INNOVATION SPEED:

AN EMPIRICAL ANALYSIS OF CONTEXT, ANTECEDENTS, AND OUTCOMES

By Eric H. Kessler

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ABSTRACT OF THE THESIS

Innovation Speed. An Empirical Analysis of Context. Antecedents. and Outcomes

By Eric H. Kessler

Thesis Director: Professor Alok K. Chakrabarti

There is a growing recognition that innovation speed is important to creating and sustaining competitive advantage amidst rapidly changing business environments. However, despite its importance, there has been little theoretical development or deductive hypotheses testing with regard to when innovation speed is appropriate, what factors differentiate fast innovations from their slower counterparts, and how differences in speed affect important project outcomes. In this dissertation I organize and integrate the innovation speed literature, develop a conceptual framework of innovation speed, and offer researchable propositions relating to the need, antecedents, and outcomes of innovation speed. Specifically, I propose that innovation speed (a) is most appropriate in environments characterized by competitive intensity, technological and market dynamism, and low regulatory restrictiveness -- i.e., *need for speed*; (b) can be positively or negatively affected by strategic orientation factors (criteria- and scope-related) and organizational capability factors (staffing- and structuring-related) -- i.e., *antecedents to speed*, and; (c) influences development costs, product quality, and ultimately project success -- i.e., *outcomes of speed*. To test propositions derived from the model, a combined field-study, mail-questionnaire research design is used to sample seventy-five new product development projects from ten large companies in a variety of industries.

Multiple linear regression analyses partially support the propositions. while subsequent parsimonious. split-sample. and finer-grained regression analyses reveal some deeper relationships between these variables and innovation speed. Overall. the results offer weak support for the need factors. mixed support for the antecedent factors. and strong support for the outcome factors. Because of the complexity of the relationships and the limitations of the study. the dissertation provides a foundation for further theoretical integration and empirical validation. Implications for scholars and R&D managers are discussed. and directions for future research are offered.

PREFACE

A dissertation is, to say the least, a massive undertaking which occupies significant amounts of one's time and cognitive and emotional energies. It most certainly has its ups and downs, and its execution has to be considered one of the most formidable academic challenges I have faced to date. Thus, I could not have successfully completed this thesis if not for the support and guidance of a number of individuals.

I want to first thank my wife, Kimberly, for her tremendous empathy, comfort, and love, especially during the more difficult times -- thank you. My parents and my family were also a constant source of strength and encouragement on which I relied.

Of course, Dr. Alok Chakrabarti played an integral role in the completion of the thesis through a mix of confidence, direction, and support. Despite his busy schedule as Dean, I always felt that I was a priority to him. Also, in addition to his help on this project, his mentoring has profoundly shaped my professional outlook and acumen.

My committee of Dr. George Farris, Dr. Cameron Ford, and Dr. Paul Lawrence also deserve credit for their insightful comments and helpful suggestions, which have most definitely improved the quality of this dissertation. This is also true for several of my colleagues at Rutgers and NJIT, who did not have to take time out and help but nevertheless did.

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CHAPTER 1
RESEARCH PROBLEM AND OVERVIEW[1]

An increasing number of organizations are recognizing the importance of speeding up operations to building competitive advantage, especially in industries with shortening product life cycles (Brown & Karagozoglu, 1993; Dumaine, 1989; Page, 1993; Peters, 1987; Smith & Reinertsen, 1992; Vesey, 1991). This relatively recent emphasis upon speed represents a paradigm shift from more traditional sources of advantage such as experience-curve strategies in the 1960s, portfolio management in the 1970s, and re-structuring in the 1980s towards a strategic orientation specifically suited to today's rapidly changing business environments (Stalk & Hout, 1990; Stalk, 1993). Time-based competition, which permeates all facets of an organization, from product innovation to manufacturing to ordering and delivery, has thus emerged as a way of increasing profitability and market share while simultaneously containing costs and market risk (Page, 1993).

The growing popularity of speed is partly due to the belief that being a fast innovator can facilitate either first-mover or second-mover strategies, depending on which is favored by industry conditions (e.g., Lieberman & Montgomery, 1988). The faster a firm can develop a new product, the greater the likelihood that they can be first-to-market and reap pioneering advantages (Birnbaum-More, 1990; Emmanuelides, 1991). However, pioneering may not provide an absolute guarantee of success and long-term rewards (e.g., Golder & Tellis, 1993; Lieberman & Montgomery, 1988; Schnaars, 1986; Strebel, 1987), particularly when a

[1] Portions of this section appear in Kessler & Chakrabarti (1996).

pioneer's first mover advantages are partly based upon the innovation speed of its followers. That is, a fast-imitation strategy, perhaps through reverse engineering, can reduce a competitor's pioneering advantages (Kerin, Varadarajan, & Peterson, 1993, Levitt, 1966). Moreover, the faster a follower can develop new products, the more distance it can put between itself and later entrants. This extends second-mover advantages and subsequently lengthens their window of profitability.

Innovation speed is defined as the time elapsed between (a) initial development efforts, including the conception and definition of an innovation, and (b) ultimate commercialization, which is the introduction of a new product into the marketplace (Mansfield, 1988; Murmann, 1994; Vesey, 1991). Thus the concept of innovation speed refers to accelerating activities from first spark to final product, including activities which occur throughout the product development process[2]. Though fairly involved, speeding up innovation is but one component of what many refer to as fast cycle time along with accelerated production, ordering, plant scheduling, and distribution.

During the last five to ten years, this literature has been significantly broadened, and speed in innovation has been written about extensively in the popular press and practitioner-oriented academic literature. Notwithstanding this expanded familiarity, innovation speed is one of the least studied factors in the new product development literature (Montoya-Weiss & Calantone, 1994) and among existing studies there has been little theoretical advancement

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[2] Though there are many different types of organizational innovations (e.g., product, process, administrative), I focus my discussion upon the speed of *product* innovations, defined as new technologies or combinations of technologies introduced commercially to meet a user or market need (Meyers & Marquis, 1969; Utterback & Abernathy, 1975).

or empirical evidence with regard to (a) the environmental conditions which influence the need for speed. including task and institutional dimensions; (b) specific factors that may facilitate or impede speed. including strategic orientation and organizational capability factors. and; (c) the bottom-line implications of speed. including primary and secondary project outcomes (Brown & Karagozoglu. 1993. Clark & Fujimoto. 1991; McDonough & Barczak. 1991). Further. there is some variability in how researchers conceptualize and measure innovation speed (Ellis & Curtis. 1995; Griffin. 1993; Rosenthal. 1992). These limitations can be seen to underlie inconsistencies of assessment. prescription, and prediction in the innovation speed literature.

Thus. there are three research problems which I address in this dissertation. manifest in the following research questions: (1) When is fast product development appropriate (i.e., *Need for Innovation Speed*); (2) What factors differentiate fast innovation efforts from their slower counterparts (i.e., *Antecedents to Innovation Speed*)?, and; (3) How does innovation speed influence development costs, product quality, and ultimately project success (i.e., *Outcomes of Innovation Speed*)? By developing a conceptually-based model of innovation speed that spans these three areas, and by systematically, deductively testing its propositions, the dissertation attempts to contribute our understanding of this important phenomenon through both theoretical integration and empirical validation.

The following chapters detail the theoretical and empirical approach of the dissertation and present the results and conclusions of the study. Specifically, Chapter 2 examines the literature related to innovation speed, organizes it into common streams, assesses its limitations, and systematically derives the study's research questions. Chapter 3 presents the conceptual model and the research propositions of the study. In this chapter, the model is broken down into three parts (context, antecedents, and outcomes), corresponding to each of the three research questions. Chapter 4 discusses the methodology used to gather data, including the selection of the sample (firms, projects, and individual respondents), data collection procedures, and operational measures. Chapter 5 delineates the statistical procedures used in data analysis, specifically with regard to data aggregation, factor reduction, data description and variable transformation, and examination of main-effect relationships, split-sample relationships, and finer-grained relationships. Chapter 6 reports the results of these analyses and their implications for the research questions generally and the propositions specifically. Chapter 7 interprets these results and offers possible explanations for them, both for findings that were expected and for those that were surprising. Finally, Chapter 8 summarizes the study, discusses its implications for scholars and practitioners, and, based upon its limitations, proposes avenues for future research.

CHAPTER 2
LITERATURE REVIEW[1]

2.1 Introduction

The central aim of this chapter is to organize and integrate what is known about the contextual applicability, antecedents, and outcomes of innovation speed as to lay the foundation for a conceptual model and propositions as well as systematic, rigorous testing of these relationships. The following discussion will (a) organize the existing literature on speed; (b) assess its limitations and inconsistencies, and; (c) based upon these limitations and inconsistencies, derive a set of research questions for the dissertation.

2.2 The Innovation Speed Literature: Theoretical Context

Many researchers have studied the implicit or explicit assumptions about time in business organizations (Bluedorn & Denhardt, 1988; Clark, 1985; Das, 1990; Doob, 1971; Gherardi & Strati, 1988; Katz, 1980). Most fundementally, in western organizations, time is considered measurable, linear, objective, and divisible (McGrath & Rotchford, 1983). Thus managers typically regard time as "out there" and constantly ticking away (i.e., a scarce resource), and as a consequence attempt to analyze and optimize its use (e.g., Parkinson, 1957; Taylor, 1911). Further, many authors agree that, in general, the demand for speed in the workplace is increasing (e.g., Holder, 1992; Jones, 1993; Toffler, 1970), forcing a greater percentage of managers to make decisions faster in the face of frequently-changing, high-velocity environments (Eisenhardt, 1989; 1990; Vinton, 1992). This phenomenon is the basis

[1] Portions of this section appear in Kessler & Chakrabarti (1996).

for concerns about speeding up innovation, for although the issue of how to do things faster is not new to organizational studies, it is only recently that scholars have addressed themselves to the importance of time in innovation where costs and performance have typically been the chief outcome metrics.

2.3 Innovation Speed: Streams of Research

There are two interrelated though distinguishable research streams within the product innovation literature (Brown & Eisenhardt, 1995): (a) an economics-oriented tradition (e.g., Dosi, 1988; Nelson & Winter, 1977), which is used to examine macro-issues such as patterns of diffusion across nations and industries and inter-sectoral differences in innovation propensity, and; (b) an organizations-oriented tradition (e.g. Cooper & Kleinschmidt, 1987; Damanpour, 1991), which is used to examine micro-issues such as the influence of structures, processes, and people on how specific products are developed. In the first stream, speed refers to the rate at which an innovation is diffused throughout a population of organizations (Rogers, 1983). In the second stream, speed refers to the rate at which a product is transformed from an idea to a marketable entity (Stalk & Hout, 1990). This dissertation focuses upon the second stream, that of intra-organizational product development.

There are also several existing streams of research specific to intra-organizational innovation speed. They can be categorized by (a) level of analysis and (b) type of analysis (see Table 1). First, writings in this field have addressed speed-related issues primarily upon three levels: the organization, the project, and the individual. Those who adopt the organizational level of analysis discuss general policies which firms can adopt to pursue an

TABLE 2-1
Summary and Categorization of the Innovation Speed Literature

TYPE LEVEL	LITERATURE REVIEWS	PERSONAL EXPERIENCE	BROAD SURVEYS	CASE STUDIES	DEDUCTIVE HYPOTHESES TESTING
ORGANIZATIONAL	1 Emmanuelides (1991) Gilbert (1993) Millson et al. (1992) Sanderson (1991) Zahra & Ellor (1993)	2 Anyas-Weiss (1993) Bower & Hout (1988) Cordero (1991) Deschamps & Nayak (1992) Donovan (1994) Dumaine (1989) Gaynor (1993) Gold (1987) Gomory (1988, 1989) Meyer (1993) Patterson & Lightman (1993) Peters (1987) Rosenau (1988, 1990) Slade (1993) Smith & Reinertsen (1991, 1992) Sonnenberg (1993) Stalk (1988, 1993) Stalk & Hout (1990) Starr (1992) Towner (1994) Uttal (1987) Vesey (1991) Vincent (1989) Von Braun (1990) Wheelwright & Clark (1992) Wolff (1988, 1991, 1992) Zangwill (1993)	3 Blackburn (1992) Brown & Karagozoglu (1993) Gupta & Wilemon (1990) Karagozoglu & Brown (1993)	4 King & Penlesky (1992) Nayak (1990)	5 Ali et al. (1995) Birnbaum-More (1993) Carmel (1995) Flynn (1993) Mansfield (1988) Meyer & Utterback (1993) Nijssen et al. (1995) Schoonhoven et al. (1990)
PROJECT	6 Graves (1989) Griffin (1993) Meyer & Utterback (1993) Zirger & Hartley (1993)	7 Burkart (1994) Crawford (1992) Hall (1991) Wheelwright & Clark (1992)	8 Murmann (1994)	9 Mabert et al. (1992) Rosenthal (1992) Rosenthal & Tatikonda (1993) Takeuchi & Nonaka (1986)	10 Clark (1989) Clark & Fujimoto (1991) Cooper & Kleinschmidt (1994) Gee (1978) Handfield (1994) Keller (1986, 1994) McDonough (1991, 1993) Tabrizi & Eisenhardt (1993)
INDIVIDUAL	11	12	13	14	15 Gupta et al. (1992) Rosenau (1989)

overall speed-based approach. Those who adopt a project level of analysis discuss process-specific actions and approaches that can be or have been undertaken to accelerate products' development from concept to market. Those that adopt an individual level of analysis discuss person-specific preferences and perceptions which can affect the speed of product development.

Second, the innovation speed literature can be classified by the type of analysis undertaken, ranging from purely conceptual literature reviews to drawing upon personal experiences, conducting broad-based surveys, analyzing cases or particularly illustrative examples, and systematically testing hypotheses -- these categories are similar to those used by Tornatzky and Klein (1982) in their meta-analysis of the innovation literature. Those who conduct literature reviews essentially argue from the writings of others, mostly academics. Those who write from personal experiences essentially argue from their related professional backgrounds, which are frequently extensive. Those who conduct broad surveys essentially argue from opinion/perception samplings which seek aggregate, "in-general" type responses. Those who conduct case studies essentially argue from small scale observations. Finally, those who systematically test hypotheses argue from better controlled and generally more valid field-studies.

2.4 Analysis of Past Research

The categorization of the literature is useful in understanding the conditions associated with innovation speed. As Table 1 indicates, the studies have focused on different units of analysis. Some variables that are important at the organizational level may not be important at the project level and vice versa. Moreover, some variables that are measurable at the project level may not be operationalized at the organizational level (e.g., degree of change attempted, project leader strength). Therefore, it is important to discern the applicability of these studies for the research questions by examining the unit of analysis used by them. By referring to the type of studies, one gets a better assessment of the basis of conclusion proposed by these authors.

Overall, the above categorization reveals that these works have broadened our knowledge of how a wide variety of factors relate to innovation speed. However, it also highlights several shortcomings in the literature which limit its scholarly and practical usefulness, namely a lack of theoretical development and model building and a dearth of systematic and empirical tests of proposed relationships, especially at the project level. Further, a finer-grained analysis discloses that there appears to be some variability in terminology and the measurement of variables, including innovation speed itself. These limitations underlie the following three general types of inconsistencies found in the literature, broadly categorized as (a) contradictions in assessment regarding the contextual applicability of speed; (b) contradictions in prescription regarding different methods to increase speed, and; (c) contradictions in prediction regarding important outcomes of speed.

2.41 Limitations within the Literature. Innovation speed is increasingly important to the survival and growth of organizations competing in industries that are characterized by shrinking product life-cycles. However, there appears to be a lack of conceptual integration and systematic empirical support for propositions related to the three types of inconsistencies outlined above. Only recently have authors examined the underlying theoretical constructs to innovation speed (e.g., Zirger & Hartley, 1993; Tabrizi & Eisenhardt, 1993). Managers need to know which factors best explain and predict differences in innovation speed, when they are appropriate, and what happens when they are adopted. The literature review approach used by the earlier studies (Table 1, column 1) have added little new information to our cumulative knowledge. Conclusions drawn by these studies are primarily based more on conjecture and not objective analysis of empirical evidence. The personal experience approach (Table 1, column 2) is reflective, and these authors offer several interesting ideas distilled from managerial practice. However, the works based upon personal experience lack both conceptual foundation and systematic empirical evidence. The survey approach reported in the literature (Table 1, column 3) deals with general perceptions and opinions of a few informants at an aggregate level as opposed to a project level. This raises questions of validity and reliability (Kerlinger, 1986). The case study approach (Table 1, column 4) is comprised of a limited number of illustrative examples and, although going into more depth than other research approaches, is plagued by small sample sizes that raise questions of generalizability. The systematic hypotheses testing approach (Table 1, column 5) produces the most valid and reliable information.

Furthermore, the project level of analysis is most directly relevant to innovation speed -- this is because projects are accelerated, not individuals or organizations. Those adopting an organizational level of analysis (Table 1, row 1) collapse the results of firms' many new product innovation projects, obscuring each project's particular characteristics and their impact upon speed-related outcomes. Additionally, by asking for in-general responses and not providing a concrete referent to respondents, individuals may be less accurate in their estimations of "average" time of development as well as relevant antecedent factors such as "average" use of external sources of technology and "average" team autonomy. Those adopting an individual level of analysis (Table 1, row 3) cover only a minor part of the picture and tend to be impressionistic and consequently less reliable and valid. Adopting a project level of analysis (Table 1, row 2) enables researchers to capture unique situational attributes which speed up or slow down actual projects, consistent with Downs and Mohr's (1976) prescribed innovation-decision design which views innovation processes and outcomes as unique events involving different organizational, social, and individual variables.

The unit of analysis is an important consideration in theory building. Variables which are appropriate in explaining the differences among organizations in terms of their ability to accelerate innovations may not be either operational or meaningful in explaining why one project is completed faster than another in the same organization. My focus in this dissertation is on the project level. As a consequence, the variables at the organizational and individual levels are of interest in this analysis to the extent that they explain or predict innovation speed at the project level.

Thus the most relevant research category is comprised of the studies which examine actual projects through systematic observations and hypotheses testing -- these studies are grouped in cell 10 of Table 1. However, even here theoretical development is modest and there is little or no attempt made at conceptual integration. Further, many of these works can be seen to have several shortcomings. For example, Keller's (1986) study takes place entirely within one organization and hence is susceptible to problems with validity and generalizability.

Cooper and Kleinschmidt (1994) examine the effects of several antecedent factors upon innovation speed by grouping firms into three speed-based classes and hence never test directly the impact of factors upon a continuous measure of time. Additionally, McDonough (1993; McDonough & Barczak, 1991) examines one stage of the development process, the design stage, thus his findings may be constrained to this limited domain.

Therefore, a gap exists between, on the one hand, what we as scholars recognize are strategic practices related to speed and, on the other hand, what has been uncovered through systematic research efforts. To illustrate, McDonough and Barczak (1991: 4) argued that "there has been little research into the methods that can be used to speed up new product development" and that there exists a "combination of the importance of speeding up new product development...and a dearth of field studies on factors that contribute to rapid development." Brown and Karagozoglu (1993: 38) similarly observed that "past research related to these [speed-oriented] factors have been mostly based on case studies and anecdotal observations...empirical studies with larger samples are hard to find." Also, Crawford (1992) and Von Braun (1990) discussed several "hidden costs" or downsides of speed such as more mistakes, heavy resource usage, and workflow disruptions which contradict those who universally tout the virtues of innovation speed. Crawford concluded that, in the innovation speed literature, "so far we have seen too much specious reasoning and hoopla and not enough hard data" (1992: 197).

Moreover, despite the limited number of attempts to develop a conceptually-based model of innovation speed and empirically test it--or more likely because of these factors--there have been numerous discrepancies in the use of terminology and the subsequent measurement of variables. As Table 2 indicates, innovation speed has been conceptualized and measured in different ways. For example, some refer to the elapsed time between the generation of an idea and the introduction of the product embodying that idea as the innovation speed. Others compare the elapsed time with budgeted or planned time. Still some compare the elapsed time of project X with the elapsed time of project Y. In addition to these conceptual differences, many efforts to measure innovation speed suffer from a "lack of rigor" in data presentation (Griffin, 1993: 113) making it difficult to compare measures of speed because of different starting and ending points (Ellis & Curtis, 1995; Rosenthal, 1992). Thus different works may be looking at different phenomena despite the fact that they all profess to be examining innovation speed. Thus we see much variability in conceptualizing the very phenomenon of innovation speed and consequent gaps in theories explaining these different phenomena.

2.42 Inconsistencies within the Literature. As a result of these limitations -- a lack of theory and model development, the dearth of empirical evidence available, and the differences in conceptualizing speed -- many have voiced contradictory prescriptions and reported contradictory findings with regard to (a) when innovation speed is appropriate; (b) how one can speed up innovation, and; (c) the results of an accelerated process. With regards to the appropriateness of speed, there is a growing counterbalance in the literature to the assumption that fast product development is universally desirable. For example, innovation speed may be purposefully slower in industries with relatively low competitive pressures because of the diminished need for speed as a source of competitive advantage (Birnbaum-

TABLE 2-2
Selected Definitions and Measures of Innovation Speed

AUTHOR(S)	DEFINITION AND MEASUREMENT OF INNOVATION SPEED
Gee (1978)	The time between the conception of an innovation (first invention or basic discovery) and its introduction into the commercial market.
Keller (1986; 1994)	The degree to which a project met an assigned schedule.
Mansfield (1988)	The length of time elapsed from the beginning of applied research (if there was any) by the innovator on a new product or process to the date of the new product's or process's first commercial introduction.
Clark (1989a; 1991)	The time elapsed between start of the development process and market introduction -- i.e., lead time.
Schoonhoven et al. (1990)	Waiting time to first product shipment of new firms.
McDonough (1991;1993)	The degree to which a project was ahead, on, or behind schedule.
Birnbaum-More (1993)	The degree to which a new product was introduced to the market, sooner or responded to another's competitive product introduction faster than others -- i.e., racing behavior.
Tabrizi & Eisenhardt (1993)	The time from the first meeting to consider the development of a new product to its stabilization.
Cooper & Kleinschmidt (1994)	The degree to which a product stayed on schedule, and the degree to which it was done relative to how fast it could have been done.
Ali et al. (1995)	Total project time from the beginning of idea generation to the end of market launch in months and in man-years.
Nijssen et al. (1995)	The degree of acceleration, or ratio faster than or slower than previous projects.

More, 1993; Porter, 1990). The competitive utility of speed is also called into question by some researchers who point to the general disadvantages of innovating quickly (Lounamaa & March, 1987; Von Braun, 1990) and pioneering new technologies (e.g., Golder & Tellis, 1993; Lieberman & Montgomery, 1988). Speed may also be slower in industries characterized by relatively static changes in (a) technology, because there are fewer opportunities to exploit with speed, and; (b) demographic preferences, because the need to keep pace with changing trends in demand is reduced. Further, the popular press is replete with stories of how speed is less desirable in industries where products directly impact the health and safely of their users, for example in pharmaceuticals, and that regulatory agencies are established in these areas for the specific end of reducing (overly) speedy product introduction.

There are also inconsistencies in this literature regarding methods for speeding up the innovation process. Consider for example the use of internal and external sources of technology. Some claim that (a) using external sources is faster; (b) using internal sources is faster, and; (c) there is no difference between the two in terms of accelerating the innovation process. One can place the scholarly-based contributions of Mansfield (1988), Karagozoglu and Brown (1993), and Rosenau (1990) in the first camp; Gee (1978) in the second; and McDonough and Barczak (1991) in the third. Likewise, one can place the experience-based contributions of Gomory (1989), Smith and Reinertsen (1992), and Peters (1987) in the first camp; Cordero (1991) and Zangwill (1993) in the second; and Gold (1987) in the third. These inconsistencies appear to be at least partly due to the fact that authors refer to different phenomena as exemplified by their choices of different units of analysis. For example, Mansfield (1988) has focused on the project level and attempted to show the underlying differences between Japanese and American practices. Of course, it is well known that Japanese firms tend to depend more on external sources of technology than their American counterparts. Thus we need to know the structural and cultural differences between the two countries and how that difference makes it possible to use external technology effectively.

Additionally, these inconsistencies may be partly due to the lack of theoretical integration in the innovation speed literature, where different approaches often address different parts of the innovation process without an explicit recognition of or appreciation for the larger picture. Though the innovation process is a relatively non-discrete and non-sequential stream of activities (e.g., Kanter, 1988; Meyers & Marquis, 1969; Schroeder, Van de Ven, Scudder, & Polley, 1989), it can be divided into general collections of tasks for the purposes of description and diagnosis (Daft, 1982; King, 1992; Zaltman, Duncan, & Holbek, 1973). One approach to understanding these collections of tasks is to divide them into pre-development and development activities (Kanter, 1988; Quinn, 1985). Using this distinction, one can observe in the innovation speed literature that some authors address primarily pre-development activities while others focus primarily upon actual project development activities, often to the neglect of the other set of variables[2].

Predevelopment activities relate to the strategic orientation of a project and provide the guidance and broad objectives for development activities (Bower, 1970; Quinn, 1985).

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[2] For the purposes of this dissertation, I have adopted a gestalt view of a project instead of focusing on the various sequential, and often interactive, stages. Although it is clear that completion of these stages is necessary for gaining speed of development, I have refrained from predicting how these factors influence the speed of any specific stage.

These factors include organizational policies and other paradigmatic activities related to the attributes of particular innovations which influence how much importance is actually placed upon fast product development (e.g., organizational culture and project stream breadth, project incrementalness and use of external sources of technology). Strategic orientation precedes the "bureaucratic release" of the project to the development team by broadly setting the context and influencing the direction of innovations (Spender & Kessler, 1995). Two distinguishable types of strategic orientation factors have been discussed in the innovation speed literature, relating to both criteria-setting and scope-setting. Criteria-related activities aimed at reducing development time include establishing a specific time goal, nurturing a supportive culture for speed, and adopting a speed-emphasizing reward system. These factors provide direction for "fuzzy" front-end development activity to focus and motivate timely development. On the other hand, scope-directed activities include mandates for incremental versus radical advance and more "creative swiping" of others' ideas and technologies. These factors reduce the uncertainty and complexity of otherwise fuzzy initiation tasks. Though conceptually distinguishable, both types of strategic orientation factors are proposed to speed up innovation by building interest and commitment for project objectives early on and limiting the amount of information needed for assessing the main issues and generating means of resolving them (Dutton & Duncan, 1987).

Alternatively, actual development factors refer to the arrangements and tools necessary to carry through with strategic plans and actually accelerate innovation efforts. These factors comprise the organizational capability of an intendedly fast innovator, or its "invisible assets" (Itami, 1987) -- i.e., manifestations of management skills, information processing and communication, and collective learning which allow firms to coordinate diverse concerns and pools of specialized knowledge as to increase their responsiveness and flexibility (Lawrence & Dyer, 1983; Prahalad & Hamel, 1990). Thus their primary influence is upon the timely execution of product innovation and its "bureaucratic capture" into the enveloping organizational system (Spender & Kessler, 1995). Two distinguishable types of organizational capability factors have been discussed in the innovation speed literature, relating to both staffing and structuring concerns. Staffing-related recommendations aimed at reducing development time include appointing a strong project leader and encouraging multifunctional team membership. These factors facilitate the movement of the project through the organization. On the other hand, structuring-directed recommendations include overhauling approval processes and attempting overlapping (i.e., concurrent) development (Crawford, 1992). These factors bridge otherwise diverse tasks to synthesize the project with broader organizational concerns. Though conceptually distinguishable, both types of organizational capability factors are proposed to speed up innovation by getting enough information to make the necessary modifications demanded by different parties and by building acceptance of the project as to incorporate it into the organization (Dutton & Duncan, 1987).

Notwithstanding inconsistencies with regard to contextual applicability and antecedent factors, there are also inconsistent predictions voiced with regards to the outcomes of innovation speed. While many argue that increasing the pace of innovation reduces development costs (e.g., Meyer, 1993; Rosenthal, 1992) and improves product quality (e.g., Takeuchi & Nonaka, 1986; Wheelwright & Clark, 1992), some claim that there are instead necessary trade-offs between innovation speed and (a) the costs of development, for it may take more resources to get the product out earlier (Crawford, 1992), and; (b) the quality of the product, for increasing speed may entail reducing performance specifications (Carmel, 1995; Smith & Reinertsen, 1991). Again, differences in the unit of analysis, conception of speed, and/or stage of development adopted by these authors may explain these inconsistencies.

2.5 Research Questions

In the previous discussion I have pointed out the complexity of issues related to innovation speed coupled with the inconsistencies among some of the research studies. Subsequently, there is a need for a conceptual model of innovation speed and the systematic testing of proposed relationships to sort out these inconsistencies regarding contextual domains, facilitating factors, and eventual outcomes. Thus three distinct research questions emerge: (1) When is fast product development appropriate (i.e., *the need for innovation speed*); (2) What factors differentiate fast innovation efforts from their slower counterparts (i.e., *the antecedents to innovation speed*)?, and; (3) How does innovation speed influence development costs, product quality, and ultimately project success (i.e., *the outcomes of innovation speed*)?

CHAPTER 3
CONCEPTUAL MODEL AND PROPOSITIONS[1]

3.1 Introduction

My analysis of the literature on innovation speed shows that one needs to focus upon the questions relating to speed with a consistency in defining the underlying issues related to unit of analysis, basis of conclusion provided by the various authors, and conception of speed. At an organizational level, one may question, for example, why and how 3M innovates faster than its competitors. This may seem to be an interesting and worthwhile question, but from a managerial point of view one may still wonder why some projects may be completed faster than others in 3M. This second question, leading to a focus on the project level of analysis and a conception of speed relating to time of product development, seems to be of value because the cumulation of the outcomes of projects in an organization makes that organization more or less faster than its competitors. Also, the variables at the project level are more managerially controllable than those at the organizational level.

Further, the discussion about innovation speed has become fashionable lately as we see rapid technological obsolescence in many industries, notably in computers and electronics. Accompanying this is an underlying bias towards speed, meaning faster is always better. Therefore, I have proposed a conceptual model of innovation speed illustrated in Figure 1 consisting of three interrelated yet distinct components: (a) need for speed, including macro factors in the industrial environment(s) of firms which influence the appropriateness of fast

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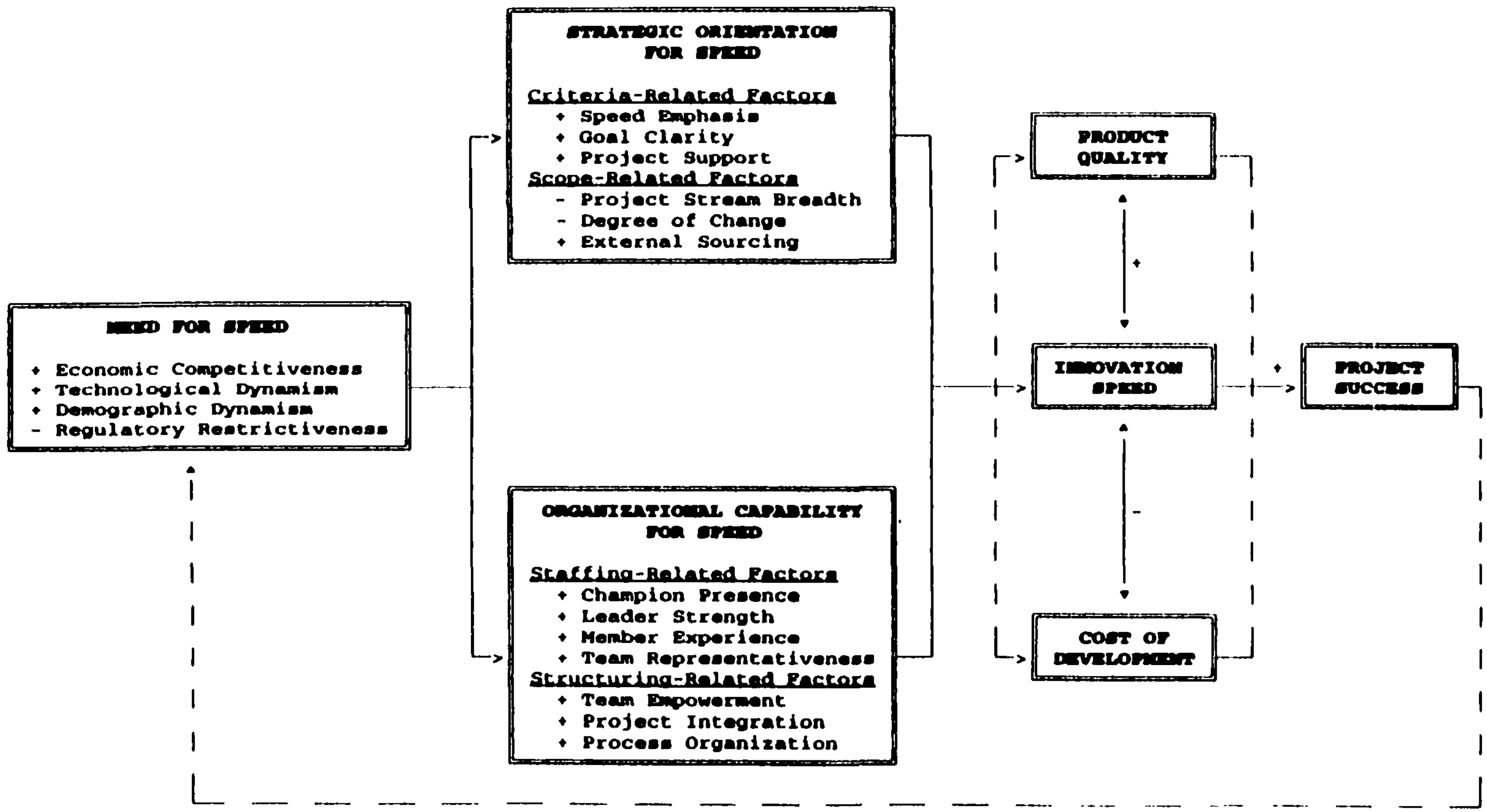
[1] Portions of this section appear in Kessler & Chakrabarti (1996).

