (less than .05) indicate that there are probably significant relationships among the variables.

4.6 PILOT STUDY RESULT

Out of 40 selected respondents that were contacted, 38 responses were received from the internet survey. 4 of the responses could not be included in the study as they contained multiple missing items. Table 4.2 summarizes the response rate for the pilot study conducted in two phases.

Table 4.2 Response Rate

Phase	1	2
Total Contacted	20	40
Usable Response	0	34
Response Rate	0%	85%
Cumulative Response Rate	0%	57%

Zikmund (1994) cautioned that even with the limited sample size of a pilot study, it remains important to demonstrate the reliability and validity. The remaining 34 responses were large enough of a sample to perform some initial statistical analysis for the proposed research model. In this way, the pilot test could provide means for assessing the preliminary reliability and convergent validity of the instrument. Reliability was assessed by calculating Cronbach's alpha and convergent validity was assessed by simple factor structure and high factor loading (>0.75).

All 34 respondents were full time employee in the product development field in the auto-industry. The number of employees working the company measured company sizes for the respondents. 58% of the company had over 10,000 employees, 15% had employees in the range of 5000-9000, another 15% had employees in the range of 1000-4,999, 13% had employees in the range of 500-999, and 9% of the companies had employees in the range of 1-499. The demographical information on the companies for which respondent worked for is summarized in Table 4.3

Table 4.3 Demography of the Respondent Company

Number of Employee			
0-499		9%	
500-999		13%	
1000-4999		15%	
5000-9999		15%	
over 10000		58%	
Total			100%
Focal Product Manufactured			
Body Exterior		0	
Body Interior		0	
Powertrain		3%	
Body Component		6%	
Chasis		82%	
Electrical/Electronic Component		6%	
Other		3%	
Total			100%
Company Position			
OEM		26%	
Auto Part Suppliers		71%	
	First-tier supplier (86%)		
	Second-tier supplier (7%)		
	Third-tier supplier (7%)		
	Other	3%	
Total			100%

In the following section the three drivers for shared knowledge – team vision, mutual trust and mutual influence, shared knowledge, and finally NPD performance outcomes are examined one by one.

4.6.1 Team Vision

The construct for Team Vision was conceptualized as having three variables (i.e. mission, strategic fit, and project targets). All the items for these three variables were borrowed from Hong (2000) that were empirically proven to be highly reliable.

Each variable had 4-5 items. Reliability analysis and factor analysis for each of the three variables was carried out first. Table 4.4 shows the initial factor loadings and corrected item total correlations (CITC) generated for each items related to a particular variable of team vision. It also gives the initial Cronbach's alpha for each scale and alpha value if items were to be dropped. During this stage, it was decided to drop items, which showed poor CITCs (<0.60). As evident from the result, the CITC for all 13 items of Team Vision has CITC >0.60. Further, Cronbach's alpha for all three variables is 0.96, 0.88, and 0.92, which indicates the high reliability of these measurements. Further, Cronbach's alpha, if items (e.g. TM1) were to be dropped individually, did not lead any significant improvement in the reliability of the variable.

When factor analysis was conduced for all 3 variables separately, a single component was extracted. Except for PTT2, the factor loadings for all remaining 12 items are in mid 0.80s and 0.90s. For PTT2, the factor loading is 0.76 that in itself is above the tolerance level. Thus, at this stage, all the 13 items of team vision were retained.

Table 4.4 Mission, Strategic Fit, and Project Target -Items, Description Initial Factor Loading, CITC, Cronbach's Alpha and Alpha if Item Deleted

Mission

Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
TM2	The project mission was well communicated to all team members	0.8424	0.966	0.898
TM1	The project purpose was well understood by the entire team	0.8886	0.9586	0.929
TM3	The project mission was well defined for all team members	0.916	0.9544	0.948
TM4	The product development team has a well-defined mission.	0.9253	0.9527	0.954
TM5	The project mission was well understood by the entire team.	0.9373	0.9519	0.961

Cronbach's Alpha = 0.9651
Extraction Method: Principal Component Analysis, 1 Component Extracted
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.849

Strategic Fit

Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
SF3	Project targets reflected the competitive situation	0.7048	0.8769	0.83
SF2	The project target were consistent with our overall business strategy	0.731	0.8657	0.849
SF1	Our firm's overall technology strategy guided a setting of the project targets	0.7812	0.845	0.883
SF4	Our firms overall product strategy guided a setting of project targets	0.8115	0.8326	0.904

Cronbach's Alpha = 0.8875
Extraction Method: Principal Component Analysis, 1 Component Extracted
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.819

Project Targets

Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
PTT2	The relative priority of each project target was clear	0.7311	0.9353	0.764
PTT4	Project targets clearly specified tradeoffs between quality and cost	0.8982	0.8808	0.853
PTT1	The project targets clearly specified tradeoffs between performance and cost	0.8841	0.8847	0.919
PTT3	The project targets clearly specified tradeoffs between time and cost	0.8216	0.9095	0.92

Cronbach's Alpha = 0.9263
Extraction Method: Principal Component Analysis, 1 Component Extracted
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.808

Next, all 13 items were included for exploratory factor analysis to investigate if 3 components could be extracted corresponding to Mission, Strategic Fit, and Project Target. The result of this step is presented in Table 4.5.

Table 4.5 Factor Analysis for all Team Vision Constructs Retained Items, Pattern Matrix

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.773		
Items	**Factor 1**	**Factor 2**
TM1	1.057	
SF4	0.631	
SF3	0.741	
PTT2	0.764	
SF1	0.781	**Strategic Fit**
TM4	0.867	
SF2	0.869	
TM5	0.891	**Team Mission**
TM2	0.912	
TM3	0.925	
PTT4		0.853
PTT1	**Project Targets**	0.919
PTT3		0.92
Eigen Value	12.287	2.17
% of Variance	64.669	11.42
Cumulative % of variance	64.669	76.089
	Extraction Method: Principal Component Analysis **2 Components Extracted** **Rotation Method: Oblimin with Kaiser Normalization**	

As presented in the pattern matrix in Table 3.4, 2 components were extracted using Eigen Value of 1 from 13 items for team vision. Items representing team mission and strategic fit showed to be consisting of a single factor as opposed to the expectations. PTT3, PTT4 and PTT1 representing project targets, consisted the second factor. PTT2, however, was found to be loading in factor 1.

Small sample size of 34 responses could be the possible explanation about the 2 components being extracted. With high sample size of 205 respondents, Hong (2000) empirical work on team vision resulted in four distinct factors that the study identified as shared team purpose and mission, strategic fit, clarity of project targets and tradeoff of project targets. All the items showed high factor loadings (> 0.75) with no cross loadings.

As shown in Table 4.5, there are no cross-loadings and the Factor 1 (mission and strategic fit) and Factor 2 (project target) discriminated clearly from each other. Factor loadings for all the 13 items in the 2 components are higher than 0.74 and mostly in 0.80s and 0.90s. The factor loading for SF4 is 0.63 and is the lowest. All the items were retained at this stage.

4.6.2 Mutual Trust

The mutual trust construct represents a single construct with a total of 10 items. Table 4.6 displays item codes, item description, factor loadings, CITCs, Cronbach's alpha and Alpha if item was deleted. The Cronbach's alpha is reported to be 0.9734 signifying very high reliability of the instrument. The CITC for each item is also very high, mainly in 0.80s and 0.90s, except for TR5 which has a CITC value of 0.7287. There is no significant improvement to Cronbach's alpha if any of the items is omitted. Thus, all the items for mutual trust are retained at this stage.

During the factor analysis, a single factor was extracted. Again, the factor loadings for all the items for mutual trust (except for TR5) are high; in 0.80s and 0.90s. For TR5, the factor loading reported is 0.774.

Because of high reliability and high factor loadings, all 10 items for mutual trust is retained during this phase.

Table 4.6 Mutual Trust -Items, Description
Initial Factor Loading, CITC, Cronbach's Alpha and Alpha if Item Deleted

Mutual Trust				
Items	**Descriptions**	**CITC**	**Alpha if Item Deleted**	**Factor Loading**
TR5	The team members shared the belief that all members were acting in good faith	0.7287	0.9753	0.774
TR8	Team members relied on each other for the truthfulness of the information shared	0.8403	0.9716	0.872
TR2	The team members trusted each other enough to share all relevant information	0.8541	0.9712	0.882
TR3	The team members were willing to share sensitive information	0.8535	0.9712	0.882
TR11	Team members trusted each other enough to share sensitive information	0.8567	0.971	0.885
TR6	The team shared a belief that all members were honest	0.8816	0.9704	0.904
TR1	There was mutual trust among team members	0.8843	0.9702	0.908
TR9	The team members trusted each other to share accurate information	0.9315	0.9684	0.946
TR4	Team members trusted each other	0.9434	0.968	0.956
TR7	The team members were confident they could trust each other	0.9678	0.9671	0.976
Cronbach's Alpha = .9734 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0. 873**				

4.6.3 Mutual Influence

The mutual influence construct also represents a single construct with a total of 9 items. Table 4.7 displays item codes, item description, factor loadings, CITCs, Cronbach's alpha and Alpha if item was deleted. The Cronbach's alpha is reported to be 0.9360 signifying very high reliability of the instrument. The CITC for each item is also high, mainly in 0.80s and 0.70s, except for MI1 which has the lowest CITC value of all of 0.6297. There is no significant improvement to Cronbach's alpha if any of the items is omitted.

During the factor analysis, a single factor was extracted. The factor loading of all the items is in 0.80s high. MI1 reported the lowest factor loading of 0.694. Because of high reliability and high factor loadings, all 9 items for mutual influence were retained during this phase.

Table 4.7 Mutual Influence -Items, Description
Initial Factor Loading, CITC, Cronbach's Alpha and Alpha if Item Deleted

Mutual Influence				
Items	**Descriptions**	**CITC**	**Alpha if Item Deleted**	**Factor Loading**
MI1	Mutual influence was broadly spread among the team	0.6297	0.9357	0.694
MI4	Each team member had some ability to affect the decisions of others	0.7388	0.641	0.8
MI3	Power was broadly shared among team members	0.7581	0.702	0.808
MI5	Each team member had at least some control over the decisions of the team	0.7546	0.7404	0.81
MI8	All team members had at least some ability to persuade each other	0.7781	0.8237	0.835
MI9	All team members had some authority to influence team decisions	0.7906	0.7144	0.842
MI2	Everyone on the team had some power to influence others	0.787	0.7784	0.842
MI7	Influence was shared among team members	0.8257	0.819	0.867
MI6	Each team member had some power to affect team decisions	0.8233	0.8503	0.867
	Cronbach's Alpha = .9360 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.857**			

4.6.4 Mutual Trust and Mutual Influence –Factor Analysis

To investigate further, it was decided to conduct factor analysis using all the retained 10 items of mutual trust and all the retained 9 items of mutual influence. The objective was to statistically check if any cross loadings appear between the two variables and if these two variables discriminated from each other. The result of exploratory factor analysis is presented in Table 4.8.

As expected the two variables discriminantly loaded separately in two factors. Factor 1 represents items for mutual trust and factor 2 represents items for mutual influence. No cross loading between the two variable was reported and the factor loadings for all the items were above 0.70 except for MI7 and MI1 with factor loading of 0.69 and 0.527 respectively. No item purification was carried out in this stage either.

Table 4.8 Factor Analysis for Mutual Trust and Mutual Influence Constructs
Initial Result / Final Result
(Pattern Matrix)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.773			
Items		**Factor 1**	**Factor 2**
TR6		1.021	
TR8		0.72	
TR3		0.721	
TR11		0.734	
TR11		0.805	
TR9		0.825	
TR2		0.847	**Mutual Trust**
TR4		0.854	
TR7		0.869	
TR5		0.956	
MI1			0.527
MI7			0.69
MI9			0.741
MI4			0.784
MI3	**Mutual Influence**		0.789
MI2			0.817
MI5			0.841
MI6			0.881
MI8			0.948
Eigen Value		12.287	2.17
% of Variance		64.669	11.42
Cumulative % of Variance		64.669	76.089
Extraction Method: Principal Component Analysis **2 Components Extracted** **Rotation Method: Oblimin with Kaiser Normalization**			

4.6.5 Team Vision, Mutual Trust, and Mutual Influence –Factor Analysis

Next, all the proposed three drivers for shared knowledge –team vision, mutual trust, and mutual influence were tested for to verify if all three discriminates into 3 clear factors. During this stage all the variables and corresponding items were submitted simultaneously for exploratory factor analysis using principal component analysis as extraction method with Eigen value as 1 and oblimin for rotation. The objective was further to examine any cross loadings by any items from these three variables. The initial result from the pattern matrix is presented in Table 4.9.

Table 4.9 Factor Analysis for Team Vision, Mutual Trust, and Mutual Influence Constructs Initial Result
(Pattern Matrix)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = Not Reported					
Items		**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
TR8		0.629			0.318
TR3		0.679	0.351		
TR1		0.691			
TR2		0.758			0.41
TR9		0.777			
TR4		0.795			
TR7	**Mutual Trust**	0.813			
TR11		0.813			
TR5		0.966			
TR6		0.991			
SF3			0.447	0.381	
TM2		0.578	0.478		
TM1		0.319	0.563	0.33	
SF2			0.616		
TM5			0.671	**Mission**	
TM4			0.759	**and Strategic**	
SF4			0.776	**Fit**	
TM3			0.828		
PTT2			0.851		
SF1			0.966		
MI7				0.587	
MI4				0.675	
MI3				0.744	
MI5				0.751	
MI9			**Mutual**	0.858	
MI2			**Influence**	0.886	
MI6				0.891	
MI8				0.982	
MI1				0.43	0.55
PTT4			0.5		0.631
PTT3				**Project**	0.67
PTT1				**Target**	0.743
Eigen Value		19.424	3.591	2.113	1.251
% of Variance		60.702	11.221	6.603	3.909
Cumulative % of Variance		60.702	71.923	78.734	82.435
Extraction Method: Principal Component Analysis **4 Components Extracted** **Rotation Method: Oblimin with Kaiser Normalization**					

As evident from the Table 4.9; the factor analysis resulted in 4 components. Factor 1 mostly represented items for mutual trust (TR); Factor 3 represented items mostly of mutual influence (MI); Factor 2 and Factor 4 represented items mostly of team vision. Factor 3 consisted of items for mission (TM) and strategic fit (SF) and Factor 4 consisted of items from project target (PTT). Clearly, some of the items demonstrated cross loadings.

TR2 and TR8 were founded to have cross loading with Factor 4 and TR3 with Factor 2. Similarly, TM1 was found to have cross loadings with Factor 1 and Factor 3; and SF3 had cross loading with Factor 3. Except for MI1, all the items of mutual influence loaded discriminantly in Factor 3. MI1 had cross loading in Factor 4. Except for PTT2, all the items of project target had discriminant loading in Factor 4. PTT2 loaded in Factor 2 with no cross loadings to any other factors.

Next, it was required to conduct item purification with all the items that had cross loadings. This was conducted using Exploratory Factor Analysis, eliminating one item at a time, one with the highest factor cross loading first. The final result of this is provided in Table 4.10.

Table 4.10 Factor Analysis for Team Vision, Mutual Trust, and Mutual Influence Constructs Final Result
(Pattern Matrix)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.559					
Items		**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
TM2		0.566			
TR8		0.621			
TR3		0.675			
TR1		0.697			
TR11	**Mutual Trust**	0.761			
TR9		0.775			
TR4		0.786			
TR7		0.799			
TR6		1.001			
TR5		1.026			
TM5			0.515	**Mission and Strategic Fit**	
TM3			0.59		
SF2			0.738		
SF4			0.923		
SF1			0.937		
MI7				-0.601	
MI4				-0.707	
MI3				-0.743	
MI5			**Mutual Influence**	-0.776	
MI9				-0.852	
MI2				-0.872	
MI6				-0.925	
MI8				-0.985	
PTT4					0.874
PTT3				**Project Target**	0.891
PTT1					0.967
Eigen Value		15.506	2.734	1.995	1.221
% of Variance		59.637	10.515	7.671	4.694
Cumulative % of Variance		59.637	70.152	77.823	82.518
Extraction Method: Principal Component Analysis **4 Components Extracted** **Rotation Method: Oblimin with Kaiser Normalization**					

4.6.6 Shared Knowledge

Shared knowledge construct consists of four variables (i.e. shared knowledge of customers, internal capabilities, suppliers, and process). Except for the shared knowledge of process, all three variables and items are borrowed directly from the empirical study of Hong (2000) on shared knowledge in new product development. Items for shared knowledge of process were developed as described in Chapter 3 and in Section 4.3.

The objective of inquiry was to find out the team member's general understanding and knowledge of changing needs of customers, about the strength and capabilities of various functions within the organization, about the strength and capabilities of suppliers, and about different product development processes involved during the product development. As such, the objective was not on finding if each team member was an expert in every other functional area involved in the cross-functional development team of which he/she was a member. The results from reliability analysis and initial factor loadings for the entire four constructs are presented in Table 4.11.

Table 4.11 Shared Knowledge of Customers, Internal Capabilities, Suppliers, and Process- Item Description, Initial Factor Loading, CITC, Cronbach's Alpha and Alpha if Item Deleted

Shared Knowledge of Customers				
Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
CT4	current customer needs.	0.6769	0.8317	0.802
CT3	Which features were most valued by target customers	0.6764	0.8336	0.817
CT2	what our customers wanted	0.8287	0.7633	0.826
CT1	customer requirements	0.6497	0.8421	0.912
	Cronbach's Alpha = 0.852 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.713**			

Shared Knowledge of Internal Capabilities				
Items	Descriptions	CITC	Alpha if Item Deleted	Initial Factor Loading
IT4	the strengths of our manufacturing facilities	0.6801	0.6906	0.745
IT3	the capabilities of our engineering staff	0.779	0.7878	0.813
IT2	the strengths of our engineering development capabilities	0.5653	0.8665	0.884
IT1	the capabilities of the process technologies we used	0.7988	0.773	0.904
	Cronbach's Alpha = 0.8551 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.616**			

Shared Knowledge of Suppliers				
Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
ST6	our suppliers' capabilities to meet quality requirements	0.8942	0.8911	0.667
ST5	our suppliers' capabilities to meet time requirements	0.6778	0.9147	0.77
ST4	our suppliers' capabilities to meet cost requirements	0.8381	0.8938	0.858
ST3	our suppliers' manufacturing facilities	0.7834	0.9006	0.896
ST2	our suppliers design capabilities	0.5645	0.9274	0.9
ST1	our suppliers' process capabilities	0.9087	0.8824	0.943
	Cronbach's Alpha = 0.9178 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.871**			

Shared Knowledge of Process				
Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
TP8	key decision points in the product development process	0.6733	0.8802	0.755
TP7	each other's roles in the product development process	0.8889	0.8316	0.795
TP6	how our firm should develop products.	0.7405	0.869	0.839
TP5	the activities in the product development process that were on the critical path	0.631	0.889	0.86
TP4	the process of product development	0.7682	0.8593	0.993
	Cronbach's Alpha = 0.8907 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.754**			

CITC for all the items of shared knowledge was at least of acceptable value. IT2 and ST2 had the lowest CITC values of 0.5653 and 0.5645, which is lower than the minimum desired value of 0.60. However, because of practical significance of these two items, they are retained. Reliability test for all the four constructs reported high Cronbach's Alpha; 0.8582, 0.8551, 0.9178, and 0.8907 for shared knowledge of customer, internal capabilities, suppliers, and process respectively. Since, dropping any item could not contribute significantly to Cronbach's alpha. All the items for each construct were retained. Once high reliability for all these four constructs of shared knowledge was established, separate factor analysis for each four construct was done to investigate initial loadings and to verify if single component would be extracted for all the four constructs. As shown, all the constructs reported single component extraction with high factor loadings; in the range between 0.70 and 0.90s. ST6 however reported the lowest factor loading of 0.667. All 19 items for shared knowledge were retained during this stage.

Next, factor analysis for all the 19 items was conducted to investigate if the four constructs discriminate from each other in 4 distinct components. Further, it was also desirable to check if any items cross-loaded, in which case item purification was required. The initial result of factor analysis of all the 19 items is shown in Table 4.12.