FIGURE 3-1
Conceptual Model of Innovation Speed[a]



[a] A "+" denotes a positive relationship with innovation speed and a "-" denotes a negative relationship with innovation speed.

development; (b) antecedents to speed, including micro factors related to firms' strategic orientations and organizational capabilities which can either facilitate or retard the pace of development efforts, and; (c) outcomes of speed, including "bottom-line" implications related to speeding up product development.

3.2 Need for Innovation Speed

The utility of speed is due primarily to the increasing intensity of global competition, exponential advancements in technology, and the frequently shifting nature of customer demand (Birnbaum-More, 1993; Nijssen, Arbouw, & Commandeur, 1995; Wheelwright & Clark, 1992). Focusing upon innovation, these factors combine in many industries to shorter product life cycles and thus create the need for faster product development. Thus firms or divisions facing highly competitive, dynamic environments are predicted to bring products to market faster than those operating in more stable, static environments. Indeed, competitiveness (or munificence) and dynamism are well accepted dimensions of firms' task environments (e.g., Aldrich, 1979; Dess & Beard, 1984; Sharfman & Dean, 1991) which have been shown to influence the strategic positioning -- including innovation strategy -- of firms (e.g., Child, 1972; Hofer & Schendel, 1978; Snow & Hrebniak, 1980).

3.21 Economic Competitiveness. First, increased levels of competition from more diverse sources drives firms to become more aggressive in their pursuit of product niches and makes it more difficult to predict the dynamics of the market. Therefore, it stands to reason that the higher the level of competitive intensity in an industry, the more likely firms are to use speed as a basis for competitive advantage (Emmanuelides, 1991; Porter, 1990). This is consistent with Mitchell's (1989) finding that the greater the competitive threat, the earlier a firm will enter an emerging technical subfield, and Schoonhoven and colleagues' (1990) finding that high concentration and competitive intensity in an industry lead to faster cycle times for new firms. The antithesis of this argument is that, if competitive pressures are low, previously established cost and differentiated advantages may be more sustainable and the utility of speed would be reduced. However, a caveat to the prediction of a positive relationship between competition and speed is that it may be curvilinear, where moderate levels of concentration and competition best facilitates speed because the conflicting effects of intensity and resource munificence are balanced (Birnbaum-More, 1993; Kamien & Schwartz, 1975; Chakrabarti, Feinman, & Fuentivilla, 1983). That is, moderate competitive pressures simultaneously provide sufficient motivation, ample resources, and the opportunity for fast innovation to undercut the market positions of competitors (Zirger & Maidique, 1990). In summary, I make the following prediction:

PROPOSITION 1a: Greater *competitive intensity in a firm's economic environment* is associated with relatively faster product development.

3.22 Technological Dynamism. Second, in many industries the rapid pace of scientific and technological developments has created a broader range of product possibilities while frequently transforming dominant product designs and standards. One result of technological dynamism is that it enables more diverse product options, which increase the scope of available "solutions" to address internal weaknesses or unsatisfied market opportunities (Wheelwright & Clark, 1992). Thus the rapidly expanding availability of newer technology pushes new products out faster. Also, the increased availability of more advanced technological inputs increases the allure of new product development. This is because a high rate of technological advance increases the number of potentially lucrative niches which can be addressed, which has been shown to be positively related to the ability of a project to draw internal R&D funding as well as to its eventual success (Cooper & Kleinschmidt, 1987; Zirger & Maidique, 1990). Thus the attractiveness of newly reachable market demand pulls products out faster. Yet another result of rapid technological advance in firms' task environments is that dominant designs and standards are frequently transformed due to changes in core concepts or the way in which they are linked into a product (Henderson & Clark, 1990). This provides the opportunity for the successful entry of new firms by quickly developing new products utilizing the new technology, while simultaneously presenting a threat to existing firms which can be reduced through speedy innovation to pre-empt the entry of potential new entrants (e.g., Ettlie, Bridges, & O'Keefe, 1984; Porter, 1980). A corollary to this reasoning is that environments characterized by relatively slower technological development would present firms with fewer opportunities to exploit with speedy innovation. In summary, I make the following prediction:

PROPOSITION 1b: Greater *dynamism in a firm's technological environment* is associated with relatively faster product development.

3.23 Demographic Dynamism. Third, in many industries customers' more sophisticated and changing tastes have enhanced their sensitivity to subtle differences in product responsiveness and variety. Rapid market changes (i.e., demographic dynamism) shorten product life cycles and hence create more opportunities for product innovations (Emmanuelides, 1991). However, the high frequency of change which created these opportunities makes them relatively short-lived and hence presents a narrow window of opportunity for firms to capitalize upon them -- rapid product development increases the chances of reaching the window (Smith & Reinertsen, 1991). More fundamentally, one of the most robust findings in the product development literature is that there is a high positive relationship between the ability of a product to satisfy customer demand and its eventual success (Cooper & Kleinschmidt, 1987; Zirger & Maidique, 1990). Thus it follows that if users' needs are changing at a high rate, new product innovation must proceed faster to keep pace. Alternatively, if users are more static in their preferences, speed would be less useful in satisfying demand and might even be counterproductive if quicker product releases cannibalize the longer, more stable life cycles of existing products. In summary, I make the following prediction:

PROPOSITION 1c: Greater *dynamism in a firm's demographic environment* is associated with relatively faster product development.

3.24 Regulatory Restrictiveness. In addition to these characteristics of task environments, which bear upon a firm's ability to bring new products to market effectively and efficiently, institutional concerns for the health and safety of a product's end users can also influence innovation speed. Institutional environments are characterized by the elaboration of rules and requirements to which individual organizations must conform in order to receive legitimacy and support (Scott, 1992: 136). A critical element of institutional environments bearing directly upon innovation speed is the state, which is "the major source of legitimate order, the agent defining, managing, and overseeing the legal framework of society" (Scott, 1992: 139). More specifically, state regulatory agencies affect speed as a function of their restrictiveness, or degree to which they are perceived by an innovation group to restrict or constrain their activities by external mandates and regulations. (Van de Ven, Angle, & Poole, 1989: 62). That is, speed is purposefully curtailed in some industries by externally imposed barriers such as regulatory testing and approval processes which are established to delay products from getting to the market too quickly.

This restrictiveness, in turn, varies as function of the degree to which products have a potentially adverse effect upon the health and safety of their users. For example, firms operating in the pharmaceutical or hospital industries face stronger institutional pressures from public regulatory agencies than those in computer software or adhesives. For pharmaceutical companies and hospitals, the Food and Drug Administration acts as a brake which helps slow the introduction of potentially dangerous products and devices until such time that they have been demonstrated to be safe. As a consequence, the introduction of new drugs, (e.g., in the treatment of AIDS) has proven to be tremendously difficult and more time-consuming than if unregulated, given the need to test the efficacy of the drugs versus the desire to help as many patients as quickly as possible. Indeed, the case of Thalidomide is an example of how the rapid release of a product which impacts peoples' lives and welfare, without adequate safety assurances, can have disastrous consequences. Regulatory restrictiveness can slow speed even further if it interacts with the economic environment to raise entry barriers in an industry and thus lower competitive intensity. However, its effects may be moderated by the demographic environment, where a high desire for a product may prioritize the process and limit the external bottleneck imposed by regulatory review as compared to others in that same regulatory environment. In summary, I make the following prediction:

PROPOSITION 1d: Lower *restrictiveness in a firm's regulatory environment* is associated with relatively faster product development. This relationship may be moderated, however, by the strength of end-user demand for the product.

3.3 Antecedents to Innovation Speed

Notwithstanding a need for speed, many organizations are not fast innovators and those that have established innovation speed as a competitive advantage have not done so without overcoming time-consuming policies and practices (e.g., Prahalad & Hamel, 1990; Sheth & Ram, 1987). Fast innovators respond to a need for speed by successfully employing one or more speed-related facilitators (e.g., overlapping activities, multifunctional teams, strong project leaders) while slower innovators run into one or more speed-related barriers (e.g., sequential activities, functionally focused teams, weak project leaders). A knowledge of the ramps and roadblocks to speedy innovation is useful because it reveals the underlying assumptions of innovation speed and helps firms apply appropriate intervention(s) to pursue it. By *facilitators* I refer to factors which align a firm's strategic orientation and/or organizational capability with speed (i.e., create "fit"), while I use *barriers* to refer to factors which work against alignment (i.e., create "misfit"). This is consistent with those who discuss organizational context as opportunity or constraint upon individual and group behavior (Goldratt & Cox, 1986; Mowday & Sutton, 1993; Rosenthal, 1992; Rubenstein, Chakrabarti, O'Keefe, Souder, & Young, 1976).

Reviews of the innovation, time, and product-development literatures suggest that attributes from several levels of analyses influence the speed of innovations (see Table 1). Therefore, the second part of my model describes two conceptually different types of antecedents to innovation speed, strategic orientation and organizational capability, which follow from the previous analysis of the literature and represent the clusters of factors across these levels which facilitate or constrain an organization from developing specific products quickly (see Figure 1). These clusters are subsequently divided into sub-types and then into specific conceptual categories.

3.31 Strategic Orientation Factors: Criteria-Related. The first type of factor which can influence the speed of innovation is *strategic orientation*. It refers to the fundamental decisions related to the early stages of a project, including before the project is undertaken. Success of fast innovators is partially the result of consciously planned, accepted, and implemented policies designed with the express purpose of speeding development (Cordero, 1991; Nayak, 1990; Uttal, 1987). This view is central to the strategic choice perspective of organizations (e.g., Child, 1972) where firms are seen to be influenced by individuals or coalitions of individuals who make decisions about the design of structural forms, scope of product-market engagements, and objectives used as standards of performance. Our model includes these organizational level variables to discern their parametric influence on specific innovations. For example, by locating its personal computer division at Boca Raton, Florida, far away from the corporate bastion at Armonk, IBM changed the organizational level variables to increase the speed of innovations.

Following this line of reasoning, one type of strategic factor relates to the criteria top management assigns to projects in order to facilitate time-based orientations. Traditionally, cost and performance have been the two core metrics used to evaluate new product development projects (Mansfield, 1968; Stalk & Hout, 1990). As a result, viewing innovations by time-based standards represents a fundamentally different view of innovation strategy and hence a potential impediment to speeding up development efforts. Criteria-related strategic orientation factors can facilitate or impede innovation speed in several ways, relating to the following conceptual categories:

(1) the relative emphasis placed upon fast new product development.

(2) the degree of ambiguity in project goals and objectives.

(3) the degree to which top management supports projects.

Speed Emphasis. First, the emphasis placed on fast development is predicted to be positively related to innovation speed. Emphasis is represented in several dimensions, including: (a) relative importance, (b) formal reward system, and; (c) culture. The *relative* importance of time in new product development is the first and most basic indicator of emphasis. Thus, a barrier to speed is not making it a primary objective of the firm in general and of project development teams in particular (Hall, 1991; Patterson & Lightman, 1993). For time to become a standard it must be recognized as an equally crucial factor to market share and profit goals as is minimizing developmental costs and maximizing product quality. As Zahra and Ellor (1993:13) state,"competing by emphasizing speed requires more than structural changes - it requires a different frame of reference, a different perspective on competition". However, as several researchers (e.g., Gupta, Brockhoff, & Weisenfeld, 1992) and practicing managers (e.g., Rosenau, 1989; Stalk & Hout, 1990) have reported, time is consistently de-emphasized or traded-off for cost reductions and product enhancements.

Trading off time for cost could take the form of denying key resources to projects that could accelerate them (Gupta & Wilemon, 1990). For example, a short-term orientation in accounting systems might view an up-front outlay of resources as an expense rather than an investment in reducing future expenses through more efficient and shorter development cycles. For example, a U.S.-Japanese study partially attributed Japanese firms' faster innovation processes to the fact that they were much more willing to invest extra resources to reduce the time taken to develop and introduce new products (Mansfield, 1988). Alternatively, trading off time for quality could involve failing to freeze product specifications and instead frequently changing them to incorporate new technological advancements as they become available -- this is often referred to as "creeping elegance" (Gupta & Wilemon, 1990) or "features creep" (Stalk & Hout, 1990). Slower projects are often delayed because product specifications are not stabilized early, forcing development teams to constantly make design adjustments while manufacturing faces delays in subsequent re-tooling and start-ups.

A second indicator of emphasis is the nature of reward systems. The manner in which an organization dispenses rewards is the most tangible and direct indicator of its goals, or what it regards as important (Kerr, 1975; Lawler, 1973, 1990). As a consequence, reward systems can promote behaviors consistent with or contradictory to speed, and if organizations want to speed up product development, they need to design pay and promotion systems that will reward behaviors facilitative of this direction. For example, dispensing rewards based solely upon cost reduction represents an ineffective way of enhancing motivation and directing attention upon speed (Kidder, 1981; Rosenau, 1990; Tabrizi & Eisenhardt, 1993). Also, reward disbursement at the individual rather than the group level of analysis is less likely to promote interaction and information-exchanges within a project (Bower & Hout, 1988; Deschamps & Nayak, 1992; Meyer & Purser, 1993; Peters, 1987) and this approach signals to organizational members a lack of time-based priorities (Meyer, 1993; Takeuchi & Nonaka, 1986). That is, rewarding employees on an individual basis motivates them to compete with one another and not to help one another (Sisco, 1992). To facilitate time-based behaviors, organizations can adopt gainsharing programs which allow teams to share in the profits earned from accelerated processes and increased productivity (Lawler, 1986) and/or distribute rewards based upon the evaluation of co-workers because evaluating each other provides motivation to interact in a positive manner (Ilgen & Feldman, 1983; Norman & Zamacki, 1991). Evidence from the motivation literature (e.g., Kerr, 1975) supports that in general it is foolish to hope for a "Behavior A" (e.g., speedy development) while rewarding a "Behavior B" (e.g., cost-reduction or feature enhancement), and this principle has been shown to apply equally well to research and development activity (Ford, 1996; Jain & Triandis, 1990; Schuster & Zingheim, 1992; Thamhain & Wilemon, 1987).

Related to reward system orientation is a third indicator of emphasis, the more subtle and informal guidelines that reflect priorities and influence the direction of organizational activities -- namely organizational culture (Smircich, 1983). Through culture the organizational mind-set can be changed, albeit not easily, from valuing cost and performance to valuing speed (Anyas-Weiss, 1993; Rosenthal, 1992). Though cultural change is one of the more difficult tasks an organization may attempt, instructing and teaching managers how to represent the values of innovation speed (e.g., through time-based success stories and symbols extolling the virtues of speedy development) can enhance the pace of development. For example, Dumaine (1989) reports that Honda actually circulates its engineers through Formula-1 teams so that they will think about the "racing spirit". These types of speed-based values include an acceptance/promotion of failures, risk-taking, and learning (Meyer, 1993; Peters, 1987).

First, innovation speed often requires that people make more mistakes (i.e. fail) at a faster pace because, in Tom Peter's (1987: 260) words, "there are an almost irreducible number of failures associated with launching anything new--for heavens sake, hurry up and get them over with." Second, a certain degree of risk taking is necessary, lest individuals adopt status-quo orientations and become overly conservative. Innovation speed often requires doing things differently (i.e., taking chances) instead of simply doing the same things faster (Cordero, 1991; Dumaine, 1989). In this vein, Ford (1996) argues that an organization's "risk orientation" can promote or inhibit creative action. Third, learning helps employees develop the skills, knowledge, and abilities which enable fast-paced development. This is consistent with the idea that innovation is facilitated by "subtle control", or freedom with direction (Clark & Fujimoto, 1991; Itami, 1987; Van de Ven, 1986). For example, Damanpour (1991) found that a positive attitude toward change was significantly related to innovativeness. Also, Dougherty (1992; Dougherty & Heller, 1994) found that innovation was furthered when different functional groups' routines were synthesized by a common belief system (i.e., a shared culture). In summary, I make the following prediction:

PROPOSITION 2a: Greater *emphasis upon innovation speed* is associated with relatively faster product development.

Goal Clarity. Second, the clarity of project related goals and targets is predicted to be positively related to innovation speed. Clarity of goals can be shown in several dimensions, including: (a) clear, specific time-based objectives, and; (b) a clear, specific product concept. Ambiguous definition of products' time-based objectives can slow new product development and ultimately reduce the success of projects (Rubenstein, et.al., 1976). It is axiomatic to organizational theory that managers and employees, when faced with several parameters of performance, will attend to and seek to attain the most visible of these criteria (March & Simon, 1958; Thompson, 1967). Therefore, organizational recognition of the importance of time is not enough to ensure that it is indeed prioritized by development teams -- it must be quantified just as costs and performance (Takeuchi & Nonaka, 1986; Thamhain & Wilemon, 1987). Indeed, although applied research on goal-setting in organizations suggests that telling people to "work faster" should have some impact upon development speed, it also suggests that this will probably have less of an impact than well conveyed, specific timetables (Locke & Latham, 1990). Similarly, there is much research on group processes in organizations to document the effectiveness of specific, clearly defined time-based objectives in shaping behavior (e.g., Gersick, 1988). For example, the productivity of engineers and scientists was seen to be positively related to the deadlines and time pressures teams faced (Andrews & Farris, 1972) -- this consistent with an inverted Parkinson's law, that work will collapse to fill the time available for it (Bryan & Locke, 1967). Conversely, failing to establish clear time-based objectives has been observed to slow down product development (Meyers & Wilemon, 1989; Murmann, 1994).

Inaccuracy and vagueness of the product concept can also slow development efforts. First, an often recognized reason for project delays is a less than satisfactory understanding of projects in the "fuzzy front end" of development (Gupta & Wilemon, 1990; Smith & Reinertsen, 1992; Wheelwright & Clark, 1992). Top management's recognition, quantification, and representation of speed-based benefits is not enough -- early misunderstandings of product targets necessitate many changes and hence cause delays in the design, marketing, and production stages of new product development (Cooper & Kleinschmidt, 1994; Thamhain & Wilemon, 1987). This is because no matter how fast a firm progresses through the early stages of projects, overall development time will remain lengthy if they are forced to continuously recycle back to correct gaps between a desired product concept and actual product development. Second, ambiguous project concepts allow for more speculation and conflict about what is to be produced per se, which can result in time-consuming re-adjustments and debates. That is, designers and other development personnel are forced to "shoot at fuzzy or moving targets" rather than clear objectives -- this increases the uncertainty surrounding tasks and makes it difficult to obtain necessary commitments for fast development (Stalk, 1993; Zangwill, 1993; Zirger & Hartley, 1993). In summary, I make the following prediction:

PROPOSITION 2b: Greater *goal clarity* is associated with relatively faster product development.

Project Support. Third, the amount of support given to a project is predicted to be positively related to innovation speed. Project support is demonstrated by the degree of top management interest in a project, which has been observed to influence the speed of development efforts (Cooper & Kleinschmidt, 1994; Mabert, Muth, & Schmenner, 1992; Page, 1993; Zirger & Maidique, 1990) mainly by providing direction and setting priorities (i.e., as a strategic orientation, criteria-related variable). This is consistent with Gupta and Wilemon's (1990) argument that top management's influence is mostly in "climate-setting" and Smith & Reinersten's (1991: 241) assertion that "unless top management is truly interested in faster product development -- and it shows -- little can be done by lower-level managers and workers to speed up product development". More specifically, the degree of interest top management shows in a project can influence its rate of development by (a) increasing the flow of financial and physical resources to it (Chakrabarti, 1974; Chakrabarti & Hauschild, 1989; Emmanuelides, 1991; Rosenau, 1988; Rubenstein, et.al.,1976); (b) attracting the best people to it (McDonough & Spital, 1984; Rosenau, 1988); (c) increasing motivation of project members by giving the project a "high-profile" and thus putting extra pressure on them (Gupta & Wilemon, 1990; Smith & Reinersten, 1991); (d) reducing delays by providing timely referrals and decisions (Rosenau, 1988); (e) helping to overcome organizational resistance (Brown & Eisenhardt, 1995; Mabert, et.al., 1992), and; (f) facilitating coordination and communication both within the project team and across departments (Chakrabarti & Rubenstein, 1976; Smith & Reinersten, 1991). In summary, I make the following prediction:

PROPOSITION 2c: Greater *project support* is associated with relatively faster product development.

3.32 Strategic Orientation Factors: Scope-Related. A second type of strategic orientation factor affecting innovation speed relates to the scope of innovation efforts. More specifically, doing too-much in terms of the number of projects initiated or the size of specific projects restricts a firm's ability to speed products to market. This is because uncertainty and complexity are increased exponentially with any increase of project stream and individual project size, thereby increasing the problems and challenges to speed. In essence, scope concerns relate to biting off too much relative to ones processing ability, for undertaking more rather than fewer tasks lengthens development time. Though on the surface this may seem obvious and perhaps uninteresting, these factors are consistently reported as sources of departure which differentiate fast and slow innovators (e.g., Clark & Fujimoto, 1991; Gee, 1978; Murmann, 1994; Schoonhoven, Eisenhardt, & Lyman, 1990). Scope-related strategic orientation factors can facilitate or impede innovation speed in several ways, relating to the following conceptual categories:

(1) the relative broadness of the project stream.

(2) the degree of change attempted.

(3) the degree to which externally sourced ideas and technologies are used.

Project Stream Breadth. First, the relative degree of breadth of product development project streams is predicted to be negatively related to innovation speed. The more projects an organization undertakes (i.e., the more innovations "in the pipeline"), the thinner it is forced to spread its resources between them. This is supported by King and Penlesky's (1992) finding that faster projects were characterized by less competing projects relative to capacity constraints. Breadth is represented in several dimensions, including competition for financial, physical, and human resources (Emmanuelides, 1991). With regard to financial resources, top management is faced with the increasingly difficult tasks of monitoring and funding them. A crowded project stream invariably results in some projects which get stuck in a resource glut and languish while awaiting reviews and funding decisions (Smith & Reinertsen, 1992). With regard to physical resources, materials, space, and equipment are also finite commodities that must be allocated among competing projects (Bower, 1970), and the lack of them could create artificial bottlenecks in the development process. With regard to human resources, individuals tend to be assigned to multiple projects, which limits their attention and time available to commit to any one project. These conditions represent "project overload", where an overabundance of projects severely drains the attention and capacity of both line and staff functions essential to the speedy completion of new product development[2].

Thus in addition to managing an individual product development project poorly, poor

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[2]Although organizations like 3M handle many projects simultaneously, I emphasize the importance of munificence of resources allocated to new product development. The "project overload" due to breadth of project stream occurs because of a lack of sufficient resources to allocate to projects. Another aspect of overload to be considered is the diversity in technological field, where companies engaged in too many technological fields may be spreading their knowledge resources too thinly (Bierly & Chakrabarti, In press; Prahalad & Hamel, 1990).

project stream management can also slow down speed-related efforts (Clark & Fujimoto, 1991; Wheelwright & Clark, 1992). Though perhaps self-evident, a lack of focus has been repeatedly reported to slow down many intendedly fast innovators. For example, Murmann (1994) found that the more projects that are carried out simultaneously, the longer the average time it takes a firm to bring each individual project to market. Similarly, Smith and Reinertsen observed that "development projects are slow mostly because they spend most of their lives waiting to be worked on" (1992: 49). In summary, I make the following prediction:

PROPOSITION 3a: Greater *project focus* is associated with relatively faster product development.

Degree of Change. Shifting the level of analysis downward, the amount of change attempted in a project is predicted to be negatively related to innovation speed. New product development projects can be categorized by their radicalness or degree of attempted advancement (Dewar & Dutton, 1986), where more radical innovation is relatively newer to the focal organization and represents a greater departure from existing practices (Damanpour, 1991; Ettlie, et.al. 1984; Henderson & Clark, 1990; Meyers & Marquis, 1969). Strategic issues, including technological innovation, that have a broad scope in the operation of a firm are generally slower to be initiated but are typically implemented faster (Dutton & Duncan, 1987). In these broad issues, it is more difficult to build a consensus among the constituents and the uncertainty is higher due to difficulty in obtaining relevant information. However, it is postulated that, once implemented, broad strategic issues may be implemented faster due to wider bases of commitment and more sources of feedback (Dutton & Duncan, 1987).

Despite this complex relationship, there seems to be a general consensus that the loss of time in new product development caused by attempting more radical advances outweighs any downstream time gain. That is, though the allure of the big-step forward is powerful, it has been consistently observed that projects which entail major changes tend to take longer than those which represent more incremental departures from the status quo (Karagozoglu & Brown, 1993; Peters, 1987; Rosenau, 1990; Starr, 1992). This is because radical innovation is more complex and increases risks and uncertainties, information needs, workloads, and people involved in projects (Dewar & Dutton, 1986; Emmanuelides, 1991; Slade, 1993; Smith & Reinertsen, 1992; Stalk & Hout, 1990). Consistently, some recommendations to reduce time to market involve (a) following the Japanese principle of "kaizen", or taking small frequent steps forward, and; (b) developing underlying core technologies and product platforms (Meyer & Utterback, 1993; Prahalad & Hamel, 1990) which spawn a number of rapidly marketable, incremental products over time to address various niches in a defined segment. Several empirical studies confirm that undertaking a big change project slows development while undertaking an incremental change project speeds development (Clark, 1989a; McDonough, 1993; Murmann, 1994; Schoonhoven et al., 1990).

It should also be noted that, in addition to being an important antecedent condition, radicalness is a widely used and typically acknowledged contingency factor in the innovation process (e.g., Damanpour, 1991; Dewar & Dutton, 1986; Ettlie et al., 1984). That is, because of differences in the degree of change attempted, many have shown that the processes involved in more and less radical innovations are different. This is consistent with some research which suggests that various antecedent conditions will have a different effect upon the speed of innovation depending on its radicalness (McDonough, 1993; Tabrizi & Eisendardt, 1993). For example, McDonough (1993) argues that one set of leader and member characteristics will facilitate routine projects while another set of leader and member characteristics will facilitate radical projects. In summary, I make the following prediction:

PROPOSITION 3b: Lower *degree of change* attempted is associated with relatively faster product development. Additionally, degree of change will moderate the relationship between other antecedent conditions and innovation speed.

External Sourcing. A third strategic orientation, scope-related factor that can slow new product development is a pre-occupation with doing all necessary work in-house. Regardless of how many projects are undertaken or how ambitious each project is, time can still be saved if organizations consciously limit the tasks required by seeking out externally available components. Referred to as the "not-invented-here syndrome", firms often lose time because they insist upon doing all the work themselves instead of speeding up projects by selectively borrowing already completed advances by others (Burkart, 1994; Gomory, 1989; Peters, 1987). The not-invented-here syndrome is formally defined as the tendency of a stable research group to believe it possesses a monopoly of knowledge in its field, thereby rejecting new ideas and technologies from the outside (Jain & Triandis, 1990; Katz & Allen, 1982). That is, slower innovators "re-invent the wheel" more than their faster counterparts (Deschamps & Nayak, 1992), while fast innovators seek out partners to keep on the cutting edge (Meyer, 1993). For example, several studies point to a preoccupation with internal development as a barrier to shortening the innovation process, particularly among U.S. firms (Karagozoglu & Brown, 1993; Mansfield, 1988; Gee, 1978)[3].

Gold (1987) has pointed out that external contracting may accelerate product development. In order to cope with the resistance to external ideas or externally generated technologies, firms can develop a more receptive culture in which collaborative efforts are facilitated. This may involve some structural changes in the industry in terms of business functions such as the marketing, distribution, and cooperative financing of projects. For example, IBM was able to introduce its personal computers at a much faster pace than its traditional lines of computers by adopting the operating system developed by Microsoft. The open architecture of the IBM personal computers then facilitated the development of application software. Thus a network of cooperative product-market relationships evolved in the personal computer industry. Microsoft and the computer manufacturers played important roles in developing and nurturing such collaborative networks. In summary, I make the following prediction:

PROPOSITION 3c: Greater *use of external sources* is associated with relatively faster product development.

3.33 Organizational Capability Factors: Staffing-Related. In addition to strategic orientation, *organizational capability* factors affect innovation speed through the

[3] However, this is not meant to imply that the other extreme of *exclusively* using external sources is desirable either. Rather, some researchers argue that using a combination of internal and external sources enables the necessary learning and skill-development to occur within the project team so that they can then recognize, assimilate, and apply external knowledge (e.g., Cohen & Levinthal, 1990). Thus greater use of externally-sourced ideas and technologies would speed development only if they are used to supplement but not substitute for internal learning.

implementation of policies and objectives. As opposed to strategic orientation factors, these variables can act as facilitators or barriers to speed not because they (mis)direct the intentions of the organization but because an intendedly fast innovator succeeds or fails to develop the proper infrastructure for speeding up innovation processes. What I term organizational capability factors is consistent with others' use of the term (e.g., Bower & Hout, 1988) and is similar to what some authors term administrative/methods-based interventions (Crawford, 1992) and management tactics (Peters, 1987). Following the earlier analysis of the innovation speed literature, organizational capability factors can be seen to fall into two distinct groups - those that are staffing-related and those that are structuring-related.

Staffing-related factors refer to the (mis)assignment of key personnel within the development process, for "it takes very special individuals to guide new products to market with speed and certainty" (Donovan, 1994: 12). More specifically, staffing-related factors can act as barriers to speedy development when the appointment of project team leaders and/or project team members are poorly matched with speed-related objectives. Staffing-related organizational capability factors can facilitate or impede innovation speed in many ways, relating to the following conceptual categories:

(1) the presence of an influential product champion(s).

(2) the relative strength of leaders assigned to head project teams.

(3) the relative experience of members assigned to work on project teams.

(4) the degree of representativeness on project teams of internal and external interest groups.

Champions. Product champions, especially influential ones, are reported by many to speed new product development (e.g., King & Penlesky, 1992; Towner, 1994). Champions are characterized as highly committed and persistent individuals (Chakrabarti, 1974; Howell & Higgins, 1990) who typically demonstrate a willingness to sacrifice their position or prestige to make possible the innovation's completion (Maidique, 1980). Specific ways in which they increase the speed of innovation include their ability to overcome resistance, get resources, "sell" the project, coordinate activity and facilitate communication, and motivate key participants (Chakrabarti, 1974). Champions typically act as advocates to overcome organizational resistance and push the project through hurdles, roadblocks (Gupta & Wilemon, 1990) or apathy (Peters, 1987). They often work towards increasing a project's political capital, thereby increasing its ability to overcome obstacles and make it to market in a timely manner (Jain & Triandis, 1990; Roberts & Fusfield, 1988; Souder & Chakrabarti, 1978; Spender & Kessler, 1995). This may be accomplished by cultivating coalitions to keep the project moving amidst opposition (Chakrabarti & Hauschild, 1989; Howell & Higgins, 1990). Finally, champions can speed up development projects by coaching others through tasks involved in getting a product to market (Chakrabarti & Hauschild, 1989; Maidique, 1980). This is consistent with Schon's (1963) classic yet seemingly timeless message that new ideas often encounter sharp resistance, and that overcoming this resistance requires vigorous promotion. In summary, I make the following prediction:

PROPOSITION 4a: Greater *product champion presence and influence* is associated with relatively faster product development.