Table 4.12 Factor Analysis for all Shared Knowledge Construct
Initial Result / Final Result
Pattern Matrix

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.73				
Items	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
IT4	0.968			
IT1	0.907			
TP4	0.837			
ST4	0.791			0.305
ST6	0.731			
TP7	0.678	0.387		
TP6	0.654	0.335	-0.361	
ST1	0.563			0.525
ST5	0.477		-0.31	0.464
TP5		0.913		
IT2		0.861		
TP8		0.812		
CT3		0.671	0.53	
IT3		0.619	0.308	
CT1			0.838	
CT2			0.79	
CT4		0.359	0.628	-0.35
ST2				0.923
ST3	0.383			0.485
Eigen Value	10.102	2.181	2.075	1.207
% of Variance	53.168	11.478	10.919	6.354
Cumulative % of variance	53.168	64.646	75.565	81.919
Extraction Method: Principal Component Analysis				
4 Components Extracted				
Rotation Method: Oblimin with Kaiser Normalization				

The result of factor analysis extracted 4 components as expected, however lots of items cross loaded on various different components. Furthermore, no clear grouping of items in single component is evident. The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.73, which is higher than the minimum value of 0.5 mentioned in SPSS 11.0 manual indicating the result of the factor analysis is probably useful. The Barlett's test of sphericity reported significant level of 0.00 which suggest the probability of significant relationships among the items of the construct.

After the result was investigated, items for each construct were examined for revision for large scale study. Empirical study of Hong (2000) on shared knowledge in new product development based on 205 sample size resulted into five distinct factors that were identified as shared knowledge of customers, suppliers, competitors, internal capabilities, and product. The study reported Kaiser-Meyer-Olkin Measure of Sampling Adequacy to be 0.86. Cronbach's Alpha for each variable was larger than 0.80 except for shared knowledge of product. Shared knowledge of product was reported to be the weakest in terms of reliabilities and overall factor loadings. For this reason, this research study proposed not to borrow this variable, but based on other literature; shared knowledge of process was developed and utilized in the pilot study.

A small sample size of 34 could be possible reason why these four factors were not clearly identified. At this stage, it was decided to retain all the items.

4.6.7 Process Outcomes (NPD Performance)

The Process Outcome Construct is one of the two constructs for NPD performance variable. Process outcomes were represented by three variables; engineering change time, team work, and team productivity. All the items on these variables were borrowed from the empirical study in the field of new product development by Syamil (2000) and Hong (2000). Each variable has 3 items. Table 4.13 shows results of individual variables on reliability analysis and factor analysis.

Table 4.13 Engineering Change Time, Team Work, and Team Productivity -Item Description, Initial Factor Loading, CITC, Cronbach's Alpha and Alpha if Item Deleted

Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
Engineering Change Time				
EC4	met engineering change deadline regularly	0.899	0.965	0.954
EC2	finished engineering change orders on time	0.9381	0.9333	0.972
EC3	delivered engineering change notices on time	0.9375	0.9363	0.972
	Cronbach's Alpha = 0.9632 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.769**			
Team Work				
TW5	coordinated design activities effectively	0.7949	0.7617	0.84
TW4	resolved design conflicts on time	0.7757	0.7806	0.905
TW2	communicated effectively	0.6665	0.8782	0.916
	Cronbach's Alpha = 0.8653 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.710**			
Team Productivity				
XTP3	worked on product improvements successfully	0.761	0.8794	0.892
XTP2	completed work quickly	0.7727	0.8705	0.897
XTP1	was productive	0.8533	0.7979	0.939
	Cronbach's Alpha = 0.8954 **Extraction Method: Principal Component Analysis, 1 Component Extracted** **Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.721**			

Engineering change time shows high reliability with Cronbach's alpha of .9362. The CITC for all three items are also in the range between 0.89 and 0.93. Since omitting any items will not improve alpha, all the three items were retained. Factor analysis resulted in a single component extraction with high factors loadings of 0.972, 0.972 and 0.974. All the items for engineering change time were retained at this stage.

The Cronbach's alpha for second variable, team Work, was 0.8653 which is high. CITC for the three items were reported as 0.6665, 0.7757, and 0.7949; all above the average acceptance value of 0.60. Comparison of Cronbach's alpha for team work versus individual items if they are dropped does not improve the reliability significantly, although TW5 could be argued for otherwise. However, because of practical significance, all the three items were retained. Next, factor analysis resulted in a single component, and the factors loading were all above 0.84. All the items for team work were retained at this stage.

The third variable for process outcome is team productivity for which the Cronbach's alpha reported was 0.8954. CITC for all three items of team productivity were in the range between 0.76 and 0.85. Omission of any item at this stage did not lead to any significant improvement in Cronbach's alpha. Thus, all the 3 items were retained at this stage. Factor analysis resulted into a single component structure, with factor loadings higher than 0.89. Thus all the items were retained at this stage.

Next factor analysis for all the items for process outcome, which were grouped into engineering change time, teamwork, and team productivity, was conducted to investigate the pattern structure and cross loadings of the items. The result is presented in Table 4.14.

Table 4.14 Factor Analysis for all Process Outcomes Construct
Initial Result / Final Result
Pattern Matrix

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.891	
Items	**Factor 1**
XTP3	0.755
TW2	0.78
XTP1	0.839
XTP2	0.84
EC2	0.899
TW4	0.899
EC3	0.902
TW5	0.906
EC4	0.921
Eigen Value	6.686
% of Variance	74.29
Cumulative % of Variance	74.29

Extraction Method: Principal Component Analysis
Only One Component Extracted
The solution cannot be rotated

All the items reported to be loading on a single factor. The KMO value was reported to be 0.891 and significance level was 0.00 that showed the items used were significant for factor analysis. Probably the small sample size of 34 could be one possible reason why a single factor was extracted instead of three factors.

With a larger sample size of 205, Hong (2000) has empirically demonstrated that process outcome of new product development resulted into 3 factors representing team work, development productivity, and time to market. Development productivity and time to market discriminated clearly from one another with no cross loadings, high Cronbach's alpha (0.81 and 0.91), and high loadings (mostly in the range of 0.70s and 0.95). However, of five items representing team work, 4 items for team work reported high (>0.81) cross loading with development productivity and 1 item reported to have high (0.88) cross loading with time to market. Instead of treating as separate factors, it was suggested that team work and team productivity could be treated as single factor in the large scale study.

At this point, all the items for process outcome were retained.

4.6.8 Product Outcome (NPD Performance)

Product outcomes are the second construct for NPD performance outcomes and contain four variables: product cost reduction, manufacturing cost reduction, product development time, and customer satisfaction. All the items for each of the variables were borrowed from empirical work on new product development by Hong (2000) and Syamil (2000).

Each of these four variables has 4 to 6 items. The result of reliability test and factor analysis is presented in Table 4.15.

Table 4.15 Product Cost Reduction, Manufacturing Cost Reduction, Product Development Time, Customer Satisfaction - Item Description, Initial Factor Loading, CITC, Cronbach's Alpha, and Alpha if Item was Deleted

Product Cost Reduction

Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
PC4	reduced the number of parts successfully	0.668	0.8232	0.683
PC3	reduced material costs successfully	0.8072	0.7537	0.815
PC2	reduced product costs successfully	0.8354	0.7383	0.9
PC1	simplified the design successfully	0.5017	0.8766	0.914

Cronbach's Alpha = .8488
Extraction Method: Principal Component Analysis, 1 Component Extracted
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.694

Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
MC5	reduced the number of manufacturing steps effectively	0.8511	0.8887	0.809
MC4	reduced production tooling costs successfully	0.8158	0.8987	0.878
MC3	reduced manufacturing cost successfully	0.7182	0.9172	0.887
MC2	reduced equipment cost successfully	0.7955	0.9023	0.891
MC1	successfully reduced assembly cost	0.8917	0.8974	0.91

Cronbach's Alpha = .9192
Extraction Method: Principal Component Analysis, 1 Component Extracted
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.876

Product Development Time

Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
YPT5	made better progress in reducing total product development time	0.6822	0.8916	0.792
YPT4	developed product from concept to commercial production faster	0.8697	0.8502	0.797
YPT3	brought product to the market before our competitors	0.6809	0.8918	0.82
YPT2	enabled our company to start volume production faster	0.7205	0.8851	0.884
YPT1	launched product to the market faster	0.8091	0.8639	0.928

Cronbach's Alpha = 0.8994
Extraction Method: Principal Component Analysis, 1 Component Extracted
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.768

Customer Satisfaction				
Items	Descriptions	CITC	Alpha if Item Deleted	Factor Loading
CS6	Was more successful in the marketplace	0.6611	0.9065	0.717
CS5	Was more highly valued by customers	0.8543	0.884	0.76
CS4	generated more new customers	0.6253	0.9163	0.84
CS3	has more loyal customers	0.7687	0.8944	0.905
CS2	fit target customers better	0.8343	0.8844	0.911
CS1	satisfied customers better	0.8501	0.8798	0.918
Cronbach's Alpha = 0.9104 Extraction Method: Principal Component Analysis, 1 Component Extracted Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.892				

Cronbach's alpha for product cost reduction was reported to be 0.8484 and all the items showed good alpha item excluding any desire to drop any of the items to improve reliability of this instrument. CITC for all PC1 was reported to be .5017, less than the desired minimum value of 0.60. However, no item purification was done at this stage. All the four items resulted in a single factor with high factor loadings. All four items were retained at this stage.

Manufacturing cost reduction has five items and reported Cronbach's alpha of 0.912. Further CITC for all the five items were in the range of 0.70s and 0.80s. No significant improvement in reliability would result if any item were to be dropped. All the items were retained at this stage. Factor analysis yielded in a single component extraction with high factor loadings for each items. All the items, thus, was retained for manufacturing cost reduction.

Product development time is the third variable of product outcomes and it contains five items. Cronbach's alpha was reported to be 0.8994 with CITC value for each item above 0.69. Further, dropping any item did not lead any improvement in the reliability for product development time. All the five items were retained at this stage. Factor analysis resulted in a single component with higher loadings between 0.79s and 0.90s.

The Cronbach's alpha for the fourth variable, customer satisfaction, was reported to be 0.9104. It has 6 items and CITC for each of these items were reported to be greater than 0.60. Further, dropping any these items would not result any significant improvement in reliability. Factor analysis resulted into a single component with high loadings (between 0.70 and 0.90). All six items were retained at this stage.

Next, factor analysis for all the items of product outcomes was performed. The result is presented in Table 4.16.

Table 4.16 Factor Analysis for all Product Outcomes Construct
Initial Result
Pattern Matrix
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.656

Items	Factor 1	Factor 2	Factor 3
PC4	0.556		
PC1	0.558	0.442	
MC3	0.805		
MC2	0.814		
PC3	0.815		
MC1	0.834		
MC5	0.852		
PC2	0.878		
MC4	0.888		
CS3		0.752	
CS6		0.788	
CS1		0.874	
CS5		0.902	
CS2		0.905	
YPT5		0.361	-0.626
YPT1		0.324	-0.654
YPT4			-0.726
YPT2			-0.75
YPT3			-0.876
CS4		0.508	-0.543
Eigen Value	8.95	3.723	1.868
% of Variance	44.751	18.613	9.33
Cumulative % of variance	44.751	63.363	72.694
Extraction Method: Principal Component Analysis 3 Components Extracted Rotation Method: Oblimin with Kaiser Normalization			

All 20 items for the Product Outcomes when subjected to factor analysis resulted into 3 separate components. Items from first two constructs – product cost reduction and manufacturing cost reduction loaded in single factor, Factor 1. Instead of having two constructs, maybe the result suggested a single construct which could be labeled as Cost Reduction. Factor loadings of both PC1 and PC4 were lower than 0.6; and in addition, PC1 had cross loadings on Factor 2. Factor 2 consisted of all the items of fourth construct, Customer Satisfaction. However, CS4 was found to have cross loadings on Factor 3. All the items of product development time loaded on Factor 3. YPT1 and YPT5 were found to have cross loadings with Factor 2.The overall KMO was reported to be 0.656; above the suggested value of 0.60.

The final pattern matrix after item purification from above factor analysis for all the items of Product Outcomes is presented in Table 4.17. PC1 and CS4 were dropped at this point. While there was a significant improvements in factor loadings of all the items, YPT1 and YPT5 still were found to have a cross loading on Factor 2. Because of small sample size and on the basis of practical significance, both the items were retained at this stage.

Table 4.17 Factor Analysis for all Product Outcomes Construct
Final Result
Pattern Matrix

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.723				
Items		**Factor 1**	**Factor 2**	**Factor 3**
PC4	**Product Cost and Manufacturing Cost Reduction**	0.553		
MC3		0.799		
PC3		0.815		
MC5		0.84		
MC2		0.84		
MC1		0.853		
PC2		0.885		
MC4		0.907		
CS3			0.757	**Customer Satisfaction**
CS6			0.802	
CS1			0.898	
CS5			0.901	
CS2			0.932	
YPT5		**Product Development Time**	0.374	-0.627
YPT1			0.325	-0.693
YPT4				-0.753
YPT2				-0.799
YPT3				-0.901
Eigen Value		8.347	3.445	1.672
% of Variance		46.372	19.14	9.288
Cumulative % of variance		46.372	65.511	74.799

4.7 METHODOLOGICAL LIMITATIONS (BIAS AND ERROR HANDLING)

One of the most frequent criticisms in research is the *provincialism* introduced by way of the researcher. Each researcher applies the constructs and methodologies typical to the academic domain in which he or she was trained or the corporate environment he or she works within (Roberts and Boyacigiller, 1984). The researcher in this case has post-secondary degrees in business and engineering which allows for a broader perspective in research methodologies. The primary researcher had taken doctoral level courses in product development, manufacturing systems, information system, research theory and methodology, and organizational behavior that are directly related with the domain of this research. In addition, the advising and research committee included expert members and researchers in the field of organizational behavior, NPD, operations management, sales and marketing, and advance statistics. Further, professionals in the field of product development were consulted on this research topic to provide insights in product development practices. The additional 'insider' working knowledge should be considered as an asset rather than a liability.

A further methodological limitation relates to *random and system error*. Random error (RA) occurs because of chance variation in the scientific selection of sampling units and will be handled statistically during large scale study in Chapter 4. Systematic errors result from some imperfect aspect of the research design or from a mistake in the execution of the research.

The two main sources of systematic error are administrative and respondent derived (de Vaus, 1995, Zikmund, 1994). Administrative error results from improper administration of the research task. Data processing sourced error is associated with the accuracy of data entry and subsequent computer generated aspects of processing the data. Frequency analysis within SPSS 11.0 was run to verify all data existed within the assigned Likert scale range. Each analysis step was carefully quality checked to minimize this type of error.

Sample selection error results when an unrepresentative sample has been chosen. In this case, several carefully determined criteria were required for participation as discussed earlier in Section 4.3.

Respondent error includes error introduced through non-response and error introduced when respondents tend to answer in a certain direction. Due to the high rate of response, the issue of non-response is treated as negligible. The criteria of anonymity and confidentiality were specifically included in the research design to minimize the deliberate falsification of responses by employees as a result of their attempts to portray a particular image, e.g. more team productivity, better customer satisfaction, etc.

Four types of bias, as applied to this study, can reflect unconscious misrepresentation: *acquiescence, extremity, auspices, and social desirability*. Acquiescence bias is due to the respondents' tendency to concur with a particular position. As the subject matter pertains to individual experience with the members of product development team in the most recently completed product development project, there really is no other company position as such. For example, there is no particular corporate position on whether trust among the team members should be promoted in order to improve customer satisfaction. The acquiescent response set could be considered by checking whether completely contradictory questions are answered the same way. Since, doing so resulted in further increase in the number of items; this was not included in the study.

Extremity bias is concerned with respondents who tend to favor extremes when responding to questions. The data was scrutinized for extreme checking using frequency analysis in SPSS 11.0. A frequency distribution was calculated for all 5-point Likert responses. Guidelines on defining what constitutes significant extreme checking are vague at best. For the purposes of this study when the sum of all 1's and 5's exceeded 50% of the responses for all the items for each respondent, extreme checking bias was deemed present. None of the cases indicated extreme checking in the 1/5 on the Likert scales.

Auspices bias reflects respondents being influenced by which organization is conducting the survey. For example, respondents' answers to a survey on oil exploration might be different depending on whether the Green Peace environmental group was conducting the survey or Exxon Oil Company was conducting the survey. Since the study was conducted as a doctoral dissertation requirement in the field manufacturing management and engineering, and with the help of leading researchers of a recognized academic institute, auspices bias is considered negligible.

Finally, social desirability bias occurs when an employee wishes to create a favorable image, e.g. education is overstated. The study included items that were measured in five-point Likert scale. No question was asked that could be deemed as personal, sensitive, confidential and/or of distinct competitive advantage for a company. No question was asked that can reveal the identity of respondent. Guaranteed anonymity and confidentiality should minimize this bias.

4.8 SUMMARY AND RECOMMENDATIONS FOR LARGE SCALE

Using the generally accepted psychometric principles, the objective of the pilot study for the knowledge integration model was to provide a general "feeling" on the instruments that is to be used for this research in large scale study. Essentially, because of the limited sample size of the pilot study, the data analysis was limited on issues surrounding reliability and validity only. Nevertheless, the pilot study result provided some useful insights on the behavior of some of the items of the research model that should be investigated closely during both the exploratory analysis and the confirmatory analysis of large-scale study.

The suggestions and proposal made here is largely based upon the statistical results of pilot study, literature reviews, and comparison of the pilot study results with previously conducted large scale study result of same variables from the doctoral dissertation of Hong (2000) and Syamil (2000). In doing so, special attention is focused on the variables that had one or more of the following characteristics – poor factor loading, presence of high cross loading with other factors and low reliability. At the same time, each item was analyzed for its practical significance for the knowledge integration model.

The summary conclusion of some of the items after the pilot study of knowledge integration model for new product development is presented in Table 4.18.

During the factor analysis of all the items of team vision, mutual trust and mutual influence, TM1, and SF3 reported to have the cross loading with mutual influence. Similarly, PTT2 had factor loading on items belonging to TM and SF. MI1 and MI7 cross-loaded with items belonging to MT.

Although no clear factors were noted for shared knowledge construct, ST2 and ST6 in particular reported to have low CITC and factor loading. A close observation of ST2 revealed resemblance in meaning with item ST1. IT1 was reworded from “engineering development” capabilities to its original form as used in Hong (2000) study to “engineering design” capabilities. Following the theory provided at http://www.npd-solutions.com/pdforum.html and PMBOK (2002), TP1, TP2, and TP3 were added to the instruments for the shared knowledge of process.

Table 4.18 : Conclusion from the Pilot Study

Items	Remarks
TM1	Cross loading with MI
SF3	Cross loading with MI
PTT2	Cross loading with SF and TM items
MI1	Cross loading with MT items
MI7	Cross loading with MT items
ST2	Low CITC, Similar to ST1
ST6	Low factor loading
IT2	Low CITC, reworded to previously used item from Hong(2000) study
TP1, TP2, TP3	Added
ALL EC	Loaded in single factor with all items of TW and TPO
ALL TW	Loaded in single factor with all items of EC and TPO
ALL TPO	Loaded in single factor with all items of TW and EC
PC1	Low CITC, Cross loading with CS
PC4	Low factor loading
ALL MC	Loaded with all items of PC
PTO1	Cross loading with items of CS
PTO5	Cross loading with items of CS
CS4	Low factor loading, Cross loading with items of PTOs

Because of complications associated with third order factor analysis in SEM for CFA, process outcomes and product outcomes were proposed to be consolidated in single factor for New Product Performance Outcomes (NPPO). PC1 was reported to have low CITC and had cross loading with CS. Similarly PC4 had a low factor loading during the factor analysis. Moreover, all the items for product cost reduction (PC) and manufacturing cost reduction (MC) loaded on a single factor. From theoretical significance perspective, it was decided to assess in the large-scale study if PC and MC could be treated as a single factor as Product Cost Reduction (PC) instead of two separate factors. PTO1 and PTO5 had cross loading with CS items. And CS4 had low factor loading along with cross loading with items of PTO.

The problems associated with above items were expected generally to be because of low sample size and it was thus decided not to drop any items from the large scale. Since the field of knowledge management in the context of new product development is new, the entire research was to be considered exploratory in nature. Thus it was recommended to conduct exploratory data analysis followed by the confirmatory approach of SEM in the large-scale study for this research. The final list of all the items recommended for the large-scale study for knowledge integration in new product development is presented in Table 4.19.