Leader Strength. The appointment of a weak project team leader -- an individual with relatively low technical, business, and/or social aptitudes -- can significantly slow down the innovation process (McDonough & Spital, 1984; Rosenthal, 1992; Smith & Reinertsen, 1991). This is because of the central role played by the leader in directing and helping team members (Farris, 1982; Jain & Triandis, 1990) as well as in assimilating and applying external information to development activities (Allen, Lee, & Tushman, 1980; Cohen & Levinthal, 1990). Additionally, weak project leaders often lack the ability to promote projects to outside members of the organization and facilitate their movement through potentially delaying bureaucratic snags (Peters, 1987), which can hinder successful schedule attainment[4]. This can occur because of relatively low standing in the organizational hierarchy, relatively low education level, or relatively short tenure in the organization (Kimberly & Evanisko, 1981). A weak leader is the antithesis of the "heavyweight" project leader who gathers firsthand information from intra- and extra-organizational sources related to the project, is able to communicate effectively with all parties concerned, directly applies technical and market-oriented knowledge to the project, and serves as the project's ultimate coordinator as well as decision maker. Heavyweight leaders have been shown to speed new products to market (Clark & Fujimoto, 1991; Cooper & Kleinschmidt, 1994; Wheelwright & Clark, 1992), so it stands to reason that weak leaders would fail to accelerate or even slow development. In summary, I make the following prediction:

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[4] Though this is similar to the effect of a product champion upon innovation speed, the two are conceptually distinct because a project leader's role is a formally defined organizational position while a champion's role is often a self-assumed, informal one (Chakrabarti, 1974).

PROPOSITION 4b: Greater *strength of the project leader* is associated with relatively faster product development.

Member Experience. With regards to project team members, assigning relatively inexperienced (i.e., "weak") individuals to project teams can also delay the new product development process. Many seasoned research and development managers argue that it is absolutely necessary that engineers have the most up-to-date skills to speed up projects (Gomory, 1989; Smith & Reinertsen, 1992), lest there exist a skill mismatch between what members bring to the project and what is required for speedy execution (Burkart, 1994; Rosenthal, 1992). This mismatch can be a function both of the human resource development and training system, which determines the general competency of available personnel, and the actual assignment of individuals from this pool to project teams.

Enablers for speed include the allocation of the "right" people to projects. These skills include both technically-related as well as teamwork-related competencies (Burkart, 1994; Flynn, 1993) so that the many, often diverse roles required of successful project team members (e.g., ambassador, scout) can be adequately filled (Ancona & Caldwell, 1990). Consistently, it has been shown that members with high levels of education and self-esteem increase the effectiveness of research and development project teams (Keller, 1986). Also, Damanpour (1991) found that member professionalism was positively and significantly related to innovativeness by increasing their boundary-spanning activity, self-confidence, and commitment to move beyond the status-quo. However, projects often become "holding areas for marginal performers" because senior management simply fails to appreciate the challenges involved in getting a product to market quickly (Donovan, 1994).

An additional indicator of project member experience is the degree of exposure to other aspects (i.e. functional areas) of product development. Assigning functional specialists with limited breadth can impede efforts to develop projects quickly because (a) it creates diverse frames of reference (Purser, Pasmore, & Tenkasi, 1994); (b) there is a lack of balance amongst members' commitment to and ability to contribute to the various functions of product development, and; (c) it precludes management's ability to redeploy project members to match the workload (Smith & Reinertsen, 1991), which can lead to time-consuming queues. Because of these obstructions, miscommunication and frequent conflict necessitate that time be used as a proxy for good integration of efforts (Meyer, 1993; Wheelwright & Clark, 1992). Thus Galbraith (1982) and Van de Ven (1986) argue that a way to bridge this problem of "part-whole relationships" is through teams with redundant functions (i.e., those staffed with experienced generalists).

Additionally, assigning members to several teams on a part time basis can slow product development because it limits the man-hours, attention, commitment, and ultimately project-specific experience available to the project. Thus the use of part-timers frequently results in time-consuming start up costs of reorientation and refocusing (Mabert, et.al., 1992; Slade, 1993; Smith & Reinertsen, 1991; Zangwill, 1993; Zirger & Hartley, 1993). However, given the human resource constraints facing many organizations today, it may be impractical to assign individuals exclusively to one project and let them carry it out to completion. A mid-level solution may be to adopt a project-matrix approach to staffing, where project managers oversee a core group of team members while functional managers assign additional personnel as needed to provide technical and related support activities. This has been shown to speed development at the Shell Development Company (Wolff, 1991) and, in a separate study, rated a close second to pure team assignment in terms of schedule attainment (Larson & Gobeli, 1988). In summary, I make the following prediction:

PROPOSITION 4c: Greater *project member experience* is associated with relatively faster product development.

Team Representativeness. Another staffing related factor influencing innovation speed is the degree to which teams are representative of pertinent interest groups both inside and outside organizational boundaries. That is, "If new product teams are able to fulfill their promise of shortening the product development cycle, they must develop the ability to obtain information and resources from diverse sources both inside and outside the organization" (Ancona & Caldwell, 1990: 25). This is because of the need for a high level of integration as to accurately represent the needs of relevant parties in the product --including major departments and external stakeholders (Shrivastava & Souder, 1987) -- in a reasonably-sized central group, the project team. External fit refers to synthesis between product specifications and customer/user needs (Cooper, 1986; Zirger & Maidique, 1990), while internal fit refers to synthesis between different functions' expertise (Souder & Chakrabarti, 1978; 1980). Thus representativeness is represented in several dimensions, including: (a) involvement of internal interest groups (i.e., multi-functionality) and; (b) involvement of external interest groups (i.e., network relationships).

First, a representation of internal interest groups on the project team can speed innovation. This multi-functional (or cross-functional) team has three characteristics that make it "indispensable" for speeding up operations (Meyer, 1993: 118): (a) it establishes a forum for iterative learning, including the overlapping of problem solving; (b) it creates a customer-based, value delivery focus instead of internally-oriented, functional silo focus, and; (c) it provides greater flexibility for managing change than more traditional structures. Having different yet complimentary skills of team members also helps build a "creative tension" that facilitates innovation activity, (Jain & Triandis, 1990; Pelz & Andrews, 1966) because different specialists are forced to converge on a product outcome, helping to overcome the often time-consuming difficulties involved in inter-department coordination (Mohrman, Mohrman, & Cohen, 1994). These problems can arise due to different sub-goals (March & Simon, 1958), needs (Pelz & Andrews, 1966), and cognitive orientations (Lawrence & Lorsch, 1967). Multifunctionality reduces some of these barriers in a timely manner through the creation of concrete linkages (Dougherty, 1992) and closer couplings (Ancona & Caldwell, 1990). Thus "holographic" groupings are created (Van de Ven, 1986) where the part (team) resembles the whole (organization) through an increased amount of and variety of information, which in turn improves the understanding of the project as a whole (Brown & Eisenhardt, 1995; Emmanuelides, 1991) and reduces the need for rework. This is consist with Damanpour's (1991) finding that the presence of a variety of specialists broadens the knowledge base and encourages the cross-fertilization of ideas.

Conversely, a lack of functional representation has been shown to create an overly narrow perspective on project teams (Karagozoglu & Brown, 1993; Mabert et al., 1992; Slade, 1993; Takeuchi & Nonaka, 1986; Vesey, 1991). In this scenario, time is wasted because communication is restricted and goals tend to be set later in the process (Anthony & McKay, 1992; Bower & Hout, 1988; Rosenau, 1988). This notion is consistent with Dougherty's (1990) finding that when one functional area dominated a firm's product development process (i.e., little multifunctinality), the market understanding matched that department's schema, and when a functional area was left out of the process, its schema was left out of the market understanding.

Second, a representation of external interest groups can similarly speed innovation. This is because poor relationships with relevant parties outside firm boundaries can also slow products from getting to market (Teece, 1992). This is especially true with regard to critical upstream (e.g., suppliers) and downstream (e.g., customers) parties where team participation tends to orient activities towards common objectives (Weiss & Birnbaum, 1989). Including suppliers on project teams brings in information and expertise regarding new inputs and technologies (Chakrabarti & Hauschild, 1989; Clark & Fujimoto, 1991; Smith & Reinertsen, 1991) and helps to identify potential problems so they can be resolved up front (Meyer, 1993; Zirger & Hartley, 1993). It also provides outsourcing and external acquisition possibilities that reduce the internal complexity of projects (Brown & Eisenhardt, 1995) and provide extra manpower to shorten their critical development path (Clark & Fujimoto, 1991; Smith & Reinertsen, 1991). Further, it coordinates communication and information exchanges better (Emmanuelides, 1991) that reduce delays due to poor supplier interface (e.g., waiting for parts to be delivered, misunderstandings and subsequent mistakes with regards to orders). It broadens the scope of tasks and issues by enabling part accessibility to be considered early on (i.e., it is a criteria or parameter), thus eliminating re-work if a design proves infeasible because of input difficulties (Clark & Fujimoto, 1991; Smith & Reinertsen, 1991). Finally, it creates a "co-developer" rather than a "lowest-bidder" mentality among suppliers, which helps them to internalizes project concerns and fosters a smoother working relationship (Meyer, 1993; Smith & Reinertsen, 1991).

With regard to customers, many claim that development time is reduced when end-users are included on development teams (Cooper, 1986; Cooper & Kleinschmidt, 1994; Meyer, 1993; Millson, Raj, & Wilemon, 1992; Peters, 1987; Von Hippel, 1986). Specifically, building close relationships with end-users can be a useful source of motivation (Karagozoglu & Brown, 1993), where for instance Van de Ven (1986) argues that direct contact with customers triggers action thresholds quicker and helps employees pay attention to new ideas, solutions, and opportunities. Second, end-users can help develop product concepts and features (Rosenthal, 1992), where for example Quality Functional Deployment incorporates the voice of the customer in product design to prevent downstream delays resulting from a mismatch between idea and need (Karagozoglu & Brown, 1993; Smith & Reinertsen, 1991). Third, steps in the development process can be reduced or eliminated. For example using end-user ideas reduces time-consuming market research studies, which in turn minimizes research and design phases since the idea and parameters are obtained directly (Gomory & Schmidt, 1988; Millson et al., 1992). Fourth, user involvement helps accurately forecast market trends and demands (Dougherty , 1990; Karagozoglu & Brown, 1993; Rothwell, et.al., 1974; Von Hippel, 1986), especially in fast moving industries, because their present needs will become general in the marketplace months or years in the future. This helps teams "get it right the first time" and limits the need for re-analysis and re-development.

In summary, I make the following prediction:

PROPOSITION 4d: Greater *project team representativeness* is associated with relatively faster product development.

3.34 Organizational Capability Factors: Structuring-Related. Structuring-related factors refer to the (dis)integration mechanisms within teams as well as the (dis)integration mechanisms between units. That is, speeding up innovation requires superior coordination both within and between relevant parties involved in the process (Keller, 1986; Takeuchi & Nonaka, 1986). Structuring-related organizational capability factors can facilitate or impede innovation speed in several ways, relating to the following conceptual categories:

(1) the degree of project team empowerment, or decision-making autonomy.

(2) the degree of project integration.

(3) the degree of development process organization.

Team Empowerment. First, decentralizing decision making autonomy -- including influence upon goals and targets, activities and tasks, and funding and resource allocation -- can speed development because it diffuses the power necessary to go against the status quo, increases workers' involvement and awareness in a project, and subsequently strengthens their commitment to it (Damanpour, 1991). Decision making autonomy also provides a buffer against excess outside interference (Ancona & Caldwell, 1990), reduces frequent, mandated changes in the product (Stalk & Hout, 1990), and limits the number of formal bureaucratic approvals required (Emmanuelides, 1991; King & Penlesky, 1992). The most direct outcome of not structuring autonomous teams is that too many "gates" are created where a preponderance of formal reviews and approval processes represent deviations along the critical path of projects that inevitably result in a longer development time (Hall, 1991; Zangwill, 1993; Stalk & Hout, 1990; Zirger & Hartley, 1993). That is, centralized responsibility often results in excessive planning, plotting, reviewing, and deciding (Deschamps & Nayak, 1992; Rosenthal, 1992; Stalk, 1988). Thus Blackburn (1992) has observed that the largest potential for time reduction tends to come from removing "white collar" waste, or non value-added activity such as formal approvals, which slow development without significantly improving the product. This is substantiated by the claim that about 90% of the time it takes to get a product to market is spent in administrative tasks (Dumaine, 1989), and an analysis by the Strategic Alignment Group highlighting the importance of empowered teams and flat structures to fast-paced innovation (Meyer, 1993). To compound this problem, a lack of decision autonomy may also result in slower development in the long run because when individuals do not make decisions it hinders their ability to learn from experience (Eisenhardt, 1989). In summary, I make the following prediction:

PROPOSITION 5a: Greater *project team autonomy* is associated with relatively faster product development.

Project Integration. Second, greater project integration can increase innovation speed. Integration is represented in several dimensions, including: (a) degree of task overlap or concurrentness in development, (b) strength of functional norms relative to shared project norms, (c) design-for-manufacturability, and; (d) proximity of team members. First, many firms engage in sequential versus overlapping development, which represents a barrier to speed insofar as there are poor logistics and transfer of tasks (Hall, 1991; Page, 1993; Rosenau, 1988; Vincent, 1989). This has also been referred to as linear rather than parallel/concurrent processing of tasks (Millson, et.al, 1992), "throwing the product over the wall" rather than coordinating efforts (Brown & Karagozoglu, 1993), and as a "relay race" method of phase-to-phase progression with functionally specialized and segmented divisions rather than a "rugby" method of constant, multi-disciplinary team oriented interplay (Smith & Reinertsen, 1991; Souder & Chakrabarti, 1978; Takeuchi & Nonaka, 1986). Concurrent engineering, according to the Institute for Defense Analysis (Handfield, 1994: 385), refers to "a systematic approach to the integrated concurrent design of products and related processes including manufacture and support. This approach causes the developers, from the outset, to consider all the elements of product life-cycle from conception through disposal including quality, cost, schedule, and user requirements." It is thus considered one of the most fundamental and effective facilitators of innovation speed, as evidenced in the logistics and operations management literatures where computer programs are widely used to identify the critical paths, slack times, and hence overlap potential of innovations (e.g., Zhu & Heady, 1994).

Conversely, a lack of overlap wastes time by forcing downstream tasks to wait for previous stages to be completed in their entirety, thereby lengthening the critical path of projects. It also limits the communications between functions, increasing the abundance of time-consuming design changes in the production phase of product introductions (Deschamps & Nayak, 1992; Vesey, 1991; Zahra & Ellor, 1993). This is because information is communicated in periodic "batches" (versus continuously), subjecting subsequent stages to technical risk as well as necessitating longer time periods to assimilate the information (Clark & Fujimoto, 1991; Rosenthal, 1992). Indeed, research suggests that breaking down information into smaller units which are constantly transferred from one stage to another produces faster, more efficient processes (Blackburn, 1992).

Second, overly strong functional norms can also slow down new product development efforts because they create myopia in the development process, subsequent conflict over direction and project goals, and ultimately the need for more time to resolve these conflicts (Clark & Fujimoto, 1991; Stalk & Hout, 1990). That is, under these conditions, individuals tend to prioritize the goals related to their different functions rather than the time-based objectives of the project (e.g., Dearborn and Simon, 1958). Due to the varying criteria employed by functional groups this can be quite problematic (Vinton, 1992). The subsequently strained relationships between different functionally-committed parties has been reported to significantly slow development efforts (Larson & Gobeli, 1988). Conversely, prioritizing project-specific goals over functional goals can facilitate communication and subsequent development speed. For example, Brockhoff and Chakrabarti (1988) argue that functions such as marketing and engineering must overcome "norms of exclusivity" and work together to create a fit between their efforts. Also, the Strategic Alignment Group argues that too much functionalism leads to different performance standards being set in different functions (versus clear, shared goals), accountability being functional instead of with project leaders, and communication occurring only through formal functional channels and limited to those with formal responsibility (Meyer, 1993).

Third, slow innovators typically fail to design for manufacturing , which is to say that they neglect speedy and efficient manufacturability as a product parameter. For example, manufacturability criteria include such elements as few parts, simplified designs, correct tolerances, and standard assemblies (Ali, Krapfel, & Labahn, 1995; Carmel, 1995; Meyer, 1993; Rosenau, 1990). Organizations which do not design for manufacturing create a mismatch or poor fit between upstream design and downstream development stages, thereby necessitating late changes in the product to fit unforseen manufacturing constraints (Clark & Fujimoto, 1991; Millson, et.al, 1992; Murmann, 1994; Wheelwright & Clark, 1992). That is, designing non-manufacturable products frequently results in work redundancy and recycling which impedes speed-oriented efforts (Vesey, 1991), primarily because production concerns are not being heard early in the process (Dean & Sussman, 1989; Hall, 1991; Smith & Reinertsen, 1991; Walleigh, 1989). IBM's "ProPrinter" project is an example of the time savings available from a design-for-manufacturing approach, where including a production specialist early in the product design stage of development reduced latent manufacturing problems and helped bring the ProPrinter to market quickly (Gomory, 1989).

Fourth, spreading out members of a project team can also lengthen development time insofar as communication is artificially limited both in quantity and quality (e.g., Allen, 1977; Jain & Triandis, 1990), making coordination and integration more difficult (Keller, 1994; Meyer, 1993). With regard to quality, highly uncertain and complex issues are forced to be resolved through information-poor media or infrequent meetings. Face-to-face communication enables more rapid feedback, decoding, and synthesis of complex information (Katz & Tushman, 1979) -- this provides a better fit with the fuzzy, often unpredictable nature of new product development. With regard to quantity, spreading people out over a greater distance tends to reduce the frequency of their interaction, which in turn impedes the development of personal relationships (Meyer, 1993) and intra-project learning (Purser, et.al., 1994). As a general rule, the lower the quality and quantity of information shared during product development the slower the process (Keller, 1986, 1994; Zirger & Hartley, 1993). Thus Peters argues that "numerous studies chronicle the astonishing exponential decrease in communication that ensues when even thin walls or a few dozen feet of separation are introduced. Hence all team members must 'live' together" (1987: 216). Consistently, many scholars (Mabert, et.al., 1992; Rosenthal, 1992; Takeuchi & Nonaka, 1986) and practicing managers (Slade, 1993; Stalk & Hout, 1990; Peters, 1987; Zangwill, 1993) point to a lack of "co-location" as a primary source of delay among innovation projects. In summary, I make the following prediction:

PROPOSITION 5b: Greater *project integration* is associated with relatively faster product development.

Development Process Organization. Third, the way in which the development process is organized can affect the speed of innovation speed. Development process organization is represented in several dimensions, including: (a) number of development milestones, (b) time spent in testing, and; (c) use of computer-aided-design tools. First, infrequent development milestones tend to reduce task motivation and create a sense of disorder within project teams, thereby slowing down new product development (Peters, 1987; Smith & Reinertsen, 1991; Tabrizi & Eisenhardt, 1993). Milestones serve as key targets which infuse team members with a sense of urgency and keep them focused upon time-based objectives (Gersick, 1988). Milestones also serve to implement previously discussed policies regarding clear time-based goals, for they structure the process by separating an otherwise formidable task into manageable parts. This further aids in translating overarching project goals into more concrete, more achievable ends which can increase task motivation during development (Locke, 1968; Bandura, 1977).

Second, infrequent testing often leads to late problem solving which can result in much re-cycling and slower project development. Slower projects tend to rely less upon tests than faster projects and hence uncover miscalculations, faulty designs, flawed performance, and other errors farther along in the development process. As a result of late discovery, there is a greater redundancy of work than if these errors had been uncovered sooner (Wheelwright & Clark, 1992). That is, more time spent in testing can speed up product development because the number as well as the severity of deviations along the critical paths of projects (i.e., errors) are minimized while a lack of testing allows these deviations to occur more frequently and more severely (Gupta & Wilemon, 1990; Mabert, et.al., 1992). Indeed, evidence from the computer industry supports the importance of frequent testing as a means of facilitating teams to meet time-based goals and thus for speeding up innovation (Tabrizi & Eisenhardt, 1993).

Third, using computer-aided-design tools represents a key technological opportunity to cut development time by reducing the time taken in individual stages and the time taken to move from one stage to another (Cordero, 1991; Smith & Reinertsen, 1991; Zangwill, 1993). Design and engineering man-hours can be significantly cut by employing computer-aided-design tools to automate what would otherwise entail complex computational and drafting procedures (Cordero, 1991; Tabrizi & Eisenhardt, 1993). That is, using these tools can speed the upstream functions which have such a large impact on downstream functions both in terms of how early they can be commenced and the frequency of changes required (Vesey, 1991). Additionally, using these tools enables information regarding specifications and other design parameters to be transferred quickly and with less error, thereby reducing between-stage delays (Karagozoglu & Brown, 1993; Mabert, et.al., 1992; Millson, et.al., 1992). For example, Kodak used computer-aided-design to improve inter-stage transfer and hence accelerate the introduction of the Funsaver camera into the marketplace. (Leonard-Barton, et.al., 1994). In summary, I make the following prediction:

PROPOSITION 5c: Greater *development process organization* is associated with relatively faster product development.

3.4 Outcomes of Innovation Speed

It is generally accepted that the three primary outcome measures of new product development which bear upon a project's success are time, cost, and quality (Clark & Fujimoto, 1991; Rosenthal, & Tatikonda, 1993). Though conceptually distinct, these measures are highly interrelated (Meyer, 1993). Thus it stands to reason that the speed of innovation affects and is effected by project costs and product quality.

3.41 Cost of Development. Traditionally it has been the belief that innovation speed is positively correlated with a product's cost of development (e.g., Clark & Fujimoto, 1991;

Graves, 1989; Page, 1993), defined as the total financial requirements and associated human resources needed to complete the project (Rosenthal, 1992). That is, speeding up development demands that a firm "buy time" by committing more man-hours, materials, and/or equipment to projects. However, a second group contends that shortening product development time brings about a higher level of self-consciousness which can result in increased efficiency of resource utilization and lower overall costs (e.g., Clark, 1989a). Along this line, innovation speed has been linked with increased coordination and subsequent reductions in costly work redundancy, errors, and recycling (e.g., Meyer, 1993; Rosenau, 1988). Moreover, faster development allows for less time to spend funds and thus provides a cap upon man-hours (Rosenthal, 1992).

More recently a third group claims that the theoretical relationship between speed and cost is a U-shaped function, where accelerating development reduces costs up to a point and after that requires more expenditures to shorten the time to bring products to market (Gupta, et.al., 1992; Murmann, 1994). In this perspective, shortening development time below the function's minimum (i.e., moving up the "U" to its left) increases costs due to additional paralleling and coordination expenditures. Thus an overly tight schedule burns resources because it pushes functions to the limit of organizational capabilities (Vincent, 1989). Similarly, lengthening development time above the function's minimum (i.e., moving up the "U" to its right) increases costs due to lost learning, reduced motivation, and higher variable expenditures (e.g., increased man-hours). Thus an overly loose schedule wastes resources due to dissipated efforts and lapses of attention (Vincent, 1989). This U-shaped function reconciles the first two views, where firms operating to the left of the minimum will experience higher costs and firms operating the right of the minimum will experience lower costs. However, proponents almost universally agree that most firms lie to the right of the minimum, where reductions in time bring about a reduction on development expenditures.

The impact of speed on costs remains a complex issue and depends upon a firm's own cost function. Moreover, one should consider the cost implications from perspectives of both short- and long-term planning horizons. Spending extra resources to accelerate an innovation can save many opportunity costs in the long term and can increase the efficiency of individuals' efforts as well as team interaction (Clark & Fujimoto, 1991). In summary, I make the following prediction:

PROPOSITION 6a: Faster product development is associated with relatively *lower costs of development*.

3.42 Product Quality. Notwithstanding the relationship with cost, it is believed that innovation speed is generally positively correlated with a product's quality, or the degree to which it satisfies customer requirements (Clark & Fujimoto, 1991). This definition of quality can be traced back to management-philosophers Deming (Gitlow & Gitlow, 1987) and Juran (Juran & Gyrna, 1988), who espoused a view that quality is derived from the satisfaction of consumer demands (i.e., its "fitness for use"), and is consistent with much of the current theorizing on quality (e.g., Dobyns & Crawford-Mason 1991; Gehani, 1993; Vroman, & Luchsinger, 1994). Today management scholars agree that although it can be conceived on many dimensions, ultimately, quality is measured in terms of customer satisfaction (Forker, 1991; Rosenthal, 1992). This is reflected in the popularity of Quality Function Deployment, which employs systematic techniques for relating product features and technologies to the needs of customers (Smith & Reinertsen, 1991)

Though fairly complex, a generally positive relationship between a product's development speed and its quality is proposed for several reasons. First, faster development is associated with higher rates of learning among employees (Eisenhardt, 1989; Patterson & Lightman, 1993) and the construction of core competencies related to developing new products (Sonnenberg, 1993). This is due partly to the increased frequency in which ideas are tested in the marketplace, mistakes are corrected, learning loops are completed, and knowledge is accumulated (Meyer, 1993). Second, forecasting is improved when time to market is reduced, for firms are required to accurately project into a shorter time period competitor movements, developments in component technologies, and customer tastes and expectancies (Wheelwright & Clark, 1992). As a result of improved forecasting, targeting is more accurate and products better fit the requirements of users (Deschamps & Nayak, 1992; Page, 1993). A third reason is that more advanced component technologies can be incorporated. That is, when comparing products which hit the market at the same time, the one which was quicker to market had the ability to incorporate more recent technological and scientific advances (Cordero, 1991). Hence, it will be seen as fresher and more current than its competitor products (Gomory & Schmidt, 1988). Finally, speed can increase the quality of a product because it facilitates a greater focus and commitment to project-specific goals (e.g., Clark, 1989b; Flynn, 1993). This is similar to Deming's argument for total quality management, whereby more efficient processes are associated with fewer errors and smoother operations (Patterson & Lightman, 1993; Takeuchi & Nonaka, 1986). However, a caveat to the above reasoning is that, if formal techniques such as Quality Function Deployment are not used to explicitly focus innovation efforts on consumer demand, quality can get lost in the narrow pursuit of speed as purely an end in itself rather than an instrumental end in the pursuit of overall project success (see Figure 1). That is, unfocused speed may compromise quality (contrast for example Boeing Aircraft's successful rapid roll-out of their 767 with the public relations fiasco surrounding Intel's introduction of the pentium computer chip). In summary, I make the following prediction:

PROPOSITION 6b: Faster product development is associated with relatively *higher product quality*.

3.43 Project Success. Notwithstanding a project's speed, quality, and cost, the ultimate "outcome" measure of new product innovation is overall project success. Success is represented in several dimensions, including; (a) goal attainment, and; (b) market advantage (Van de Ven, et.al., 1989). Consider first goal attainment, which is a more internally-driven metric. Organizations have multiple goals, and these goals are sometimes inconsistent or contradictory (Cameron & Whetten, 1983; Kanter & Brinkerhoff, 1981). It follows then that projects may be commenced for different purposes, therefore the process of labeling them successes or failures should be linked with these ends (Van de Ven, et.al., 1989). For example, a project may attempt to maximize traditional measures of financial return and/or market share. With regard to profit, many argue that speeding up innovation efforts will increase margins by entering market windows earlier and extending the life of a product (Smith & Reinertsen, 1991; Vesey, 1991) while also enabling firms to charge a premium price

(Meyer, 1993; Reiner, 1989). To this end, Dumaine (1989) reports that it is more profitable to bring a new product to market on time and over budget than late and on budget -- If a project runs six months late and is on budget, there is a 33% reduction in profit; if a project runs on time but 50% over budget, there is only a 4% reduction in profits. Thus speed is not necessarily equivalent to haste, consistent with previous discussions on concurrent engineering and quality, when it is prudently pursued as a means towards goal attainment and not as an end in itself.

With regard to market share, historically US firms have lost ground not because they were behind in science but because they were behind in product cycles by generations (Gomory, 1989). Innovation speed can address this problem by helping establish early market segments and customer loyalty (Gee, 1978; Stalk & Hout, 1990). Additionally, speedy product development combats market share lost through product obsolescence because firms replace their out-of-date product themselves instead of allowing their competitor to replace it with a more current version (Cordero, 1991). Moreover, speedy product development allows a firm to quickly develop second-generation models based upon feedback from original launches, thereby better satisfying market demands (Meyer, 1993). It is in this vein that Gomory (1989: 102) comments, "one cannot overestimate the importance of getting through each turn of the (product development) cycle more quickly than a competitor. It takes only a few turns for the company to build up a commanding lead".

A project's success can also be judged by how the new product does in competitive situations (Clark & Fujimoto, 1991; Griffin, 1993; Lengnick-Hall, 1992), which is a more externally-driven metric often used to balance measurements of internal satisfaction with that of actual commercial performance. This is because not all projects that satisfy internal goals actually perform well in the marketplace on a long-term basis (Rubenstein, et.al., 1976), and metrics such as profitability and market share are often unavailable because they are frequently aggregated at the product line or brand level (Griffin, 1993). Innovation speed may further the commercial success of new products in many contexts because, in competitive, dynamic environments, fast product development represents a "fit" between external situations and internal action (e.g., Lawrence & Lorsch, 1967; Miles, et.al., 1978). Here speed can help both pioneers and early followers succeed, and both of these strategies should be associated with faster product development than market defenders who focus upon more mature technologies. Hence Meyer's (1993: 11-12) argument that speed can further success because "as long as the global rate of change continues to accelerate, the competitor who not only recognizes the change but acts on it can achieve a competitive advantage...(and) when the competitive environment heats up, players seek any advantage they can...speed is one such advantage". It also follows that this relationship between success and environmental context should be dynamic, where success achieved through speedy innovation at time "t" would affect the nature of competition, technological advance, and customer preferences firms face at time "t+1". Of course, the degree to which speed could provide a competitive advantage is contingent upon other external factors as well, such as a restrictive regulatory environment which mandates lengthy, uncontrollable, and often indeterminant review times (e.g.,in the pharmaceutical industry). In summary, I make the following prediction:

PROPOSITION 6c: Faster product development is associated with relatively *higher project success.*

CHAPTER 4
METHODOLOGY

4.1 Introduction

This chapter details the decisions made for testing the previously discussed research propositions. First, the nature of the sample (i.e., the company field sites, product development projects, and individual respondents) will be described, including rationale for its selection and its general characteristics. Second, the method for collecting the data will be detailed, including entry-point interviews and the questionnaire instrument used. Third, the operational indicators of the study's variables will be reviewed, including those for innovation speed as well as relevant need, antecedent and outcome measures. For each measure, references will also be given to their corresponding item(s) on the questionnaire instrument and code names used in data analysis.

4.2 Sample

In this section I detail the rationale and processes whereby organizations, projects, and respondents were selected to participate in the study.