Table 4.19: Recommended Measures for Large Scale Study

Constructs	Variables (Factors)	Items	Description
Team Vision (TV)			
	Mission (TM)	TM1	The project purpose was well understood by the entire team
		TM2	The project mission was well communicated to all team members
		TM3	The project mission was well defined for all team members
		TM4	The product development team has a well defined mission
		TM5	The project mission was well understood by the entire team
	Strategic Fit (SF)	SF1	Our firm's overall technology strategy guided a setting of the project targets
		SF2	The project target were consistent with our overall business strategy
		SF3	Project targets reflected the competitive situation
		SF4	Our firms overall product strategy guided a setting of project targets
	Project Targets (PTT)	PTT1	The project targets clearly specified tradeoffs between performance and cost
		PTT2	The relative priority of each project target was clear
		PTT3	The project targets clearly specified tradeoffs between time and cost
		PTT4	Project targets clearly specified tradeoffs between quality and cost
Mutual Trust (MT)		TR1	There was mutual trust among team members
		TR2	The team members trusted each other enough to share all relevant information
		TR3	The team members were willing to share sensitive information
		TR4	Team members trusted each other
		TR5	The team members shared the belief that all members were acting in good faith
		TR6	The team shared a belief that all members were honest
		TR7	The team members were confident they could trust each other
		TR8	Team members relied on each other for the truthfulness of the information shared
		TR9	The team members trusted each other to share accurate information
		TR11	Team members trusted each other enough to share sensitive information

Mutual Influence (MI)	MI1	Mutual influence was broadly spread among the team
	MI2	Everyone on the team had some power to influence others
	MI3	Power was broadly shared among team members
	MI4	Each team member had some ability to affect the decisions of others
	MI5	Each team member had at least some control over the decisions of the team
	MI6	Each team member had some power to affect team decisions
	MI7	Influence was shared among team members
	MI8	All team members had at least some ability to persuade each other
	MI9	All team members had some authority to influence team decisions
Shared Knowledge of (SK)		
Customer (CT)	CT1	customer requirements
	CT2	what our customers wanted
	CT3	which features were most valued by target customers
	CT4	current customer needs
Internal Capabilities (IT)	IT1	the capabilities of the process technologies we used
	IT2	the strengths of our engineering design capabilities
	IT3	the strength of our engineering staff
	IT4	the strengths of our manufacturing facilities
Suppliers (ST)	ST1	our suppliers' process capabilities
	ST2	our suppliers design capabilities
	ST3	our suppliers' manufacturing facilities
	ST4	our suppliers' capabilities to meet cost requirements
	ST5	our suppliers' capabilities to meet time requirements
	ST6	our suppliers' capabilities to meet quality requirements
Process (TP)	TP4	the process of product development
	TP5	the activities in the product development process that were on the critical path
	TP6	how our firm should develop products
	TP7	each other's roles in the product development process
	TP8	key decision points in the product development process
	TP1	the steps in the product development process
	TP2	The points in the product development process where information needed to be exchanged
	TP3	where key deliverables in the product development process were essential to subsequent activities

New Product Development Performance Outcomes (NPPO)		
Engineering Change Time (EC)	EC2	finished engineering change orders on time
	EC3	delivered engineering change notices on time
	EC4	met engineering change deadline regularly
Team Performance (PERF)	TW2	communicated effectively
	TW4	resolved design conflicts on time
	TW5	coordinated design activities effectively
	TPO1	was productive
	TPO2	completed work quickly
	TPO3	worked on product improvements successfully
Product Cost (PC)	PC1	simplified the design successfully
	PC2	reduced product costs successfully
	PC3	reduced material costs successfully
	PC4	reduced the number of parts successfully
	MC1	successfully reduced assembly cost
	MC2	reduced equipment cost successfully
	MC3	reduced manufacturing cost successfully
	MC4	reduced production tooling costs successfully
	MC5	reduced the number of manufacturing steps effectively
Product Development Time (PTO)	PTO1	launched product to the market faster
	PTO2	enabled our company to start volume production faster
	PTO3	brought product to the market before our competitors
	PTO4	developed product from concept to commercial production faster
	PTO5	made better progress in reducing total product development time
Customer Satisfaction (CS)	CS1	satisfied customers better
	CS2	fit target customers better
	CS3	has more loyal customers
	CS4	generated more new customers
	CS5	was more highly valued by customers
	CS6	was more successful in the marketplace

A large-scale study for the proposed research model of knowledge integration in new product development was conducted next. The details of the large-scale study are provided in Chapter Five.

Chapter Five

Large Scale Study

The pilot study as discussed in Chapter Four provided substantial support to conduct the large-scale study for the hypothesized model of knowledge integration in new product development. The objective of this study is to empirically test the propositions through large-scale data collection from a wider community of product development professionals. For the large-scale study, instruments proposed at the end of pilot study were used. In this section of the study -large scale research method, exploratory data analysis and confirmatory factor analysis were conducted first. Second order constructs, which are the building blocks of the proposed model, were tested next. Finally, the entire model was tested using SEM methodology for all the proposed hypotheses.

5.1 LARGE SCALE SURVEY METHOD

The questionnaire for the large-scale study for knowledge integration was based on the items recommended from the pilot study. A total of 82 items were utilized to test the proposed model of this research. The Society of Automotive Engineers (SAE) provided the mailing list of active product development professionals. SAE mailing lists have been used in the past doctoral researches in the product development, and have been found to have a good response rate (e.g. Hong, 2000; Syamil, 2000). However, the response rate in the research stream of business has declined over the years. In order to improve the response rate, it was decided to use both the mail-in survey and internet survey as the methods of collecting the data.

A structured, self-administered survey questionnaire with the self-addressed envelopes was mailed to a total of randomly selected 3000 product development professionals provided by the SAE. The respondents were given option to respond either using the mail-in survey, or using the on-line Internet survey. An incentive of $500.00 cash prize through lucky draw for completed questionnaire response received was also presented to the respondents. Respondents had also option to request the report of the research findings.

A total of 132 responses were received in the first three weeks after the dispatch of the first round of questionnaire. Out of 132, 20 responses had multiple items missing and thus were excluded from the study. Another 73 responses were received following a second round of questionnaire mailed along with email and telephone call request made to participate in the study. Out of 73, only 58 responses were considered complete and suitable to be included in the large-scale study. Thus out of 205 total responses received, only 170 responses were used for the large scale data analysis making the response rate for this study to be 5.6 %. This low response rate is to be considered in the context of continuous decrease in survey responses (Kathuria, 2000). The detail of the responses received is presented in Table 5.1.

Table 5.1: Response Methods

	Mail	Internet	Total
Early	80	32	112
Late	23	35	58
Total	**103**	**67**	**170**

A chi-square test for mail versus Internet survey, using company size (number of full time employees), and early versus late respondents, using company industry position (first tier, second tier, third tier, and other) was conducted to test if the samples represented the target population. Result of chi-square test between the mail and Internet survey is presented in Table 5.2.

Table 5.2 Respondent Bias: Mail vs. Internet

Size of Company	Mail	Internet (Observed)
1-499	31	17
500-599	6	8
1000-4999	25	16
5000-9999	15	6
over 10,000	26	18
Total	**103**	**65**
Calculated Chi Square: 6.451553 df: 4 Chi Square critical (alpha .05): 9.48		

Since calculated chi-square was less than the critical chi-square at alpha .05, there was no significance difference between mail and internet respondent based upon the company size.

Similarly, as presented in Table 5.3, calculated chi-square, 5.31, was less than the critical chi-square, 7.81, at alpha .05 signifying no difference between the early and late respondents based upon company position in the industry.

Table 5.3 Respondent Bias: Early vs. Late

Company Position	Early	Late (Observed)
First Tier	85	32
Second Tier	20	3
Third Tier	2	2
Other	5	1
Total	**112**	**38**
Calculated Chi Square:		5.317647
df: 3		
Chi Square critical (alpha 05):		7.81

Sample characteristics of the surveyed sample are presented in Table 5.4 which shows that 28% of the respondents worked for companies with employees up to 499.

Table 5.4 Sample Demographics

Demographics	Percentage	Total
Number of employees		
up to 499	28%	
500-999	8%	
1,000-4,999	24%	
5,000-9999	12%	
over 10,000	27%	
		100%
Focal Product Manufactured		
Body Exterior	4%	
Body Interior	14%	
Powertrain	25%	
Body Component	9%	
Chassis	27%	
Electrical / Electronic Component	9%	
Other	14%	
		100%
Company Status		
OEM	24%	
Supplier	67%	
Other	9%	
		100%
Supplier Ownership		
Owned by OEM	10%	
Independent	90%	
		100%
Supplier Level		
First tier	78%	
Second tier	15%	
Third tier	3%	
Other	4%	
		100%

These respondents represented manufacturing firm that developed and produced diverse product category for the automobile industry. In addition, about 67% represented supplier companies out of which, 78% belonged to first-tier suppliers.

5.2 RESEARCH METHODS

For the exploratory data analysis for knowledge integration model, results from the 170 responses were analyzed with several objectives in mind: purification, reliability, and simplicity of factor structure and discriminant validity. Next, confirmatory factor analysis or the measurement model for the first order construct was conducted using SEM methodology with AMOS 5.0. Second order factor analysis was also conducted for team vision, shared knowledge, and new product performance outcomes. Finally, structural model was tested for all the proposed hypotheses. The structural model test would either validate or fail to validate the hypotheses proposed for this study.

Item purification was performed using corrected-item-total-correlation (CITC) analysis using SPSS 12.0. Items were eliminated if their CITC was less than 0.60. The reliability of all the scales was examined using Cronbach's alpha. In general, reliabilities above 0.80 would indicate that the scale performs well (Nunnally, 1978).

All instruments were then factor analyzed. Exploratory factor analysis is designed for the situation where links between the observed and latent variables (factors) are unknown or uncertain. DeVellis (1991) provides three reason for using factor analysis: 1) to determine how many latent variables underlie a set of items (or other variable); 2) to provide a means of explaining variation among relatively many original variables using relatively few newly created variables (i.e. factors); and 3) to define the substantive content or meaning of the factors (i.e. latent variables) that account for the variation among a larger set of items. This is accomplished by identifying groups of items that covary with one another and appear to define meanings that underlie latent variables. If anticipated item groupings are identified prior to factoring, a factor analytic solution that is consistent with these groupings provides some evidence of factorial validity (Comrey, 1988).

The numbers of factors to extract in this research was based on Kaiser's Eigen values greater than 1 (e.g. Nunnally, 1978).

To achieve stable factor structure, it is suggested that the ratio of the respondents to items should be at least between 5 to 10 (Tinsley and Tinsley, 1987). Items with factor loading below 0.60, as in the pilot study, and / or cross loading of 0.30 or above were to be deleted. Exploratory factor analysis was conducted using SPSS 12.0.

Discriminant validity, using AMOS methodology, was assessed for those variables (i.e. factors) or constructs that seemed to be similar. Using AMOS methodology, models were constructed 1) with the correlation between the latent variables fixed at 1.0, and 2) with the correlation between the latent variable free to assume any other value. The difference in chi-square values for the fixed and free solutions would indicate whether a uni-dimensional model would be sufficient or not (Koufteros, 1995).

First order and second order measurement models of knowledge integration were than to be tested using the confirmatory factor analysis (CFA) methodology of AMOS (Byrne, 2001). In contrast to exploratory factor analysis, CFA is appropriately used when the researcher has some knowledge of the underlying latent variable structures. Because the CFA model focuses solely on the link between factors and their measured variables, within the framework of SEM, it represents what has been termed as measurement model

In contrast to the measurement model, the full latent variable model allows for the specification of regression structure among the latent variables. The researcher can hypothesize the impact of one latent construct on another in the modeling of casual directions and thus the model is termed complete because it comprises both a measurement model and a structural model where the structure model depicts the links among the latent variables (Byrne, 2001).

Structural relations of the hypothesized knowledge integration model were tested using SEM methodology for which AMOS 5.0 was used. SEM is a statistical methodology that takes a confirmatory (i.e. hypothesis-testing) approach to the analysis of a structural theory bearing on some phenomenon (Byrne, 2001). Structural relation was tested for both the hypothesized model and for any alternate model as discussed in chapter Three.

The aim in SEM, is to specify a model such that it meets the criterion of overidentification. AMOS methodology automatically assigns1 to single arrow when drawing the path diagram which is related to the issue of model identification (Byrne, 2001). Linked to the issue of identification is the requirement that every latent variables have its scale is determined. This requirement arises because these variables are unobserved and therefore have no definite metric scale, which is accomplished in AMOS where unmeasured latent variable is mapped onto its related observed indicator variable. This scaling requisite is satisfied by constraining to some non-zero value (typically 1.0).

As discussed earlier in chapter Three and Four, the option of generating alternate model was left open should one or more hypotheses were rejected.

In summarizing the general strategic framework for testing structural equation models, Joreskog (1993) distinguished among three scenarios: which is termed as strictly confirmatory (SC), alternative models (AM), and model generating (MG). In first instance, the researcher postulates single model based on theory, collects the appropriate data, and then tests the fit of the hypothesized model to the sample data; no further modification to the models are made. Given the many costs associated with collecting the sample data, SC case is not common in practice (Byrne, 2001).

In the AM case, the researcher proposes several alternative models, all of which are grounded in theory. Following analysis of a single set of empirical data, the researcher selects one model as most appropriate in representing the data. AM approach to modeling has also been an uncommon practice (Byrne, 2001).

In the MG scenario, the researcher, having postulated and rejected a theoretically derived model on the basis of its poor fit to the sample data, proceeds in an exploratory (rather than confirmatory) fashion to modify and re-estimate the model. The primary focus, in this instance, is to locate the source of misfit in the model and to determine a model that better describes the sample data (Byrne, 2001).

5.3 RESULTS OF EXPLORATORY DATA ANALYSIS (ITEM PURIFICATION, RELIABILITY, AND CONSTRUCT VALIDITY)

In this section, the data was analyzed for each construct and variables within for item purification (CITC), reliability (Cronbach's alpha) and simple factor structure (exploratory factor analysis) using SPSS 12.0 as discussed earlier in chapter Four.

5.3.1 Team Vision (TV)

Team vision was conceptualized with three variables: mission (TM), strategic fit (SF), and project targets (PTT). First, Cronbach's alpha and CITC was computed for each items for each three variables of the TV construct. The result of this test is presented in Table 5.5.

Table 5.5 Reliability, Item Purification, and Factor Validity

Mission			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
TM2	0.762	0.926	0.844
TM1	0.818	0.914	0.889
TM5	0.825	0.912	0.891
TM4	0.828	0.911	0.892
TM3	0.855	0.906	0.913
Cronbach's Alpha: .93 **Extracted Method: Principal Component Analysis** **Kaiser-Meyer-Olkin Measure of Sample Adequacy: .89**			

Strategic Fit			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
SF3	0.348	0.834	0.532
SF2	0.616	0.719	0.8
SF4	0.706	0.667	0.869
SF1	0.714	0.661	0.874

Cronbach's Alpha: .784
Extracted Method: Principal Component Analysis
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .723

Project Targets			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
PTT2	0.452	0.861	0.632
PTT4	0.703	0.76	0.849
PTT3	0.73	0.746	0.867
PTT1	0.745	0.738	0.876

Cronbach's Alpha: .828
Extracted Method: Principal Component Analysis
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .79

The first column for each variable represents the items for each of the three variables. CITC and the factor loading are presented in the third and fourth column respectively.

The reliability of TM, SF, and PTT was reported to be .93, .784 and .828 respectively. CITC for all the items were good except for SF3, PTT2 and SF2. CITC for SF3, PTT2, and SF2 were reported to be .348, .452, and .616. If SF3 was to be dropped, the Cronbach's alpha for remaining items were reported to be .827 with CITC for SF1, SF2, and SF4 to be .888, .802, and .895. Similarly, if PTT2 was to be dropped, the new Cronbach's alpha was reported to be .861 with CITC for PTT1, PTT3, and PTT4 to be .89, .885, and .879 respectively.

An exploratory factor analysis was then conducted separately for all the three variables using principal components as the means of extraction and oblimin as the method of rotation. Factor loading for each item in each variable was reported to be high except for SF3 (.532) and PTT2 (.632).

Next, all the 13 items of team vision were subjected to the factor analysis without specifying the numbers of factors. The ratio of respondents (170) to items (13) was 13.0 and met the general guidelines. The final results of the factor analysis are presented in Table 5.6.

Table 5.6 Factor Analysis for TV

Final Result Pattern Matrix			
Items	**Factor 1**	**Factor 2**	**Factor 3**
TM2	0.792		
TM4	0.844		
TM3	0.891		
TM1	0.912		
TM5	0.929		
SF3			0.703
SF1			0.876
SF4			0.933
PTT3		0.845	
PTT1		0.88	
PTT4		0.898	
Eigen Value	5.321	1.912	1.367
% of Variance	48.375	17.383	12.426
Cumulative %	48.375	65.758	78.184
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .858 Extraction Method: Principal Component Analysis Rotation Method: Oblimin with Kaiser Normalization			

Eigen values for the three factors were reported to be 5.321, 1.921, and 1.367. The cumulative variance explained by the three factors was 78%. All items, in the final analysis loaded in their respective factors with dropping of SF2 and PTT2, which also had problems associated with their respective CITCs. Factor loading for each item was greater than 0.60, which was desirable.

Overall, based upon the reliability, item purification, and factor analysis, two items (SF2 and PTT2) were deleted at this stage with reliabilities and the factor loading of the remaining items were high.

5.3.2 Mutual Trust (MT)

The assessment of this construct with 10 items (TR1-9, and TR 11) begins with analysis of Cronbachs's alpha, CITC, and factor loading. The result is presented in Table 5.7.

The Cronbach's alpha for MT was reported to be .958 with high CITC for each of the items. Similarly, all the items had high factor loading; above 0.60. Eigen value was reported to be 7.292 and % of variance (and the cumulative %) to be 72.9 %.

Table 5.7 Reliability, Item Purification, and Factor Validity

Mutual Trust			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
TR8	0.678	0.959	0.731
TR5	0.766	0.956	0.809
TR11	0.796	0.955	0.835
TR9	0.807	0.954	0.846
TR1	0.81	0.954	0.848
TR6	0.837	0.953	0.871
TR3	0.844	0.953	0.876
TR2	0.851	0.953	0.882
TR7	0.861	0.952	0.891
TR4	0.914	0.95	0.934
Cronbach's Alpha: .958			
Extracted Method: Principal Component Analysis			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .948			

At this stage, all the items for MT were retained.

5.3.3 Mutual Influence (MI)

The result of reliability, item purification, and factor analysis is presented in Table 5.8.

Table 5.8 Reliability, Item Purification, and Factor Validity

Mutual Influence			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
MI2	0.663	0.934	0.727
MI5	0.717	0.93	0.783
MI1	0.734	0.93	0.789
MI7	0.775	0.927	0.826
MI3	0.777	0.927	0.829
MI4	0.787	0.926	0.839
MI9	0.789	0.926	0.842
MI6	0.796	0.926	0.845
MI8	0.802	0.926	0.853
Cronbach's Alpha: .936 Extracted Method: Principal Component Analysis Kaiser-Meyer-Olkin Measure of Sample Adequacy: .931			

Eigen value for MI was reported to be 5.988 and % of variance to be 66.53%. Because of high CITC, high Cronbach's alpha, and high factor loading, all the items of MI were retained.

5.3.4 Factor Analysis for MT and MI

In order to investigate the factor validity, all the items for MT and MI were subjected to the factor analysis without specifying the number of factors. Since the respondents to items ratio was 8.9, it met general guideline for factor analysis. All the items were expected to load separately in two factors with factor loading above 0.6 and no cross loading above 0.3. During the factor analysis, the pattern matrix resulted with MI1 having cross loading of .35 with factor 1 representing items for MT. Moreover, MI1 had factor loading of .579 in factor 2 representing MI. The final result of the factor analysis, after deleting MI1, is presented in Table 5.9.

Table 5.9 Factor Analysis for Mutual Trust and Mutual Influence

Final Result Pattern Matrix		
Items	**Factor 1**	**Factor 2**
MI2		0.587
MI3		0.654
MI7		0.737
MI5		0.85
MI8		0.853
MI6		0.881
MI4		0.883
MI9		0.921
TR8	0.726	
TR9	0.786	
TR1	0.803	
TR5	0.821	
TR11	0.826	
TR3	0.869	
TR2	0.879	
TR6	0.893	
TR7	0.915	
TR4	0.956	
Eigen Value	10.486	2.973
% of Variance	54.948	16.304
Cumulative %	54.948	71.252
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .944		
Extraction Method: Principal Component Analysis Rotation Method: Oblimin with Kaiser Normalization		

5.3.5 Shared Knowledge (SK)

This construct was conceptualize to consist of 4 variables; shared knowledge of customer (CT), shared knowledge of internal capabilities (IT), shared knowledge of suppliers (ST), and shared knowledge of process (TP). The result of corresponding reliability, item purification, and independent factor analysis is presented in Table 5.10.

For CT, Cronbach's alpha was reported to be .827 with CITC value for CT3 to be .459. If CT3 was to be dropped, the new Cronbach's alpha was reported to be .876, which is a considerable improvement. In addition, CT3 was reported to have lowest factor loading of .634.

For IT, Cronbach's alpha was reported to be .71. All the items had low CITC, with IT4 being the lowest at .414. The factor loading of IT4 was also the lowest compared to all the other three items for IT at .639.