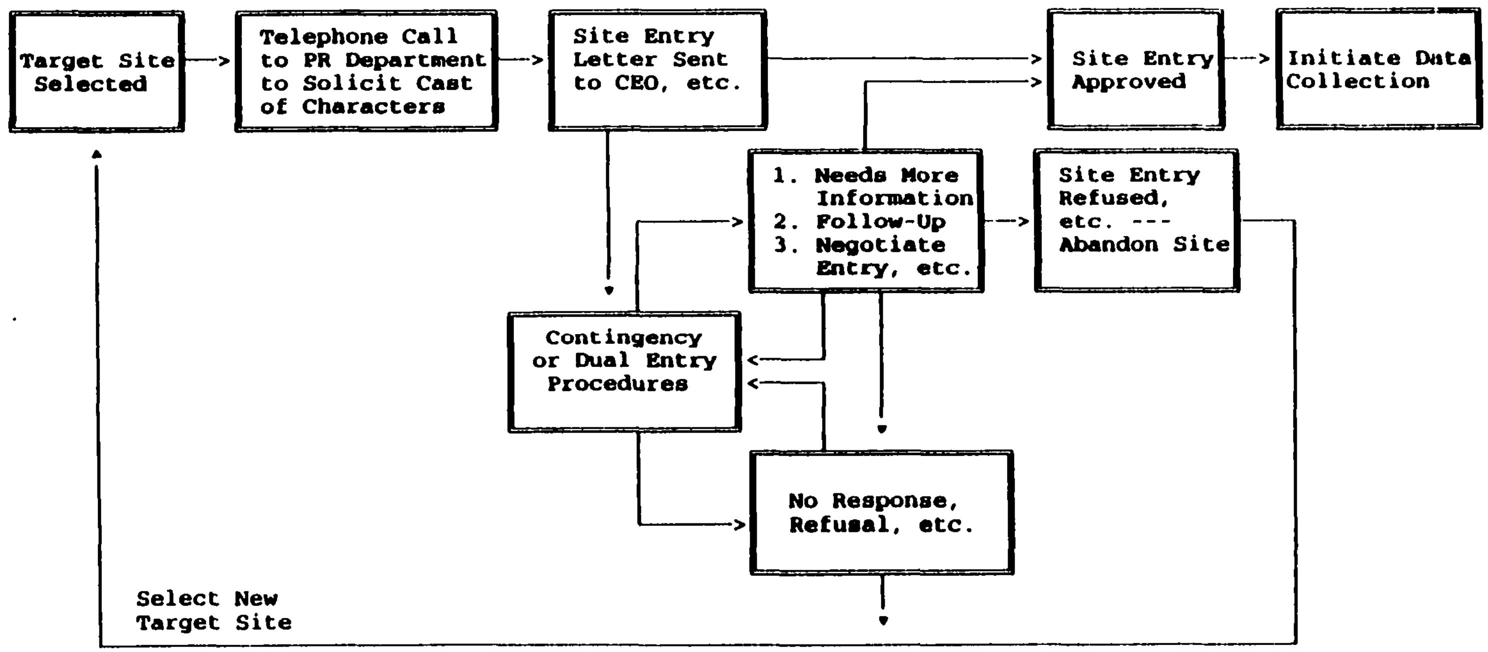
4.21 Organizations. Fast product development is of interest to firms in many industries, primarily those that are facing fast-moving (i.e., dynamic) environments. Thus careful selection of the research sample is motivated by the objective of being able to generalize the findings of this study beyond (a) the idiosyncratic nature of undeveloped, unconventional product development programs and instead across organizational boundaries, and; (b) the idiosyncratic nature of one or two task/institutional environments and instead across industry boundaries. As a result, my sample consists of large (greater than $50 million in sales) companies in a variety of industries. Large firms were chosen because they are more likely to have established new product development programs as opposed to smaller firms with more idiosyncratic programs. Companies within different industries were chosen because they provided access to a range of task and institutional environments where innovation speed is pursued and hence allowed the study to more broadly examine the underlying constructs which influence the need, antecedents, and outcomes of speed.

In addition to consisting of large firms in multiple industries, the objectives of the study dictate further criteria. First, that each company have an active, established new product development program. This is because it makes little sense to study new product development in firms which do not actively engage in it. Second, that new product development represented an important component to the long run success of the company. In addition to being a selling point for gaining access to companies and a requirement for accessing a sufficient number of development projects, it is important because I wished to examine firms which are committed to this activity and are not just pursuing symbolic or tangential programs. Third, that companies perceive a need for fast product development in the relevant industries which they are operating. Since the purpose of this study is to ascertain the affect of various antecedent factors upon innovation speed as well as the need factors which motivate speed and the outcome factors which result from speed, it stands to reason that I should select companies which have a reason to pursue speed.

Given these criteria, company names were assembled in a systematic manner following the site selection algorithm developed by Souder and colleagues (1977). This algorithm is graphically illustrated in Figure 4-1. Thirty (30) companies were chosen which met the criteria of the study and were headquartered locally, which was a practical research constraint (e.g., travel resources). Initially, I obtained summary information of these selected companies (e.g., relevant names, addresses, and phone numbers of key individuals) from their annual report, other publicly-available documents (e.g., CorpTech Directory), public relations department, or personal contact. I then send a site entry letter to the chief executive officer (CEO) or top research and development executive (e.g., VP, R&D) of these firms which provided a general overview of the study, explained the nature of the commitment requested, and detailed the benefits of participation. Additionally, enclosures accompanied the letter which provided (a) an abstract of the research project; (b) a description of the research institutions as well as the primary researchers, and; (c) a statement of the confidentiality policy observed by the researchers, where parties were assured that the names of field sites, projects, and participating individuals will remain anonymous and only aggregate results will be reported. Two to three weeks after these letters were send, direct telephone calls were made to these individuals to answer any questions they had about the study and arrange a mutually convenient time for an on-site interview (to secure commitment).

Ultimately, this procedure resulted in ten (10) companies agreeing to participate in the study for a response rate of 33%. Table 4-1 lists the industry profile of the participating companies, which operated in a variety of industries and had an average of 89,662 employees and an average of $16,014.36 million in sales (1994 figures).

FIGURE 4-1
Site-Selection Algorithm



(From Souder, et.al., 1977)

TABLE 4-1
Industry Break-Down of Firm Sample

	NUMBER OF FIRMS*	PERCENTAGE
Advanced/Scientific Materials	3	30%
Chemicals/Chemical Materials	2	20%
Confectionary/Consumer Goods	3	30%
Industrial Equipment/Products	2	20%

* Participating companies had an average of 89,662 employees and $16,014.36 million in sales (1994 figures)

The way in which companies were selected means that sample is not completely random. As a result, findings should be interpreted in the strictest sense as applying only to those companies in the sample. However, since a relatively broad cross-section of industries was studied, the study's findings may be generalizable to some degree to firms in these industries (Cooper & Kleinschmidt, 1994). Further, given this broad sample and the idiosynchracities of innovation between different industries, statistically significant findings might be *less* likely. That is, there may be a "conservative bias" in the study insofar as cross-industry effects are more difficult to obtain than single-industry effects. Thus in this sense the results may be more generalizable than studies which examine single industries.

4.22 Projects. The unit of analysis was the new product development project. This is because the project level of analysis is most directly relevant to innovation speed -- projects are accelerated, not individuals or organizations. As argued previously in the review of the literature, adopting an organizational level of analysis collapses the results of firms' many new product innovation projects, obscuring each project's particular characteristics and their impact upon speed-related outcomes. Additionally, by asking for in-general responses and not providing a concrete referent to respondents, individuals may be less accurate in their estimations of "average" time of development as well as relevant antecedent factors such as "average" use of external sources and "average" team autonomy. Adopting an individual level of analysis covers only a minor part of the picture and tend to be impressionistic and consequently less reliable and valid. Adopting a project level of analysis, defined as "a goal directed effort with a readily-identified end in view" (Rubenstein, Chakrabarti, & O'Keefe, 1974: 37), enables the study to capture unique situational attributes which speed up or slow down actual projects, consistent with Downs and Mohr's (1976) prescribed innovation-decision design which views innovation processes and outcomes as unique events involving different organizational, social, and individual variables. The unit of analysis is important because variables which are appropriate in explaining the differences among organizations in terms of their ability to accelerate innovations may not be either operational or meaningful in explaining why one project is completed faster than another in the same organization. Thus variables at the organizational and individual levels are of interest in this analysis to the extent as they explain or predict innovation speed at the project level.

Examining several projects from each firm versus one or two, which has been the typical research strategy undertaken in this developing literature, provides a more representative picture of the firms's overall new product development program and is less likely to result in a sample of exception and outlier projects. Additionally, examining more projects within a limited number of companies allows for more in-depth study of each company's projects. Aside from the research issues, a practical benefit of this approach is that it reduces the number of research sites required to gain a sufficiently large sample of projects, which create economies of scale and hence is more pragmatic given the resource constraints of this research effort.

The product development projects included in the study were chosen by both company executives as well as myself. This was to ensure that the projects fit the following pre-specified criteria: They (a) were all recent and fully completed within the past five years, (b) contained significant technological components, and (c) were seen as typical for their respective companies. For each company I requested about half of the projects be perceived as "relatively fast" and half be perceived as "relatively slow". This was done to increase the likelihood of obtaining variability on the primary variable of innovation speed. In this vein it helped reduce the bias of companies volunteering only their fastest projects. It was also beneficial for the participating companies, for it enabled them to get more useful feedback regarding the factors affecting the appropriability, manipulation, and implications of innovation speed. Further, for each company I requested about half of the projects be "more successful" and half "less successful". This was done to encourage variability across project attributes and reduce the potential bias of firms only volunteering very successful projects. A successful product was defined as one which has met expectations and attain organizational goals while an unsuccessful product was defined as one which failed to achieve these outcomes (Van de Ven, Angle, & Poole, 1989). Success may or may not be independent of timeliness, for expectations and goals can vary.

As Table 4-2 indicates, 86 projects which met the forementioned criteria were selected from the ten participating firms. Of this population, questionnaires representing 75 projects were returned (87% response rate). Thus, on the average, approximately seven-to-eight projects were studied per company. The actual number of projects studied from each company is indicated in Table 4-3.

4.23 Respondents. Due to the nature of the methodology, the data collected is primarily retrospective in nature -- i.e., it is dependent upon respondents' memories of previously completed projects. Thus multiple respondents were polled for each project to

TABLE 4-2
Response-Rates for Projects and Respondents

	Questionnaires Sent	Questionnaires Returned	Percentage
Projects	86	75	87%
Respondents	205	127	62%

TABLE 4-3
Number of Projects per Company

FIRM	NUMBER OF PROJECTS	PERCENT	CUMULATIVE PERCENT
1	11	14.7	14.7
2	5	6.7	21.3
3	13	17.3	38.7
4	15	20.0	58.7
5	9	12.0	70.7
6	5	6.7	77.3
7	1	1.3	78.7
8	5	6.7	85.3
9	4	5.3	90.7
10	7	9.3	100.0

increase the validity and reliability of retrospective reports (Bagozzi, Yi, & Phillips, 1991; Kumar, Stern, & Anderson, 1993). That is, surveying multiple respondents for each project provides some protection against memory failures, inaccurate recalling of past events, and distortion of past events. The latter could occur due to hindsight bias, impressions management, or selective perception.

In this vein, both project leader and project member perspectives were sought. This is because leaders and members have different tasks and are exposed to different aspects of projects, at different times, and to different degrees (Ancona & Caldwell, 1990; Chakrabarti & Hauschildt, 1989; Katz & Tushman, 1988; Roberts & Fusfield, 1988); thus, they may bring slightly different perspectives to a project. Additionally, within the sampling of project members, both technically-oriented and marketing-oriented individuals were requested. This is because individuals from these two broadly-defined areas of projects, because of differing backgrounds (Dearborn & Simon, 1958) and responsibilities (Wheelwright & Clark, 1992), emphasize different aspects of projects and sometimes see them differently (Brockhoff & Chakrabarti, 1988; Souder & Chakrabarti, 1978). In summary, when it was possible (i.e., frequent turnover in some R&D departments resulted in individuals not remaining with the organization at the time of the study), three individual respondents were requested for each project: (1) the project leader; (2) a marketing member, and; (3) a technical member.

As Table 4-2 indicates, a total of 205 individuals from the 86 projects were identified as potential respondents. Of this population, 127 surveys were returned (62% response rate). Thus, on the average, approximately one-to-two individuals responded per project, and almost thirteen individuals in total responded per company. Table 4-4 reports the frequency of projects with one, two, and three respondents. Here it is shown that over half of the projects (54.7%) had multiple respondents. Table 4-5 reports the frequency of leader, marketing member, and technical member responses. Here is is shown that 60 of the 127 responses (47.2%) were from project leaders, with the remaining responses almost equally split between marketing members (34 responses) technical members (33 responses). The actual number of leader, marketing member, and technical member responses received for each project in each company is listed in Table 4-6.

4.3 Data Collection Procedure

Data was collected using a detailed ten-page questionnaire instrument containing scales for innovation speed-related independent and dependent variables relevant to the previously described propositions. This is because a questionnaire is an efficient, cost-effective way of collecting a wide array of quantifiable information from a large number of respondents (Fowler, 1988). Development of this instrument included a search of the literature for previously constructed and validated measures as well as several iterations of constructing indicators of constructs for which scales could not be found. The instrument was then reviewed by polling several individuals with experience in new product development and pilot testing the instrument with these individuals. It was then revised as per information gained through pilot testing before being administered to the research sample. In addition to questions and scales for response, the research instrument contained detailed instructions, definitions of key terms, an overview of the research, and the names and phone numbers of researchers whom the respondents could contact if they had any questions.

TABLE 4-4
Number of Projects with One, Two, and Three Respondents

NUMBER OF RESPONDENTS	FREQUENCY	PERCENT	CUMULATIVE PERCENT
1	34	45.3	45.3
2	30	40.0	85.3
3	11	14.7	100.0

TABLE 4-5
Number of Responses from Project Leaders, Marketing Members, and Technical Members

TYPE OF RESPONDENTS	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Project Leader	60	47.2	47.2
Marketing Member	34	26.8	74.0
Technical Member	33	26.0	100.0

TABLE 4-6
Number of Projects and Type of Respondents for Each Company[a]

	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8	Firm 9	Firm 10
1	LT	L	LMT	L	LT	L	M	LMT	LT	MT
2	L	L	T	L	LMT	L		LMT	LT	M
3	LM	M	LT	L	LMT	L		L	LT	MT
4	L	M	M	LMT	MT	L		MT	LT	MT
5	L	T	L	LM	LT	L		L		MT
6	L		LM	LM	LT					T
7	LM		L	L	LM					MT
8	LMT		LM	L	LMT					
9	L		LMT	L	LM					
10	L		LM	LM						
11	LT		LT	L						
12			LT	L						
13			LM	L						
14				LMT						
15				LMT						

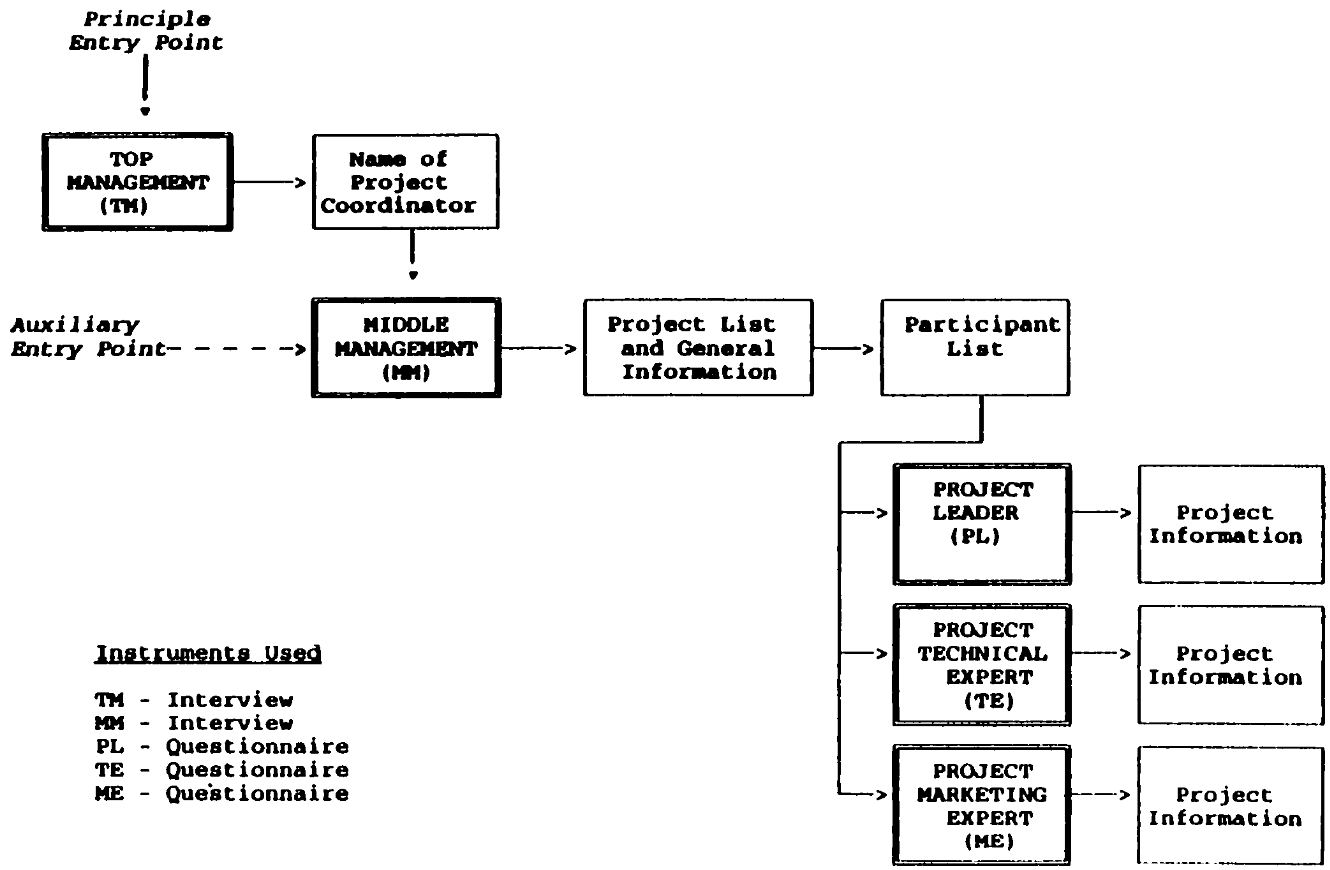
[a] The Following Codes Apply:
L = Project Leader
M = Marketing Member
T = Technical Member

Data gathering proceeded in several stages, following an algorithm derived from previous product development field studies (Rubenstein, Chakrabarti, & O'Keefe, 1974; Souder and colleagues, 1977; Tabrizi & Eisenhardt, 1993). This algorithm is graphically illustrated in Figure 4-2. At each research site, a variety of people provided information, according to the specific information required (Fowler, 1988). This information was to be provided through both interview and questionnaire formats.

First, cooperation of the companies serving as field sites were secured from top management in the manner described previously. In addition, telephone interviews were conducted to inform the CEO or VP R&D of the study requirements and to request the appropriate contact person who coordinates product development projects. I personally contacted all companies and secured access to them. Assistance and information for some companies were provided by Dr. Alok Chakrabarti, Dean of the School of Industrial Management at NJIT, and Dr. Melvin Druin executive director of the Center for Plastic Packaging Production at NJIT.

Second, once on-site, I interviewed the principle contact person and/or a staff specialist to develop a list of projects which fit the objectives of the study. The interviews were semi-structured to ensure that appropriate projects were selected and to allow participants the opportunity to voice any questions, concerns, or opinions they may have about the projects selected. A portfolio was then constructed that listed appropriate projects and their status (e.g., more or less successful, relatively fast or slow, year of completion), from which projects were jointly selected. These interviews were also used to get a list of the project leader and, when available, one marketing person and one technical person directly

FIGURE 4-2
Data-Collection Algorithm



Instruments Used

TM - Interview
MM - Interview
PL - Questionnaire
TE - Questionnaire
ME - Questionnaire

involved on each of the project development projects chosen (see Table 4-2). Jointly constructing the lists of informants helped address the "selection problem" of querying multiple informants in organizations (Kumar, Stern, & Anderson, 1993), where it is necessary to assure that appropriate respondents are identified (Fowler, 1988).

Third, I worked from this list to put together survey packets for each respondent, which included a questionnaire instrument and a pre-addressed return envelope. The packets were then mailed to the contact persons to distribute to each respondent for completion, under the assumption that individuals were more likely to respond if they received the questionnaire from their boss than from an unknown graduate student. This helped to address a major weakness of survey data collection methodology, namely enlisting cooperation from respondents (Fowler, 1988). It should also be noted that, because of their wide involvement in the R&D activities of participating companies, there were several occasions where the same individual worked on more than one project in the sample and was thus sent questionnaires for more that one project.

Of course, in collecting data through mailed questionnaires, a trade-off is made with respect to efficiency (e.g., lower cost, time, and staff requirements) versus accuracy (e.g., lower degree of objectivity in the data). In this vein, Fowler (1988: 91) reports that there are four basic reasons why survey respondents may report events with less than perfect accuracy: (1) They do not know the information, (2) they cannot recall the information, (3) they do not want to report the information, or (4) they do not understand the questions. While no precautions can completely eliminate these potential problems, several actions were taken to limit them. To the issue of knowledge level, as mentioned previously, respondents were jointly selected to identify those that were most knowledgeable about the specific projects being studied. Additionally, by providing respondents with a relatively lengthy time period for response (several weeks or, in some cases, months), they were given the opportunity to consult with archival sources of data (e.g., progress reports) to support their responses on appropriate items. To the issue of information recall, as mentioned previously, only relatively recent projects were requested (i.e., fully completed within the past five years). To the issue of willingness, participants were informed that their organization would receive feedback on the study's findings. Also, as mentioned previously, a written confidentiality policy assured participants that the names of individuals, projects, and firms would remain anonymous and only reported in the aggregate. To the issue of question clarity, as mentioned previously, the questionnaire was reviewed by several individuals with experience in new product development before being administered to the research sample. Additionally, as mentined previously, included with the survey were detailed instructions, definitions of key terms, and the names and phone numbers of researchers to contact if they had any questions.

4.4 Measures

The following details the operationalization of the key variables in the study. Included are descriptions and code names of each variable and a reference to the appropriate question number in the questionnaire instrument. The questionnaire instrument (both leader and member versions) are provided in Appendix A[1] (Attachments 4-1 and 4-2). The two versions

[1] For purposes of dissertation format, the size of the questionnaires in the Appendix were reduced. The questionnaires used in this study were printed on standard 8"x11" paper.

of the questionnaire did *not* differ an any substantive way -- only in the phrasing of certain questions (i.e., when asking about the power of the project leader, the leader version contained the referent "you" whereas the member version contained the referent "the project leader"). It should also be noted that the questionnaire was fairly broad and contained some items not used in this dissertation.

4.41 Development Time. The accurate measurement of time is linked to many of the constructs in this study and is central the the research propositions -- therefore, it is critical to the validity of this research effort. Therefore it was operationalized through the following absolute and relative measures:

Absolute Time (TIMEAB: Questions #1 and #5). First, the measurement of several constructs (e.g., overlap, percentage of time spent in testing) requires ascertaining the overall length of projects' product development process. I used Tabrizi and Eisenhardt's (1993) operationalization of absolute product development time, which is conceptually consistent with definitions adopted by Clark and Fujimoto (1991), Mansfield (1988), Murmann (1994), Vesey (1991) and others. This is because time is by nature an absolute measure -- e.g., months and years (Cooper and Kleinschmidt, 1994). Thus respondents were asked to identify both (a) the month and year when product development activities commenced and (b) the month and year when product development activities ended. The difference between the two dates (in months) represented the absolute time of the project.

In addition, the measurement of several constructs (e.g., overlap) requires dividing the product development process into stages and ascertaining the time taken to complete each stage. Similar to the above measure, these stages were adopted from Tabrizi and Eisenhardt (1993), who developed them in conjunction with several experienced management consultants and engineers. The stages are: (a) Pre-development/planning, which begins with the start of the project and ends with the completion of basic product requirements; (b) Conceptual design, which begins with the basic concepts and ends with final specifications of the product; (c) Product design, which begins with the engineering work to take the specifications to a fully designed product and ends with final release to system test; (d) Testing: Begins with component and system test and ends with the release of the product to production; (e) Process development, which begins with the first process design and ends at the completion of the first pilot run; and (f) Production start-up: Begins with production ramp-up and ends with the stabilization of production. These measures were calculated in number of months as well as by percentage of months relative to total project time.

Time Goal (TIMEGOAL: Question #2). Second, I used McDonough and colleagues' (McDonough, 1993; McDonough & Barczak, 1991) operationalization of product development time relative to its schedule, which is conceptually consistent with the research approaches taken by Rosenau (1989) and Gupta, Brockhoff, and Weisenfeld (1992). This is because relative measures enable two dissimilar product development projects to be compared with one another (Cooper & Kleinschmidt, 1994) -- for example, even if project A was done in 12 months and project B in 20 months, it may be the case that 12 months was too long for project A and project B was actually done more efficiently. Thus projects were categorized by the extent to which they were ahead of schedule, behind schedule, or on schedule. Respondents were asked to check off one of thirteen boxes describing varying degrees of bringing a product to market faster than time goals, slower than time goals, or equal to time goals. A score of thirteen indicated that a project was extremely behind schedule and a score of one indicated that a project was extremely ahead of schedule.

Time Past (TIMEPAST: Question # 3). Third, I measured time by asking respondents the degree to which the project was faster than, slower than, or about the same pace as similar, previously completed projects in their organization. This is because the term "acceleration" is often used in the innovation speed literature, implying that the *relative improvement* of project completion time is also an important component of innovation speed and thus is also a concern of scholars and R&D managers (e.g., Crawford, 1992; Graves, 1989; Gold, 1992; Gupta & Wilemon, 1990; Millson et al., 1992; Nijissen et al., 1995; Patterson & Lightman, 1993; Starr, 1992; Zahra & Ellor, 1993; Zirger & Hartley, 1993). Thus respondents were asked to check off one of thirteen boxes describing varying degrees of bringing a product to market faster than, slower than, or equal to similar past projects. A score of thirteen indicated that a project was extremely slower than past projects and a score of one indicated that a project was extremely faster than past projects.

Time Competition (TIMECOMP: Question # 4). Fourth, I measured time by asking respondents the degree to which the project was faster than, slower than, or about the same pace as similar projects of competitors. This is because many refer to competitive advantages accrued through innovation speed (e.g., Smith & Reinertsen 1991; Stalk & Hout, 1990; Vesey, 1991), so it stands to reason that an important component of innovation speed is the pace of a project relative to its competition. Indeed, Birnbaum-More (1993) measured speed as the degree to which a new product was introduced to the market sooner or responded to another's competitive product introduction faster than others (i.e., racing behavior). Thus respondents were asked to check off one of thirteen boxes describing varying degrees of bringing a product to market faster than, slower than, or equal to similar competitor projects. A score of thirteen indicated that a project was extremely slower than competitor projects and a score of one indicated that a project was extremely faster than competitor projects.

4.42 Need Factors[2]. *Economic Intensity* (ECONINT: Question #44c). The amount of competitive intensity in a project's task environment was measured through a 5-point likert scale asking the degree to which the respondent would characterize the economic environment of this innovation -- e.g., levels of domestic and international competition -- as very simple (few competitors) or very complex (many competitors). A score of five indicates a highly competitive context and a score of one indicates a low degree of competition. This measure was adopted from Van de Ven, Angle, and Poole (1989).

Technological Dynamism (TECHDYN: Question #45a). The amount of technological dynamism in a project's task environment was measured through a 5-point likert scale asking the degree to which the respondent would characterize the technological environment of this innovation -- e.g., advances in research and development of new products, devices, and processes -- as very dynamic (changing rapidly) or very stable (virtually no change). A score of one indicates a highly dynamic context and a score of five

[2] It was often the case that field-site coordinators did <u>not</u> reveal the names of projects or describe them in sufficient detail to identify their particular competitive, technological, demographic, and regulatory contexts. This precluded me from researching more *objective* measures for these variables (see Sharfman & Dean, 1991). Thus, the following perceptual measures, as provided by the respondents, were used.

indicates a low degree of dynamism. These scores were then inverted so that, consistent with other measures, technological dynamism was calibrated on an increasing (versus decreasing) scale. This measure was adopted from Van de Ven, Angle, and Poole (1989).

Demographic Dynamism (DEMDYN: Question #46a). The amount of demographic dynamism in a project's task environment was measured through a 5-point likert scale asking the degree to which the respondent would characterize the demographic environment of this innovation -- e.g., social trends, population shifts, income and educational levels -- as very dynamic (changing rapidly) or very stable (virtually no change). A score of one indicates a highly dynamic context and a score of five indicates a low degree of dynamism. These scores were then inverted so that, consistent with other measures, demographic dynamism was calibrated on an increasing (versus decreasing) scale. This measure was adopted from Van de Ven, Angle, and Poole (1989).

Regulatory Restrictiveness (REGRES: Question #47c). The amount of regulatory restrictiveness in a project's institutional was measured through a 5-point likert scale asking the degree to which the respondent would characterize the legal/regulatory environment of this innovation -- e.g., government policies, regulations, incentives, and laws -- as very hostile/adversarial or very friendly/supportive. A score of one indicates a highly restrictive context and a score of five indicates a low degree of restrictiveness. These scores were then inverted so that, consistent with other measures, reulatory restrictiveness was calibrated on an increasing (versus decreasing) scale. This measure was adopted from Van de Ven, Angle, and Poole (1989).

4.43 Strategic Orientation, Criteria-Related Factors. *Relative Importance* (SPEEDIMP: Question #16). The relative importance placed upon innovation speed was measured through a comparative ranking of development time, development cost, and product quality, according to their importance to top management. A score of one indicates a high priority placed upon speed and a score of three indicates that speed was a relatively low priority. These scores were then inverted so that, consistent with other measures, the relative importance of speed was calibrated on an increasing (versus decreasing) scale. This measure was adapted from Gupta, Brockhoff, and Weisenfeld (1992) and Rosenau (1989).

Reward System (REWSYS: Question #20). The degree to which the reward system supported innovation speed was measured on four 5-point Likert scales asking to what degree product development personnel are rewarded for meeting schedules and punished for not meeting them, both individually and as a group (questions a through d). This measure was adapted from Tabrizi and Eisenhardt (1993) and Van de Ven, Angle, and Poole (1989). These responses were then pooled into a single score with a potential range of 4 to 20. A score of twenty indicates a high degree of reward-for-speed and a score of four indicates a low degree of reward-for-speed.

Culture (CULTURE: Question #21). The degree to which the culture supports innovation speed was the combined measure of three 5-point Likert scales asking whether (a) it will be considered a serious blight on an individual's career in the organization if they try something new and fail; (b) the organization places a high value on taking risks, even if there are occasional mistakes, and; (c) the organization places a high priority on learning and experimenting with new ideas. These responses were then pooled into a single score with a potential range of 3 to 15 (item 21a was reverse coded, so its score was reversed in the calculation of the overall culture score). A score of fifteen indicates a high degree of cultural support for speed and a score of three indicates a low degree of cultural support for speed. This measure was adopted from Van de Ven, Angle, and Poole (1989).

Time Goal Clarity (GOAL: Question #17). The nature of time-based goals was measured on two 5-point Likert scales asking to what degree they were made clear and to what degree they were made specific. These responses were then pooled for a possible score ranging from 2 to 10. A score of ten indicates a high degree of time goal clarity and a score of two indicates a low degree of time goal clarity.

Product Concept Clarity (CONCEPT: Question #18). The nature of product concepts was measured on two 5-point Likert scales asking to what degree they were made clear and to what degree they were made specific. These responses were then pooled for a possible score ranging from 2 to 10. A score of ten indicates a high degree of product concept clarity and a score of two indicates a low degree of product concept clarity.

Top Management Support (MGMTSUP: Question #19). The degree of top management support was measured on a 5-point Likert scale asking to what extent top management was interested in this project, ranging from very high to very low. A score of five indicates a high degree of management support and a score of one indicates a low degree of management support.

4.44 Strategic Orientation, Scope-Related Factors. *Project Stream Breadth* (BREADTH: Question #22). The relative number of projects in the pipeline was measured through four 5-point Likert scales asking about the munificence of resources. Specifically, respondents were asked to rate the degree to which their project team was forced to compete with other projects for (a) financial resources, (b) materials, space, and equipment, (c) management attention, and (d) personnel. This measure was adopted from Van de Ven, Angle, and Poole (1989). These responses were then pooled into a single score with a potential range of 4 to 20. A score of twenty indicates a high degree of breadth and a score of four indicates a low degree of breadth.

Degree of Change (RADICAL: Questions # 23 and #24). The radicalness of a project was measured through two scales. First, a six-point scale was used which asked respondents to evaluate the type of work done on the project. The labels ranged from pure applications engineering (1=least radical), a clever combination of mature technologies, applying state-of-the-art technology, a minor extension of state-of-the-art technology, a major extension of state-of-the-art technology, to the development or application of new technology (6=most radical). This measure was adopted from McDonough and Barczak (1991). Additionally, a four-point scale was used which asked respondents to evaluate the degree of change involved in the project. The labels ranged from an imitation of existing products (1=least radical), improvement of existing products, major improvement of existing products, and radically new product (4=most radical). This measure was adopted from Chakrabarti (1989). These responses were then pooled into a single score with a range of 2 to 10. A score of ten indicates a high degree of radicalness and a score of two indicates a low degree of radicalness.

External Sourcing (SOURCE: Questions #25 and #26). The degree to which project are developed in-house was measured on two 5-point Likert scales asking to what extent (a) ideas for this product and (b) technological developments for this product came from internal sources (i.e., members of the research and/or development staff) as opposed to external sources (i.e., capital goods, suppliers, licensing arrangements). This measure is adapted from McDonough and Barczak (1991). It is conceptually consistent but more discriminating than Mansfield's (1988) measure because it is continuous rather than categorical -- Mansfield sorted projects into two categories, internally sourced and externally sourced, based upon whether the majority of the work was done in-house or out-of-house. These responses were then pooled into a single score with a potential range of 2 to 10. A score of ten indicates a low percentage of external sourcing and a score of two indicates a high percentage of external sourcing. These scores were then inverted so that, consistent with other measures, externalness was calibrated on an increasing (versus decreasing) scale.

4.45 Organizational Capability, Staffing-Related Factors. *Champion Presence* (PCHAMP: Questions #35a and #35b). The presence of a champion(s) was measured by asking (a) if there was a champion or champions for this project, and; (b) if so, how many champion(s) were there. If the answer to (a) was "no", then the score was 0. If the answer to (a) was "yes", then the score was the number response to (b). A higher score indicates that more champion(s) were present.

Champion Influence (ICHAMP: Question #35c). The influence of a product champion was measured on a 5-point Likert scale asking, if a champion(s) was present, how influential or politically savvy was the champion or most active champion. A score of five indicates greater influence and a score of one indicates lesser influence.

Leader Position (LPOS: Questions #27). The strength of the project leader was represented in part by their position in the organizational hierarchy. This was measured by asking if the project manager report directly to the divisional manager. An answer of "no" was scored as 0 and an answer of "yes" was scored as 1. This measure was adopted from Tabrizi and Eisenhardt (1993).

Leader Power (LPOW: Question #28). The strength of the project leader was also represented in part by their decision making power. This was measured by asking if the project manager was the final decision maker for the project budget, project team composition, and development timetables. All together, three yes-or-no questions were asked, each scored as zero (no) or one (yes). These responses were then pooled into a single score with a potential range of 0 to 3. A score of three indicated a high degree of power and a score of 0 indicated a low degree of power. These measures were adapted from Murmann (1994) and Tabrizi and Eisenhardt (1993).

Leader Tenure (LTEN: Question 29) . The tenure of the project manager was measured by asking how long they had been with the organization (in months). A higher score indicates longer tenure. This measure was adopted from McDonough and Barczak (1991).

Leader Assignment (LASS: Question # 30). The full-time or part-time assignment status of the project leader was measured by a 5-point Likert scale asking to what extent the project leader was assigned exclusively to this project or had responsibilities outside the project. A score of one indicates a high degree of exclusive involvement and a score of five indicates a low degree of exclusive involvement. These scores were then inverted so that, consistent with other measures, project leader involvement was calibrated on an increasing (versus decreasing) scale.

Member Education (MEDUC: Question # 31). The education of project team members was measured by the level of the highest degree they earned. Respondents were asked to check one box, ranging from high-school or equivalent (score of 1) to 1-3 year college or trade school, bachelor's level, master's level, and doctorate level (score of 5). A score of five indicates a higher degree earned and a score of one indicates a lower degree earned. This measure is adapted from McDonough and Barczak (1991).

Member Orientation (MEXP: Question #32). The generalist-specialist orientation of project team members was measured by the total number of functional areas in which members had experience. The functions are the same as those used in the multifunctionality measure adopted from Tabrizi and Eisenhardt (1993): purchasing, manufacturing, marketing/sales, engineering, service, and finance/accounting. A score of five (experience in all areas) indicates a higher degree of generalist orientation and a score of one indicates a lower degree of generalist orientation (i.e., more of a specialist).

Member Tenure (MTEN: Question # 33). The tenure of project team members was measured by the average number of months they worked for the organization. A higher score indicates longer tenure. This measure is adapted from McDonough and Barczak (1991).

Member Assignment Status (MASS: Question #34). The full-time or part-time status of project team members was measured by a 5-point Likert scale asking to what extent the members were assigned exclusively to this project or had responsibilities outside the project. A score of one indicates a high degree of exclusive involvement and a score of five indicates a low degree of exclusive involvement. These scores were then inverted so that, consistent with other measures, project member involvement was calibrated on an increasing (versus decreasing) scale.

Team Representativeness (REP: Questions #38 and #39). The degree of representation on development teams was measured through two matrixes. First, internal representation (REPINT) was measured by whether personnel from various specific functions were involved in the various stages of development specified earlier. The functions examined are purchasing, manufacturing, marketing/sales, engineering, service, and finance/accounting. Involvement was defined as having one or more employees of a functional area as recognized members on the product development team, including active participation in team meetings and design activities. For each stage, the total number of functions represented is summed. The total internal representativeness score is the sum of the five group scores across the six stages, yielding a potential score of 0 to 30. A score of thirty indicates a higher degree of internal representativeness and a score of zero indicates a lower degree of internal representativeness. This measure is adopted from Tabrizi and Eisenhardt (1993).

Second, external representation (REPEXT) was measured by whether end-users/customers, suppliers, and distributors were involved in the various stages of development specified earlier. Involvement was defined and calculated in a manner identical to that for internal representation. Thus the total external representativeness score is the sum of the three group scores across the six stages, yielding a potential score of 0 to 18. A score of eighteen indicates a higher degree of external representativeness and a score of zero indicates a lower degree of external representativeness. Ultimately, the final representativeness score was calculated as the sum of the internal and external scores and ranged from forty-eight (high) to zero (low).

4.46 Organizational Capability, Structuring-Related Factors. *Autonomy* (AUT: Question #37). The autonomy of the project team was measured through a series of four 5-point Likert scales asking how much influence the project team had in each of the following decisions that may have been made during the project: (a) setting goals and performance targets, (b) deciding what work activities to be performed, (c) deciding on funding and resources, and (d) recruiting individuals to work on the project. These responses were then pooled into a single score with a potential range of 4 to 20. A score of twenty indicates a higher degree of autonomy and a score of four indicates a lower degree of autonomy. This measure was adopted from Van de Ven, Angle, and Poole (1989).

Overlap (OVER: Questions #1 and #5). The degree to which stages of the development processes were undertaken in parallel was calculated as the sum of the time in months of the six stages of the product development project (as describer earlier) divided by the total product development time. For example, if the project was undertaken sequentially, the sum of the stage times would equal the total time; if the project was undertaken in parallel (i.e., two or more stages overlapped), the sum of the stage times would be greater than the total time. A higher score indicates a higher degree of project overlap. This measure is adapted from Tabrizi and Eisenhardt (1993).

Strength of Functional Norms (FUNC: Question #40). The strength of functional (versus project) norms was measured on a 5-point Likert scale by asking how much "turf guarding" there was between different departments and professional groups connected with this project. A score of five indicates a higher degree of turf-guarding (or functionalness) and a score of one indicates a lower degree of turf-guarding. This measure is adopted from Van de Ven, Angle, and Poole (1989).

Design for Manufacturing (DFM: Question #38b). The degree to which manufacturing concerns were incorporated in development was calculated as the number of stages in the project (as described earlier) a representative from manufacturing was present on the product development team. A score of six (they were present for all stages) indicates a greater consideration of manufacturability and a score of zero (they were not present for any stages) indicates a lesser consideration of manufacturability.

Proximity (PROX: Question #43). The geographic dispersement of the project team was measured through a 7-point scale that asked which of the following statements best characterized the location of team members: in the same office (most proximal= 7), on the same floor but not in the same office, in the same building but not on the same floor, in the same city but not in the same building, in the same state but not in the same city, in the same country but not in the same state, and not in the same country (least proximal=1). A score of seven indicates greater proximity and a score of one indicates lesser proximity.

Milestones (MILE: Question #42). The frequency of developmental milestones was measured by asking the project team members the average time (in weeks) between milestones or goals to be accomplished. This was then divided by the total project development time to ascertain a percentage representing the time between milestones relative to project duration. Since more time *between* milestones indicates a relatively lower frequency *of* milestones, these scores were then inverted so that relative milestone frequency was calibrated on an increasing (versus decreasing) scale. This measure was adopted from Tabrizi and Eisenhardt (1993).

Testing (TEST: Questions #1 and #5d). The relative frequency of testing was calculated as the total time in months spent on the "testing" stage of development (as described earlier) divided by the total elapsed time in months of the development project. Higher scores indicate greater percentages of time spent in testing. This measure was adopted from Tabrizi and Eisenhardt (1993).

CAD usage (CAD: Question #41). The use of computer-aided-design was measured by (a) asking if CAD systems were used by design engineers on the product development team and (b) what percentage of these engineers used CAD systems. If the answer to (a) was "no", then the score was zero. If the answer to (a) was "yes", the score was the percentage response to (b). A higher score indicates that CAD systems were more widely used. This measure was adopted from Tabrizi and Eisenhardt (1993).

4.46 First-Order Outcome Factors. *Cost Goal* (COSTGOAL: Question #7). Development cost was measured in three ways, which mirrored the measurement of innovation speed. First, a project's cost relative to its budget was measured in a similar manner to TIMEGOAL - respondents were asked to check off one of thirteen boxes asking to what degree the project came in under budget, over budget, or on budget. A score of thirteen indicates that a project was much more costly than budgeted and a score of one indicates that a project was much less costly than budgeted.

Cost Past (COSTPAST: Question #8). Second, the cost of a project relative to its past projects was measured in a similar manner to TIMEPAST - respondents were asked to check off one of thirteen boxes asking to what degree the project was more expensive, less expensive, or equally expensive than similar past projects in their organization. A score of thirteen indicates that a project was much more costly than past projects and a score of one indicates that a project was much less costly than past projects.

Cost Competition (COSTCOMP: Question #9). Third, the cost of a project relative to competitor projects was measured in a similar manner to TIMECOMP - respondents were asked to check off one of thirteen boxes asking to what degree the project was more expensive, less expensive, or equally expensive to similar projects of competitors. A score of thirteen indicates that a project was much more costly than competitor projects and a score of one indicates that a project was much less costly than competitor projects.

Quality Goal (QUALGOAL: Question #10). Product quality was also measured in three different ways, again mirroring the measurement of innovation speed. First, quality was measured relative to pre-set product standards in a manner consistent with that of TIMEGOAL and COSTGOAL. Respondents were asked to check off one of thirteen boxes asking to what degree the product was superior to, inferior to, or equal to preset specifications. A score of thirteen indicates that a project was far superior than planned and a score of one indicates that a project was far inferior than planned.

Quality Past (QUALPAST: Question #11). Second, quality was measured relative to similar past projects in a manner consistent with that of TIMEPAST and COSTPAST. Respondents were asked to check off one of thirteen boxes asking to what degree the product was of a higher quality, lower quality, or equal quality as compared to similar past projects in their organization. A score of thirteen indicates that a project was far superior than past projects and a score of one indicates that a project was far inferior than past projects.

Quality Competition (QUALCOMP: Question #12). Third, quality was measured relative to similar competitors' projects in a manner consistent with that of TIMECOMP and COSTCOMP. Respondents were asked to check off one of thirteen boxes asking to what degree the product was of a higher quality, lower quality, or equal quality as compared to similar projects of competitors. A score of thirteen indicates that a project was far superior than competitor projects and a score of one indicates that a project was far inferior than competitor projects.

4.47 Second-Order Outcome Factors. *Project Success - Internal* (SUCCINT: Question #14). Consistent with conceptual arguments, success was measured in two different ways. First, the internal success of a project was measured on a 5-point Likert Scale asking to what extent the project met expectations and attained organizational goals, ranging from not-at-all to completely. A score of five indicates that a project was very successful and a score of one indicates that a project was not very successful.

Project Success - External (SUCCEXT: Question #15). Second, the external success of a project was measured on a 5-point Likert Scale asking to what extent the project was a marketplace success -- i.e., to what extent did the product "win" in competitive situations, ranging from product-flop to completely-successful. This measure was adapted from Griffin (1993). A score of five indicates that a project was very successful and a score of one indicates that a project was not very successful.

CHAPTER 5
ANALYSIS

5.1 Introduction

This chapter details the analytical approach and means of analysis which I used to test the research propositions. The statistical package that was used to perform all of the following analyses was *SPSS* (Statistical Package for the Social Sciences), *Version 6.1 for Windows* (SPSS, 1994).

For the purpose of overview, the first three procedures (data aggregation, factor reduction, and data description and transformation) describe *pre-inferential* steps necessary to convert the data into an appropriate form to test the propositions. These steps are required to aggregate the data to the project-level of analysis, operationalize the outcome concepts, and correct for excessively skewed distributions which depart from assumptions of normality. The next two procedures (main-effect and parsimonious analyses) describe inferences of *direct* relationships between innovation speed and its context, antecedents, and outcomes. They provide the most literal tests of the research propositions. The following procedure (split sample analysis) describes inferences of *moderated* relationships between innovation speed and its context, antecedents, and outcomes. It provides a test of the contingency relationships proposed in Proposition 3b and, because of the widely reported differences in projects due to radicalness, may provide some of the most meaningful results. The final procedure (finer-grained analysis) describes inferences of relationships between the disaggregated measures of antecedent factors and innovation speed. It probes *deeper* into these relationships by examining how their components affect the speed of projects.

5.2 Data Aggregation Analysis

As discussed earlier, the unit of analysis in this research is the new product development project. However, given the retrospective and often subjective nature of some of the variables associated with innovation processes, data was collected from multiple respondents for each project (e.g., project leaders, marking-oriented team members, and technical-oriented team members). Thus the first issue to be addressed in analyzing this data is how to aggregate the individual-level responses to the project level.

To investigate the relative inter-rater agreement for projects, I followed Keller (1994) in performing a one-way analysis of variance on each of the independent and dependent variables to determine whether between-group differences were significant compared to within-group differences. This is necessary to address the "perceptual agreement problem" of using multiple informants in organizations (James, 1982; Kumar, Stern, & Anderson, 1993). The analysis of variance procedure breaks down between-groups variance (i.e., differences between respondents on different projects) and within-groups variance (i.e., differences between respondents on the same project) and analyzes their ratio to draw conclusions about the differences bewteen group means (Iverson & Norpoth, 1987; Kerlinger, 1986; SPSS, 1994). An F-Statistic is calculated as the ratio of the between-groups mean-squares to the within-groups mean-squares. The greater the F-statistic, the lower the *intra*-group variance on a variable relative to the *inter*-group variance on that variable (i.e., the lower the perceptual agreement problem).

After obtaining F-statistics for each variable in the model, I examined their significance levels to assess inter-rater agreement. Following Keller (1986), respondents' scores were aggregated into project scores via unweighted average when there was little inter-rater disagreement -- That is, when the F-statistics were statistically significant[1]. However, as pointed out by several authors (e.g., James, 1982; Keller, 1994), when the theory and subsequent hypotheses require a certain level of analysis, aggregation may be appropriate even without statistical justification. Consequently, responses for all variables were aggregated to the project unit of analysis. However, though Keller simply took the means of variables with low inter-rater reliability, I adopted an alternative approach. When there was considerable discrepancy on a question, the project leader's information was used with the assumption that they were the most familiar with the project and its characteristics. This is consistent with the approaches taken by other researchers in this area (e.g., McDonough, 1993; McDonough & Barczak, 1991).

5.3 Factor Reduction Analysis

Once the data has been aggregated to the appropriate level of analysis, the second issue to be addressed in analyzing this data is the operationalization of the concepts *innovation speed (or time), development costs, product quality,* and *project success.* As discussed earlier, each of the above concepts were measured in several ways. The first three concepts (time, costs, and quality) were estimated by three scales measuring them relative to

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[1] Significance is calculated at the .10 level. Though admittedly a marginal level of significance, it was adopted because others (e.g., Keller, 1994) pooled responses regardless of inter-rater reliability. Thus this higher level allowed marginally-significant variables to be aggregated in a consistent manner while reserving the alternative (and arguably more extreme) approach of disregarding project members' responses and adopting only the project-leaders' responses for variables with excessively low inter-rater agreement levels.

plans (i.e., schedule, budget, specifications), similar past projects, and similar competitor projects. The last concept (success) was estimated by two scales measuring it relative to internal aspirations and external comparisons. Thus the questions exist as to whether these forementioned measurements are independent variables or components of single variables.

To this end, factor analysis was used to test the degree to which the measures of (a) innovation speed; (b) development cost; (c) product quality, and; (d) project success could be represented as single factors in the subsequent regression analyses. Factor analysis is a statistical technique used to derive a relatively small number of factors that can be used to represent relationships among sets of interrelated variables (SPSS, 1994: 47). That is, it attempts to identify underlying, fundamental, unobserved factors that can be used to simplify a more complex set of observed variables based upon the correlations between these variables (Kim & Mueller, 1978). Specifically with regard to the present study, factor analysis is useful because it provides a check upon the theoretical expectations of the study (e.g., that success is both an internally- as well as externally-anchored phenomena) and limits the unwarranted aggregation of these variables by computing statistically testable values of communality among measures (Kerlinger, 1986).

The extraction method chosen is principal components analysis. The goal of factor extraction is to determine the appropriate number of factors that emerge from the collection of variables subjected to it. In principle component analysis, perhaps the most common method of extraction used and the default option in the SPSS factor analysis procedure, linear combinations of the observed variables are formed and components are derived that explain progressively lesser portions of variance (i.e., in descending order). Kerlinger (1986: 576) refers to this method of extraction as "mathematically satisfying because it yields a mathematically unique solution of a factor problem". Ultimately the original set of correlated variables is transformed into a smaller set of uncorrelated variables, whereby principle components are combined as estimates of common factors.

The factor extraction criterion chosen is eigenvalues-greater-than-one, or the 'Kaiser criterion'. Factor extraction criteria determine the number of factors that are included in the factor solution, or final representation of the variable set. Eigenvalues represent the total variance explained by each factor. In the eigenvalues-greater-than-one criterion for extraction, perhaps the most common criterion used (Kim & Mueller, 1978) and the default option in the SPSS factor analysis procedure, only factors that explain at least as much variance as a single variable (each variable has a variance of one) are included in the final factor solution.

In the event of a multi-factor solution for any of the forementioned variable sets, it is often necessary to rotate the factor solution to obtain meaningful results. That is, factor rotation transforms the factor matrix into one that is more easily interpretable. Though there are several algorithms that can be used to rotate a factor solution, perhaps the most common approach used and the default option in the SPSS factor analysis procedure is the varimax method. The varimax method, chosen for this study, attempts to minimize the number of variables that have high loadings on a factor.

Ultimately, the factor analysis procedure will result in a factor matrix which plots the component weights for each variable on the number of factors extracted -- This shows how well each of the factors represent each of the variables. These coefficients are sometimes referred to as factor *loadings*, which represent the degree to which a factor represents a given measure (Kerlinger, 1986; Kim & Mueller, 1978). Since the objective of this procedure is to reduce sets of several variables into smaller factors, the variables will be combined into composite factor scores by weighted average according to their principle component weights (i.e. factor loadings) (Kerlinger, 1986: 585; Kim & Mueler, 1978: 50). Thus, if for example the three measures of time combine to produce a single factor, each component will be multiplied by its factor loading to obtain a weighted average of time. In this example, a new variable of TIME will replace the variables TIMEGOAL, TIMEPAST, and TIMECOMP and will be used in the subsequent regression analyses. The same logic applies to the results for costs, quality, and success. If, however, multiple factors emerge for any of the above concepts, different regression analyses will be used for each of the factors. That is, applying this alternative scenario to development time, there would be different regressions run to test the relationships between the different *types* of speed and its context, antecedents, and outcomes. Again, the same logic applies for costs, quality, and success.

5.4 Descriptive Analysis

The next step that must be taken before any inferences are drawn is to examine the nature of the data. Thus, descriptive information will be derived for each variable in the study to convey a sense of what the data looks like (e.g., central tendencies, measures of dispersion, ranges, skewness, etc.). In this vein, I will report measures for each variable that describe its central tendency (i.e., mean), dispersion (i.e., standard deviation, maximum and minimum values), distribution shape (i.e., kurtosis, skewness), and number of valid observations.

This information will then be used to explore the data set. Variables will be examined to see whether their means are close to the middle of their questionnaire scales (i.e., within one standard-deviation). Additionally, maximum and minimum scores will be examined for each variable to see whether there is a wide range of responses or a narrow, restricted range. Moreover, the shape of each variable's distribution will be examined to assess its relative normality. Although regression hypothesis testing is usually quite insensitive to moderate departures from normality, it is still important to identify significant departures from normality and transform these variables so that the analytical model will be more accurate. Thus, following the recommendations for the SPSS multiple linear regression procedure (SPSS, 1994: 336), if a variable is found to be negatively skewed (i.e., skewness < -1.0), the square transformation will be used to transform the variable. Alternatively, if a variable is found to be positively skewed (i.e., skewness >1.0), the log transformation will be used to transform the variable.

5.5 Main-Effect Analysis

Once responses are aggregated to the appropriate level of analysis, measures are combined into underlying factors, and variables are transformed to cope with excessive skewness, the data is ready to be analyzed. To test the propositions advanced in Chapter 3, multiple linear regression (MLR) analysis was selected. This technique was chosen because it is able to ascertain the relationship between several continuous and categorical independent variables (IVs) and a single continuous dependent variable (DV) -- this is the nature of the propositions. Thus, the MLR procedure was used to test (a) how much variance in the focal 1st order DV (i.e., development time) was accounted for by each of the context-related IVs,

(b) how much variance in the focal 1st order DV was accounted for by each of the antecedent-related IVs, and (c) how much variance in the other 1st order DVs (i.e., project cost and product quality) and 2nd order DV (i.e., project success) was accounted for by the focal 1st order DV (Tabachnik & Fidell, 1989; Kerlinger, 1986).

In the MLR procedure, the effects and magnitude of the effects of more than one independent variable upon one dependent variable are calculated (Kerlinger, 1986). It does this by generating a test statistic (t) for each variable in the model based on the ratio of its partial regression coefficient (b) -- i.e., the deviation sums of squares and cross products for the independent and dependent variables -- to the standard error of its partial regression coefficient (s.e. b) (SPSS, 1994). The greater the t-statistic (+ or -), the stronger the relationship between the independent and dependent variables. The positive or negative value of the t-statistic indicates the direction of the relationship.

Specifically, six separate models were tested, each with several independent variables. The following regression models[2] correspond to the six groups of propositions in Chapter 3:

5.51 Need Factors. Model 1 tests the effects of need factors on time of development. In equation form:

(1) $\text{TIME} = B_0 + B_1\text{ECONINT} + B_2\text{TECHDYN} + B_3\text{DEMDYN} + B_4\text{REGRES} + e$

[2] Of course, if factor analysis reveals that there are multiple independent factors of time (TIME), then the regression models would be tested for each of these factors. The same logic applies for development cost (COST), product quality (QUAL), and project success (SUCC).

Where TIME = time of development (speed), ECONINT= competitive intensity, TECHDYN = technological dynamism, DEMDYN = demographic dynamism, and REGRES = regulatory restrictiveness.

To recall, there were four propositions advanced with regard to the contextual appropriability for speed. They are listed below, along with the appropriate variable code-names that appear in the regression equation:

PROPOSITION 1a: Greater *competitive intensity in a firm's economic environment* (ECONINT) is associated with relatively faster product development (TIME).

PROPOSITION 1b: Greater *dynamism in a firm's technological environment* (TECHDYN) is associated with relatively faster product development (TIME).

PROPOSITION 1c: Greater *dynamism in a firm's demographic environment* (DEMDYN) is associated with relatively faster product development (TIME).

PROPOSITION 1d: Lower *restrictiveness in a firm's regulatory environment* (REGRES) is associated with relatively faster product development (TIME).

5.52 Strategic Orientation, Criteria-Related Factors. Model 2 tests the effects of strategic orientation, criteria-related factors on time of development. In equation form:

(2) $TIME = B_0 + (B_1 SPEEDIMP + B_2 REWSYS + B_3 CULTURE) + (B_4 GOAL + B_5 CONCEPT) + B_6 MGMTSUP + e$

Where TIME = time of development (speed), SPEEDIMP = relative importance of speed, REWSYS = reward system, CULTURE = culture, GOAL = time goal clarity, CONCEPT = concept clarity, and MGMTSUP = top management support.

To recall, there were three propositions advanced with regard to the strategic orientation, criteria-related antecedents to speed. They are listed below, along with the appropriate variable code-names that appear in the regression equation:

PROPOSITION 2a: Greater *emphasis upon innovation speed* (SPEEDIMP, REWSYS, CULTURE) is associated with relatively faster product development (TIME).

PROPOSITION 2b: Greater *goal clarity* (GOAL, CONCEPT) is associated with relatively faster product development (TIME).

PROPOSITION 2c: Greater *project support* (MGMTSUP) is associated with relatively faster product development (TIME).

5.53 Strategic Orientation, Scope-Related Factors. Model 3 tests the effects of strategic orientation, scope-related factors on time of development. In equation form:

(3) $TIME = B_0 + B_1 BREADTH + B_2 RADICAL + B_3 SOURCE + e$

Where TIME = time of development (speed), BREADTH = product stream breadth, RADICAL = radicalness, and SOURCE = external sourcing.

To recall, there were three propositions advanced with regard to the strategic orientation, scope-related antecedents to speed. They are listed below, along with the appropriate variable code-names that appear in the regression equation:

PROPOSITION 3a: Greater *project focus* (BREADTH) is associated with relatively faster product development (TIME).

PROPOSITION 3b: Lower *degree of change* (RADICAL) attempted is associated with relatively faster product development (TIME).

PROPOSITION 3c: Greater *use of external sources* (SOURCE) is associated with relatively faster product development (TIME).

5.54 Organizational Capability, Staffing-Related Factors. Model 4 tests the effects of organizational capability, staffing-related factors on time of development. In equation form:

(4) $$\text{TIME} = B_0 + (B_1\text{PCHAMP} + B_2\text{ICHAMP}) + (B_3\text{LPOS} + B_4\text{LPOW} + B_5\text{LTEN} + B_6\text{LASS}) + (B_7\text{MEDUC} + B_8\text{MEXP} + B_9\text{MTEN} + B_{10}\text{MASS}) + B_{11}\text{REP} + e$$

Where TIME = time of development (speed), PCHAMP = presence (i.e., number) of champion(s), ICHAMP = influence of champion(s), LPOS = leader position, LPOW = leader power, LTEN = leader tenure, LASS = leader assignment status, MEDUC = member education, MEXP = member experience, MTEN = member tenure, MASS = member assignment status, and REP = representativeness.

To recall, there were four propositions advanced with regard to the organizational capability, staffing-related antecedents to speed. They are listed below, along with the appropriate variable code-names that appear in the regression equation:

PROPOSITION 4a: Greater *product champion presence and influence* (PCHAMP, ICHAMP) is associated with relatively faster product development (TIME).

PROPOSITION 4b: Greater *strength of the project leader* (LPOS, LPOW, LTEN, LASS) is associated with relatively faster product development (TIME).

PROPOSITION 4c: Greater *project member experience* (MEDUC, MEXP, MTEN, MASS) is associated with relatively faster product development (TIME).

PROPOSITION 4d: Greater *project team representativeness* (REP) is associated with relatively faster product development (TIME).

5.55 Organizational Capability, Structuring-Related Factors. Model 5 tests the effects of organizational capability, structuring-related factors on time of development. In equation form:

(5) $\text{TIME} = B_0 + B_1\text{AUT} + (B_2\text{OVER} + B_3\text{FUNC} + B_4\text{DFM} + B_5\text{PROX}) + (B_6\text{MILE} + B_7\text{TEST} + B_8\text{CAD}) + e$

Where TIME = time of development (speed), AUT = autonomy, OVER = overlap, FUNC = functionalness (turf-guarding), DFM = Design for Manufacturing, PROX = proximity, MILE = milestone frequency (as a percent of total development time), TEST = testing frequency (as a percent of total development time), and CAD = use of CAD systems.

To recall, there were three propositions advanced with regard to the organizational capability, structuring-related antecedents to speed. They are listed below, along with the appropriate variable code-names that appear in the regression equation:

PROPOSITION 5a: Greater *project team autonomy* (AUT) is associated with relatively faster product development (TIME).

PROPOSITION 5b: Greater *project integration* (OVER, FUNC, DFM, PROX) is associated with relatively faster product development (TIME).

PROPOSITION 5c: Greater *development process organization* (MILE, TEST, CAD) is associated with relatively faster product development (TIME).

5.56 Outcome Factors. Model 6 is, strictly speaking, a collection of three separate regression analyses. Model 6.1 tests the effect of time of development on project development costs. Model 6.2 tests the effect of time of development on product quality. Model 6.3 tests the effect of time of development on project success. In equation form:

(6.1) $$\text{COST} = B_0 + B_1\text{TIME} + e$$

(6.2) $$\text{QUAL} = B_0 + B_1\text{TIME} + e$$

(6.3) $$\text{SUCC} = B_0 + B_1\text{TIME} + e$$

Where TIME = time of development (speed), COST = development costs, QUAL = product quality, and SUCC = project success.

To recall, there were three propositions advanced with regard to the outcomes of innovation speed. They are listed below, along with the appropriate variable code-names that appear in the regression equation:

PROPOSITION 6a: Faster product development (TIME) is associated with relatively *lower costs of development* (COST).

PROPOSITION 6b: Faster product development (TIME) is associated with relatively *higher product quality* (QUAL).

PROPOSITION 6c: Faster product development (TIME) is associated with relatively *higher project success* (SUCC).

5.6 Parsimonious Analysis of Antecedent Factors

Although the previously described antecedent regression equations (Model 2 through Model 5) test each component of the second research question, a potential problem exists insofar as they do not control for all other antecedent variables. For example, the effects of strategic-orientation criteria-related antecedents on innovation speed are tested without controlling for strategic-orientation scope-related antecedents, organizational-capability staffing-related antecedents, or organizational-capability structuring-related antecedents. Therefore, the task remains to test the relationships between the antecedent factors (IVs) and development time (DV) while controlling for the other antecedent factors in the model.

In situations such as this one, where there are many independent variables, an automatic search procedure (or stepping procedure) is called for that sequentially develops a "best" (or parsimonious) subset of independent variables to be included in the regression model (Neter, Wasserman, & Kutner, 1990: 458). There are several, largely similar analytical approaches to the task of sequentially analyzing all antecedent factors while adjusting for the affects of one another on innovation speed. The most frequently used of these "stepping procedures" are stepwise-selection, forward-selection, and backward-elimination (SPSS, 1994). To the end of selecting one of these procedures over the others, SPSS (1994: 347) reports that "none of these selection procedures are 'best' in any absolute sense." Instead, the choice between approaches should be made on the basis of the objectives of the analysis.

Because it is the objectives of this analysis to test the antecedent variables while simultaneously controlling for the others, backward elimination is chosen -- backward-elimination MLR analysis allows the researcher to examine each independent variable in the regression function adjusted for all the other independent variables in the pool (Neter, Wasserman, & Kutner, 1990: 458). Specifically, backward-elimination of independent variables starts with all the variables in the equation (as opposed to forward-selection and stepwise-selection, which add variables one at a time) and sequentially removes them. The removal criteria used is "probability of F-to-remove" (POUT). The POUT procedure removes variables from the regression equation sequentially, beginning with the variable with the highest p-value, and continues to recompute the regression equation and remove variables until all remaining variables have a p-value of less than 0.10 (default criterion). The final equation represents the parsimonious (or "best") regression model.

Therefore, in model 7, the antecedent factors described in Models 2 through Model 5 are entered into a backward-elimination multiple linear regression equation to test their effects on innovation speed.

5.7 Split-Sample Analysis

The preceding analyses examines the context, antecedents and outcomes of innovation speed for all projects in the sample. However, as noted earlier, some previously-discussed research suggests that product innovation projects should be distinguished by their degree of radicalness (e.g., Dewar & Dutton, 1986; Damanpour, 1991) and that, specifically with regard to innovation speed, projects of different degrees of radicalness should be examined separately (e.g., McDonough, 1993; Tabrizi & Eisendardt, 1993). That is, innovation radicalness may *moderate* (Baron & Kenny, 1986) the proposed relationships involving innovation speed. Thus a split-sample analysis was performed on the data by first dividing projects into categories of radicalness and then re-running the previously discussed multiple linear regression analyses on these categories.