Table 5.10 Reliability, Item Purification, and Factor Validity

Shared Knowledge of Customer			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
CT3	0.459	0.876	0.634
CT1	0.688	0.769	0.852
CT2	0.746	0.738	0.884
CT4	0.758	0.734	0.891
Cronbach's Alpha: .827 **Extracted Method: Principal Component Analysis** **Kaiser-Meyer-Olkin Measure of Sample Adequacy: .789**			
Shared Knowledge of Internal Capabilities			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
IT4	0.414	0.697	0.639
IT3	0.485	0.655	0.738
IT1	0.521	0.634	0.746
IT2	0.581	0.6	0.807
Cronbach's Alpha: .710 **Extracted Method: Principal Component Analysis**			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .693			

Shared Knowledge of Suppliers			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
ST2	0.628	0.928	0.724
ST3	0.731	0.915	0.811
ST4	0.793	0.906	0.865
ST5	0.837	0.9	0.896
ST6	0.841	0.9	0.897
ST1	0.844	0.9	0.901
Cronbach's Alpha: .923			
Extracted Method: Principal Component Analysis			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .903			

Shared Knowledge of Process			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
TP6	0.537	0.892	0.648
TP1	0.593	0.887	0.684
TP7	0.595	0.886	0.689
TP4	0.682	0.879	0.753
TP3	0.691	0.879	0.754
TP2	0.693	0.879	0.774
TP5	0.679	0.88	0.776
TP8	0.707	0.877	0.793
Cronbach's Alpha: .893			
Extracted Method: Principal Component Analysis			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .886			

Similarly, for ST, the Cronbach's alpha was reported to be .923. Based on the high CITC and factor loading, all the items are retained.

For TP, the Cronbach's alpha was reported to be .893 with TP1 reported to be the lowest CITC value of .593 and the lowest factor loading among all the items at .684.

Next, all the items for shared knowledge were subjected to factor analysis. The respondents to items ratio was 7.7, which was adequate to perform the factor analysis as per the general guideline. Multiple items had cross loading and after dropping such items, the final result of the factor analysis is presented in Table 5.11.

Table 5.11 Factor Analysis for all Constructs of Shared Knowledge

Final Result
Pattern Matrix

Items	Factor 1	Factor 2	Factor 3	Factor 4
CT4			0.866	
CT2			0.885	
CT1			0.902	
IT2				0.751
IT3				0.87
ST3		-0.725		
ST6		-0.856		
ST5		-0.871		
ST1		-0.926		
ST4		-0.934		
TP1	0.628			
TP4	0.664			
TP8	0.762			
TP3	0.809			
TP2	0.882			
IT1	0.62			
Eigen Value	0.6685	2.941	1.528	1.132
% of Variance	39.321	17.299	8.991	6.658
Cumulative %	39.321	56.62	65.611	72.269

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .887
Extraction Method: Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalization

In the final analysis, IT1 still ended up loading with TP. However, because IT had only three items left, IT1 was decided to be included in CFA.

5.3.6 New Product Performance Outcomes (NPPO)

NPPO was conceptualized to have two variables product outcomes and process outcomes with altogether seven variables between the two. However, considering problems with third order constructs and as recommended in the pilot study for the sake of simplicity of running CFA, NPPO was re-conceptualize of having seven constructs: engineering change time (EC), product cost reduction (PC), manufacturing cost reduction (MC), team work (TW), team productivity (TPO), product development time (PTO), and customer satisfaction (CS).

The initial results of the data analysis are presented in Table 5.12.

Table 5.12 Reliability, Item Purification, and Factor Validity

Engineering Change Time			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
EC2	0.845	0.901	0.931
EC4	0.849	0.898	0.933
EC3	0.863	0.887	0.94
Cronbach's Alpha: .928 **Extracted Method: Principal Component Analysis** **Kaiser-Meyer-Olkin Measure of Sample Adequacy: .765**			
Team Work			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
TW2	0.598	0.804	0.811
TW4	0.651	0.753	0.849
TW5	0.74	0.66	0.897
Cronbach's Alpha: .811 **Extracted Method: Principal Component Analysis** **Kaiser-Meyer-Olkin Measure of Sample Adequacy: .682**			
Team Productivity			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
TPO3	0.516	0.751	0.774
TPO2	0.573	0.712	0.814
TPO1	0.703	0.553	0.887
Cronbach's Alpha: .757			
Extracted Method: Principal Component Analysis **Kaiser-Meyer-Olkin Measure of Sample Adequacy: .646**			

Product Cost			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
PC4	0.6	0.794	0.772
PC1	0.621	0.784	0.789
PC3	0.665	0.764	0.825
PC2	0.687	0.753	0.839
Cronbach's Alpha: .821			
Extracted Method: Principal Component Analysis			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .757			

Manufacturing Cost			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
MC4	0.577	0.87	0.712
MC2	0.65	0.854	0.775
MC1	0.739	0.832	0.846
MC3	0.748	0.83	0.852
MC5	0.768	0.825	0.865
Cronbach's Alpha: .871			
Extracted Method: Principal Component Analysis			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .817			
Product Development Time			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
PTO3	0.725	0.934	0.817
PTO2	0.812	0.918	0.881
PTO1	0.843	0.912	0.904
PTO5	0.851	0.911	0.91
PTO4	0.872	0.907	0.923
Cronbach's Alpha: .932			
Extracted Method: Principal Component Analysis			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .85			
Customer Satisfaction			
Items	**CITC**	**Alpha if Items Deleted**	**Factor Loading**
CS4	0.655	0.893	0.752
CS1	0.677	0.888	0.785
CS2	0.721	0.882	0.819
CS3	0.735	0.88	0.821
CS6	0.757	0.876	0.834
CS5	0.829	0.865	0.892
Cronbach's Alpha: .899			
Extracted Method: Principal Component Analysis			
Kaiser-Meyer-Olkin Measure of Sample Adequacy: .854			

All the variables had high Cronbach's alpha, above .8 except for TPO that reported to be .757. Also, all the items had high factor loading and CITC was also reported to be high for each item within each variable. MC4, however reported to have lowest CITC value of .57. If MC4 was to be dropped, there was no significant improvement in the Cronbach's alpha for MC.

Next, all the items for NPPO were subjected for factor analysis. The respondents to the items ratio were 5.86, which is within the range of advisable value. The final factor analysis results from the seven separate factors for NPPO resulted in Table 5.13.

Table 5.13 Factor Analysis for all Constructs of New Product Performance Outcomes

Final Result
Pattern Matrix

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
EC2	0.921				
EC3	0.885				
EC4	0.888				
TW2					0.491
TW4	0.818				
TW5	0.669				0.315
TPO1					0.648
TPO2	0.545			-0.373	
TPO3					0.582
PC1			-0.669		
PC4			-0.735		
MC1			-0.741		
PC3			-0.781		
MC2			-0.783		
MC5			-0.798		
MC3			-0.844		
PC2			-0.85		
PTO3				-0.739	
PTO5				-0.769	
PTO4				-0.839	
PTO1				-0.919	
PTO2				-0.926	
CS1		0.687			
CS4		0.701			
CS2		0.739			
CS6		0.798			
CS5		0.869			
CS3		0.876			
Eigen Value	11.347	3.403	2.893	1.628	1.094
% of Variance	40.523	12.153	10.333	5.814	3.909
Cumulative %	40.523	52.676	63.009	68.823	72.732

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .908

Extraction Method: Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalization

Instead of seven separate factors, only five factors were extracted. In the final analysis, PC and MC again loaded on single factor (factor 3). Final cost of a product is a factor dependent on various cost elements, for example, material, labor, expenditures, tooling, machinery and equipment (M&E), investment etc of which manufacturing cost is only one element, which generally becomes a subject of study for design-for-manufacturing. From product development and manufacturing (or production) stand point of view, the cost of product may include upfront cost (design cost, tooling design and fabrication cost), production setup cost, and production cost (component production cost, assembly cost, quality cost etc.) (http://www.octs.com/inventhelp/mfrcost.html). However, since this study focuses on a more generic cost objectives of product development team from strategic focus on product cost reduction, product cost and manufacturing cost could be treated as a single factor for performance objectives, which is also evident from the data from both pilot study as well as the large scale.

Thus, factor 1 represented EC, factor 3 represented PC (PC and MC consolidated in one factor), factor 4 represented PTO, and factor 2 represented CS.

Items for TW and TPO did not result into a simple stable factor. Based upon the items wording and practical significance, it was decided to consolidate TPO and TW into a single factor that can be interpreted as team performance (PERF) with items TW2, TPO1, and TPO3. TW5, although loaded on factor 5, the loading was low (.315) and had a very high cross loading with factor 1 (.669). It was thus decided to exclude TW5 from factor 5.

5.3.7 Conclusion

Based upon the above exploratory results, it was decided from the subsequent data analysis to:

1. drop SF2 and PTT2 from Team Vision construct
2. retain all the items for Mutual Trust construct
3. drop MI1 from Mutual Influence construct
4. drop CT3, IT4, ST2, TP5, TP6, TP7 from Shared Knowledge construct
5. drop MC4, consolidate MC and PC items in single factor PC; drop TPO3, TW4, and TW5 ; consolidate TW and TPO items in a single factor PERF for New Product Performance Outcomes construct.

Deletion of items PTT2, MI1, and ST2 was also recommended during the pilot study. In addition, pilot study had also recommended consolidating PC and MC in one single factor.

For subsequent data analysis, the final list of items to be used is presented in table 5.14.

Table 5.14: Recommended Measures for Large Scale Study

Constructs	Variables (Factors)	Items	Description
Team Vision (TV)			
	Mission (TM)	TM1	The project purpose was well understood by the entire team
		TM2	The project mission was well communicated to all team members
		TM3	The project mission was well defined for all team members
		TM4	The product development team has a well defined mission
		TM5	The project mission was well understood by the entire team
	Strategic Fit (SF)	SF1	Our firm's overall technology strategy guided a setting of the project targets
		SF3	Project targets reflected the competitive situation
		SF4	Our firms overall product strategy guided a setting of project targets
	Project Targets (PTT)	PTT1	The project targets clearly specified tradeoffs between performance and cost
		PTT3	The project targets clearly specified tradeoffs between time and cost
		PTT4	Project targets clearly specified tradeoffs between quality and cost

Mutual Trust (MT)	TR1	There was mutual trust among team members
	TR2	The team members trusted each other enough to share all relevant information
	TR3	The team members were willing to share sensitive information
	TR4	Team members trusted each other
	TR5	The team members shared the belief that all members were acting in good faith
	TR6	The team shared a belief that all members were honest
	TR7	The team members were confident they could trust each other
	TR8	Team members relied on each other for the truthfulness of the information shared
	TR9	The team members trusted each other to share accurate information
	TR11	Team members trusted each other enough to share sensitive information
Mutual Influence (MI)	MI2	Everyone on the team had some power to influence others
	MI3	Power was broadly shared among team members
	MI4	Each team member had some ability to affect the decisions of others
	MI5	Each team member had at least some control over the decisions of the team
	MI6	Each team member had some power to affect team decisions
	MI7	Influence was shared among team members
	MI8	All team members had at least some ability to persuade each other
	MI9	All team members had some authority to influence team decisions
Shared Knowledge of (SK)		
Customer (CT)	CT1	customer requirements
	CT2	what our customers wanted
	CT4	current customer needs
Internal Capabilities (IT)	IT1	the capabilities of the process technologies we used
	IT2	the strengths of our engineering design capabilities
	IT3	the strength of our engineering staff
Suppliers (ST)	ST1	our suppliers' process capabilities
	ST3	our suppliers' manufacturing facilities
	ST4	our suppliers' capabilities to meet cost requirements
	ST5	our suppliers' capabilities to meet time requirements
	ST6	our suppliers' capabilities to meet quality requirements
Process (TP)	TP4	the process of product development
	TP8	key decision points in the product development process
	TP1	the steps in the product development process
	TP2	The points in the product development process where information needed to be exchanged
	TP3	where key deliverables in the product development process were essential to subsequent activities

New Product Development Performance Outcomes (NPPO)		
Engineering Change Time (EC)	EC2	finished engineering change orders on time
	EC3	delivered engineering change notices on time
	EC4	met engineering change deadline regularly
Team Performance (PERF)	TW2	communicated effectively
	TPO1	was productive
	TPO2	completed work quickly
Product Cost (PC)	PC1	simplified the design successfully
	PC2	reduced product costs successfully
	PC3	reduced material costs successfully
	PC4	reduced the number of parts successfully
	MC1	successfully reduced assembly cost
	MC2	reduced equipment cost successfully
	MC3	reduced manufacturing cost successfully
	MC5	reduced the number of manufacturing steps effectively
Product Development Time (PTO)	PTO1	launched product to the market faster
	PTO2	enabled our company to start volume production faster
	PTO3	brought product to the market before our competitors
	PTO4	developed product from concept to commercial production faster
	PTO5	made better progress in reducing total product development time
Customer Satisfaction (CS)	CS1	satisfied customers better
	CS2	fit target customers better
	CS3	has more loyal customers
	CS4	generated more new customers
	CS5	was more highly valued by customers
	CS6	was more successful in the marketplace

5.4 DISCRIMINANT VALIDITY

Discriminant validity is demonstrated when a measure does not correlate very highly with another measure from which it should differ (Venkatraman, 1989). In the context of this study, it refers to the degree to which measures of different factors of knowledge integration model are unique from each other. This is achieved when measures of each dimension converge on their corresponding true scores and can be tested that the correlation between the pairs of dimensions are significantly different from unity. This requires a comparison of a model with this correlation constrained to equal one with the unconstrained model. A significantly lower chi-square value for the model with the unconstrained correlation, when compared with the constrained model, provides support for discriminant validity (Venkatraman, 1989). A chi-square difference value with an associated p-value less than 0.05 (Joreskog, 1971) supports the discriminant validity criterion.

Only those constructs and variables of knowledge integration that seemed similar theoretically with only items from recommended from the exploratory data analysis were subjected for the test of discriminant validity using AMOS 5.0 and MS Excel function of chidist( ).

Figure 5.1 represents the constrained and unconstrained models for TM and SF. Similar models were tested for the other pairs for discriminant validity.

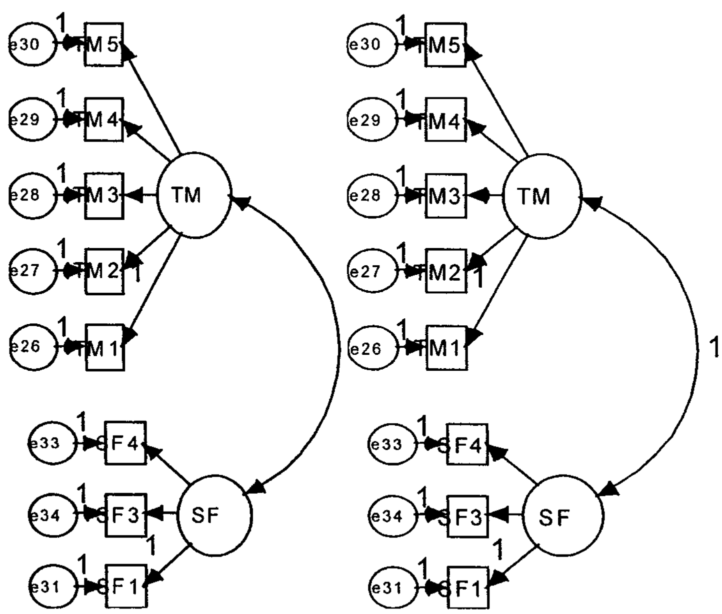

Figure 5.1 Unconstrained and Constrained models for TM and SF in AMOS for Discriminant Validity

Table 5.15 reports the pairwise tests of some of the factors conducted for discriminant validity.

Table 5.15 Pairwise Test for Discriminant Validity

Assessment Items	df-Unconstrained	df-Constrained	Chi Square Unconstrained	Chi Square Constrained	p-Computed
TM and SF	19	20	50.71	107.256	5.49E-14
TM and PTT	19	20	28.337	90.085	3.83E-15
SF and PTT	8	9	13.246	42.552	6.18E-08
MT and MI	64	65	88.54	267.386	8.66E-41
SK of IT and SK of TP	19	20	53.252	101.959	2.97E-12

With p-value reported to be less than 0.01 for all the pairwise tests, all the tests indicated strong support for the discriminant validity criterion, i.e. the factors should be considered distinct for the knowledge integration model.

5.5 EXPLORATORY STRUCTURE ANALYSIS

To explore the relationship of team vision, mutual trust, and mutual influence on shared knowledge and the effect of shared knowledge on new product performance outcomes, structural equations modeling (SEM) methodology was used. This not only allows the assessment of construct validity of the constructs, but also gives an initial sensation of testing substantive hypotheses. In general, SEM model can be decomposed into two sub models: a measurement model, and a structural model. The measurement model defines relations between the observed indicator variables and the underlying constructs they are designed to measure (i.e. unobserved latent variables). The measurement model, then, represents the CFA model (Byrne, 2001). In contrast, structural model defines the relations among the unobserved variables. Although a two-step process was followed, first the measurement model and then structural, results should be interpreted with caution since the same large-scale data was used for both the measurement model and the structural model.

However, since the nature of this study is exploratory, the remaining data analysis should still be considered exploratory even though SEM methodology has been employed.

To be congruent with the hypothesized model of knowledge integration in Chapter 3, team vision (TV) was treated as exogenous variable. Also, since it was hypothesized that mutual trust (MT) and mutual influence (MI) are also positive driver of shared knowledge, both these constructs were also to be considered as exogenous variables. Shared knowledge (SK) and new product performance outcomes (NPPO) were treated as endogenous variables. The term exogenous variables and endogenous variables within SEM terminology are synonymous with independent and dependent variables respectively. These terms are introduced here and will be used in the rest of the chapter where necessary.

5.5.1 Confirmatory Factor Analysis (CFA)

Within SEM methodology, CFA tests the validity of factors that are empirically and theoretically derived by the researchers. In order to assess CFA, factors need to be already empirically established through other methods (Byrne, 2001).

The factors proposed in the pilot and exploratory factor analysis of the large-scale data analysis for the knowledge integration model was subjected to the CFA with AMOS 5.0 Graphics. During the earlier data analysis, these factors were obtained from the data analysis with SPSS. This outcome was considered exploratory factor analysis because SPSS by nature suggests the best possible factors within the criteria (fixed number of factors or factors with Eigen value of one or more) stipulated by the researcher. SEM procedure (for which AMOS 5 is used here) tests constructs (factors) that are suggested by researchers, and gives output with indicators signifying their suitability (or otherwise) as the constructs.

For each measurement models (first order and second order) tested, statistical significance of parameter estimates (unstandardized regression weights and standardized regression weights) and the goodness-of-fit statistics were reported.

Within AMOS methodology, the test statistic is the critical ratio (C.R.), which represents the parameter estimate, divided by the standard error (S.E.); as such, it operates as a z-statistics in testing that the estimate is statistically different from zero. Based on a level of 0.05, the test statistic needs to be >+_ 1.96 before the hypothesis (that the estimate equals 0) can be rejected (Byrne, 2001).

There are many indices in the CFA that researchers may consider. CMIN (minimum discrepancy) represents the discrepancy between the unrestricted sample covariance matrix and the restricted covariance matrix and, in essence, represents the likelihood ratio test statistics, commonly expressed as chi-square. CMIN/df ratio takes into account of degrees of freedom.

The CFI (comparative fit index) is one of the incremental fit measures in SEM. It is an adaptation and improvement of the NFI (normed fit index). NFI compares the researcher's model (default model) with the null model. The null model assumes that all the indicators considered in the default model fit perfectly to a single construct. CFI is an improvement over NFI because it takes into account the sample size. Therefore, it is useful even for the smaller sample size and also in model development. This is also considered a more robust indicator where the multivariate normality is in doubt. It is recommended that CFI be the index of choice (Byrne, 2001). Another incremental index, consistent with the NFI and CFI in reflecting of indication of good fit is the TLI (Tucker-Lewis index). The RMSEA (root mean square error of approximation) is the average of discrepancy between the estimated value and observed value of the covariance. It has been recognized as one of the most informative criteria in covariance structure modeling (Byrne, 2001).

The recommended value of these fit indices is summarized in Table 5.16.

Table 5.16 Recommended Values for Model-fit

CMIN/DF	Chi-Square/df (Wheaton et al., 1977), good fit if CMIN/df < 2.00
TLI	Value range from 0 to 1, closer to 0.95 good fit (Hu and Bentler, 1992)
CFI	Value range from 0 to 1, >0.9 well-fitting model (Bentler, 1992)
RMSEA	<0.05 good fit (Browne and Cudeck, 1993), 0.05 to 0.08 reasonable (Browne and Cudeck, 1993), .08 to .1 mediocre (MacCallum et al., 1996), >.1 poor fit (MacCallum et al., 1996); 0.06 good fit (Hu and Bentler, 1999)

5.5.1.1 Team Vision (TV)

TV was conceptualized to consist of mission (TM), strategic fit (SF) and project targets (PTT) factors and is the exogenous variable in hypothesized knowledge integration model. After the pilot study, and the large-scale exploratory study, TM was recommended to have 5 indicators, where as SF and PTT had three indicators each.