To review, the radicalness scale used in this research was a continuous measure ranging from possible scores of two (least radical) to ten (most radical). While dividing the projects into two halves -- high (i.e. radical) and low (i.e., incremental) -- is perhaps the most straightforward and simple approach, some research suggests that this distinction is not fine grained enough. That is, taking a median split is overly simplistic because a median split approach does not make the distinction between these extreme types and "moderately" radical projects such as those which involve minor changes in either components or linkages (Henderson & Clark, 1990). Instead, a median split forces these moderately radical projects into the two broad categories and subsequently fails to capture the variance in speed explained by a slightly more sophisticated conceptualization of innovation radicalness. Further, a statistical problem emerges from a median split insofar as innovations rated as a "six" on the radicalness scale are exactly in the middle and do not have a clear membership to the radicalness or incremental categories. Thus the 75 projects in the sample were divided into three categories: (1) *low* degree of radicalness - representing 17 projects with scores in the lower-third of the radicalness scale (from 2.00-4.67); (2) *moderate* degree of radicalness, representing 37 projects with scores in the middle-third of the radicalness scale (from 4.68 to 7.33), and; (3) *high* degree of radicalness, representing 21 projects with scores in the upper-third of the radicalness scale (from 7.34 to 10.00).

Subsequently, the six previously described regression models were each segmented into three models to test the projects in each of the three categories of radicalness. These regression models are almost identical to the main-effect models detailed above; the only way in which the split-sample models differ from the main-effect models is that each model is subdivided into three models by radicalness. Thus Model 1 in the main effects analysis is now Model 1a (high radicalness), Model 1b (moderate radicalness) and Model 1c (low radicalness) in the split-sample analysis. The logic is the same for models 2 through 6.

5.8 Finer-Grained Analysis of Disaggregated Measures

As discussed in Chapter 4 (Section 4) there were several variables in the study that have multiple indicator scales. Thus the following "finer-grained" MLR models are tested to probe deeper into these relationships by examining the disaggregated measures of these variables. For example, if representativeness is found to be related (positively or negatively) or unrelated to speed, why? Is it because representing some interest groups (e.g., customers, marketers) sped up innovation processes while representing others (e.g., distributors, accountants) slowed them down? Similarly, if the nature of a firm's reward-system has an effect on the speed of a given project, is it because specific individuals (versus groups) were rewarded (versus punished) on the basis of time? Alternatively, if reward system has no effect, is it because positively- and negatively-related components canceled each other out? The following sub-sections detail selected finer-grained MLR models examined.

5.81 Reward System. To recall, Model 2 (as well as Models 2a-2c in the split-sample analysis) examined the effects of reward system on innovation speed. The nature of reward systems, in turn, consisted of four measures: rewarding individuals (REWIND), punishing individuals (PUNIND), rewarding collectives (REWCOL), and punishing collectives (PUNCOL). Thus the following model was tested to discern the relative impact of each of these dimensions upon the speed of innovation:

(2d) $$\text{TIME} = B_0 + B_1\text{REWIND} + B_2\text{PUNIND} + B_3\text{REWCOL} + B_4\text{PUNCOL} + e$$

5.82 Culture. To recall, Model 2 (as well as Models 2a-2c in the split-sample analysis) also examined the effects of cultural orientation on innovation speed. The nature of a culture, in turn, consisted of three measures: support for failing (FAIL), support for learning (LEARN), and support for risk-taking (RISK). Thus the following model was tested to discern the relative impact of each of these dimensions upon the speed of innovation:

(2e) $$TIME = B_0 + B_1 FAIL + B_2 LEARN + B_3 RISK + e$$

5.83 Project Stream Breadth Dimensions. To recall, Model 3 (as well as Models 3a-3c in the split-sample analysis) examined the effects of product stream breadth (i.e., resource munificence) on innovation speed. Product stream breadth, in turn, consisted of four measures: competition for financial resources (FIN), competition for materials/space/equipment (MSE), competition for management attention (ATT), and competition for personnel (PER). Thus the following model was tested to discern the relative impact of each of these dimensions upon the speed of innovation:

(3d) $$TIME = B_0 + B_1 FIN + B_2 MSE + B_3 ATT + B_4 PER + e$$

5.84 Representativeness. To recall, Model 4 (as well as Models 4a-4c in the split-sample analysis) examined the effects of interest group representativeness upon innovation speed. Representativeness, in turn, consisted of two different groups of measures: *internal* interest group representativeness and *external* interest group representativeness. On the one hand, internal representativeness consisted of five measures: purchasing (PUR), manufacturing (MAN), marketing (MAR), engineering (ENG), and finance/accounting (FA). Thus the following model was tested to discern the relative impact of each of these internal dimensions upon the speed of innovation:

(4d) $\text{TIME} = B_0 + B_1\text{PUR} + B_2\text{MAN} + B_3\text{MAR} + B_4\text{ENG} + B_5\text{FA} + e$

On the other hand, external representativeness consisted of three measures: customers (CUS), distributors (DIS), and suppliers (SUP). Thus the following model was tested to discern the relative impact of each of these external dimensions upon the speed of innovation:

(4e) $\text{TIME} = B_0 + B_1\text{CUS} + B_2\text{DIS} + B_3\text{SUP} + e$

5.85 Autonomy. To recall, Model 5 (as well as Models 5a-5c in the split-sample analysis) examined the effects of a measure of project team autonomy (or empowerment) on the speed of innovation. Autonomy, in turn, consisted of four measures: authority over activities (ACT), authority over targets/goals (TAR), authority over recruiting/people (REC), and authority over resources/finances (RES). Thus the following model was tested to discern the relative impact of each of these dimensions upon speed of innovation:

(5d) $\text{TIME} = B_0 + B_1\text{ACT} + B_2\text{TAR} + B_3\text{REC} + B_4\text{RES} + e$

CHAPTER 6
RESULTS

6.1 Introduction

This chapter details the results of the previously discussed analyses used to test the research propositions. First, the data aggregation results will be presented. Second, the factor reduction results will be presented. Third, the descriptive results and variable transformations will be presented. Fourth, the main-effect multiple linear regression (MLR) results will be presented. Fifth, the split-sample MLR results will be presented. Sixth, the finer-grained, disaggregated measures MLR results will be presented.

6.2 Data Aggregation Statistics: One-Way Analyses of Variance

Table 6-1 reports the results for the One-Way ANOVAs for each variable which compare within-project to between-project variance in responses. For each factor, F-statistics, significance-levels, and aggregation decisions are included.

As Table 6-1a indicates, all of the indicators for innovation speed were significant, indicating that there was a higher ratio of within-project to between-project agreement on the rate at which products were developed (i.e., respondents were more consistent with people on their project than people on other projects when evaluating innovation speed). Hence, the individual respondents' scores were aggregated to the project level via unweighted average.

Table 6-1b indicates that there was some disagreement among project members in their interpretation of the relevant task and institutional environments. This is consistent with research that reports a subjective component to environmental perception and interpretation

TABLE 6-1a
One-Way ANOVA Results and Data Aggregation Decisions
Innovation Speed Components

FACTOR	F-STATISTIC	P-LEVEL	DECISION
Time-Goal	1.89	.0106	Average
Time-Past	1.90	.0103	Average
Time-Competitors	1.83	.0479	Average

TABLE 6-1b
One-Way ANOVA Results and Data Aggregation Decisions
Model 1: Need Factors

FACTOR	F-STATISTIC	P-LEVEL	DECISION
Economic Intensity	1.32	.1746	Leader
Technological Dynamism	1.76	.0231	Average
Demographic Dynamism	1.26	.2236	Leader
Regulatory Restrictiveness	1.36	.1464	Leader

TABLE 6-1c
One-Way ANOVA Results and Data Aggregation Decisions
Model 2: Strategic Orientation. Criteria-Related Factors

FACTOR	F-STATISTIC	P-LEVEL	DECISION
Relative Importance	1.50	.0736	Average
Reward System	1.09	.3776	Leader
Culture	0.93	.6125	Leader
Goal Clarity	1.31	.1563	Leader
Concept Clarity	1.48	.0721	Average
Management Support	2.35	.0008	Average

TABLE 6-1d
One-Way ANOVA Results and Data Aggregation Decisions
Model 3: Strategic Orientation: Scope-Related Factors

FACTOR	F-STATISTIC	P-LEVEL	DECISION
Project Stream Breadth	.89	.6725	Leader
Radicalness	1.06	.4234	Leader
External Sourcing	2.46	.0005	Average

TABLE 6-1e
One-Way ANOVA Results and Data Aggregation Decisions
Model 4: Organizational Capability: Staffing-Related Factors

FACTOR	F-STATISTIC	P-LEVEL	DECISION
Champion (Number)	2.61	.0003	Average
Champion (Influence)	1.56	.0633	Average
Leader Position	1.20	.2569	Leader
Leader Power	1.37	.1212	Leader
Leader Tenure	1.93	.0160	Average
Leader Involvement	3.01	.0000	Average
Member Education	1.25	.2044	Leader
Member Experience	0.58	.9809	Leader
Member Tenure	1.03	.4691	Leader
Member Involvement	1.76	.0174	Average
Representativeness	1.75	.0222	Average

TABLE 6-1f
One-Way ANOVA Results and Data Aggregation Decisions
Model 5: Organizational Capability: Structuring-Related Factors

FACTOR	F-STATISTIC	P-LEVEL	DECISION
Autonomy	1.79	.0160	Average
Overlap	3.39	.0015	Average
Turf-Guarding	1.62	.0364	Average
Design for Manufacturing	1.86	.0122	Average
Proximity	2.57	.0003	Average
Milestones	2.68	.0009	Average
Testing	3.93	.0007	Average
CAD Use	2.29	.0823	Average

TABLE 6-1g
One-Way ANOVA Results and Data Aggregation Decisions
Model 6: Outcome Factor Components

FACTOR	F-STATISTIC	P-LEVEL	DECISION
Development Cost (Goal)	2.47	.0048	Average
Development Cost (Past)	1.17	.3180	Leader
Development Cost (Competitors)	2.10	.0800	Average
Product Quality (Goal)	1.02	.4750	Leader
Product Quality (Past)	1.26	.2021	Leader
Product Quality (Competitors)	1.20	.2718	Leader
Project Success (External)	1.87	.0183	Average
Project Success (Internal)	1.09	.3760	Leader

(e.g., Dutton & Jackson, 1987; Thomas, Clark, & Gioia, 1993; Weick, 1979). Thus the leaders' responses were adopted for three of the four context-related variables with the exception of technological dynamism, which had a high ratio of within-project to between-project agreement.

Tables 6-1c and 6-1d report mixed levels of agreement for the strategic orientation antecedent variables. Relative importance, concept clarity, management support (criteria-related variables), and external sourcing (scope-related variable) had high ratios of within-project to between-project agreement; thus an unweighted average was taken. Reward system, culture, goal clarity (criteria-related variables), project stream breadth, and radicalness (scope-related variables) had low ratios of within-project to between-project agreement; thus the project leaders' responses were adopted.

Tables 6-1e and 6-1f report mixed levels of agreement for the organizational capability antecedent variables. Champion presence, champion influence, leader tenure, leader involvement, member involvement, representativeness (staffing-related variables), autonomy, overlap, turf-guarding, design-for-manufacturing, proximity, milestones, testing, and CAD use (structuring-related variables) had high ratios of within-project to between-project agreement; thus an unweighted average was taken. Leader position, leader power, member education, member experience, and member tenure (staffing-related variables) had low ratios of within-project to between-project agreement; thus the project leaders' reponses were adopted.

Table 6-1g reports mixed levels of agreement for the outcome variables. Cost-goal, cost-competitors, and success-external had high ratios of within-project to between-project agreement; thus an unweighted average was taken. Cost-past, quality-goal, quality-past, quality-competitors, and success-internal had low ratios of within-project to between-project agreement; thus the project leaders' responses were adopted.

6.3 Factor Reduction Statistics: Principle Component Factor Analyses

Table 6-2 summarizes the results from the factor analyses using (a) principle component analysis as the method of extraction and (b) using the number of variables with eigenvalues equal to or greater than one as the criteria for extraction.

As Table 6-2a indicates, the three measures of development time all loaded onto a single factor of innovation speed with an eigenvalue-greater-than-one. This was also true of the three measures of development cost (Table 6-2b), the three measures of product quality (Table 6-2c), and the two measures of project success (Table 6-2d). These results indicate that innovation speed, development cost, product quality, and project success were single factors. Subsequently, the multiple components of speed, cost, quality, and success were combined into single factors by taking the weighted average of each of their components (weights determined by the appropriate factor loading). For example, in each project, time was calibrated by taking the weighted average of the responses for time-goal (multiplied by its factor loading of .86213), time-past (multiplied by its factor loading of .75515), and time-competition (multiplied by its factor loading of .72916).

Thus the result of factor reduction was the creation of composite measures for speed, costs, quality, and success. The aggregated innovation speed scores (TIME) ranged from one (fastest, least time) to thirteen (slowest, most time). The aggregated development cost scores

TABLE 6-2a
Principal Component Factor Analysis
Innovation Speed

VARIABLE	COMMUNALITY	FACTOR	EIGNEVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCANTAGE
Time - Competitors	1.00000	1	1.84520	61.5	61.5
Time - Goal	1.00000	2	.72568	24.2	85.7
Time - Past	1.00000	3	.42912	14.3	100.0

	FACTOR 1
Time - Competitors	.72916
Time - Past	.75515
Time - Goal	.86213

TABLE 6-2b
Principal Component Factor Analysis
Development Cost

VARIABLE	COMMUNALITY	FACTOR	EIGNEVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCANTAGE
Cost - Competitors	1.00000	1	1.70765	56.9	56.9
Cost - Goal	1.00000	2	.75976	25.3	82.2
Cost - Past	1.00000	3	.53259	17.8	100.0

	FACTOR 1
Cost - Competitors	.66651
Cost - Past	.77545
Cost - Goal	.81369

TABLE 6-2c
Principal Component Factor Analysis
Product Quality

VARIABLE	COMMUNALITY	FACTOR	EIGNEVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCANTAGE
Quality - Competitors	1.00000	1	2.13613	71.2	71.2
Quality - Goal	1.00000	2	.52165	17.4	88.6
Quality - Past	1.00000	3	.34222	11.4	100.0

	FACTOR 1
Quality - Competitors	.81274
Quality - Past	.83304
Quality - Goal	.88409

TABLE 6-2d
Principal Component Factor Analysis
Project Success

VARIABLE	COMMUNALITY	FACTOR	EIGNEVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCANTAGE
Success-External	1.00000	1	1.52380	76.2	76.2
Success-Internal	1.00000	2	.47620	23.8	100.0

	FACTOR 1
Success-External	.87287
Success-Internal	.87287

(COST) ranged from one (cheapest, lowest expense) to thirteen (dearest, highest expense). The aggregated product quality scores (QUAL) ranged from one (worst, lowest quality) to thirteen (best, highest quality). The aggregated success scores (SUCC) ranged from one (dud, least successful) to five (winner, most successful).

6.4 Descriptive Statistics and Variable Transformations

Table 6-3 reports descriptive information for each variable in the study to convey a sense of what the data looks like (e.g., central tendencies, measures of dispersion, ranges, skewness, etc.).

As Table 6-3 indicates, there was a wide range of responses for all variables. First, regarding time[1,2], Table 6-3a reports that projects were on the average slightly faster than the

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[1] Because time in this study is essentially a subjective and perceptual measure, checks were undertaken to guard against a possible "halo" effect (i.e., overly positive estimations of a project's speed) due to single-respondents for projects or leaders' attempts at impression management. Separate analysis of variance procedures revealed that there were no significant between-group differences (a) at the project level of analysis, for projects with one, two, or three respondents regarding the aggregated time factor (F=0.31, p=.74) and (b) at the individual level of analysis, for type of respondent (i.e., leaders, marketing members, and technical members) regarding time-goal (F=2.19, p=.12), time-past (F=0.42, p=.66), or time-competition (F=2.09, p=.13) measures. Further, Pearson bivariate correlations revealed a significant, positive relationship between absolute time (number of months elapsed in the product development process) and the perceptually-based aggregated time factor (r=.40, p<.01). These results all point away from halo effects.

[2] Because several companies from different industries were sampled, tests for between-group differences in speed were undertaken. Separate analysis of variance procedures and post-hoc Tukey multiple-comparison procedures revealed that (a) there were between-company differences (F=3.48, p<.01), with the average speed of projects for two companies (#6 and #3) significantly slower than the other companies, and (b) there were between-industry differences, (F=7.55, p<.01), with the average speed of projects from the Chemical/Chemical Products and Confectionary/Consumer Products industries significantly faster than those from the Advanced/Scientific Materials and Industrial Equipment/Products industries. Thus, strictly speaking, the results are generalizable only to the specific firms and industries represented in the sample because of the divergent nature of macro-level context. That is, company and industry may be important variables to consider. However, to the extent that variations in these contexts produced differences in strategic orientation

TABLE 6-3a
Descriptive Statistics
Time of Development

FACTOR	MEAN	SD	MAX	MIN	KURTOSIS	SKEWNESS	VALID OBSERVATIONS
Time	5.35	1.39	9.45	2.59	.314	.365	62

TABLE 6-3b
Descriptive Statistics
Model I: Need Factors

FACTOR	MEAN	SD	MAX	MIN	KURTOSIS	SKEWNESS	VALID OBSERVATIONS
Economic Intensity	2.98	1.11	5.00	1.00	-.705	-.250	74
Technological Dynamism	2.80	.95	5.00	1.00	-.338	.509	73
Demographic Dynamism	2.62	1.01	5.00	1.00	-.468	.146	71
Regulatory Restrictiveness	2.97	.95	5.00	1.00	-.126	-.302	72

TABLE 6-3c
Descriptive Statistics
Model 2: Strategic-Orientation Criteria-Related Factors

FACTOR	MEAN	SD	MAX	MIN	KURTOSIS	SKEWNESS	VALID OBSERVATIONS
Relative Importance	1.36	.64	3.00	1.00	-.538	.715	71
Reward System	11.25	2.99	18.00	4.50	-.512	-.207	75
Culture	9.01	2.53	13.00	3.00	-.775	-.176	74
Goal Clarity	7.85	2.18	10.00	2.00	.181	-.955	74
Concept Clarity	8.10	1.75	10.00	2.00	1.658	-1.189	74
Management Support	3.93	1.00	5.00	1.00	.384	-.888	75

TABLE 6-3d
Descriptive Statistics
Model 3: Strategic-Orientation Scope-Related Factors

FACTOR	MEAN	SD	MAX	MIN	KURTOSIS	SKEWNESS	VALID OBSERVATIONS
Project Stream Breadth	11.61	3.59	20.00	4.00	-.374	-.093	74
Radicalness	6.14	1.93	10.00	2.00	-.538	.224	75
External Sourcing	2.38	1.94	10.00	2.00	.249	-.738	75

TABLE 6-3e
Descriptive Statistics
Model 4: Organizational-Capability Staffing-Related Factors

FACTOR	MEAN	SD	MAX	MIN	KURTOSIS	SKEWNESS	VALID OBSERVATIONS
Champion (Number)	1.96	1.43	10.00	0.00	12.776	2.731	75
Champion (Influence)	3.79	0.94	5.00	1.00	-.162	-.410	71
Leader Position	0.41	0.48	1.00	0.00	-1.838	.364	74
Leader Power	1.41	1.24	4.00	0.00	-1.196	.331	75
Leader Tenure	166.94	106.78	446.00	30.00	-.505	.640	72
Leader Involvement	3.31	1.16	5.00	1.00	-.901	-.162	75
Member Education	3.63	0.79	5.00	2.00	-.581	.256	75
Member Experience	3.53	1.26	5.00	1.00	-1.026	-.336	73
Member Tenure	96.49	52.77	360.00	36.00	8.371	2.338	70
Member Involvement	3.01	1.03	5.00	1.00	-.664	-.084	75
Representativeness	20.63	7.27	42.00	7.00	.225	.531	73

TABLE 6-3f
Descriptive Statistics
Model 5: Organizational-Capability Structuring-Related

FACTOR	MEAN	SD	MAX	MIN	KURTOSIS	SKEWNESS	VALID OBSERVATIONS
Autonomy	14.01	3.07	20.00	7.00	-.156	.243	74
Overlap	2.05	0.79	4.00	1.00	.015	.770	60
Turf Guarding	2.59	1.04	5.00	1.00	-.506	.457	74
DFM	3.29	1.60	6.00	0.00	-.842	.129	74
Proximity	4.40	1.51	7.00	1.00	-.485	-.518	75
Milestones (Pct)	0.56	0.21	1.00	.05	-.395	.339	59
Testing (Pct)	0.42	0.23	.90	.07	-.791	.454	63
CAD Use (Pct)	0.32	0.42	1.00	0.00	-1.134	.826	66

TABLE 6-3g
Descriptive Statistics
Model 6: Outcome Factors

FACTOR	MEAN	SD	MAX	MIN	KURTOSIS	SKEWNESS	VALID OBSERVATIONS
Development Cost	6.06	1.21	8.70	2.64	.369	-.244	52
Product Quality	7.30	1.38	10.65	4.34	-.218	.663	72
Project Success	4.12	.71	5.00	1.00	4.859	-1.495	61

midpoint of their scales (about 10% faster than benchmarks); however, they ranged from very fast (about 75% faster than benchmarks) to very slow (about 75% slower than benchmarks). There was a low degree of kurtosis (i.e., spiking) and skewness (i.e., imbalance) in its distribution, which suggests that there is no significant threat to the assumption of normality.

Second, Table 6-3b reports the mean for all four need factors were also close to the midpoint of their scales, and their ranges also included both the high and low extremes. There were also no signs of significant departures from normality.

Third, Table 6-3c reports that the strategic-orientation criteria-related antecedent factors had wide ranges of values and their means were generally within one standard deviation from their scales' midpoints. Noticeable exceptions included time-goal and concept clarity (high mean scores) and management support (high mean score). In other words, projects in the sample tended to be defined clearly and supported by top management. However, only concept clarity had a skewness greater than one (tail toward lower values, skewness = -1.189) -- there was a disproportionately large number of projects in the sample with high concept clarity. Because of a threat to normality, this score underwent a square-transformation to compensate for its negative skewness[3] (SPSS, 1994: 336).

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and/or organizational capability which underlie the observed differences in speed, generalizability might not be so limited. In fact, the results might be *more* generalizable because it is harder to find significant effects that hold across different company and industry contexts (especially divergent ones) than it is to find significant effects within a single company or industry. Additionally, sampling projects from companies and industries varying in speed might be beneficial for avoiding restriction in range problems.

[3] It should be noted that the F-test used in regression hypothesis testing is quite insensitive to moderate departures from normality. However, to be conservative, the square transformation was used for negatively-skewed results (greater than one) and the log transformation was used for positively skewed results (greater than one) (SPSS, 1994: 336).

Fourth, Table 6-3d reports that the strategic-orientation scope-related antecedent factors also had wide ranges of values and their means were generally within one standard deviation from their scales' midpoints. There were no signs of significant departures from normality.

Fifth, Table 6-3e reports that the organizational-capability staffing-related antecedent factors had generally broad ranges and central means. Noticeable exceptions were champion presence (tail toward larger values, skewness = 2.731) and member tenure (tail toward larger values, skewness = 2.338) -- there were a small number of projects in the sample with disproportionately large numbers of champions and with disproportionately long tenures of team members. Because of threats to normality, these scores underwent log-transformations to compensate for their positive skewness (SPSS, 1994: 336).

Sixth, Table 6-3f reports that the organizational-capability structuring-related antecedent factors also had generally broad ranges and central means. The only variable with a mean greater than one standard deviation from its scale's midpoint was autonomy (high mean score). In other words, projects in the sample tended to be undertaken by empowered teams. Notwithstanding, there were no signs of significant departures from normality.

Seventh, Table 6-3g reports that for the outcome factors[4] development cost and

[4] Tests for company and industry differences in the outcome factors were also performed. Separate analysis of variance procedures and post-hoc Tukey multiple-comparison procedures revealed that (a) there were no between-company differences with regard to projects' average development cost ($F=1.21$, $p=.32$), product quality ($F=1.02$, $p=.44$) or project success ($F=1.27$, $p=.28$), and (b) there were no between-industry differences with regard to projects' average development cost ($F=1.04$, $p=.38$) or product quality ($F=0.53$, $p=.66$). However, there were significant differences between industries regarding project success ($F=2.98$, $p<.05$): The average success of projects from the Confectionary/Consumer Products industry was significantly higher than those from the other three industries.

product quality also had broad ranges and generally central means. Projects tended to be on the average quite successful. However, there was a large range of projects examined, ranging from the most successful to the least successful. Notwithstanding, project success did have a skewness greater than one (tail toward lower values, skewness = -1.495) -- there was a disproportionately large number of projects in the sample with high levels of success. Because of a threat to normality, this score underwent a square-transformation to compensate for its negative skewness (SPSS, 1994: 336).

Because of the importance of measuring time to the research propositions, Table 6-4 provides more detailed description of what the this data looks like. Specifically, it lists the frequency of responses, at the project level of analysis, for the aggregated time factor (Table 6-4a) as well as time relative to goals (Table 6-4b), time relative to similar past projects (Table 6-4c), and time relative to similar competitor projects (Table 6-4d). Together, the tables show that just over half of the projects in the sample were rated as relatively fast (54.9%) -- this is because most projects were rated as faster than similar past projects (71%) and similar competitor projects (59%) and despite the fact that a minority of projects were rated as faster than their time-goal (20%). Thus it appears that most projects in the sample are getting faster (i.e., development is being accelerated) and are outpacing their competition, but that schedules are also being set more aggressively. Tables 6-4b through 6-4d also show that there were relatively broad ranges of responses for all three questions regarding time; Respondents' assessments of their projects' speed spanned almost the entire range of values for each scale.

TABLE 6-4a
Frequency of Responses, at the Project Level of Analysis, for the Aggregated Time Factor

VALUE	LABEL	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
1.0-1.4	>100% faster	0	0	0	0
1.5-2.4	76-100% faster	0	0	0	0
2.5-3.4	51-75% faster	7	9.3	11.3	11.3
3.5-4.4	26-50% faster	11	14.7	17.7	29.0
4.5-5.4	0-25% faster	16	21.3	25.9	54.9
5.5-6.4	the same	20	26.7	32.3	87.1
6.5-7.4	0-25% slower	3	4.0	4.8	91.9
7.5-8.4	26-50% slower	4	5.3	6.5	98.4
8.5-9.4	51-75% slower	1	1.3	1.6	100.0
9.5-10.4	76-100% slower	0	0	0	100.0
10.5-11.0	> 100% slower	0	0	0	100.0
Missing	-----	13	17.3	-----	-----

TABLE 6-4b
Frequency of Responses, at the Project Level of Analysis, for
Time Relative to Goals

VALUE	LABEL	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
4.00	26-50% faster	3	4.0	4.2	4.2
4.50		2	2.7	2.8	7.0
5.00	0-25% faster	2	2.7	2.8	9.9
5.33		1	1.3	1.4	11.3
5.50		5	6.7	7.0	18.3
5.67		1	1.3	1.4	19.7
6.00	the same	22	29.3	31.0	50.7
6.50		3	4.0	4.2	54.9
7.00	0-25% slower	10	13.3	14.1	60.9
7.33		2	2.7	2.8	71.8
7.50		2	2.7	2.8	74.6
7.67		1	1.3	1.4	76.1
8.00	26-50% slower	3	4.0	4.2	80.3
8.33		2	2.7	2.8	83.1
8.50		3	4.0	4.2	87.3
8.67		1	1.3	1.4	88.7
9.00	51-75% slower	3	4.0	4.2	93.0
9.50		1	1.3	1.4	94.4
10:50		1	1.3	1.4	95.8
11.00	>100% slower	3	4.0	4.2	100.0
Missing	-----	4	5.3	-----	-----

TABLE 6-4c
Frequency of Responses, at the Project Level of Analysis, for
Time Relative to Similar Past Projects

VALUE	LABEL	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
1.00	> 100% faster	3	4.0	4.2	4.2
1.50		1	1.3	1.4	5.6
2.00	76-100% faster	3	4.0	4.2	9.7
2.50		2	2.7	2.8	12.5
3.00	51-75% faster	7	9.3	9.7	22.2
3.33		1	1.3	1.4	23.6
3.50		1	1.3	1.4	25.0
4.00	26-50% faster	12	16.0	16.7	41.7
4.33		1	1.3	1.4	43.1
4.50		2	2.7	2.8	45.8
4.67		2	2.7	2.8	48.6
5.00	0-25% faster	11	14.7	15.3	63.9
5.33		2	2.7	2.8	66.7
5.50		2	2.7	2.8	69.4
5.67		1	1.3	1.4	70.8
6.00	the same	13	17.3	18.1	88.9
6.67		1	1.3	1.4	90.3
7.00	0-25% slower	2	2.7	2.8	93.1
8.00	26-50% slower	3	4.0	4.2	97.2
9.00	51-75% slower	1	1.3	1.4	98.6
11.00	> 100% slower	1	1.3	1.4	100.0
Missing	-----	3	4.0	-----	-----

TABLE 6-4d
Frequency of Responses, at the Project Level of Analysis, for
Time Relative to Similar Competitor Projects

VALUE	LABEL	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
1.0	> 100% faster	5	6.7	7.9	7.9
2.0	76-100% faster	7	9.3	11.1	19.0
3.0	51-75% faster	3	4.0	4.8	23.8
3.5		1	1.3	1.6	25.4
4.0	26-50% faster	12	16.0	19.0	44.4
5.0	0-25% faster	9	12.0	14.3	58.7
6.0	the same	18	24.0	28.6	87.3
7.0	0-25% slower	5	6.7	7.9	95.2
8.0	26-50% slower	2	2.7	3.2	98.4
11.0	> 100% slower	1	1.3	1.6	100.0
Missing	-----	12	16.0	-----	-----

6.5 Main-Effect Statistics: Multiple Linear Regression Analyses[5]

To reiterate, six separate main-effect MLR models were tested, corresponding to the six groups of propositions advanced in Chapter 3. For each model, Table 6-5 lists each individual factor, its partial regression coefficient (b), standard error of the partial regression coefficient (s.e. b), slope (β), t-statistic (b divided by s.e. b), direction (consistent or contrary to prediction), statistical significance, and variance inflation factor. Also provided are the results for each regression model's F-test, its significance level, and the variance explained (R^2) by the model.

6.51 Need Factors. Model 1 tests the effects of need for speed factors on time of development. Table 6-5a indicates that, although three of the four results are in the predicted direction, none are statistically significant. Therefore Propositions 1a, 1b, 1c, and 1d are not supported. Further, Model 1 as a whole is found to not significantly predict innovation speed ($F = 0.96$, $p > .10$) and explains a very small portion of variance in innovation speed ($R^2 = .07$).

6.52 Strategic Orientation, Criteria-Related Factors. Model 2 tests the effects of strategic orientation, criteria-related factors on time of development. Table 6-5b indicates that the results are mixed in terms of direction and are all non-significant. Therefore Propositions 2a, 2b, and 2c are not supported. Further, Model 2 as a whole is found to not

[5] For all of the following multiple linear regression models, VIF scores indicated that there was no significant danger of colinearity.

TABLE 6-5a
Multiple Linear Regression Analyses
Model 1: Need Factors with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level	VIF
Economic Intensity	.003	.176	.003	.018	Contrary	ns	1.156
Technological Dynamism	-.149	.194	-.102	-.764	Consistent	ns	1.045
Demographic Dynamism	-.107	.186	-.078	-.578	Consistent	ns	1.070
Regulatory Restrictiveness	.312	.201	.213	1.547	Consistent	ns	1.118

Regression F = 0.96
p-value = .44
R^2 = .07

TABLE 6-5b
Multiple Linear Regression Analyses
Model 2: Strategic-Orientation Criteria-Related Factors with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level	VIF
Relative Importance	-.284	.311	-.130	-.914	Consistent	ns	1.083
Reward System	-.006	.066	-.014	-.095	Consistent	ns	1.085
Culture	.033	.081	.061	.414	Contrary	ns	1.151
Goal Clarity	-.099	.102	-.155	-.964	Consistent	ns	1.377
Concept Clarity	.002	.009	.031	.197	Contrary	ns	1.330
Management Support	.038	.213	.027	.176	Contrary	ns	1.263

Regression F = 0.42
p-value = .87
R^2 = .05

TABLE 6-5c
Multiple Linear Regression Analyses
Model 3: Strategic-Orientation Scope-Related Factors with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level	VIF
Project Stream Breadth	-.015	.053	-.038	-.275	Contrary	ns	1.147
Radicalness	-.047	.102	-.065	-.460	Contrary	ns	1.222
External Sourcing	.163	.096	.227	1.691	Contrary	p<.10	1.103

Regression F = 1.33
p-value = .27
R^2 = .07

TABLE 6-5d
Multiple Linear Regression Analyses
Model 4: Organizational-Capability Staffing-Related Factors with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level	VIF
Champion (Number)	-.846	.923	-.144	-.917	Consistent	ns	1.497
Champion (Influence)	.108	.222	.073	.487	Contrary	ns	1.363
Leader Position	-.370	.482	-.127	-.766	Consistent	ns	1.672
Leader Power	.198	.197	.176	1.007	Contrary	ns	1.851
Leader Tenure	.004	.002	.282	1.848	Contrary	p<.10	1.417
Leader Involvement	-.149	.219	-.124	-.679	Consistent	ns	2.027
Member Education	-.261	.266	-.147	-.981	Consistent	ns	1.369
Member Experience	-.274	.165	-.249	-1.664	Consistent	p<.10	1.355
Member Tenure	-1.294	.971	-.186	-1.332	Consistent	ns	1.183
Member Involvement	.018	.245	.013	.073	Contrary	ns	1.982
Representativeness	.065	.028	.342	2.369	Contrary	p<.05	1.267

Regression F = 1.25
p-value = .29
R^2 = .23

TABLE 6-5e
Multiple Linear Regression Analyses
Model 5: Organizational-Capability Structuring-Related Factors with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level	VIF
Autonomy	-.008	.069	-.069	-.111	Consistent	ns	1.423
Overlap	-.512	.317	-.291	-1.613	Consistent	p<.10	1.967
Turf-Guarding	.107	.194	.080	.553	Consistent	ns	1.265
Design for Manufacturing	.173	.126	.199	1.370	Contrary	ns	1.277
Proximity	-.077	.180	-.083	-.426	Consistent	ns	2.319
Milestones	-.876	.902	-.135	-.971	Consistent	ns	1.167
Testing	2.156	1.099	.354	1.962	Contrary	p<.05	1.968
CAD Use	1.559	.639	.468	2.440	Contrary	p<.05	2.217

Regression F = 2.18
p-value = .049
R^2 = .29

TABLE 6-5f
Multiple Linear Regression Analyses
Model 6: Outcome Factors with Innovation Speed (TIME) as the Independent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level	VIF
Development Cost	.110	.128	.126	.859	Consistent	ns	1.00
Product Quality	-.342	.122	-.345	-2.800	Consistent	p<.01	1.00
Project Success	-1.631	.481	-.433	-3.392	Consistent	p<.01	1.00

<u>Cost</u>
Regression F = 0.74
p-value = .39
R^2 = .02

<u>Quality</u>
Regression F = 7.84
p-value > .01
R^2 = .12

<u>Success</u>
Regression F = 11.51
p-value > .01
R^2 = .19

significantly predict innovation speed ($F = 0.42$, $p > .10$) and explains a very small portion of variance in innovation speed ($R^2 = .05$).

6.53 Strategic Orientation, Scope-Related Factors. Model 3 tests the effects of strategic orientation, scope-related factors on time of development. Table 6-5c indicates that the results are all contrary in terms of direction. Both project stream breadth and radicalness are non-significant while external sourcing is marginally significant ($t = 1.691$, $p < .10$). That is, products were developed faster when there was a lower (versus higher) use of external sources of ideas and technologies. Therefore Propositions 3a, 3b, and 3c are not supported, while Proposition 3c is actually reversed. However, Model 3 as a whole is found to not significantly predict innovation speed ($F = 1.33$, $p > .10$) and explains a very small portion of variance in innovation speed ($R^2 = .07$).

6.54 Organizational Capability, Staffing-Related Factors. Model 4 tests the effects of organizational capability, staffing-related factors on time of development. Table 6-5d indicates that, while champion number was consistent in direction and champion influence was contrary in direction, both were non-significant. Therefore Proposition 4a is not supported.

Leader position and involvement were consistent in direction, while leader power and tenure were contrary in direction. All were non significant except leader tenure, which was marginally significant ($t = 1.848$, $p < .10$). This finding suggests that products were developed faster when they were overseen by individuals who have been with the organization for a shorter (versus longer) duration. Therefore, Proposition 4b is not supported and is actually partially reversed.

Three of the four results regarding members were consistent in direction, with only member experience statistically being marginally significant ($t = -1.664$, $p < .10$). This finding suggests that products were developed faster when they were worked on by members with broad (versus narrow) arrays of functional experience -- i.e., when members were more generalists than specialists. Therefore, Proposition 4c is partially supported. Additionally, representativeness was contrary in direction and statistically significant ($t = 2.369$, $p < .05$). This finding demonstrates that products were developed faster when they were worked on by a fewer (versus greater) number of members from different functional areas -- i.e., when there was less rather than more cross-functional involvement. Therefore, Proposition 5d is not supported and is actually reversed.

However, Model 4 as a whole is found to not significantly predict innovation speed ($F = 1.25$, $p > .10$), though it explains a larger small portion of variance in innovation speed than previously discussed strategic-orientation factors ($R^2 = .23$).

6.55 Organizational Capability, Structuring-Related Factors. Model 5 tests the effects of organizational capability, structuring-related factors on time of development. Table 6-5e indicates that autonomy, while consistent in direction, was non-significant. Therefore, Proposition 5a was not supported. Overlap and functionalness (turf-guarding) were consistent in direction while design-for-manufacturing and proximity were contrary in direction. All were non-significant except overlap, which was marginally significant (t =

-1.613, $p<.10$). This finding suggests that products were developed faster when the process was undertaken in parallel rather than executed sequentially. Therefore, Proposition 5b was partially supported.

Milestone frequency was consistent in direction but non-significant. Alternatively, both testing frequency ($t = 1.962$, $p<.05$) and CAD use ($t = 2.440$, $p<.05$) were contrary in direction and both statistically significant. These findings demonstrate that products were developed faster when there was a lesser (versus greater) percentage of time spend in testing and when there was a lower (verses higher) use of CAD systems. Therefore, Proposition 5c was not supported and generally reversed.

Additionally, Model 5 as a whole is found to significantly predict innovation speed ($F = 2.18$, $p < .05$) and also explains a larger portion of variance in innovation speed than previously discussed strategic-orientation factors ($R^2 = .29$).

6.56 Outcome Factors. Model 6 is, strictly speaking, a collection of three separate regression analyses. Model 6.1 tests the effect of time of development on project development costs. Model 6.2 tests the effect of time of development on product quality. Model 6.3 tests the effect of time of development on project success. Table 6-5f indicates that development cost was consistent in direction but non-significant. Therefore, Proposition 6a was not supported. Further, Model 6.1 is found to not significantly predict development costs ($F = 0.74$, $p >.10$) and explains a very small portion of variance in development costs ($R^2 = .02$).

Product quality was consistent in direction and highly significant ($t = -2.800$, $P<.01$).

This finding demonstrates that speedy product development led to higher product quality. Therefore, Proposition 6b was supported. Further, Model 6.2 is found to significantly predict product quality ($F = 7.84$, $p < .01$) and explains a moderate portion of variance in product quality ($R^2 = .12$).

Project success was also consistent in direction and also highly significant ($t = -3.392$, $p < .01$). This finding demonstrates that speedy product development led to higher product success. Therefore, Proposition 6c was also supported. Further, Model 6.3 is found to significantly predict project success ($F = 11.51$, $p < .01$) and explains a moderate portion of variance in project success ($R^2 = .19$).

6.6 Parsimonious Antecedent Statistics: Backward-Elimination Multiple Linear Regression Analysis

Table 6-6 reports each individual factor selected for the parsimonious antecedent model (the model numbers from the previous main-effect analyses appear in parentheses), its partial regression coefficient (b), standard error of the partial regression coefficient (s.e. b), slope (β), t-statistic (b divided by s.e. b), direction (consistent or contrary to prediction), and statistical significance. Also provided are the results for the regression model's F-test, its significance level, and the model's variance explained (R^2).

In Model 7, the clarity of time goals ($t = -1.731$, $p < .10$) was marginally significant in the direction of speeding up innovation -- this result partially supports Proposition 2b. Project member tenure ($t = -3.449$, $p < .01$) significantly sped up innovation -- this result partially supports Proposition 4c. Overlap ($t = -3.581$, $p < .01$) significantly sped up

TABLE 6-6
Multiple Linear Regression Analyses
Full Model: Backward-Elimination with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level
Time Goal Clarity (2b)	-.136	.078	-.212	-1.731	Consistent	p<.10
Project Member Tenure (4c)	-3.144	.912	-.452	-3.449	Consistent	p<.01
Overlap (5b)	-1.057	.295	-.600	-3.581	Consistent	p<.01
Design for Manufacturing (5b)	.196	.098	.225	1.997	Contrary	p<.05
Testing (5c)	2.827	.980	.464	2.885	Contrary	p<.01
CAD Use (5c)	1.814	.444	.544	4.088	Contrary	p<.01

Regression F = 5.999
p-level > .001
R^2 = .44

innovation -- this result partially supports Proposition 5b. Alternatively, design for Manufacturing ($t = 1.997$, $p<.05$) significantly slowed down innovation -- this result partially reverses Proposition 5b. Both percentage of time spent in testing ($t = 2.885$, $p<.01$) and use of CAD systems ($t = 4.088$, $p <.01$) significantly slowed down innovation -- these results partially reverse Proposition 5c. This parsimonious antecedent model was found to significantly predict innovation speed ($F = 5.999$, $p > .001$) and explained a large portion of variance in innovation speed ($R^2 = .44$).

6.7 Split-Sample Statistics: Multiple Linear Regression Analyses

Again, six separate models were tested for each of the three categories of radicalness. For each model, Table 6-7 lists each individual factor and, for each level of radicalness, its partial regression coefficient (b), standard error of the partial regression coefficient (s.e. b), slope (β), t-statistic (b divided by s.e. b), direction (consistent or contrary to prediction), and statistical significance. Also provided are the results for each regression model's F-test, their significance levels, and the variance explained (R^2) by each model.

6.71 Need Factors. For Models 1a-c, the results did not reveal much difference between projects of different degrees of radicalness, except for the observation that the variance-explained by these models was notably higher. Table 6-7a reports that technological dynamism was found to be negatively related to time (or positively related to speed) for low-radicalness innovations ($t = -2.514$, $p<.05$). This finding demonstrates that incremental products were developed faster in fast-changing technological environments than in slow-

TABLE 6-7a
Split-Sample Multiple Linear Regression Analyses
Model 1a: Need Factors with Innovation Speed (TIME) as the Dependent Variable
Low Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Economic Intensity	.104	.361	.084	.287	Contrary	ns
Technological Dynamism	-1.309	.521	-.590	-2.514	Consistent	p<.05
Demographic Dynamism	.492	.403	.296	1.222	Contrary	ns
Regulatory Restrictiveness	.632	.359	.519	1.759	Consistent	ns

Regression F = 2.39
p-value = .13
R^2 = .52

TABLE 6-7b
Split-Sample Multiple Linear Regression Analyses
Model 1b: Need Factors with Innovation Speed (TIME) as the Dependent Variable
Moderate Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Economic Intensity	-.136	.213	-.129	-.640	Consistent	ns
Technological Dynamism	.298	.237	.237	1.256	Contrary	ns
Demographic Dynamism	-.351	.230	-.305	-1.530	Consistent	ns
Regulatory Restrictiveness	.209	.274	.145	.762	Consistent	ns

Regression F = 1.02
p-value = .42
R^2 = .14

TABLE 6-7c
Split-Sample Multiple Linear Regression Analyses
Model 1c: Need Factors with Innovation Speed (TIME) as the Dependent Variable
High Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Economic Intensity	.249	.506	.143	.491	Contrary	ns
Technological Dynamism	-.559	.478	-.327	-1.168	Consistent	ns
Demographic Dynamism	-.139	.475	-.083	-.293	Consistent	ns
Regulatory Restrictiveness	.386	.501	.219	.771	Consistent	ns

Regression F = 0.56
p-value = .69
R^2 = .17

TABLE 6-7d
Split-Sample Multiple Linear Regression Analyses
Model 2a: Strategic-Orientation Criteria-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Low Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Relative Importance	-.122	.774	-.050	-.158	Consistent	ns
Reward System	.015	.159	.030	.093	Contrary	ns
Culture	-.051	.230	-.075	-.223	Consistent	ns
Goal Clarity	-.595	.277	-.787	-2.148	Consistent	p<.10
Concept Clarity	-.004	.025	-.046	-.151	Consistent	ns
Management Support	.021	.578	.013	.037	Contrary	ns

Regression F = 1.31
p-value = .38
R^2 = .57

TABLE 6-7e
Split-Sample Multiple Linear Regression Analyses
Model 2b: Strategic-Orientation Criteria-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Moderate Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Relative Importance	-.308	.408	-.167	-.756	Consistent	ns
Reward System	.035	.082	.088	.425	Contrary	ns
Culture	-.028	.100	-.064	-.285	Consistent	ns
Goal Clarity	-.168	.145	-.250	-1.157	Consistent	ns
Concept Clarity	-.007	.010	-.153	-.679	Consistent	ns
Management Support	.033	.273	.027	.121	Contrary	ns

Regression F = 0.59
p-value = .73
R^2 = .14

TABLE 6-7f
Split-Sample Multiple Linear Regression Analyses
Model 2c: Strategic-Orientation Criteria-Related Factors with Innovation Speed (TIME) as the Dependent Variable
High Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Relative Importance	-.821	1.021	-.251	-.804	Consistent	ns
Reward System	.209	.203	.378	1.032	Contrary	ns
Culture	.338	.263	.411	1.288	Contrary	ns
Goal Clarity	.140	.272	.236	.516	Contrary	ns
Concept Clarity	.012	.025	.207	.462	Contrary	ns
Management Support	.045	.598	.031	.075	Contrary	ns

Regression F = 0.67
p-value = .68
R^2 = .31

TABLE 6-7g
Split-Sample Multiple Linear Regression Analyses
Model 3a: Strategic-Orientation Scope-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Low Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Project Stream Breadth	-.177	.123	-.383	-1.438	Contrary	ns
Radicalness	-----	-----	-----	-----	-----	-----
External Sourcing	.194	.198	.261	.979	Contrary	ns

Regression F = 1.57
p-value = .25
R^2 = .22

TABLE 6-7h
Split-Sample Multiple Linear Regression Analyses
Model 3b: Strategic-Orientation Scope-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Moderate Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Project Stream Breadth	-.034	.068	-.094	-.506	Contrary	ns
Radicalness	-----	-----	-----	-----	-----	-----
External Sourcing	.157	.108	.270	1.446	Contrary	ns

Regression F = 1.10
p-value = .35
R^2 = .08

TABLE 6-7i
Split-Sample Multiple Linear Regression Analyses
Model 3c: Strategic-Orientation Scope-Related Factors with Innovation Speed (TIME) as the Dependent Variable
High Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Project Stream Breadth	.094	.128	.215	.740	Consistent	ns
Radicalness	-----	-----	-----	-----	-----	-----
External Sourcing	.064	.335	.055	.191	Contrary	ns

Regression F = 0.45
p-value = .65
R^2 = .06

TABLE 6-7j
Split-Sample Multiple Linear Regression Analyses
Model 4a: Organizational-Capability Staffing-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Low Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Champion (Number)	-.8.866	6.416	-1.348	-1.382	Consistent	ns
Champion (Influence)	1.007	1.246	.700	.808	Contrary	ns
Leader Position	3.887	3.970	1.180	.979	Contrary	ns
Leader Power	-1.236	2.414	-.787	-.512	Consistent	ns
Leader Tenure	-.006	.007	-.562	-.926	Consistent	ns
Leader Involvement	-.964	1.036	-.775	-.931	Consistent	ns
Member Education	-1.316	1.708	-.546	-.770	Consistent	ns
Member Experience	.504	1.247	.479	.405	Contrary	ns
Member Tenure	-OUT-	-OUT-	-OUT-	-OUT-	-OUT-	-OUT-
Member Involvement	1.164	1.207	.763	.964	Contrary	ns
Representativeness	-.078	.208	-.367	-.375	Consistent	ns

Regression F = 0.65
p-value = .74
R^2 = .76

TABLE 6-7k
Split-Sample Multiple Linear Regression Analyses
Model 4b: Organizational-Capability Staffing-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Moderate Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Champion (Number)	-1.349	1.333	-.264	-1.012	Consistent	ns
Champion (Influence)	.084	.376	.059	.223	Contrary	ns
Leader Position	-.813	.913	-.320	-.890	Consistent	ns
Leader Power	.196	.301	.185	.649	Contrary	ns
Leader Tenure	-.001	.003	-.051	-.192	Consistent	ns
Leader Involvement	-.296	.433	-.264	-.682	Consistent	ns
Member Education	-.510	.501	-.316	-1.020	Consistent	ns
Member Experience	-.224	.256	-.235	-.877	Consistent	ns
Member Tenure	-2.516	1.840	-.401	-1.367	Consistent	ns
Member Involvement	.102	.370	.084	.276	Contrary	ns
Representativeness	.081	.048	.432	1.678	Contrary	ns

Regression $F = 0.53$
p-value = .85
$R^2 = .27$

TABLE 6-71
Split-Sample Multiple Linear Regression Analyses
Model 4c: Organizational-Capability Staffing-Related Factors with Innovation Speed (TIME) as the Dependent Variable
High Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Champion (Number)	.227	3.342	.033	.068	Contrary	ns
Champion (Influence)	.083	.951	.047	.088	Contrary	ns
Leader Position	-.870	1.540	-.276	-.565	Consistent	ns
Leader Power	.862	.721	.684	1.196	Contrary	ns
Leader Tenure	.007	.006	.474	1.127	Contrary	ns
Leader Involvement	-.902	.837	-.666	-1.078	Consistent	ns
Member Education	-.632	.662	-.365	-.955	Consistent	ns
Member Experience	-.380	.520	-.264	-.730	Consistent	ns
Member Tenure	1.557	4.616	.140	.337	Contrary	ns
Member Involvement	.543	.785	.377	.692	Contrary	ns
Representativeness	.128	.092	.662	1.394	Contrary	ns

Regression F = 0.96
p-value = .57
R^2 = .72

TABLE 6-7m
Split-Sample Multiple Linear Regression Analyses
Model 5a: Organizational-Capability Structuring-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Low Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Autonomy	.021	.178	.040	.117	Contrary	ns
Overlap	-.039	1.241	-.018	-.029	Consistent	ns
Turf-Guarding	-.104	.546	-.082	-.190	Contrary	ns
Design for Manufacturing	.939	.431	1.031	2.179	Contrary	ns
Proximity	1.526	.619	1.858	2.464	Contrary	ns
Milestones	-.666	1.888	-.124	-.353	Consistent	ns
Testing	3.291	2.959	.461	1.112	Contrary	ns
CAD Use	-1.995	2.917	-.554	-.684	Consistent	ns

Regression F = 1.80
p-value = .41
R^2 = .88

TABLE 6-7n
Split-Sample Multiple Linear Regression Analyses
Model 5b: Organizational-Capability Structuring-Related Factors with Innovation Speed (TIME) as the Dependent Variable
Moderate Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Autonomy	-.054	.104	-.122	-.520	Consistent	ns
Overlap	-.088	.491	-.043	-.179	Consistent	ns
Turf-Guarding	.072	.281	.053	.255	Consistent	ns
Design for Manufacturing	.177	.177	.222	1.002	Contrary	ns
Proximity	-.522	.239	-.640	-2.186	Consistent	p<.05
Milestones	3.013	1.310	.490	2.299	Contrary	p<.05
Testing	-.312	1.428	-.053	-.218	Consistent	ns
CAD Use	1.829	.830	.626	2.202	Contrary	p<.05

Regression F = 1.85
p-value = .14
R^2 = .48

TABLE 6-7o
Split-Sample Multiple Linear Regression Analyses
Model 5c: Organizational-Capability Structuring-Related Factors with Innovation Speed (TIME) as the Dependent Variable
High Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Autonomy	-.249	.095	-.582	-2.611	Consistent	$p<.05$
Overlap	-2.369	.493	-1.530	-4.808	Consistent	$p<.01$
Turf-Guarding	1.226	.226	.879	5.412	Consistent	$p<.01$
Design for Manufacturing	1.200	.175	1.215	6.840	Contrary	$p<.01$
Proximity	-OUT-	-OUT-	-OUT-.	-OUT-	-OUT-	-OUT-
Milestones	-3.211	1.287	-.322	-2.495	Consistent	$p<.10$
Testing	6.348	1.486	1.083	4.272	Contrary	$p<.05$
CAD Use	4.861	.805	1.315	6.036	Contrary	$p<.01$

Regression F = 12.63
p-value = .01
R^2 = .96

TABLE 6-7p
Split-Sample Multiple Linear Regression Analyses
Model 6a: Outcome Factors with Innovation Speed (TIME) as the Independent Variable
Low Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Development Cost	.622	.206	.673	3.015	Consistent	p<.01
Product Quality	.096	.223	.123	.430	Contrary	ns
Project Success	-1.477	1.195	-.400	-1.236	Consistent	ns

Cost
Regression F = 9.09
p-value = .01
R^2 = .45

Quality
Regression F = 0.18
p-value = .68
R^2 = .02

Success
Regression F = 1.53
p-value = .25
R^2 = .16

TABLE 6-7q
Split-Sample Multiple Linear Regression Analyses
Model 6b: Outcome Factors with Innovation Speed (TIME) as the Independent Variable
Moderate Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Development Cost	-.277	.177	-.317	-1.567	Contrary	ns
Product Quality	-.469	.177	-.447	-2.643	Consistent	p< .01
Project Success	-2.553	.716	-.581	-3.568	Consistent	p<.01

<u>Cost</u>
Regression F = 2.45
p-value = .13
R^2 = .10

<u>Quality</u>
Regression F = 6.99
p-value = .01
R^2 = .20

<u>Success</u>
Regression F = 12.73
p-value > .01
R^2 = .34

TABLE 6-7r
Split-Sample Multiple Linear Regression Analyses
Model 6c: Outcome Factors with Innovation Speed (TIME) as the Independent Variable
High Radicalness Innovations

FACTOR	b	s.e. b	β	t	Direction	p-level
Development Cost	.041	.256	.053	.160	Consistent	ns
Product Quality	-.450	.245	-.440	-1.833	Consistent	p<.10
Project Success	-.843	.840	-.268	-1.004	Consistent	ns

Cost
Regression F = 0.03
p-value = .88
R^2 = .00

Quality
Regression F = 3.36
p-value = .09
R^2 = .19

Success
Regression F = 1.01
p-value = .33
R^2 = .07

changing technological environments. This partially supports Proposition 1b. However, Model 1a did not significantly predict innovation speed for incremental innovations (F=2.39, p>.10) despite the fact that it explained a large portion of variance in innovation speed (R^2 = .52).

Alternatively, Table 6-7b reports that none of the need factors were significant for moderate-radicalness innovations and Table 6-7c reports that none of the need factors were significant for high-radicalness innovations. Model 1b did not significantly predict innovation speed for moderate-radicalness innovations (F=1.02, p>.10, R^2 = .14) and Model 1c did not significantly predict innovation speed for high-radicalness innovations (F=0.56, p>.10, R^2 = .17).

6.72 Strategic Orientation, Criteria-Related Factors. For Models 2a-c, the results did not reveal many statistically-significant differences between projects of different degrees of radicalness, although once again the variance-explained by these models was notably higher. Table 6-7d reports a marginally significant relationship between goal-clarity and speed for incremental projects (t = -2.148, p<.10). This finding suggests that incremental products were developed faster when project timetables were well-defined versus poorly-defined. This partially supports Proposition 2b. However, Model 2a did not significantly predict innovation speed for incremental innovations (F=1.31, p>.10) despite the fact that it explained a large portion of variance in innovation speed (R^2 = .57).

Alternatively, Table 6-7e reports that none of the need factors were significant for moderate-radicalness innovations and Table 6-7f reports that none of the need factors were significant for high-radicalness innovations. Model 2b did not significantly predict innovation speed for moderate-radicalness innovations (F=0.59, p>.10, R^2 = .14) and Model 2c did not significantly predict innovation speed for for high-radicalness innovations (F=0.67, p>.10, R^2 = .31).

6.73 Strategic Orientation, Scope-Related Factors. For Models 3a-c, the results did not reveal any statistically-significant differences between projects of different degrees of radicalness and did not significantly predict innovation speed. Specifically, Table 6-7g reports that, in Model 3a (F=1.57, p>.10, R^2 = .22) , none of these factors were significant for low-radicalness innovations. Table 6-7h reports that, in Model 3b (F=1.10, p>.10, R^2 = .08), none of these factors were significant for moderate-radicalness innovations. Table 6-7i reports that, in Model 3c (F=0.45, p>.10, R^2 = .06), none of these factors were significant for high-radicalness innovations.

6.74 Organizational Capability, Staffing-Related Factors. For Models 4a-c, the results did not reveal any statistically-significant differences between projects of different degrees of radicalness, except for the observation that the variance-explained by these models was substantially higher. Specifically, Table 6-7j reports that, in, Model 4a (F=0.65, p>.10, R^2 = .76), none of these factors were significant for low-radicalness innovations. Table 6-7k reports that, in Model 4b (F=0.53, p>.10, R^2 = .27), none of these factors were significant for moderate-radicalness innovations. Table 6-7l reports that, in Model 4c (F=0.96, p>.10, R^2 = .72), none of these factors were significant for high-radicalness innovations.

6.75 Organizational Capability, Structuring-Related Factors. For Models 5a-c, the results revealed many statistically-significant differences between projects of different degrees of radicalness, including the general observation that (once again) the variance-explained by these models was substantially higher. Looking first at low-radicalness (e.g., incremental) innovations, Table 6-7m reports that, in Model 5a (F=1.80, p>.10, R^2 = .88), there were no significant relationships with regard to development time.

Looking second at moderate-radicalness innovations, Table 6-7n reports that, in Model 5b (F=1.85, p>.10, R^2 = .48) , there were several significant relationships. Proximity was negatively related to time (t = -2.186, p<.05) This finding demonstrates that moderately radical products were developed faster when they were staffed by more co-located (versus more dispersed) members. This partially supports Proposition 5b. However, milestone frequency (t = 2.299, p<.05) and CAD use (t = 2.202, p<.05) were positively related to time. These findings demonstrate that moderately radical products were developed faster when they had less (versus more) frequent milestones and when CAD systems were used less (versus more) frequently . These results partially reverse Proposition 5c.

Looking third at high-radicalness innovations, Table 6-7o reports that, in Model 5c (F=12.63, p<.01, R^2 = .96), there were many significant relationships. Autonomy was found to be negatively related to time (t = -2.611, p<.05) -- This finding demonstrates that radical products were developed faster when teams were give a greater (versus lesser) amount of empowerment. This partially supports Proposition 5a.

Overlap (t = -4.808, p<.01) was found to be negatively related to time while turf-guarding (t = 5.412, p<.01) was found to be positively related to time -- These findings demonstrate that radical products were developed faster when they were undertaken in parallel (versus sequentially) and there was little (versus much) turf-guarding. These results partially support Proposition 5b. Further, design for manufacturing was found to be positively related to time ($t = 6.840$, $p<.01$) -- This finding demonstrates that radical products were developed faster when they incorporated to a lesser (versus greater) extent the input of a manufacturing representative. This partially reverses Proposition 5b.

Milestone frequency was found to be (marginally) negatively related to time ($t = -2.496$, $p<.10$) -- This finding suggests that radical products were developed faster when they has more frequent milestones. This partially supports Proposition 5c. However, the results for testing ($t = 4.272$, $p<.05$) and CAD use ($t = 6.036$, $p<.01$) were both positively related to time. These findings demonstrate that radical products were developed faster when they had a lower (versus higher) percentage of time dedicated to testing and when CAD systems were used less (versus more) frequently. These results partially reverse Proposition 5c.

6.76 Outcome Factors. For Models 6a-c , the results were generally consistent with the overall sample results. They did, however, reveal some statistically-significant differences between projects of different degrees of radicalness. Looking first at low-radicalness innovations, Table 6-7p reports that, in Model 6.1a ($F=9.09$, $p<.01$, $R^2 = .45$), time was positively related to development costs ($t = 3.015$, $p<.01$) -- This finding demonstrates that speeding up incremental products decreased their expense. This partially supports Proposition 6a. However, for Model 6.2a ($F=0.18$, $p>.10$, $R^2 = .02$) and Model 6.3a ($F=1.53$, $p>.10$, $R^2 = .16$), there were no significant relationships between time and either product quality or project success.

Looking second at moderate-radicalness innovations, Table 6-7q reports that, in Model 6.1b (F=2.45, p>.10, R^2 = .10), there was no significant relationship between time and costs. However, in Model 6.2b (F=6.99, p<.01, R^2 = .20), it was found that time was negatively related to product quality (t = -2.643, p<.01). This finding demonstrates that speeding up moderately radical products increased their quality. This partially supports Proposition 6b. Similarly, in Model 6.3b (F=12.73, p<.01, R^2 = .34), it was found that time was significantly related to project success (t = -3.568, p<.01). This finding demonstrates that speeding up moderately radical products increased their eventual success. This partially supports Proposition 6c.

Looking third at high-radicalness innovations, Table 6-7r reports that, in Model 6.1c (F=0.03, p>.10, R^2 = .00), there was no significant relationship between time and costs. However, in Model 6.2c (F=3.36, p<.10, R^2 = .19), it was found that time was (marginally) negatively related to product quality (t = -1.833, p<.10) -- This finding suggests that speeding up radical products increased their quality. This partially supports Proposition 6b. However, in Model 6.3c (F=1.01, p>.10, R^2 = .07), it was found that time was not significantly related to project success.

6.8 Finer-Grained Statistics: Disaggregated Measures Multiple Linear Regression Analyses

Five separate, finer-grained models were tested for the previously discussed variables For each model, Table 6-8 lists each individual indicator for the selected variables along with

TABLE 6-8a
Multiple Linear Regression Analyses of Disaggregated Measures
Model 2d: Reward System Dimensions with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level
Reward Individuals	-.185	.285	-.134	-.648	Consistent	ns
Punish Individuals	.220	.167	.196	1.314	Contrary	ns
Reward Collectives	.383	.256	.379	1.494	Contrary	ns
Punish Collectives	-.516	.207	-.309	-2.492	Consistent	$p < .01$

Regression F = 1.98
p-value = .10
R^2 = .12

TABLE 6-8b
Multiple Linear Regression Analyses of Disaggregated Measures
Model 2d: Cultural Dimensions with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level
Support for Failing	.171	.204	.130	.839	Contrary	ns
Support for Learning	-.303	.205	-.235	-1.477	Consistent	ns
Support for Risk Taking	.262	.171	.216	1.531	Contrary	ns

Regression F = 1.29
p-value = .52
R^2 = .06

TABLE 6-8c
Multiple Linear Regression Analyses of Disaggregated Measures
Model 3d: Project Stream Breadth (Scarcity) Dimensions with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level
Financial Resources	.259	.216	.212	1.200	Consistent	ns
Materials, Space, Equipment	-.217	.226	-.162	-.961	Contrary	ns
Management Attention	.153	.275	.112	.557	Consistent	ns
Personnel	-.269	.217	-.220	-1.237	Contrary	ns

Regression F = 0.93
p-value = .45
R^2 = .06

TABLE 6-8d
Multiple Linear Regression Analyses of Disaggregated Measures
Model 4d: Representativeness Dimensions (Internal Interest Groups) with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level
Purchasing	-.075	.164	-.090	-.457	Consistent	ns
Manufacturing	.060	.165	.069	.363	Contrary	ns
Marketing	-.096	.130	-.110	-.738	Consistent	ns
Engineering	.226	.128	.272	1.761	Contrary	$p<.10$
Finance/Accounting	.038	.179	.045	.212	Contrary	ns

Regression F = 1.17
p-value = .34
R^2 = .09

TABLE 6-8e
Multiple Linear Regression Analyses of Disaggregated Measures
Model 4e: Representativeness Dimensions (External Interest Groups) with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level
Customers	-.113	.100	.148	-1.125	Consistent	ns
Distributors	-.199	.205	.121	-.971	Consistent	ns
Suppliers	.290	.101	.382	2.874	Contrary	p<.01

Regression F = 2.89
p-value = .04
R^2 = .13

TABLE 6-8f
Multiple Linear Regression Analyses of Disaggregated Measures
Model 5d: Autonomy Dimensions with Innovation Speed (TIME) as the Dependent Variable

FACTOR	b	s.e. b	β	t	Direction	p-level
Activities	-.440	.369	-.206	-1.193	Consistent	ns
Goals	.018	.290	.011	.063	Contrary	ns
People	.104	.265	.080	.393	Contrary	ns
Resources	.237	.254	.189	.932	Contrary	ns

Regression F = 0.82
p-value = .52
R^2 = .06

its partial regression coefficient (b), standard error of the partial regression coefficient (s.e. b), slope (β), t-statistic (b divided by s.e. b), direction (consistent or contrary to prediction), and statistical significance. Also provided are the results for each regression model's F-test, their significance levels, and the variance explained (R^2) by the models.