A first order CFA was conducted on the five indicators of TM. Standardized regression weights for all the five indicators for TM were reported be above.78, and were significant at 0.01. CFI for the model was reported to be .987. Overall, the CFA result for the first order model for TM with all the retained 5 indicators was either very good, or above satisfactory level and hence it was decided to retain all the five indicators.

Next, a first order measurement model was tested for all the items for TM, SF, and PTT with the CFA procedure suggested by Byrne (2001). The first-order model for TV is shown in Figure 5.2.

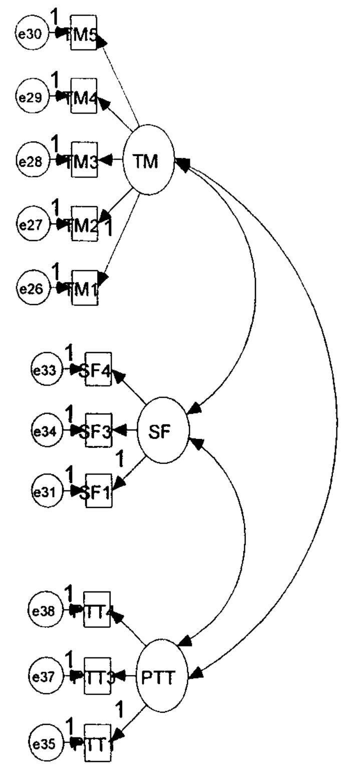

Figure 5.2: First order measurement model of TV

The output of the first order model for TV is presented in Table 5.17. Each of the items loaded significantly on their respective factors. This table reports the results of estimates for both unstandardized regression weights and covariances. The first column of the table represents the relationships between the item and the respective factor, the second column represents the estimate values or the unstandardized regression weight, the third column represents the critical ratio (interpreted as z-scores), the fourth column represents standard error or S.E. , the fifth column represents the standardized regression weight and the last column represents the significance at p = 0.001 level. All significant relations are represented by "***".

Table 5.17 Final AMOS Output for First Order Model Team Vision (TV): Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weights	p
TM1 <-- TM	1			**0.864**	
TM2 <-- TM	1.085	0.084	12.841	**0.791**	***
TM3 <-- TM	1.142	0.07	16.274	**0.903**	***
TM4 <-- TM	1.131	0.075	15.043	**0.866**	***
TM5 <-- TM	1.009	0.069	14.543	**0.85**	***
SF1 <-- SF	1			**0.891**	
SF3 <-- SF	0.327	0.07	4.657	**0.381**	***
SF4 <-- SF	0.868	0.099	80774	**0.814**	***
PTT1 <--PTT	1			**0.833**	
PTT3 <--PTT	1.012	0.089	11.321	**0.831**	***
PTT4 <--PTT	0.916	0.084	10.493	**0.797**	***
Covariances					
TM <--> SF	0.247	0.054	4.546		***
TM <--> PTT	0.214	0.051	4.191		***
SF <--> PTT	0.365	0.079	4.624		***

The goodness-for-fit value for the first order model, as presented in Table 5.18, demonstrated the overall fit for the model as acceptable.

Table 5.18 Goodness-for-Fit Model Summary for First Order Model of Team Vision

CMIN/DF	1.742
TLI	0.964
CFI	0.973
RMSEA	0.066

TV was conceptualized to consist of TM, SF and PTT. Figure 5.3 represents the second order measurement model for TV.

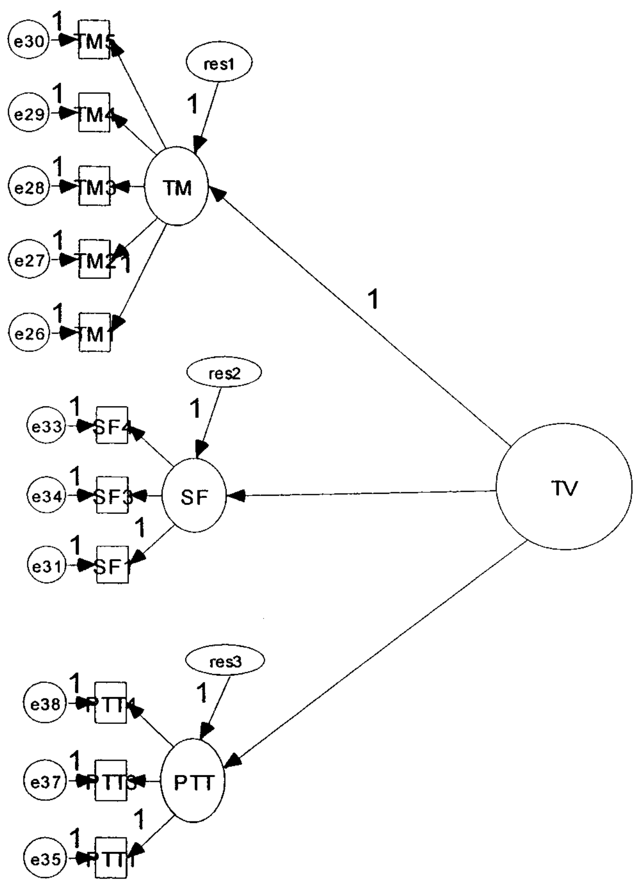

Figure 5.3 Second order measurement model for TV

The fit estimates, as reported in Table 5.19, shows all items strongly loaded in their respective factors.

Table 5.19 AMOS Output for the Second Order Model Team Vision (TV): Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
TM <-- TV	1			**0.607**	
SF <-- TV	1.707	0.399	4.275	**0.715**	***
PTT <-- TV	1.475	0.34	4.336	**0.652**	***

The standardized regression weight for TM and TV was .607, SF and TV was .715, and PTT and TV was .652. All three factors of TV were highly correlated to each other demonstrating they belong together. The goodness-for-fit values for the second order model for TV, as presented in Table 5.20, showed the overall fit for model to be acceptable.

Table 5.20 Goodness-for-Fit Model Summary for Second Order Model of Team Vision

CMIN/DF	1.742
TLI	0.964
CFI	0.973
RMSEA	0.066

5.5.1.2 Mutual Trust (MT)

MT was conceptualized to contain single factor and accordingly, CFA was conducted with all the 10 indicators of MT, as shown in Figure 5.4.

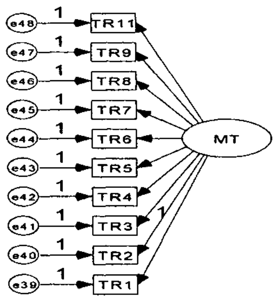

Figure 5.4 First order measurement model of MT

The modification index suggested some correlation error associated with TR3, TR5, and TR 11. With all the 10 items of MT, the RMSEA value for the default model was reported to be 0.118. Elimination of TR3, and TR5, and TR 11 led to improvement of the RMSEA value to 0.086, 0.054, and 0.024 respectively. Since, there was a significant improvement in the RMSEA value for MT, it was thus decided to drop TR3, TR5, and TR11 from subsequent analysis.

The output of revised first order measurement model for MT is presented in Table 5.21, which shows high loading of the indicators on the construct.

Table 5.21 Final AMOS Output for First Order Mutual Trust (MT): Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weights	p
TR1 <-- TR	1			.84	
TR2 <-- TR	1.039	0.073	14.315	.857	***
TR4 <-- TR	1.244	0.074	16.811	.937	***
TR6 <-- TR	1.088	0.077	14.197	.853	***
TR7 <-- TR	1.141	0.075	15.275	.89	***
TR8 <-- TR	0.661	0.062	10.624	.706	***
TR9 <-- TR	0.921	0.071	13.055	.811	***

The standardized regression weight of TR1, TR2, TR4, TR6, TR7, TR8, and TR9 was .84, .857, .937, .853, .89, .706, and .811. From Table 5.22, the goodness-for-fit value for the model indicated that the date fit for the model was acceptable.

Table 5.22 Goodness-for-Fit Model Summary for First Order Model of Mutual Trust

CMIN/DF	1.097
TLI	0.998
CFI	0.999
RMSEA	0.024

5.5.1.3 Mutual Influence (MI)

From the exploratory data analysis of the large-scale study, it was concluded that MI1 be dropped from the MI factor. The result of parameter estimates of the first order measurement model for MI, as presented in Table 5.23, demonstrated a strong items loading of the indicators on MI. During the CFA, MI2 and MI7 were dropped because of correlation in the respective error terms and improvement in the RMSEA values. The standardized regression weight for MI3, MI4, MI5, MI6, MI8, and MI9 was .743, .815, .816, .844, .835, and .848.

Table 5.23 Final AMOS Output for First Order Mutual Influence (MI): Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
MI3 <-- MI	1			.743	
MI4 <-- MI	0.96	0.089	10.784	.815	***
MI5 <-- MI	0.969	0.09	10.798	.816	***
MI6 <-- MI	0.959	0.086	11.204	.844	***
MI8 <-- MI	0.901	0.081	11.067	.835	***
MI9 <-- MI	1.038	0.092	11.254	.848	***

As shown in Table 5.24, the goodness-for-fit values concluded the overall model-data fit for the MI.

Table 5.24 Goodness-for-Fit Model Summary for First Order Model of Mutual Influence

CMIN/DF	1.797
TLI	0.983
CFI	0.99
RMSEA	0.069

5.5.1.4 Shared Knowledge (SK)

SK had four factors: shared knowledge of customer (CT), internal capabilities (IT), suppliers (ST), and process (TP). From the conclusion of the large-scale exploratory data analysis, CT3, IT4, ST2, TP5, TP6, and TP7 were dropped from the CFA.

Since TP had more than 3 items, CFA was conducted for the TP. The result from the parameter estimate is presented in Table 5.25.

Table 5.25 Final AMOS Output for First Order Shared Knowledge of Process: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
TP1 <-- TP	1			**0.593**	
TP2 <-- TP	1.165	0.154	7.567	**0.791**	***
TP3 <-- TP	1.044	0.147	7.093	**0.712**	***
TP5 <-- TP	1.169	0.159	7.346	**0.752**	***
TP8 <-- TP	1.302	0.169	7.717	**0.821**	***

The standardized regression weight for TP1, TP2, TP3, TP5, and TP8 were .593, .791, .712, .752, and .821 respectively. The goodness-for-fit values (Table 5.26) for TP were considered good.

Table 5.26 Goodness-for-Fit Model Summary for First Order Model of Shared Knowledge of Process

CMIN/DF	1.005
TLI	1
CFI	1
RMSEA	0.006

Similarly, a first order CFA was conducted for ST that had more than 3 indicators. The standardized regression weight for ST1, ST3, ST5, and ST6 were reported to be .868, .729, .907, and .893. The goodness-for-fit values for ST were also acceptable. The result of parameter estimates and goodness-for-fit value is presented in Table 5.27 and Table 5.28 respectively.

Table 5.27 Final AMOS Output for First Order Shared Knowledge of Suppliers: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
ST1 <-- ST	1			**0.868**	
ST3 <-- ST	0.836	0.075	11.224	**0.729**	***
ST5 <-- ST	1.106	0.069	16.111	**0.907**	***
ST6 <-- ST	1.057	0.067	15.718	**0.893**	***

Table 5.28 Goodness-for-Fit Model Summary for First Order Model of Shared Knowledge of Suppliers

CMIN/DF	1.361
TLI	0.995
CFI	0.998
RMSEA	0.046

Next, as shown in Figure 5.5, all the factors of SK were analyzed in the first order CFA.

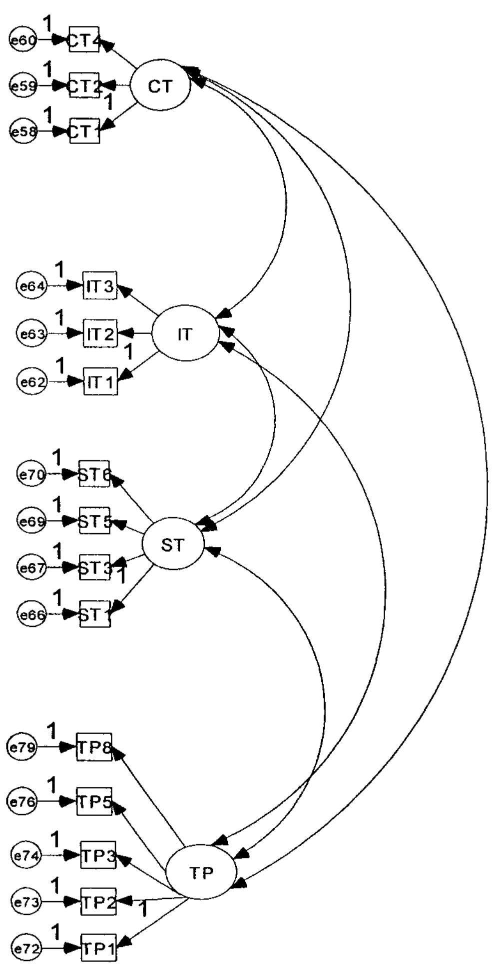

Figure 5.5 First order measurement model of SK

Parameter estimates for the first order model for SK, as presented in Table 5.29, indicated a strong loading of the indicators on their respective factors.

Table 5.29 Final AMOS Output for First Order Model Shared Knowledge: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
TP1 <-- TP	1			**0.606**	
TP2 <-- TP	1.106	0.143	7.737	**0.767**	***
TP3 <-- TP	1.043	0.14	7.465	**0.728**	***
TP5 <-- TP	1.13	0.149	7.572	**0.743**	***
TP8 <-- TP	1.287	0.159	8.118	**0.83**	***
ST1 <-- ST	1			**0.866**	
ST3 <-- ST	0.84	0.075	11.281	**0.731**	***
ST5 <-- ST	1.105	0.069	16.1	**0.905**	***
ST6 <-- ST	1.062	0.067	15.826	**0.895**	
IT1 <-- IT	1			**0.743**	***
IT2 <-- IT	0.705	0.098	7.194	**0.62**	***
IT3 <-- IT	0.667	0.099	6.715	**0.577**	***
CT1 <-- CT	1			**0.807**	
CT2 <-- CT	1.15	0.098	11.721	**0.845**	***
CT4 <-- CT	1.142	0.096	11.876	**0.862**	***
Covariances					
IT <--> CT	0.117	0.037	3.149		0.002
ST <--> CT	0.039	0.042	0.927		0.354
TP <--> CT	0.14	0.033	4.27		***
ST <--> IT	0.391	0.07	5.632		***
TP <--> IT	0.283	0.053	5.338		***
TP <--> ST	0.219	0.052	4.233		***

The covariance between IT and CT was reported to be 0.002 and can be considered to be statistically significant at p = 0.01 level. However, the covariance between ST and CT (0.354) was not significant. The standardized regression weight for this first order model is presented in Table 5.29, which are all highs.

The goodness-for-fit values for the first order measurement model are presented in Table 5.30 demonstrating an overall acceptable model.

Table 5.30 Goodness-for-Fit Model Summary for First Order Model of Shared Knowledge

CMIN/DF	1.653
TLI	0.95
CFI	0.96
RMSEA	0.062

Since, SK was conceptualized based, upon the previous studies, to compromise of shared knowledge of customers, suppliers, process and internal capabilities, a second order CFA was tested for Figure 5. 6 next.

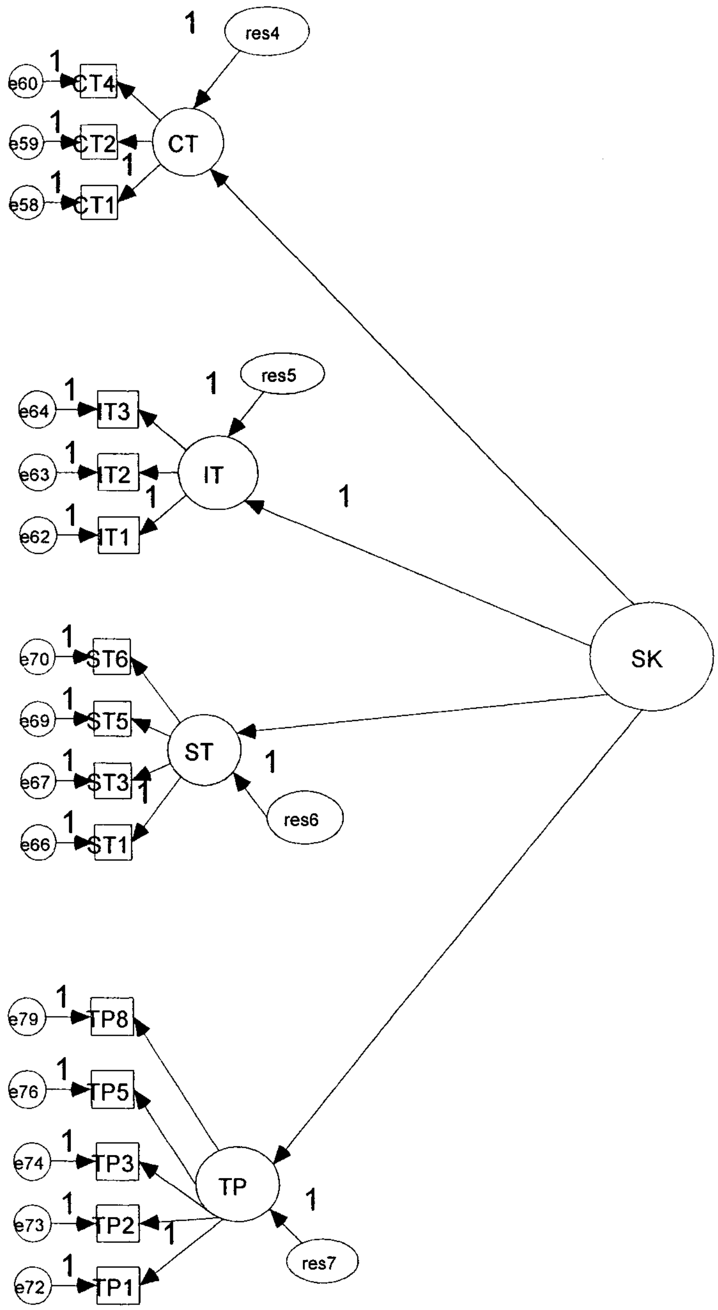

Figure: 5.6: Second order Measurement Model of SK

Table 5.31 summarizes the result of the parameter estimates for the second order model of SK.

Table 5.31 AMOS Output for Second Order Model Shared Knowledge: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
CT <--SK	0.31	0.08	3.891	**.374**	***
IT <-- SK	1			**1.108**	
ST <-- SK	0.83	0.139	5.986	**.697**	***
TP <-- SK	0.66	0.117	5.641	**.704**	***

The standardized regression weight for CT and SK was .374, IT and SK was 1.108, ST and SK was .697, and TP and SK was .704 which were all high.

Prior research has shown that the understanding user needs and incorporating them into new product design is a key determinant of development success.

Kahn and Pinegar (1999) classified customers role in application development and technology development into four categories; coaching (technology forecasting, identification of problems and opportunities, concept generation and definition), partnering (co-development, resource sharing, exploring), advising (product councils, focus group, beta testing), and reporting (testing, customer research, market sensing).

The data in this research points out that shared knowledge of customer has very low standardized regression estimate of 0.374. There could be two possible explanations for this.

First, this research did not differentiate between the radical or truly innovative product and the incremental or not –so innovative product. In their analysis, Song and Montoya-Weiss (1998) revealed that business and market opportunity analyses, while related to success incremental innovations, were not helpful to firms developing really new product given how user needs are often ill defined. Veryzer (1998) noted that in the early phase of development, radical innovation tend to use a qualitative research techniques that allow organization to explore and gain a deeper understandings of the users whereas formal, quantitative techniques such as focus groups and market studies used in incremental product developments. His case analyses revealed that new product ideas did not come from customers. Lynn et al. (1996) found that, only was the information generated from conventional market research techniques not useful in radical innovation project, it was often misleading. Therefore, probably the shared knowledge of customer in NPD is dependent upon the nature product innovation types, which may determine to what extent customers should be involved in the development process.

Another possible explanation could be found in the timing of customers in the product development. Von Hippel (1986) defines 'lead users; as those that have needs well in advance of the general marketplace. Lead user analysis, although a complex process, however, involves accurate information on market trend, identification of the users, generation of product concept, testing etc. (Urban and von Hippel, 1988). The implication is that in such scenario, shared knowledge of customer begins from the beginning of product development process, i.e. customer involvement is high in the process. Whereas in other cases, customers maybe involved in beta testing or product testing phase only. In such cases where customers are involved occasionally, customer knowledge is not continuous process but a one point input as feedback in the development process. Probably this could have been the reason why the respondents of this survey did not find shared knowledge of customer as valuable as shared knowledge suppliers, internal capabilities, and process.

All the factors were significantly correlated with one another. Table 5.32 concluded that the model fit indices for the second order model was acceptable.

Table 5.32 Goodness-for-Fit Model Summary for Second Order Model of Shared Knowledge

CMIN/DF	1.816
TLI	0.938
CFI	0.949
RMSEA	0.069

5.5.1.5 New Product Performance Outcomes (NPPO)

NPPO was re-conceptualize to consist of 5 factors: engineering change time (EC), team performance (PERF), product cost (PC), product development time (PTO), and customer satisfaction (CS).

As recommended in the large-scale exploratory data analysis, it was decided to drop MC4, TPO3, TW4, and TW5 from the CFA.

A first order CFA for PC resulted in the standardized regression weight for PC1, PC3, PC4, MC1, MC3, and MC5 to be .707, .668, .749, .854, .81, and .846. The parameter estimates and the goodness-for-fit for PC are presented in Table 5.33 and Table 5.34. The result for CMIN/df is although greater than 2, but it is still in the range of 5 and thus considered to be an average fit. Similarly, the RMSEA value reported was also above 0.05 and can be considered as mediocre fit (MacCallum et al., 1996).

Table 5.33 Final AMOS Output for First Order Product Cost: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
PC1 <-- PC	1			**0.707**	
PC3 <-- PC	0.945	0.115	8.208	**0.668**	***
PC4 <-- PC	1.073	0.117	9.177	**0.749**	***
MC1 <-- PC	1.3	0.125	10.387	**0.854**	***
MC3 <-- PC	1.227	0.124	9.893	**0.81**	***
MC5 <-- PC	1.239	0.12	10.295	**0.846**	***

Table 5.34 Goodness-for-Fit Model Summary for First Order Model of Product Cost

CMIN/DF	2.597
TLI	0.958
CFI	0.975
RMSEA	0.097

The standardized regression weight for CS2, CS3, CS4, CS5, and CS6 were reported at .708, .81, .697, .902, and .814. The computed parameter estimates and goodness-for-fit for CS is presented in Table 5.35 and Table 5.36.

Table 5.35 Final AMOS Output for First Order Customer Satisfaction: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
CS2 <-- CS	1			**0.708**	
CS3 <-- CS	1.387	0.14	9.895	**0.81**	***
CS4 <-- CS	1.187	0.139	8.564	**0.697**	***
CS5 <-- CS	1.404	0.13	10.836	**0.902**	***
CS6 <-- CS	1.353	0.136	9.948	**0.814**	***

Table 5.36 Goodness-for-Fit Model Summary for First Order Model of Customer Satisfaction

CMIN/DF	2.464
TLI	0.969
CFI	0.984
RMSEA	0.093

Based upon MacCallum et al. (1996)'s suggestion, the RMSEA value of 0.093 for CS was considered to be mediocre.

The standardized regression weight for PTO1, PTO3, PTO4, and PTO5 were reported to be .832, .765, .95, and .983. The parameter estimates and the goodness-for-fit values from the CFA of PTO are presented in Table 5.37 and Table 5.38.

Table 5.37 Final AMOS Output for First Order Product Development Time: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
PTO1 <-- PTO	1			**0.832**	
PTO3 <-- PTO	0.872	0.075	11.676	**0.765**	***
PTO4 <-- PTO	1.094	0.068	16.196	**0.95**	***
PTO5 <-- PTO	1.053	0.071	14.893	**0.983**	***

Table 5.38 Goodness-for-Fit Model Summary for First Order Model of Product Development Time

CMIN/DF	0.362
TLI	1.007
CFI	1
RMSEA	0

Next, CFA for first order model for NPPO was conducted. The parameter estimates for the first order model is presented in Table 5.39.

Table 5.39 Final AMOS Output for First Order Model New Product Performance Outcomes: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
EC2 <-- EC	1			**0.882**	
EC3 <-- EC	1.064	0.062	17.169	**0.913**	***
EC4 <-- EC	1.035	0.061	16.911	**0.905**	***
PTO1 <-- PTO	1			**0.832**	
PTO3 <-- PTO	0.884	0.075	11.726	**0.775**	***
PTO4 <-- PTO	1.087	0.074	14.716	**0.944**	***
TW2 <-- PERF	1			**0.781**	
TPO1 <-- PERF	0.757	0.085	8.947	**0.736**	***
TPO3 <-- PERF	0.68	0.082	8.335	**0.683**	***
PC1 <--PC	1			**0.714**	
PC3 <-- PC	0.929	0.113	8.245	**0.662**	***
PC4 <-- PC	1.059	0.114	9.287	**0.746**	***
MC1 <-- PC	1.3	0.122	10.684	**0.862**	***
MC3 <-- PC	1.214	0.121	10.052	**0.809**	***
MC5 <-- PC	1.217	0.117	10.416	**0.839**	***
CS2 <- CS	1			**0.715**	
CS3 <-- CS	1.362	0.137	9.956	**0.803**	***
CS4 <-- CS	1.185	0.136	8.728	**0.703**	***
CS5 <-- CS	1.382	0.126	10.999	**0.896**	***
CS6 <-- CS	1.349	0.133	10.164	**0.82**	***
Covariances					
EC <--> PTO	0.372	0.078	4.78		***
CE <--> PERF	0.474	0.077	6.176		***
EC <--> PC	0.397	0.077	5.123		***
EC <--> CS	0.142	0.049	2.908		0.004
PTO <--> PERF	0.32	0.068	4.73		***
PTO <--> PC	0.438	0.08	5.494		***
PTO <--> CS	0.313	0.059	5.33		***
PC <--> CS	0.171	0.049	0.3497		***
PERF <-->CS	0.146	0.043	3.39		***
PERF <--> PC	0.399	0.071	5.626		***

All the items loaded high on their respective factors. The covariance between the factors was also reported to be significant at 0.001 level, except for EC and CS, which were significant at 0.05 level. Goodness-for-fit from Table 5.40 indicated an overall acceptable model fit for the first order model of NPPO.

Table 5.40 Goodness-for-Fit Model Summary for First Order Model of New Product Performance Outcomes

CMIN/DF	1.606
TLI	0.948
CFI	0.956
RMSEA	0.06

Next, CFA for the second order measurement model of NPPO was conducted as shown in Figure 5.7. The parameter fit statistics (Table 5.41) and goodness-for-fit values (Table 5.42) for the second order model led to conclude the overall model for NPPO to be acceptable.

Table: 5.41 AMOS Output for Second Order Model New Product Performance Outcomes: Factor Loading Parameter Estimates

	Estimates	S.E.	C.R.	Standardized Regression Weight	p
PTO <-- NPPO	0.933	0.143	6.515	0.695	***
PERF <-- NPPO	0.91	0.132	6.874	0.844	***
PC <-- NPPO	0.745	0.118	6.31	0.731	***
CS <-- NPPO	0.442	0.092	4.811	0.721	***
EC <-- NPPO	1			0.883	

The standardized regression weight of PTO and NPPO was .695, PERF and NPPO was .844, PC and NPPO was .731, CS and NPPO was .721, and EC and NPPO was .883.

Table 5.42 Goodness-for-Fit Model Summary for Second Order Model of New Product Performance Outcomes

CMIN/DF	1.782
TLI	0.932
CFI	0.941
RMSEA	0.068

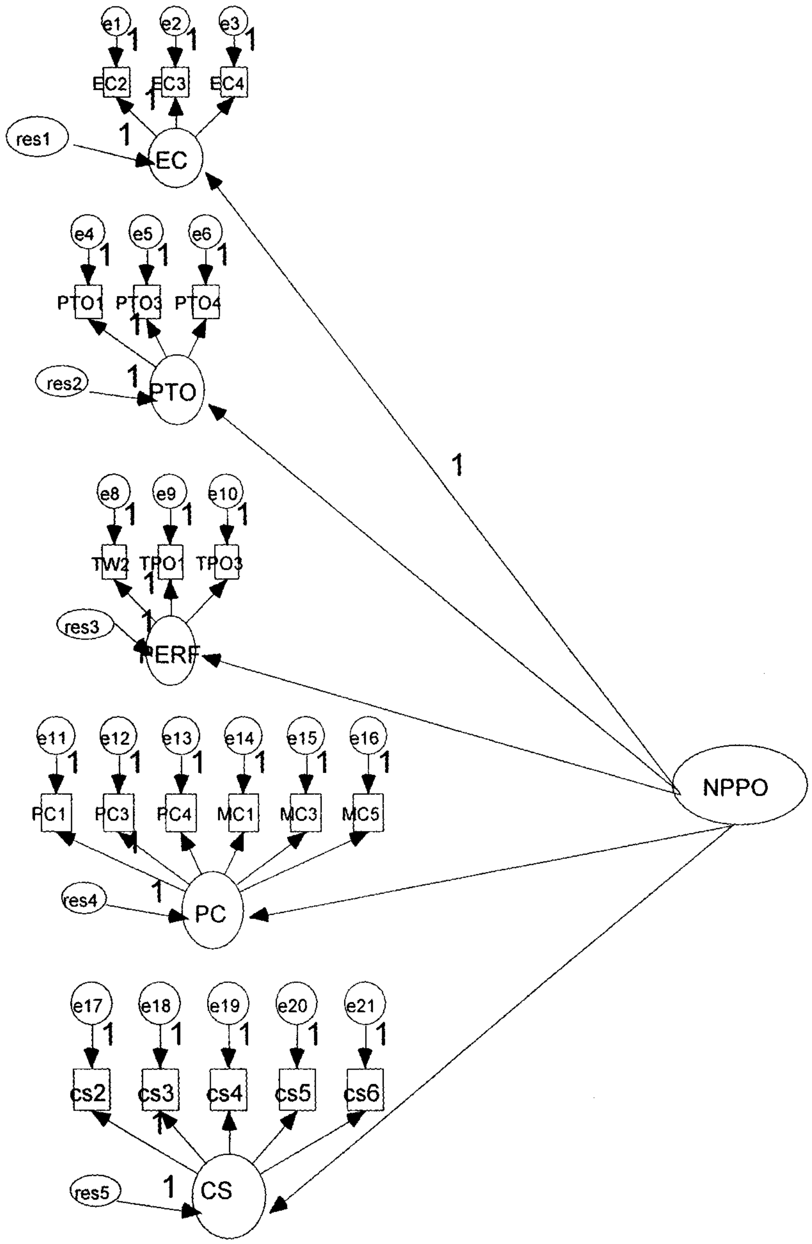

Figure 5.7: Second Order Model for NPPO

Based upon the parameter estimates and goodness-for-fit values, the second order measurement model for NPPO was acceptable.

5.5.2 The Complete Model

The purpose of exploratory factor analysis (along with analysis of reliability and item purification) and CFA (first order, and second order) was to statistically make sure that each constructs of the hypothesized complete model for knowledge integration are valid measures of the concepts they are to embody. In contrast to the factor-analytic model, the full latent variable model allows for the specification of regression structure among the latent variables of knowledge integration. Next, the hypotheses for the proposed model for knowledge integration in new product development were tested using the complete structural model.

According to the conceptualized model, team vision (TV) has direct and positive impact on mutual trust (MT), mutual influence (MI), and shared knowledge (SK). Also, both MT and MI have direct and positive impact on SK. SK was hypothesized to have a direct and positive impact on the new product performance outcome (NPPO).

The complete path diagram model in the AMOS 5.0 is presented in Figure 5.8. Each of the second order model was tested separately as discussed earlier. The AMOS analysis tested the viability of these measurement models and the relationships (the hypotheses) between the factors simultaneously.

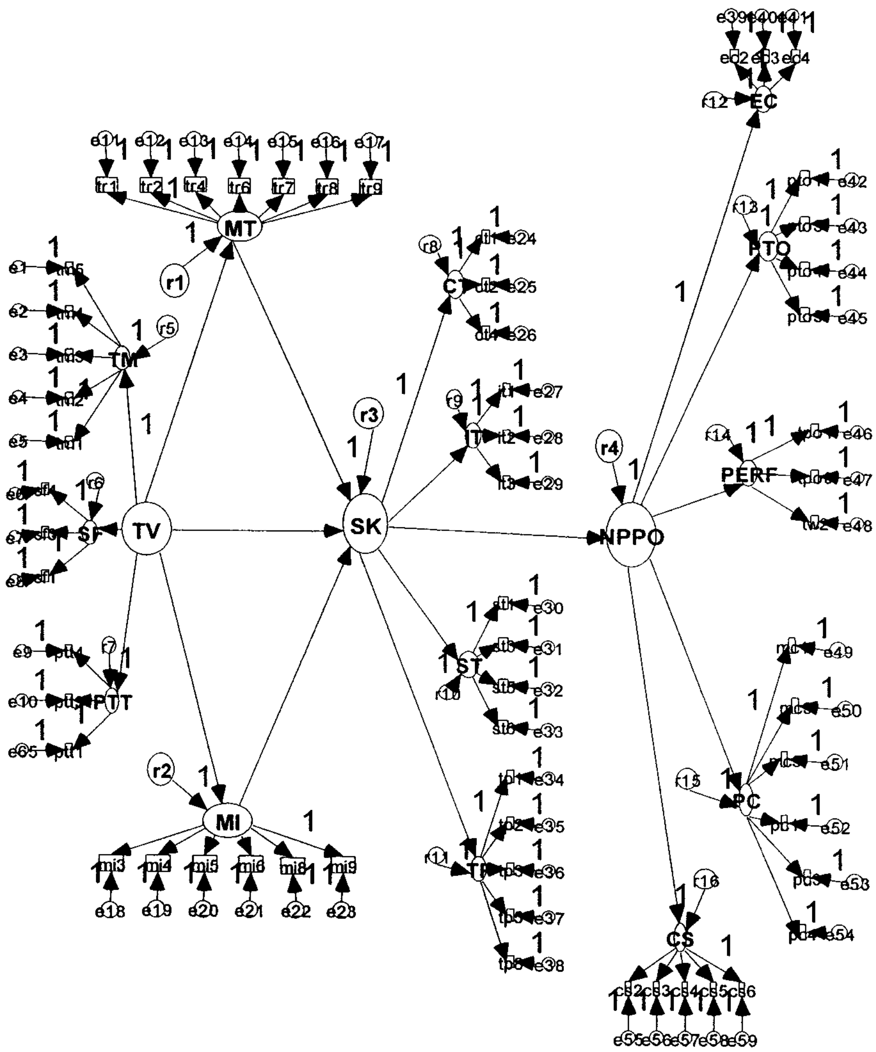

Figure 5.8: Complete Structural Model for Knowledge Integration

The result from the structural analysis is presented in Table 5.40. The standardized regression weight for TV and MT was reported to be .706, for TV and MI was .711, for MT and SK was .14, for MI and SK was .016, for TV and SK was .74, and for SK and NPPO was .92.

Table 5.43 AMOS result of the Complete Structural Model

Relationship (Hypothesis)			Estimate	S.E.	C.R.	Standardized Regression Weight	P
MT	<---	TV	0.965	6.944	7	**0.706**	***
MI	<---	TV	1.005	1.18	6.944	**0.711**	***
SK	<---	MT	0.048	0.136	1.18	**0.14**	0.238
SK	<---	MI	0.005	2.98	0.136	**0.016**	0.892
SK	<---	TV	0.345	4.476	2.98	**0.74**	0.003
NPPO	<---	SK	2.549	0.569	4.476	**0.92**	***

From Table 5.43, the relationship between MT and SK, and between MI and SK were found not significant, i.e. there is no direct and positive impact of MT and MI on SK. The relationship between TV and SK were found to be significant at 0.005 level. Besides, MT and TV were strongly and positively correlated. Also, TV had significant impact on SK. SK had positive and strong correlation with NPPO.

The goodness-for-fit for this model is presented in Table 5.44.

Table 5.44: Goodness-for-Fit Model Summary for Complete Model

CMIN/DF	1.552
TLI	0.874
CFI	0.871
RMSEA	0.057

CMIN/df, TLI, CFI and RMSEA values indicated an adequate overall fit for the model.

5.5.2.1 Model Generation for Knowledge Integration in New Product Development

Next it was decided to follow the MG approach and test the knowledge integration model again. Although, the relationship between TV and SK, and SK and NPPO has been a subject of at least one study in the past (Hong, 2000), there has been no empirical study, the researcher's best of the knowledge, between the relationship of TV and MT, and TV and MI. Thus it was decided to drop the two relations from the proposed model of knowledge integration, and test if TV, MT, and SK had direct and positive impact on the SK.

The new generated model is presented in Figure 5.9.

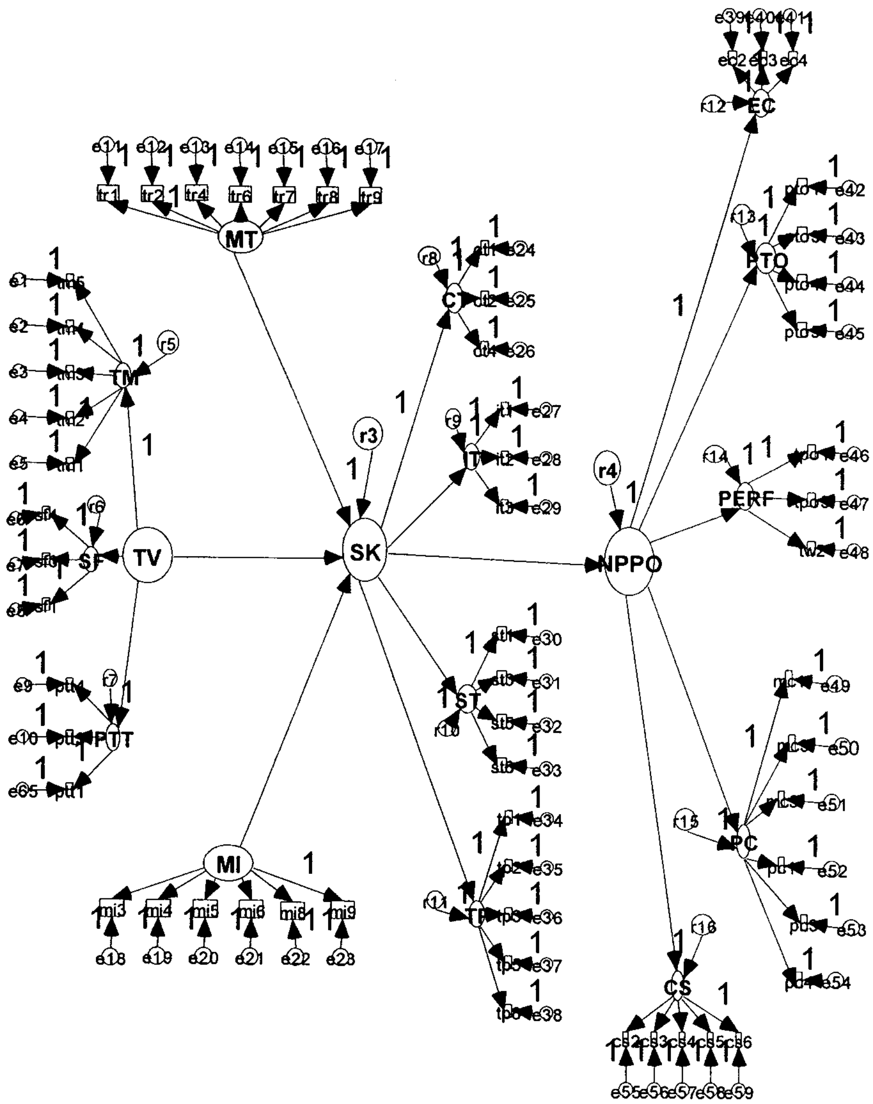

Figure 5.9: Model Generation 1

The result of the parameter estimates for the above structural model is presented in Table 5.45.

Table 5.45 Selected AMOS output for New Model: Factor Loading Parameter Estimates

Relationship			Estimate	S.E.	C.R.	Standardized Regression Weight	p
SK	<---	MT	0.121	0.036	3.394	**0.437**	***
SK	<---	MI	0.074	0.026	2.831	**0.28**	0.005
SK	<---	TV	0.281	0.089	3.15	**0.571**	0.002
NPPO	<---	SK	2.626	0.732	3.588	**0.892**	***

The above results for the newly generated model are substantially different from the earlier results. In the new model, TV, MT, and MI are the exogenous variables whereas SK and NPPO are the endogenous variables. The standardized regression weight for MT and SK was reported to be .437, MI and SK was .28, TV and SK was .571, and SK and NPPO was .892. The relationship between the MT and SK, and SK and NPPO was statistically significant at 0.001 level. The relationship between MI and SK, and TV and SK was significant at 0.01 level.

Table 5.46 presents the goodness-for-fit indices value for the new model. Judging for the CMIN/df, TLI, CFI, and RMSEA it could be concluded that overall, the new model is adequate.

Table 5.46: Goodness-for-Fit Model Summary

CMIN/DF	1.626
TLI	0.857
CFI	0.863
RMSEA	0.061

The theoretical definition assume that there if there exists a shared understanding of the team vision, it will lead to an increased level of mutual trust and mutual influence among the product development team members. Team vision was defined in terms of shared understanding of the project mission, strategic fit, and project targets. Mutual trust was defined to promote good faith among the team members; where as mutual influence was defined as the existence of symmetrical power distribution among the team members. A plausible argument, based upon the rejection of the hypotheses of team vision impacting mutual trust and mutual influence could be that, just because a team has an understanding of the vision, does not lead to any improvement in improving faith among the team members or to symmetrical power distribution among the team members. A shared understanding of team vision may exist in an environment when the interpersonal trust is low or there exists asymmetrical power distribution.

Team vision provides the team with direction and places a reference point for future course of actions. It is important that such vision formulation process should involve team member's participation, which then could generate some impact on the mutual trust and/or mutual influence. Both mutual trust and mutual influence provide the "glue" for sharing knowledge, which may not be dependent on team vision. While mutual trust promotes shared knowledge based on good faith, mutual influence provides an opportunity of increased participation which permits open, frequent, and powerful communication, or sharing of knowledge amongst the NPD team members. While hypothesizing, the study based upon past theories, assumed that a clear definition of future actions lead to increase in trust and influence, while ignoring the fact that, probably this could be a case when collective team vision formulation took place. With shared team vision, it may not be correct to assume, that team vision will promote trust or influence and merely serves as a driver for the shared knowledge.

Moreover, it could be also interpreted that organization is pervaded by goal conflicts even if there exists a consensus on team vision. Put simply, the cross-functional team members although may work collectively, while sharing knowledge towards the performance factors of new product, it maybe meaningless to assert that such shared team vision will lead to mutual trust or mutual influence.

It may also be the case of the distinction made between strategic autonomy and operational autonomy as discussed by Judge et al. (1997). Since team vision is strategic in nature, there can be very good reason that team vision is generally outlined by the top managers of the development team. However, the individual members, all of who cannot be from the top management, carry the execution of development task. Strategic autonomy aligns individuals with organizational interest, and thus promoting organizational interest first, whereas operational autonomy is guided towards the individual performance. If such is the case, then it makes sense that team vision will have little or no significant impact on mutual trust and mutual influence as the result shows. A closer look into the instruments used in this study provides some clue that team vision is strategical in nature, where as the measurement instruments for the mutual trust and mutual influence is interpersonal.

As the statistical result demonstrate that even the hypotheses of team vision and mutual trust and mutual influence was rejected the three are still the positive drivers of the shared knowledge in IPD.

5.6 CONCLUSION

Overall, the data indicates that team vision leads to shared knowledge of customers, internal capabilities, suppliers, and process in new product development. Also, shared knowledge in the cross-functional product development team leads to positive impact on the product development performance. As hypothesized in the beginning of this research, team vision seemed to have a positive impact on the mutual trust and mutual influence among the product development team members. However, from the model generation, it appears that mutual trust and mutual influence, along with team vision, have a positive impact on the shared knowledge among the team members. As pointed out by the structural model results of both original hypothesized model of knowledge integration and the new generated model, shared knowledge seems to have a positive impact on the product performance outcomes in terms of quality (customer satisfaction), time (engineering change time and product development time), team productivity, and cost (product cost and manufacturing cost).

However, these conclusions should be drawn with caution, as they may only be applicable to the particular sample of this research, which included primarily firms in the automotive industry. Since this research can be labeled primarily as an exploratory study where such study of mutual trust and mutual influence in knowledge integration has not been conducted in the past, additional efforts must be expended in the future research to establish valid and reliable instruments in the context of concurrent engineering. Moreover, confirmatory study for the hypothesized model with a new large-scale data can also help in concluding the plausibility of the result of this study.

Chapter Six

Summary, Recommendations and Discussions

6.1 SUMMARY

Knowledge management researchers argue that shared knowledge practices yield an improvement in the business performances. Researchers in product development also point out that knowledge sharing and shared team vision are critical for superior product development process in terms of cost, time, and quality which are critical manufacturing competence in the dynamic global competitive business environment. Owing to the relative newness of knowledge integration concepts in general and more so in the context of new product development, much speculation about its influence on performance (and in the product development strategy on a more organizational context) has become a popular subject of interest among the research communities. However, much of the research evidence concerning knowledge management is theoretical and anecdotal, based primarily on personal experiences, case studies, and very few surveys research. Although these studies have made important contributions, the literatures on knowledge integration and product development performance is still fragmentary and lacks precision. More importantly, what constitutes shared knowledge in a knowledge-intensive environment such as new product development had not been broadly studied.

The purpose of this research was to complement the previous studies in knowledge integration and product development and to bring some uniformity to the literature. By hypothesizing a conceptual model for knowledge integration for new product development and conducting an analysis across a relatively large number of organizations with reliable instruments, this study represents an initial investigation of the relationship between team vision, mutual trust, mutual influence on shared knowledge; and the relationship of shared knowledge on new product development performance outcomes. A set of reliable and valid measurements were developed to measure team vision, mutual trust, mutual influence, shared knowledge, and product development performance outcomes. The study contributes to our understanding of knowledge integration in a number of ways.

First, a theoretical knowledge integration framework for new product development is provided that identifies the role of team vision, mutual trust, and mutual influence on shared knowledge and shared knowledge impact on new product development performance outcomes. The framework forms a theoretical foundation for research in shared knowledge by identifying team vision, mutual trust, and mutual influence as salient dimensions of shared knowledge in a cross-functional new product development environment. Use of these constructs permits researchers to formulate and test numerous propositions. Other constructs may be added to complement this framework of constructs in the future research. Unexplained variance in the existing knowledge integration model may be explained by the addition of other relevant constructs.

Second, the study provides a set of validated instruments of knowledge integration constructs. Some of the constructs were borrowed from previous multiple studies, while new measurements were added or modified for mutual trust, mutual influence, shared knowledge of process, team productivity, and customer satisfaction. Such measurement instruments have been lacking in the context of a more comprehensive framework of knowledge integration. It is hoped that this research has provided the groundwork for future research in the field of knowledge sharing and product development.

Third, this research provides a methodological guide for researchers in manufacturing management who may not be familiar with rudimentary and advanced procedures for assessing reliability, validity, and AMOS methodology for CFA for basic instruments. Because empirical research is relatively new to the field of manufacturing management (Koufteros, 1995), this study provides a guide to those who are to undertake empirical research in the area.

Fourth, this study also provides a valuable tool for the product development professionals to assess their product development practices. For example, the heavyweight product managers to evaluate the extent of knowledge sharing during the project and to study their relative impact on performance can use the knowledge integration framework. In fact, a large number of respondents have indicated that they would like to receive the results from this study.

Fifth, the study provides supporting evidence of previously untested statements regarding mutual trust and mutual influence constructs in the context of knowledge management. As presented in the model generation section of large-scale structural analysis, higher mutual trust and mutual influence can improve the shared knowledge among the cross-functional team members in the product development.

The lack of support for some of the relationships between the drivers of shared knowledge provides an opportunity to point to several measurement as well as structural issues and problems that may have contributed to the absence of significant correlation.

By addressing these issues, possible directions for future research are provided next.

6.2 RECOMMENDATIONS AND DISCUSSIONS FOR MEASUREMENT ISSUES

This section presents future recommendations for the measurement results from the study.

Recommendation 1: Future research should cross validate the scale using firms from the same referent population and other industries.

The generic nature of the shared knowledge and product development performance used in this study allows for their broad usage. While using these scales, a researcher may have to be careful for using the proposed scales. The scales were developed here with the objective being used confidently in common product development practices and performance objectives.

Certain knowledge sharing practices may not be applicable. For example, in certain cases customers and suppliers may not be involved during the product development and hence shared knowledge of suppliers and customers may not be required, especially when the new project is a minor modification (or incremental innovation) of the existing product as opposed to the radical innovation.

Similarly, different projects may not have equal priority to the cost, time, and quality objectives and accordingly certain performance measures of this study maybe more relevant than others.

The generalizability of the scales is currently supported by acceptable reliabilities (above 0.80; except shared knowledge of internal capabilities at 0.71 and team productivity at 0.75) across the automotive industry and its supply chain (first tier, second tier, third tier, and OEMs). Due to exploratory nature of this study, these scales should be cross-validated in the same industries and also in other industries.

Recommendation 2: Future research should conduct confirmatory study for the hypothesized model.

This study has presented the development of three instruments for measuring mutual trust, mutual influence, and shared knowledge of process. Overall, there had been only a handful of empirical studies for team mission, strategic fit, and project targets. Measurements of performance outcomes were consolidated from multiple studies. Due to all this, the entire study was exploratory in nature. The research cycle for developing standardized measurement instrument has two steps: 1) exploratory studies that develop the hypothesized measurement model (s) via the analysis of empirical data from a referent population, and 2) confirmatory studies that test the hypothesized measurement models against new data gathered from the same referent population.

Although, SEM methodology for measurement model and structural model was used in the large-scale study, the same data sample used for both exploratory and confirmatory study. Based upon the results of this study, a new set of large-scale data should be collected and subjected to confirmatory study in order to provide a more rigorous and systematic test for the knowledge integration model.

Recommendation 3: Future research should conduct factorial invariance tests.

The generalizibility of measurement instruments may be further supported by factorial invariance tests. Using the instruments developed in this research, one may test for factorial invariance across the supply chain (first tier, second tier, third tier, OEM, customer involvement) and across different firm size (small versus medium versus large). The instruments developed were to be widely applicable and the factor structure is expected to be similar across different groups. Factorial invariance tests are very rare in the manufacturing research as a part of instrument development for research.

Marsch and Hocevar (1985) provide a detailed account to carry out factorial invariance tests using LISREL methodology. Such tests are relevant to the researchers who use factor analysis in theory development. The value of one factor is greatly enhanced if the same factor can be replicated in random samples from the same population and identified in responses from different population (Bejar, 1980). Although it is rarely tested, an implicit assumption in the comparison of different group is that the underlying construct being measured is the same for the two groups, and this is the issue of factorial invariance (Marsch and Hocevar, 1985). However, to conduct factorial invariance tests, it is necessary to collect sufficient data for each of the groups for comparison.

Recommendation 4: Future research should measure to what extent the product development project being assessed is a radical departure from the previous or existing products.

This research did not measure the extent to which the project being assessed is a radical departure from previous or existing product or is the new product actually an incremental improvement of previous or existing product. The need for shared knowledge may vary depending upon the type of new product. A radical new product development may involve a higher level of shared knowledge among the team members including suppliers and customers. In some cases, a new product development process may also be introduced which may result in a different knowledge integration mechanism. Future study should also focus on categorizing the two product types and then comparing the knowledge integration mechanism between the two.

Recommendation 5: Future research should use multiple methods of obtaining data.

The use of single respondent to represent project team wide variables may have generated some inaccuracy. Responses received showed less than 5% of the respondent to the survey questionnaire (both internet and mail-survey) worked in the same project. Thus it could be inferred that the respondents were responding to complex questionnaire dealing with team wide variables and thus the responses can be considered individual perception about the project they were involved in. More than the usual amount of random error is likely because informants were making individual inferences about macro-level phenomena or perform aggregation over team and project. Over-reporting or under-reporting of certain phenomena may occur as a function of informant's position, length of time in the project, project outcomes, job satisfaction, or role characteristics (Bagozzi et al., 1991). It is also sometime recognized that biases arising from a common method used to derive measures across independent and dependent variables can artificially increase the association observed therein (Fiske, 1982). It is thus suggested that multiple methods (e.g. subjective and objective methods) should be used to derive the estimates, which can then be analyzed, using multitrait-multimethod approach (Campbell and Fiske, 1959).

Recommendation 6: Future research should focus on new product complexity to analyze the importance of knowledge integration of customer and supplier.

The present research provided a generic model of knowledge integration without taking into account of the product (and process) complexity faced by the company or the industry. In a more product complex environment, the level of customer and supplier involvement in the product development may vary. Moreover customers and supplier involvement may be limited during the initial and the final stages of the product development process as oppose to their continuous involvement throughout the product development stages. As such, measures for the level of product (and process) complexity and the level of customer and supplier participation in the product development should be developed and studied.

Recommendation 7: Future research should include measures for design glitches during product development.

Design glitches are problem associated with new product design and development. In their earlier work, Hoopes and Postrel (1999) created a taxonomy of "surprises" in product development which partitioned unexpected problems into four categories: discovery surprise (new phenomena previously unknown to the development team), coordination (scheduling and resource allocation mistakes that leads delay in critical path), cooperation (individuals or subgroups pursue their own interest to the detriment of overall team objectives) and design glitches. Glitches were defined as errors because of lack of inter-functional or inter-specialty knowledge about problems (Hoopes and Postrel, 1999).

Design glitches affect the performance of new product negatively and had been a subject of interest for both researcher and practitioner communities. However, there had been no empirical studies in this area. Lack of shared knowledge in the product development can very likely affect negatively on the product development performance. A very important future extension of the current research could be the development and inclusion of instruments of the design glitches in knowledge integration model.

Recommendation 8: Future research should include measures for team members past work history with the same team members in other previous projects.

Past working relations with the team members can be a substitute or complement the drivers of knowledge shared knowledge (team vision, mutual trust, and mutual influence). If the team members had worked in similar development projects previously, the members would have developed the working relation, which can then influence how the knowledge is shared among the team members. If measure of past working relation in development project is included, then the future research can compare the knowledge integration model among the two groups: 1) projects in which considerable number of team members were working for the first time, and 2) the projects in which the team members have worked together in other development projects.

6.3 RECOMMENDATIONS AND DISSCUSSIONS FOR STRUCTURAL ISSUES

In this section recommendation and discussion surrounding the structural issues for future study is presented.

Recommendation 9: Future research should test the knowledge integration hypotheses with a different referent population.

Society of Automotive Engineers (SAE) that focuses on engineering development work in the automotive industry provided the mailing address that was used for this study to collect large scale data.

As such, one of the recommendations (and also a limitation of this study from generalizing the result) is to test the structural relation with a different population that represents multiple industries (and not only the automotive industry). Traditionally, researchers use Analysis of Variance (ANOVA) and Multivariate Analysis of Variance (MANOVA) to establish that there is no difference in means across industries. Assuming an adequate sample in each industry, one may study the covariance or correlation matrices by industry and check for significant differences. Where significant differences are apparent and a sufficient sample is available for each industry, structural analyses may be done by industry.

More so, some researchers may also argue that the need of knowledge sharing perceived by engineers could be different compared to other functional professionals (such as marketing, purchasing, production etc.) during product development. Thus a more generic mailing list that multiple functional product development professionals could be used in the future research to collect the data and to test the structural relation.

Recommendation 10: Future research should also test structural relationship at the specific shared knowledge level.

This research only hypothesized relationship at the aggregate level of shared knowledge and the drivers of shared knowledge. The use of the aggregate variables for testing purposes was supported by high target values for all instruments (high target coefficients for second order factor structure accounted for high proportion of the covariation of the first order factors). Alleged relationships were then tested at the aggregate level. Practitioners, however, would be interested to know how each driver affects particular shared knowledge factors. It has not be looked at how team vision, mutual trust, and mutual influence specific shared knowledge of customer, suppliers, internal capabilities and process. Specific practices may also be involved with shared knowledge of customer with performance (time, customer satisfaction, etc.) and shared knowledge of suppliers and performance (cost reduction, development time, etc.)

Recommendation 11: Future research should incorporate contextual variables in the structural model.

The proposed structural relationships may also be affected by contextual variables. For example, Handfield (1994) measures the complexity of the products, recognizing that some variance can be explained by contextual variables. This research focused on shared knowledge in product development and had no a priori hypotheses concerning the relationships between contextual variables and model variables. To uncover potentially useful contextual variables concerning degree of technology change, competitive environment of the industry, team financial and non-financial incentives, individual financial and non-financial incentives, and fair process. Through extensive literature review, a total of 19 instruments for multiple contextual variables have been developed. Future study may incorporate such contextual variables as antecedents in the model.

Recommendation 12: Future research should investigate the relationship of knowledge integration model with work integration in new product development.

Past researches have focused on work integration model for new product development and its impact on performance. Work integration model, in general, had been subject of empirical study consisting of variables such as heavyweight product manager, supplier involvement, customer involvement, and concurrent engineering. A more comprehensive study through which practitioners in the field of product development can benefit immensely would be one that studies empirically both the work integration model and the current knowledge integration model simultaneously. Such future research can test the structural relationships between the work integration and knowledge integration and the relationship of the two with product development performance outcome.

Chapter 7

Conclusion

Product innovation strategy has become an important aspect of competitive strategy. Many new product development initiatives continue to bring disappointing results for the company despite of huge resources allocated for such initiatives. Most of the literatures in product development continue to focus on improving regular routines through new products could be successfully launched. Researches in the field of knowledge management are few, but have been accumulating rapidly in recent years.

The purpose of this dissertation was to develop a theoretical framework for knowledge integration in new product development. Thus, a major contribution of this study has been to integrate two popular research streams of knowledge integration and new product development. In addition, the research has contributed to develop standard measurement instruments for knowledge integration model. The inventory of research in manufacturing field has been improved with the addition of several scales developed and validated in this research. Sixteen scales (mission, strategic fit, project targets, mutual trust, mutual influence, shared knowledge of customer, shared knowledge of internal capabilities, shared knowledge of suppliers, shared knowledge of process, engineering change time, team work, team productivity, customer satisfaction, product cost reduction, manufacturing cost reduction, and product development time) has been utilized to measure the impact shared knowledge on product performance outcomes and the relationship between these constructs have been explored through disciplined research methodology. These scales may be used individually or in combination in the future researches depending upon the research questions.

The generic nature of shared knowledge and its drivers render them readily available to be tested with other variables from different research fields. In fact, all scales have performed well when subjected to a variety of validity and reliability tests. Reliabilities for the scales are, in general, higher than those reported in other empirical research in manufacturing. This can be attributed to the implementation of an instrument development methodology that is followed by other disciplines with a rich tradition of empirical research. The use of pilot study has helped to enhance the measurement attributes of scales and to gain a better understanding of the behavior of these scales before the large-scale administration.

Against the background of these empirical results, the issue of power and trust has moved center-stage in many contributions to the analysis of organizational activities. On a macro level, trust has been seen as becoming the central mechanism to allow for an honest solution of the problem of coordinating expectations and interactions between various parties. From resource-based view knowledge integration view, mutual trust is a valuable asset that can have surplus value in knowledge sharing. Hierarchical relations are controlled by asymmetrical, bureaucratic power based mechanism of coordinating interactions which is based on the idea that participating members simply use of individual resources, knowledge, expertise, and power to follow idiosyncratic interests, irrespective of what damage they might impose upon others in the development team. Both mutual trust and mutual influence seems to be a precondition of performance in any exchange based activities such as new product development, and other business operations. As businesses now operate in an information economy, where knowledge management is a strategical issue for most organizations, the sociology of knowledge tells us that ill-defined, implicit, tacit knowledge needs to be incorporated in business routines and practices that will promote coordination, interaction, and more importantly help in collectively solving complex business problems. Exactly on this premises, the knowledge integration research framework of this research was based upon. In a knowledge-intensive activity, such as product development, knowledge sharing, which as the result shows here has a positive impact on the performance, the coordinating and integrating mechanism thus can be viewed as being positively and strongly impacted by shared team vision, mutual trust, and mutual influence. However, this research is only a starting point for research in knowledge management in product development. Several directions for future research have been provided and recommendations for both measurement as well as structural issues have been offered.

Appendix I : Pilot Study Questionnaire

I. The following questions enable you to describe factors that encourage team members to share their knowledge/expertise with other members of their cross-functional team. For each item, please choose the response that best describes the focal project you named above.

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. There was mutual trust among team members.	1	2	3	4	5
2. Everyone on the team had some power to influence others.	1	2	3	4	5
3. The project mission was well communicated to all team members.	1	2	3	4	5
4. The team members shared a belief that all members were acting in good faith.	1	2	3	4	5
5. The team shared a belief that all members were honest.	1	2	3	4	5
7. Our firm's overall technology strategy guided a setting of the project targets.	1	2	3	4	5
8. Each team member had some ability to affect the decisions of others.	1	2	3	4	5
9. Our firms overall product strategy guided a setting of project targets.	1	2	3	4	5
10. Team members trusted each other enough to share sensitive information.	1	2	3	4	5
11. Mutual influence was broadly spread among the team.	1	2	3	4	5
12. The project mission was well understood by the entire team.	1	2	3	4	5
13. Team members trusted each other.	1	2	3	4	5
14. Power was broadly shared among the members.	1	2	3	4	5
15. Each team member had at least some control over the decisions of the team.	1	2	3	4	5
16. The project targets clearly specified tradeoffs between performance and cost.	1	2	3	4	5
17. The team members were confident they could trust each other.	1	2	3	4	5
18. The project purpose was well understood by the entire team.	1	2	3	4	5
19. Each team member had some power to affect team decisions.	1	2	3	4	5
20. The team members trusted each other to share accurate information.	1	2	3	4	5
21. The relative priority of each project target was clear.	1	2	3	4	5
22. The team members relied on each other for the truthfulness of the information shared.	1	2	3	4	5
25. Project targets clearly specified tradeoffs between quality and cost.	1	2	3	4	5
26. The team members trusted each other enough to share all relevant information.	1	2	3	4	5
27. Influence was shared among the team members.	1	2	3	4	5
29. The project mission was well defined for all team members.	1	2	3	4	5
30. The team members were willing to share sensitive information.	1	2	3	4	5
31. All the team members had some authority to influence team decisions.	1	2	3	4	5
32. Project targets reflected the competitive situation.	1	2	3	4	5
33. The project targets clearly specified tradeoffs between time and cost.	1	2	3	4	5
34. All the team members had at least some ability to persuade each other.	1	2	3	4	5
35. The product development team had a well-defined mission.	1	2	3	4	5
36. The project targets were consistent with our overall business strategy.	1	2	3	4	5
37. The Relative priority of each project target was clear	1	2	3	4	5

II. The following questions enable you to describe the level of shared or common knowledge among the members of your product development team. For each item, please choose the response that best describes the focal project named above.

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. This product development team shared knowledge of:	
a. Our suppliers design capabilities.	1 2 3 4 5
b. Which features were most valued by target customers.	1 2 3 4 5
c. The capabilities of our engineering staff.	1 2 3 4 5
d. Our suppliers' manufacturing facilities.	1 2 3 4 5
b. Key decision points in the product development process.	1 2 3 4 5
e. What our customers wanted.	1 2 3 4 5
f. The strengths of our manufacturing facilities.	1 2 3 4 5
g. Our suppliers' capabilities to meet quality requirements.	1 2 3 4 5
h. Customer requirements.	1 2 3 4 5
i.. Our suppliers' capabilities to meet time requirements.	1 2 3 4 5
j. How our firm should develop products.	1 2 3 4 5
k. The strengths of our engineering development capabilities.	1 2 3 4 5
l. Our suppliers' capabilities to meet cost requirements.	1 2 3 4 5
m. The process of product development.	1 2 3 4 5
n. Our suppliers' process capabilities.	1 2 3 4 5
o. Each other's roles in the product development process.	1 2 3 4 5
p. Current customer needs.	1 2 3 4 5
q. **The activities in the product development process that were on the critical path**	1 2 3 4 5
	1 2 3 4 5
r. The capabilities of the process technologies we used.	

III. The following statements describe process outcomes. Please choose the appropriate number to indicate the extent to which you agree or disagree with each statement.

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. This product development team:	
a. Finished engineering change orders on time.	1 2 3 4 5
b. Coordinated design activities effectively.	1 2 3 4 5
c. Was productive.	1 2 3 4 5
d. Delivered engineering change notices on time.	1 2 3 4 5
e. Worked on product improvements successfully.	1 2 3 4 5
2. This product development team:	
a. Resolved design conflicts on time.	1 2 3 4 5
b. Met engineering change deadline regularly.	1 2 3 4 5
c. Completed work quickly.	1 2 3 4 5
d. Communicated effectively.	1 2 3 4 5

IV. The following statements describe product outcomes. Please choose the appropriate number to indicate the extent to which you agree or disagree with each statement.

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. This product development team:	
a. Reduced the number of parts successfully.	1 2 3 4 5
b. Reduced manufacturing cost successfully.	1 2 3 4 5
c. Reduced the number of manufacturing steps effectively.	1 2 3 4 5
d. Reduced product costs successfully.	1 2 3 4 5
e. Successfully reduced assembly cost.	1 2 3 4 5
2. This product development team:	
a. Reduced material costs successfully.	1 2 3 4 5
b. Reduced equipment costs successfully.	1 2 3 4 5
c. Simplified the design successfully.	1 2 3 4 5
d. Reduced production tooling costs successfully.	1 2 3 4 5
3. Compared to the average industry our product development team:	
a. Launched product to the market faster.	1 2 3 4 5
b. Enabled our company to start volume production faster.	1 2 3 4 5
c. Brought product to the market before our competitors.	1 2 3 4 5
d. Developed product from concept to commercial production faster.	1 2 3 4 5
e. Made better progress in reducing total product development time.	1 2 3 4 5
4. Compared to the average in the industry, our product:	
a. Satisfied customers better.	1 2 3 4 5
b. Fit target customers better	1 2 3 4 5
c. Has more loyal customers.	1 2 3 4 5
d. Was more successful in the marketplace.	1 2 3 4 5
e. Was more highly valued by customers.	1 2 3 4 5
f. generated more new customers	1 2 3 4 5

V. Shared knowledge "glitches" in NPD. (Glitch is a problem that occurs in design, development, ramp-up, and marketing introduction of new product development): Please rate to what extent "glitches" occurred?

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. To what extent in each of the following did "glitches" occur:					
a. Product design did not meet customer requirements.	1	2	3	4	5
b. Product design did not meet supplier requirements.	1	2	3	4	5
c. Product design did not meet internal manufacturing requirements.	1	2	3	4	5
d. The product was not designed well for assembly.	1	2	3	4	5
e. The design went out for development without considering problem constraints.	1	2	3	4	5
2. General Information:					
a. Knowledge intensity of your product development process is	1	2	3	4	5
b. Your firm's product complexity is	1	2	3	4	5
c. Your firm's process complexity is	1	2	3	4	5
d. The rate of technology change that your firm currently experiences is	1	2	3	4	5
e. The intensity of competition that your firm currently experiences is	1	2	3	4	5

VI. General Information: Please provide the following information for statistical purpose.

1. Number of employees

a. _____ up – 499
b. _____ 500 – 999
c. _____ 1,000 – 4,999
d. _____ 5,000 – 9,999
e. _____ Over 10,000

2. In which vehicle system is your company's focal product mentioned (page 1) primarily used?

a. _____ Body Exterior
b. _____ Body Interior
c. _____ Powertrain
d. _____ Body Component
e. _____ Chassis
f. _____ Electrical/Electronic Equipment
g. _____ Other (please describe)

3. The primary status of your company is:

a. _____ Auto Manufacturer / Original Equipment Manufacturer (OEM)
b. _____ Auto supplier
c. _____ Other (please describe)

4. If you are an auto supplier, your company is:

a. _____ An auto supplier owned fully or partially by an OEM
b. _____ An independent auto supplier not owned by an OEM

5. If you are an auto supplier, you company is:

a. _____ First-tier supplier
b. _____ Third-tier supplier
c. _____ Second-tier supplier
d. _____ Other (please describe)

6. If you are an auto supplier, how are you primarily involved by your customer in the design of your products?

a. _____ Customers provide concept, we do the rest
b. _____ We provide initial feedback to the customer on their design
c. _____ Customers provides critical specifications, we do the rest
d. _____ Customer provides complete design, we are not involved
e. _____ We work with the customer to co-develop the design
f. _____ Other (please describe)

7. In what form do you primarily involve your suppliers in product development?

a. _____ We provide concept. Suppliers do the rest
b. _____ Suppliers provide initial feedback to our design
c. _____ We provide critical specifications, suppliers to the rest
d. _____ We provide complete specifications to suppliers
e. _____ We work with suppliers to co-develop the design
f. _____ Other (please describe)

Thank you again for your assistance!

If you have any comments, please write in the following area

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Appendix II : Large Scale Study Questionnaire

A Survey of Work Integration and Knowledge Integration
In Integrated Product Development

Dear Product Development Professional,

As a doctoral student in manufacturing management and engineering at the University of Toledo, I am conducting my doctoral dissertation research to develop theories on important drivers of work integration and knowledge integration during new product development (NPD) process.

Such research has not been conducted in the past, and it is our belief that the findings of this research will serve a valuable contribution to uncover important practices for product development practitioners that can help in better managing product development processes.

As our survey has been targeted to limited practitioners, I would be personally grateful to you if you can take 20 minutes of your valuable time to fill and mail this questionnaire to me. The data collected in this research is strictly meant for my doctoral dissertation and will not be used for any other purpose. Also, you are not required to disclose any personal information in this survey. As a token of my appreciation for your participation in this survey, please include your business card along with your response to this survey in order to be entered in Lucky Draw that carries a cash prize of **$500.00.** The Lucky Draw would be held on May15, 2004 at the Business School.

This questionnaire should be answered by those (e.g., product development manager, vice-president, CEO) who have recently managed a cross-functional product development team. Your response to this questionnaire should be based on a particular project in which you were involved, regardless of its success or disappointing result in the market.

Please supply us with information on a particular product development project that you have been involved with:

Name of the Project: ______________________

Market Introduction Date: ___________________

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I. For each item, please choose the response that best describes the extent of these practices in the focal project you named above.

The 5 point scale is as follows:

1	2	3	4	5
None or to a Little extent	**To Some Extent**	**To a Moderate Extent**	**To a Great Extent**	**To a very Great Extent**

1. Various disciplines were involved in product development from the early stage.	1	2	3	4	5
2. We involved customers in the early stages of product development.	1	2	3	4	5
3. Product development team members represented a variety of disciplines.	1	2	3	4	5
4. Our suppliers were involved in the early stages of product development.	1	2	3	4	5
5. Our suppliers did the product engineering of component parts for us.	1	2	3	4	5
6. Product development managers have broad influence across the organization.	1	2	3	4	5
7. Our product development team met with customers.	1	2	3	4	5
8. Product requirements are solicited, consolidated, and fed back to potential customers.	1	2	3	4	5
9. During the requirements definition, potential customers are involved continuously and interactively.	1	2	3	4	5
10. Product development managers were given "real" authority over personnel.	1	2	3	4	5
11. Product and process designs were developed concurrently by a team of employees from various departments.	1	2	3	4	5
12. Product performance is verified by testing of prototypes by customers.	1	2	3	4	5
13. Product improvements/redesigns occur because improvement ideas from customers are solicited.	1	2	3	4	5
14. The team consisted of cross-functional members of the organization.	1	2	3	4	5
15. Our suppliers developed whole subassemblies for us.	1	2	3	4	5
16. Product development managers had enough influence to make things happen.	1	2	3	4	5
17. The entire project team was involved since the early stages of the project.	1	2	3	4	5
18. All necessary functions of the organization were represented in the project team.	1	2	3	4	5
19. Product development managers had a final say in product design decisions.	1	2	3	4	5
20. We visited our customers to discuss product development issues.	1	2	3	4	5
21. Process engineers were involved from the early stage of product development.	1	2	3	4	5
22. Our suppliers developed component parts for us.	1	2	3	4	5
23. We made use of suppliers' expertise in the development of our products.	1	2	3	4	5
24. Manufacturing engineers were involved from the early stages of product development.	1	2	3	4	5
25. The team simultaneously planned the product, process, and manufacturing activities of the project.	1	2	3	4	5
26. Product development managers had a final say in budget decisions.	1	2	3	4	5

II. For each item, please choose the response that best describes the focal project you named above.

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. There was mutual trust among team members.	1	2	3	4	5
2. Everyone on the team had some power to influence others.	1	2	3	4	5
3. The project mission was well communicated to all team members.	1	2	3	4	5
4. The team members shared a belief that all members were acting in good faith.	1	2	3	4	5
5. The team shared a belief that all members were honest.	1	2	3	4	5
6. Our firm's overall technology strategy guided a setting of the project targets.	1	2	3	4	5
7. Each team member had some ability to affect the decisions of others.	1	2	3	4	5
8. Our firms overall product strategy guided the setting of project targets.	1	2	3	4	5
9. Team members trusted each other enough to share sensitive information.	1	2	3	4	5
10. Mutual influence was broadly spread among the team.	1	2	3	4	5
11. The project mission was well understood by the entire team.	1	2	3	4	5
12. Team members trusted each other.	1	2	3	4	5
13. Power was broadly shared among the members.	1	2	3	4	5
14. Each team member had at least some control over the decisions of the team.	1	2	3	4	5
15. The project targets clearly specified tradeoffs between performance and cost.	1	2	3	4	5
16. The team members were confident they could trust each other.	1	2	3	4	5
17. The project purpose was well understood by the entire team.	1	2	3	4	5
18. Each team member had some power to affect team decisions.	1	2	3	4	5
19. The team members trusted each other to share accurate information.	1	2	3	4	5
20. The relative priority of each project target was clear.	1	2	3	4	5
21. The team members relied on each other for the truthfulness of the information shared.	1	2	3	4	5
22. Project targets clearly specified tradeoffs between quality and cost.	1	2	3	4	5
23. The team members trusted each other enough to share all relevant information.	1	2	3	4	5
24. Influence was shared among the team members.	1	2	3	4	5
25. The project mission was well defined for all team members.	1	2	3	4	5
26. The team members were willing to share sensitive information.	1	2	3	4	5
27. All the team members had some authority to influence team decisions.	1	2	3	4	5
28. Project targets reflected the competitive situation.	1	2	3	4	5
29. The project targets clearly specified tradeoffs between time and cost.	1	2	3	4	5
30. All the team members had at least some ability to persuade each other.	1	2	3	4	5
31. The product development team had a well-defined mission.	1	2	3	4	5
32. The project targets were consistent with our overall business strategy.	1	2	3	4	5

III. For each item, please choose the response that best describes the focal project named above.

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

Item					
1. This product development team shared knowledge of:					
a. Our suppliers design capabilities.	1	2	3	4	5
b. Which features were most valued by target customers.	1	2	3	4	5
c. The strength of our engineering staff.	1	2	3	4	5
d. Our suppliers' manufacturing facilities.	1	2	3	4	5
e. The steps in the product development process.	1	2	3	4	5
g. The activities in the product development process that were on the critical path.	1	2	3	4	5
h. The points in the product development process where information needed to be exchanged.	1	2	3	4	5
i. Key decision points in the product development process.	1	2	3	4	5
j. What our customers wanted.	1	2	3	4	5
k. The strengths of our manufacturing facilities.	1	2	3	4	5
2. This product development team shared knowledge of:					
a. Our suppliers' capabilities to meet quality requirements.	1	2	3	4	5
b. Customer requirements.	1	2	3	4	5
c. Our suppliers' capabilities to meet time requirements.	1	2	3	4	5
d. How our firm should develop products.	1	2	3	4	5
e. The strengths of our engineering design capabilities.	1	2	3	4	5
f. Our suppliers' capabilities to meet cost requirements.	1	2	3	4	5
g. The process of product development.	1	2	3	4	5
h. Our suppliers' process capabilities.	1	2	3	4	5
i. Each other's roles in the product development process.	1	2	3	4	5
j. Current customer needs.	1	2	3	4	5
3. This product development team shared knowledge of:					
a. Where key deliverables in the product development process were essential to subsequent activities.	1	2	3	4	5
b. The capabilities of the process technologies we used.	1	2	3	4	5
c. Key decision points in the product development process.	1	2	3	4	5
d. What percentage of this team's member had worked with each other in prior development project? _____________ % .					
e. NPD team members had frequent work interactions.	1	2	3	4	5

IV. Please choose the appropriate number to indicate the extent to which you agree or disagree with each statement.

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. This product development team:					
a. Finished engineering change orders on time.	1	2	3	4	5
b. Coordinated design activities effectively.	1	2	3	4	5
c. Was productive.	1	2	3	4	5
d. Delivered engineering change notices on time.	1	2	3	4	5
e. Worked on product improvements successfully.	1	2	3	4	5
f. Resolved design conflicts on time.	1	2	3	4	5
g. Met engineering change deadline regularly.	1	2	3	4	5
h. Completed work quickly.	1	2	3	4	5
i. Communicated effectively.	1	2	3	4	5
2. This product development team:					
a. Reduced the number of parts successfully.	1	2	3	4	5
b. Reduced manufacturing cost successfully.	1	2	3	4	5
c. Reduced the number of manufacturing steps effectively.	1	2	3	4	5
d. Reduced product costs successfully.	1	2	3	4	5
e. Successfully reduced assembly cost.	1	2	3	4	5
f. Simplified the design successfully.	1	2	3	4	5
g. Reduced material costs successfully.	1	2	3	4	5
h. Reduced equipment costs successfully.	1	2	3	4	5
i. Simplified the design successfully.	1	2	3	4	5
j. Reduced production tooling costs successfully.	1	2	3	4	5
3. Compared to the average industry our product development team:					
a. Launched product to the market faster.	1	2	3	4	5
b. Enabled our company to start volume production faster.	1	2	3	4	5
c. Brought product to the market before our competitors.	1	2	3	4	5
d. Developed product from concept to commercial production faster.	1	2	3	4	5
e. Made better progress in reducing total product development time.	1	2	3	4	5
4. Compared to the average in the industry, our product:					
a. Satisfied customers better.	1	2	3	4	5
b. Fit target customers better.	1	2	3	4	5
	1	2	3	4	5
c. Has more loyal customers.	1	2	3	4	5
d. Was more successful in the marketplace.	1	2	3	4	5
e. Was more highly valued by customers.	1	2	3	4	5
f. Generated more new customers	1	2	3	4	5

V. Please rate to what extent did following occur?

The 5 point scale is as follows:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

1. To what extent do you agree that following occurred:					
a. Product design did not meet customer requirements.	1	2	3	4	5
b. Product design did not meet supplier requirements.	1	2	3	4	5
c. Product design did not meet internal manufacturing requirements.	1	2	3	4	5
d. The product was not designed well for assembly.	1	2	3	4	5
e. The design went out for development without considering problem constraints.	1	2	3	4	5
2. To what extent do you agree on following:					
a. Individual NPD team members received regular feedback on their performance.	1	2	3	4	5
b. NPD team received regular feedback on how well the project was progressing.	1	2	3	4	5
c. NPD team membership is considered to be a matter of pride.	1	2	3	4	5
d. Team members receive bonus for successful NPD projects.	1	2	3	4	5
e. Financial incentives are provided for individual performance.	1	2	3	4	5
f. Non-financial incentives (recognition, certificate, etc.) are provided for individual performance.	1	2	3	4	5
g. Financial incentives are provided for team performance.	1	2	3	4	5
h. Non-financial incentives (recognition, certificate, etc.) are provided for team performance.	1	2	3	4	5
i. Team members had a fair chance to participate in decision makings.	1	2	3	4	5
j. Team leaders provided rationale regarding the final decisions.	1	2	3	4	5
k. When trade-offs had to be considered, the decision making process was fair to all.	1	2	3	4	5
l. Team leaders encouraged participation during the meetings.	1	2	3	4	5
m. All meetings and events were announced in advance in time and through proper channels.	1	2	3	4	5
n. Decision making was free from personal or political motives.	1	2	3	4	5
o. Decisions were implemented as per earlier agreement.	1	2	3	4	5
3. Please use the following scale to answer these questions.					
1 (very low) ___ **2** (low) ___ **3** (moderate) ___ **4** (high) ___ **5** (very high)					
a. Your firm's product complexity is	1	2	3	4	5
b. Your firm's process complexity is	1	2	3	4	5
c. The rate of technology change that your firm currently experiences is	1	2	3	4	5
d. The intensity of competition that your firm currently experiences is	1	2	3	4	5

VI. General Information: Please provide the following information for statistical purpose.

1. Number of employees in your company

a. _____ up – 499 b. _____ 500 – 999
c. _____ 1,000 – 4,999 d. _____ 5,000 – 9,999
e. _____ Over 10,000

3. If in auto industry, in which vehicle system is your company's focal product mentioned (page 1) primarily used?

a. _____ Body Exterior b. _____ Body Interior
c. _____ Powertrain d. _____ Body Component
e. _____ Chassis f. _____ Electrical/Electronic Equipment
g. _____ Other (please describe) ____________________________________

4. The primary status of your company is

a. _____ Manufacturer / Original Equipment Manufacturer (OEM) go to #7
b. _____ Supplier
c. _____ Other (please describe)________________________

5. If you are a supplier, your company is:

a. _____ A supplier owned fully or partially by an OEM
b. _____ An independent supplier not owned by an OEM

6. If you are a supplier, you company is:

a. _____ First-tier supplier b. _____ Third-tier supplier
c. _____ Second-tier supplier d. _____ Other (please describe)

8. If you are a supplier, how are you primarily involved by your customer in the design of your products?

a. _____ Customers provide concept, we do the rest
b. _____ We provide initial feedback to the customer on their design
c. _____ Customers provides critical specifications, we do the rest
d. _____ Customer provides complete design, we are not involved
e. _____ We work with the customer to co-develop the design
f. _____ Other (please describe)___________________________

9. In what form do you primarily involve your suppliers in product development?

a. _____ We provide concept. Suppliers do the rest
b. _____ Suppliers provide initial feedback to our design
c. _____ We provide critical specifications, suppliers to the rest
d. _____ We provide complete specifications to suppliers
e. _____ We work with suppliers to co-develop the design
f. _____ Other (please describe)_____________________________

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