6.81 Reward System Dimensions. For Model 2d ($F=1.98$, $p>.10$, $R^2 = .12$), Table 6-8a revealed that punishing collectives significantly sped up development time ($t = -2.492$, $p<.01$). This partially supports Proposition 2a. However, all other dimensions of reward system orientation were non-significant.

6.82 Culture Dimensions. For Model 2e ($F=1.29$, $p>.10$, $R^2 = .06$).Table 6-8b did not reveal any significant results between dimensions of culture and innovation speed.

6.83 Project Stream Breadth Dimensions. For Model 3d ($F=0.93$, $p>.10$, $R^2 = .06$), Table 6-8c did not reveal any significant results between dimensions of project stream breadth (i.e., scarcity) and innovation speed.

6.84 Representativeness Dimensions. For Model 4d ($F=1.17$, $p>.10$, $R^2 = .09$), Table 6-8d revealed that representing engineering on project teams tended to slow development time ($t = 1.761$, $p<.10$). This partially reverses Proposition 4d. However, all other dimensions of internal representativeness were non-significant.

For Model 4e ($F=2.89$, $p<.05$, $R^2 = .13$), Table 6-8e revealed that representing suppliers on project teams also slowed development time ($t = 2.874$, $p < .01$). This also partially reverses Proposition 4d. However, the other two dimensions of external representativeness were non-significant.

6.85 Autonomy Dimensions. For Model 5d ($F=0.82$, $p > .10$, $R^2 = .06$), Table 6-8f did not reveal any significant results between dimensions of project team autonomy and innovation speed.

CHAPTER 7
DISCUSSION

7.1 Introduction

Overall, this study produced several interesting results. Some were consistent with the propositions whereas others were surprising. This chapter discusses the findings presented in Chapter 6 as they apply to (a) the general research questions in Chapter 2; (b) the specific research propositions in Chapter 3, and; (c) the larger innovation, product development, and time/speed literatures. Each of the three components of the model will be examined (see Table 7-1 for an overview of *all* findings, Table 7-2 for a more in-depth summary of *main-effect and split-sample* findings, and Table 7-3 for a more focused overview of statistically-significant *contrary* findings), followed in Chapter 8 with a broader discussion of what the results suggest about the conceptual model as a whole.

While interpreting these results, it is important to consider several factors. First, the relatively embryonic nature of theory development and systematic empirical investigation in the innovation speed literature. Thus, these results should be viewed as an early attempt to broaden our general understanding of important phenomena related to innovation speed, rather than a later attempt to fine-tune established knowledge in a mature field. Second, the nature and size of the sample in the study. The sample (a) spans several different industries, which may represent a conservative bias in the attainment of significant results, and (b) is relatively small given the number of variables examined, which limits its accuracy of estimation. Third, the nature of data collection.

TABLE 7-1a
Summary of Results[a]
Model 1: Need Factors

FACTOR	MAIN-EFFECT ANALYSIS	SPLIT-SAMPLE ANALYSIS	FINER-GRAINED ANALYSIS
Economic Intensity			-----
Technological Dynamism		(L) Sped Up *	-----
Demographic Dynamism			-----
Regulatory Restrictiveness			-----

[a] For Tables 7-1a through 7-1e, the following codes apply:

(H)	=	High-Radicalness Condition (For split-sample analysis only)
(M)	=	Moderate-Radicalness Condition (For split-sample analysis only)
(L)	=	Low-Radicalness Condition (For split-sample analysis only)
Slowed	=	Factor increased development time
Sped Up	=	Factor decreased development time
-----	=	Not Applicable
**	=	Significant effect at the .01 level
*	=	Significant effect at the .05 level
†	=	Significant effect at the .10 level

TABLE 7-1b
Summary of Results[a]
Model 2: Strategic-Orientation Criteria-Related Factors

FACTOR	MAIN-EFFECT ANALYSIS	PARSIMONIOUS ANALYSIS	SPLIT-SAMPLE ANALYSIS	FINER-GRAINED ANALYSIS
Relative Importance				------
Reward System				Sped Up **
Culture				
Goal Clarity		Sped Up †	(L) Sped Up †	------
Concept Clarity				------
Management Support				------

TABLE 7-1c
Summary of Results[a]
Model 3: Strategic-Orientation Scope-Related Factors

FACTOR	MAIN-EFFECT ANALYSIS	PARSIMONIOUS ANALYSIS	SPLIT-SAMPLE ANALYSIS	FINER-GRAINED ANALYSIS
Project Stream Breadth				
Radicalness			-----	-----
External Sourcing	Slowed †			-----

TABLE 7-1d
Summary of Results[a]
Model 4: Organizational-Capability Staffing-Related Factors

FACTOR	MAIN-EFFECT ANALYSIS	PARSIMONIOUS ANALYSIS	SPLIT-SAMPLE ANALYSIS	FINER-GRAINED ANALYSIS
Champion (Number)				-----
Champion (Influence)				-----
Leader Position				-----
Leader Power				-----
Leader Tenure	Slowed †			-----
Leader Involvement				-----
Member Education				-----
Member Experience	Sped Up †			-----
Member Tenure		Sped Up **		-----
Member Involvement				-----
Representativeness	Slowed *			(Engineers) Slowed † (Suppliers) Slowed**

TABLE 7-1e
Summary of Results[a]
Model 5: Organizational-Capability Structuring-Related Factors

FACTOR	MAIN-EFFECT ANALYSIS	PARSIMONIOUS ANALYSIS	SPLIT-SAMPLE ANALYSIS	FINER-GRAINED ANALYSIS
Autonomy			(H) Sped Up *	
Overlap	Sped Up †	Sped Up **	(H) Sped Up **	-----
Turf-Guarding			(H) Slowed **	-----
Design for Manufacturing		Slowed *	(H) Slowed **	-----
Proximity			(M) Sped Up *	-----
Milestones			(M) Sped Up * (H) Slowed †	-----
Testing	Slowed *	Slowed **	(H) Slowed *	-----
CAD Use	Slowed *	Slowed **	(M) Slowed * (H) Slowed **	-----

TABLE 7-1f
Summary of Results[b]
Model 6: Outcome Factors

FACTOR	MAIN-EFFECT ANALYSIS	SPLIT-SAMPLE ANALYSIS	FINER-GRAINED ANALYSIS
Development Cost		(L) Decreased **	-----
Product Quality	Increased **	(M) Increased ** (H) Increased †	-----
Project Success	Increased **	(M) Increased **	-----

[b] For Table 7-1f, the following codes apply:

(H)	=	High-Radicalness Condition (For split-sample analysis only)
(M)	=	Moderate-Radicalness Condition (For split-sample analysis only)
(L)	=	Low-Radicalness Condition (For split-sample analysis only)
Increased	=	Speed increased factor
Decreased	=	Speed decreased factor
-----	=	Not Applicable
**	=	Significant effect at the .01 level
*	=	Significant effect at the .05 level
†	=	Significant effect at the .10 level

TABLE 7-2a
Standardized Regression Coefficients for Main-Effect and Split-Sample Analyses [a]
Model 1: Need Factors

FACTOR	MAIN EFFECT	LOW-RADICALNESS	MODERATE-RADICALNESS	HIGH-RADICALNESS
1a. Economic Intensity	.003	.084	-.129	.143
1b. Technological Dynamism	-.102	-.590 *	.237	-.327
1c. Demographic Dynamism	-.078	.296	-.305	-.083
1d. Regulatory Restrictiveness	.213	.519	.145	.219
	R^2= .07	R^2= .52	R^2= .14	R^2= .17

[a] For Tables 7-1a through 7-1f, the following codes apply:

** = Significant effect at the .01 level
* = Significant effect at the .05 level
† = Significant effect at the .10 level

TABLE 7-2b
Standardized Regression Coefficients for Main-Effect and Split-Sample Analyses
Model 2: Strategic-Orientation, Criteria-Related Antecedent Factors

FACTOR	VARIABLE	MAIN EFFECT	LOW-RADICALNESS	MODERATE-RADICALNESS	HIGH-RADICALNESS
2a. Speed Emphasis	Relative Importance	-.130	-.050	-.167	-.251
	Reward System	-.014	.030	.088	.378
	Culture	.061	-.075	-.064	.411
2b. Goal Clarity	Time Goal	-.155	-.787 †	-.250	.236
	Product Concept	.031	-.046	-.153	.207
2c. Project Support	Top Management Interest	.027	.013	.027	.031
		R^2= .05	R^2= .57	R^2= .14	R^2= .31

TABLE 7-2c
Standardized Regression Coefficients for Main-Effect and Split-Sample Analyses
Model 3: Strategic-Orientation, Scope-Related Antecedent Factors

FACTOR	MAIN EFFECT	LOW-RADICALNESS	MODERATE-RADICALNESS	HIGH-RADICALNESS
3a. Project Stream Breadth	-.038	-.383	-.094	.215
3b. Radicalness	-.065	-------	-------	-------
3c. External Sourcing	.227 †	.261	.270	.055
	R^2= .07	R^2= .22	R^2= .08	R^2= .06

TABLE 7-2d
Standardized Regression Coefficients for Main-Effect and Split-Sample Analyses
Model 4: Organizational-Capability, Staffing-Related Antecedent Factors

FACTOR	VARIABLE	MAIN EFFECT	LOW-RADICALNESS	MODERATE-RADICALNESS	HIGH-RADICALNESS
4a. Champion(s)	Number	-.144	-1.348	-.264	.033
	Influence	.073	.700	.059	.047
4b. Leader Strength	Position	-.127	1.180	-.320	-.276
	Power	.176	-.787	.185	.684
	Tenure	.282 †	-.562	-.051	.474
	Involvement	-.124	-.775	-.264	-.666
4c. Member Strength	Education	-.147	-.546	-.316	-.365
	Experience	-.249 †	.479	-.235	-.264
	Tenure	-.186	-OUT-	-.401	.140
	Involvement	.013	.763	.084	.377
4d. Team Representation	Representativeness	.342 *	-.367	.432	.662

R^2= .23 R^2= .76 R^2= .27 R^2= .72

TABLE 7-2e
Standardized Regression Coefficients for Main-Effect and Split-Sample Analyses
Model 5: Organizational-Capability, Structuring-Related Antecedent Factors

FACTOR	VARIABLE	MAIN EFFECT	LOW-RADICALNESS	MODERATE-RADICALNESS	HIGH-RADICALNESS
5a. Empowerment	Autonomy	-.069	.040	-.122	-.582 *
5b. Project Integration	Overlap	-.291 †	-.018	-.043	-1.530 **
	Turf-Guarding	.080	-.082	.053	.879 **
	DFM	.199	1.031	.222	1.215 **
	Proximity	-.083	1.858	-.640 *	-OUT-
5c. Process Organization	Milestones	-.135	-.124	.490 *	-.322 †
	Testing	.354 *	.461	-.053	1.083 *
	CAD Use	.468 *	-.554	.626 *	1.315 **
		R^2= .29	R^2= .88	R^2= .48	R^2= .96

TABLE 7-2f
Standardized Regression Coefficients for Main-Effect and Split-Sample Analyses
Model 6: Outcome Factors

FACTOR	MAIN EFFECT	LOW-RADICALNESS	MODERATE-RADICALNESS	HIGH-RADICALNESS
6a. Development Cost	.126	.673 **	-.317	.053
6b. Product Quality	-.345 **	.123	-.447 **	-.440 †
6c. Project Success	-.433 **	-.400	-.581 **	-.268
	R^2= .02	R^2= .45	R^2= .10	R^2= .00
	R^2= .12	R^2= .02	R^2= .20	R^2= .19
	R^2= .19	R^2= .16	R^2= .34	R^2= .07

TABLE 7-3
Summary of Statistically-Significant Contrary Findings and Possible Explanations Regarding Innovation Speed

FACTOR	PREDICTED RELATIONSHIP	OBSERVED RELATIONSHIP	POSSIBLE EXPLANATION(S)	PAGE(S)
External Sourcing (3c)	Speed-Up	Slowed-Down	Lower Prior Understanding of External Technologies Less Perceived Ownership of External Technologies Artifact of Measurement of Time Specific to US Industrial Context	221-222
Leader Tenure (4b)	Speed-Up	Slowed-Down	"Not-Invented Here" Effects of Less External Monitoring Lower Competencies (re: More Stagnant Career Paths) Conservatism (re: Higher Age)	224-226
Representativeness (4d)	Speed-Up	Slowed-Down	Slower Pace of Decisions with Larger Team Size More and Less Appropriate Times for Group Representation re Engineers: Bias to High Quality re Engineers: Reverse-Effect re Suppliers: Bias to Low Costs re Suppliers: Specific to US Industrial Context	228-230

Design for Manufacturing (5b)	Speed-Up	Slowed-Down	Status-Quo Orientation Poor Integration	234-235
Testing (5c)	Speed-Up	Slowed-Down	Bias to High Quality Overly Optimizing (vs Satisficing) Market Release Criteria	236-237
CAD Use (5c)	Speed-Up	Slowed-Down	Inappropriate Implementation Created New Sources of Delay Status-Quo Orientation	237-238

The data is both perceptual and retrospective, and, despite the use of safeguards intended to limit and detect sources of bias, must be interpreted carefully

It is also important to keep in mind that, in the social sciences, regression analysis should be interpreted more as supplying a *description* of the data rather than specifying *causality* in its strictest sense. That is, because of the "complexity of the social world" and the inherently intricate manner in which specified variables interact (not to mention the intricate ways in which non-specified variables interact with the specified variables), social scientists should be weary of making overly-causal empirical generalizations (Achen, 1982; Dubin, 1975). Further, quasi-experimental designs (such as this study) are in general more difficult to interpret than more highly controlled, laboratory experiments (Cook & Campbell, 1976; Filley, House, & Kerr, 1976). Thus the following discussion should be viewed as providing possible explanations for the observed relationships (or non-relationships) and, by relating them back to the research questions and theoretical model, serving as a basis for further modeling and predicting these relationships regarding the speed of innovation.

7.2 Need Factors (Research Question #1)

Regarding the first component of the model, the results were generally nonsupportive in reference to the factors posited to create a "need for speed" and subsequently faster new product development. That is, no clear answer emerged from the results for the question of when it is most appropriate to speed up innovations.

Table 7-1a illustrates that, in the main-effect regression analysis, none of the need factors were significantly related with speed. Although three of the four variables were in the predicted direction, and the one variable that was contrary to predictions had the weakest affect upon speed, the variance explained by this need model was extremely low and nonsignificant. The results were also mainly in the predicted directions for the three split-sample regression equations, and the variance explained by them was noticeably higher. However, the relationships between the need factors and speed were mostly nonsignificant. These non-findings are inconsistent with the predictions of this study presented in Chapter 3.

Essentially, it was found that there are both fast and slow innovations in competitive, fast-moving, unregulated contexts. Likewise, it was found that there are both fast and slow innovations in noncompetitive, slow-moving, regulated contexts. This is consistent with research describing the existence of a wide range of product arrival times within industries -- i.e., early-movers and late-movers (e.g., Golder & Tellis, 1993; Kerin, Varadarajan, & Peterson, 1993; Levitt, 1966; Lieberman & Montgomery, 1988; Miles et al., 1978; Schnaars, 1986; Strebel, 1987). However, this literature is at best indirectly related to innovation speed, and for it makes the assumption that products which hit the market earlier were completed in a more timely manner.

These results might also be explained by the idea that environment alone won't influence innovations to go faster or slower. Rather, the effect of external context is moderated by orientation and capability. This is consistent with research establishing differences between the way firms interpret and react to similar task and institutional environments (e.g., Berger & Luckmann, 1967; Dutton & Jackson, 1987; Weick, 1979).

It should also be noted that, to facilitate project comparisons, the measures of time used in the analyses were not of *absolute* innovation speed (i.e., actual months and years) but of *relative* innovation speed (i.e., development time compared to schedules, similar past projects, and similar competitors' projects). Thus it might be the case that more competitive, dynamic, unrestricted environments shrunk the absolute time of development but not its relative time because benchmarks were also faster (e.g., schedules were more aggressive or similar past projects and similar competitor's projects were completed in fewer months).

Specifically regarding the economic intensity non-finding, the results are nevertheless consistent with those of Birnbaum-More (1994) and Cooper and Kleinschmidt (1994), who both found that industry concentration (re: competitive intensity) did not significantly affect innovation speed. Additionally, as argued in Chapter 3, some research does exist to suggest that there is not a linear relationship between economic intensity and time (e.g., Kamien & Schwartz, 1975; Chakrabarti, Feinman, & Fuentivilla, 1983) because of the conflicting effects of competitive pressure upon motivation, resources, and opportunity (Zirger & Maidique, 1990). For example, Cooper and Kleinschmidt (1994: 391) attribute this non-effect to the "two-edged sword" of competitiveness -- competitive pressures influence innovators to move quickly whereas competitive markets are often hostile to new product introductions and thus discourage project managers from moving quickly. Thus, if a relationship does exist between competitive intensity and innovation speed, it might be curvilinear rather than linear.

Among the need factors, only technological dynamism was found to significantly speed up innovation, and this applied only to incremental innovations. That is, the only thing the results revealed for this section of the model is that a dynamic technological environment motivated incremental innovations to be completed faster. This is consistent with the predictions of this study presented in Chapter 3. In general, this is also consistent with the previously described arguments advanced by Cooper and Kleinschmidt (1987), Ettlie, Bridges, and O'Keefe (1984), Henderson and Clark (1990), Porter (1980), Wheelwright and Clark (1992), and Zirger and Maidique (1990).

However, to reiterate, this relationship was significant only for incremental innovations. This might be explained by the existence of a time-lag between the external context for innovation and the subsequent speed of development. Perhaps there is too long of a lag between environmental context and the completion of longer-term innovation projects (highly radical and moderately radical) for the questionnaire to identify the relationship. That is, a longer-term innovation responding to external circumstances at time "t" might not be detectable until time "t+n". With incremental innovations, it may be that the time-lag is sufficiently short that, in this type of study (cross-sectional versus longitudinal), it would still be detected.

In sum, there is no support for Proposition 1a (Economic Intensity), Proposition 1c (Demographic Dynamism), and Proposition 1d (Regulatory Restrictiveness). There is, however, partial support for Proposition 1b (Technological Dynamism).

7.3 Antecedent Factors (Research Question #2)

Regarding the second component of the model, the results were mixed in reference to factors posited to speed up and slow down innovations. That is, there emerged a complex, though sometimes seemingly contradictory, answer for the question of how firms can increase innovation speed.

7.31 Strategic Orientation: Criteria-Related Factors. In general, strategic-orientation antecedents did not have a strong influence on the speed of innovation: However, there were a few important findings in this area. Looking first at criteria-related variables, Table 7-1b illustrates that there were some significant relationships between these larger, policy-related decisions regarding speed and the subsequent pace of new product development projects.

Two strategic-orientation criteria-related variables emerged from the model to (partially) influence projects to speed up or slow down. Finer-grained multiple regression analysis revealed that punishing collectives for not meeting deadlines, which is a component of the reward system, tended to accelerate innovation. This is consistent with the predictions of this study presented in Chapter 3. Insofar as reward systems were shown to affect innovation speed, it is also generally consistent with the previously described arguments advanced by Kidder (1981) and Rosenau (1990). However, the fact that only one component of reward systems was significant, and *punishment* of *collectives* at that, was unexpected.

Regarding the effect of punishment on innovation speed, it may be the case that the rewards offered for timely development did not appeal to salient needs of people involved with the innovation projects. It is axiomatic to organizational studies that rewards (and punishers) have a greater impact on the behavior of individuals to the extend that they appeal to salient needs (Alderfer, 1969; McClelland, 1961; Vroom, 1964). We also know that "R&D people" tend to be different from the typical employee in terms of their needs (Burgelman & Sayles, 1986; Kidder, 1981). For example, R&D people tend to value such things as autonomy and creative freedom more so than money and power. Thus traditional reward systems that emphasize the latter would not appeal as much to project team personnel. Indeed, the questionnaire did not ask about the nature of the rewards or punishers or the nature of the needs they tried to appeal to; it only asked whether they were administered and on what level. Research has shown that the acts of rewarding and punishing individuals may focus on different types of object (Bolles, 1975; Kessler, Ford, & Bailey, 1996). Rewards tend to focus upon positively-valent objects (e.g., receiving money) while punishers tend to focus upon negatively valent objects (e.g., receiving an uninspiring assignment). Thus it is a possibility that punishments appealed to more instrumental needs than did rewards.

Another possible explanation for the effect of punishment on innovation speed involves the concept of *negative feedback*, which is defined as the promotion of goals by avoiding not achieving the goals (Van de Ven, 1986). In other words, actions which are appropriate are left unregulated whereas actions which stray from prescribed directions are brought back in line. This is at its essence about top management setting broad constraints and getting involved in day-to-day innovative activity only when there are clear violations of these boundaries. Indeed, many have argued that top management most effectively influences innovation through this type of up-front direction-setting, mainly because it allows the innovators to innovate without bureaucratic interference (Burgelman, Maidique, & Wheelwright, 1996; Hayes, Wheelwright, & Clark, 1988; Spender & Kessler, 1995; Van de Ven, 1986). Thus punishment may be more consistent with negative feedback than rewards, because it is applied only on those instances when the "wrong" things happen as opposed to instances when the "right" things occur. It therefore might be a more effective way of designing speed-oriented reward systems.

The facilitating effect of a collective-level reward system on innovation speed is consistent with the previously described arguments of Bower and Hout (1988), Deschamps and Nayak (1992), Ilgen and Feldman (1983), Meyer and Purser (1993), Norman and Zamacki (1991), Peters (1987), Sisco (1992), and Takeuchi and Nonaka (1986). To recall, these authors contended that group-level reward systems are more likely to promote interaction and communication within a project because it motivates individuals to help one another. Thus, it seems that this idea generalized well to the firms and projects in the sample.

Having a clear, specific time-goal (i.e., schedule) also tended to speed up innovation. This relationship was shown to be marginally significant both (a) in the split-sample analysis for incremental innovations only and (b) in the backward-elimination analysis for the entire sample of innovations. This is consistent with the predictions of this study presented in Chapter 3. This is also consistent with the previously described work of Andrews and Farris (1972), Bryan and Locke (1967), Meyers and Wilemon (1989), Murmann (1994), Takeuchi and Nonaka (1986), and Thamhain and Wilemon (1987). However, because of the marginal level of significance, great care should be taken in drawing any strong conclusions. With this in mind, one can say that well conveyed, specific timetables may speed up innovation more effectively than ambiguous definition of time-based objectives.

Contrary to predictions, the relative importance of speed (versus costs or quality) firm did not have an effect on the speed of innovation. Notwithstanding, it is consistent with a finding by Rosenthal and Tatikonda (1993) that the stated importance of time relative to other concerns, such as cost or functionality, was unrelated to innovation speed. This could be because "actions speak louder than words". In other words, perhaps statements of importance did not match what was actually rewarded and punished. Hence Kerr's (1975) argument that it is folly to hope for an 'action A' if you are rewarding something else (e.g., an 'action B'). Perhaps the emphasis placed upon speed by top management was not supported by the reward system. The results regarding reward system orientation (see Table 6-5b) seem to support this explanation.

Contrary to predictions, the culture of a firm did not have an effect on the speed of innovation. One way of interpreting this result is to say that cultural support for speed is not a sufficient precondition for its occurrence. Perhaps for an espoused culture to have an effect upon performance (in this case, speed), it needs to be communicated effectively throughout the organization (or, in this case, the relevant project team). Indeed, Gordon and DiTomaso (1992) found that "stronger" (i.e., more widely diffused) cultures were associated with higher performance than "weaker" ones. Therefore, in addition to what the culture says, it might be just as important that the culture is widely diffused. This is consistent with the argument that, if a culture is not widely shared, then it neither communicates the values of top management nor does it guide the behavior of individuals in a manner consistent with these values (Christensen & Kessler, 1995). In other words, a poorly diffused culture translates into an espoused culture "not making it out of the strategists' office" and into the project team.

This speculation seems to be supported by the ANOVA analysis (see Table 6-1c), which revealed an unusually high degree of intra-project variance in assessing cultural dimensions related to speed -- that is, the perspective of cultural orientation varied greatly between individuals within the *same organization* and on the *same project team* (F=0.93, p=.61). This suggests that there may not have been a strong culture widely shared by project team members. Indeed, it is often the case that there exist competing subcultures in an organization which vary between functional areas, levels of management, and other groups of individuals (Smircich, 1983). Thus, rather than determining that culture in and of itself has no effect on speed, one may interpret the results to suggest that there was not a strong, dominant culture surrounding projects in the sample.

Contrary to predictions, the degree of top-management support given to a project did not have an effect on the speed of innovation. Again, this could be because of the distance between strategic (i.e., espoused) action and actual innovative activity; this is similar to previously discussed explanations offered on why other strategic-orientation criteria-related variables such as relative importance and culture were not significant. That is, once projects are "released" from the enveloping organizational system to the project team, top management might be too far removed from "where the rubber meets the road" to significantly impact the speed of innovation. This is consistent with the argument that, after the initial direction is set, top management should refrain from interfering in innovative activities until they are ready to be incorporated back into the organization (Spender & Kessler, 1995).

Another possible explanation is that top management support did not convey to the team the benefits assumed in Chapter 3. That is, perhaps a high degree of top management interest in a project did not translate into more resources, better staff, more timely referrals and decisions, and the like. This might be because there are different *types* of support top management can give to projects, and that some types are more effective than others (Burgelman, Maidique, & Wheelwright, 1996). In this vein, Burgelman and colleagues argue that top management support can be operationalized to mean (a) pre-project, or early, support, (b) project execution, or real-time, support, and (c) post-project, or late, support. These authors also make the argument that top management's influence over the outcomes of projects are greatest in pre-project or early stages of development. Moreover, even within these three areas, Burgelman and colleagues argue that there are different ways in which top management can support projects. For example, in the pre-project area, top management can actually screen projects and make individualized go/no-go decisions (less effective, traditional approach) or they can set broad criteria and guidelines for different development-related objectives and then allow specific projects to search for legitimacy within these parameters (more effective, leadership approach). Unfortunately, the questionnaire instrument in this study did not probe for the nature of support, but only for its magnitude. However, these relationships might interesting to pursue in future research.

In sum, there is partial support for Proposition 2a (Speed Emphasis) and Proposition 2b (Goal Clarity). There is no support for Proposition 2c (Project Support).

7.32 Strategic Orientation: Scope-Related Factors. Table 7-1c illustrates that there were few significant relationships between decisions regarding scope-related decisions and the subsequent pace of new product development projects. Regarding project stream breadth (scarcity), there was no significant effect detected. Perhaps there is a time-lag between the breadth of a firm's project stream (time 't') and the effect of that breadth on the speed of specific projects (time 't+n') similar to that discussed above regarding the Need Factors. That is, there may have been too long of a gap between the effects of stream breadth and the subsequent market introduction of a new product innovation.

In addition, there might not have been sufficient depth in the questionnaire instrument to ascertain (a) *how* the projects competed with other projects for people, funds, materials, and other resources (i.e., on what basis - forecasted returns, speed, quality, etc.) or (b) *when* they had to compete for resources (e.g., at what stage of development were resources scarce or most scarce). This is consistent with the idea that the nature of inter-project competition and resource allocation may influence innovation speed (e.g., Bower, 1970; Burgelman & Sayles, 1986; Prahalad & Hamel, 1990).

Alternatively, perhaps there are contradictory effects of resource munificence upon speed. That is, in a manner similar to the effect of external resource munificence (i.e., competitive intensity) on firms, project stream breadth may also be a "double-edged sword". Resource scarcity may simultaneously require projects to wait around for resources (slow them down) and pressure them to perform well on preset criteria such as time (speed them up). Subsequently, there may be a curvilinear relationship between breadth and speed where moderate amounts of scarcity balance these effects.

Regarding project radicalness, there was no significant effect upon innovation speed detected. Although surprising, this is consistent with Cooper and Kleinschmidt's (1994) finding that the familiarity of a project (i.e., its radicalness) -- measured by such indicators as its relationship to existing product categories and use of existing technology -- was unrelated to innovation speed. Notwithstanding the absence of a *main effect*, when one examines the split-sample results (Table 6-7) it becomes clear that radicalness had a *moderating effect* on how some of the need, antecedent and outcome factors in the study related to innovation speed. That is, there were somewhat different sets of answers for the three research questions, depending upon the radicalness of the specific project being examined.

Additionally, this failure to detect a main-effect between radicalness and speed may be the result of the measurement of speed used in the analyses. To recall, speed was a composite of time relative to *schedule*, time relative to *past* similar projects, and time relative to *competitors'* similar projects. Regarding schedule, it may just be the case that radical projects had longer planned time-frames. Therefore, if a radical new product having a 35 month schedule was developed in 32 months, it shows up in the analysis as "faster" than an incremental project having a 12 month schedule that was developed in 15 months. The same logic applied to the other components of speed used in this study, because comparing a radical project to similar past and competitor projects may yield a benchmark of 40 months to an incremental project's benchmark of 20 months.

However, one strategic-orientation scope-related variable did appear to partially influence projects to speed up or slow down. Multiple regression analysis revealed that internally-sourcing ideas and technologies for a project tended to accelerate innovation. Again, because of the marginal level of significance, it is important to refrain from drawing any strong conclusions. Nevertheless, the direction of the finding is inconsistent with the predictions of this study presented in Chapter 3. However, this is consistent with the results reported by Bierly and Chakrabarti (1996), who found that, in the pharmaceutical industry, technology cycle time was significantly faster for firms who generated new knowledge internally (versus externally). Therefore, a possible explanation for the direction of this finding is that there are lower "start-up costs (of time)" when a project is internally driven -- people may already had some understanding of it before the formally defined beginning of the project. Bierly and Chakrabarti explain this as the efficiency of internal versus external learning. More specifically, these authors attribute the difference in speed between internal versus external sources of knowledge to (a) the greater sense of ownership project members have for internally-generated products, and (b) the greater understandability and interpritability of internally-generated ideas (outsiders may have different codes, standards, and other forms of codifying knowledge).

It is also possible that this marginal result may also be an artifact of the way development time is measured in firms. That is, the "clock" may start later for innovations derived from internally generated ideas and technologies (much of the work was done in the "fuzzy front-end" of projects which are often regarded as being pre-project) whereas the clock for innovations derived from externally generated ideas and technologies may start as soon as a relationship is commenced. Because it is difficult to measure these fuzzy front-end activities (Smith & Reinertsen, 1991), it is certainly possible that they may simply not be quantified and subsequently not counted as part of product development time. Alternatively, because the beginning of a relationship with an external partner is more concrete, it would most probably be regarded as the point at which to start tracking product development time.

In addition, a point that should be made is that the sample for this study was comprised entirely of U.S. firms and U.S. affiliates of foreign firms. It might the case that productive network relationships with external parties are easier to forge in industrial contexts like Japan than for U.S. companies, because of the institutional relationships between firms. Indeed, exploring the subtleties of an argument expressed earlier, Mansfield (1988) found that external sourcing accounted for a significant portion of the difference between faster Japanese firms and slower U.S. firms. This is consistent with Gee's (1978) findings a decade earlier regarding U.S. firms. Thus the nature of national context might be responsible for the effects of external sourcing of innovation speed.

In sum, there is no support for Proposition 3a (Project Stream Breadth) and Proposition 3b (Degree of Change). There is some evidence to suggest a partial reversal of Proposition 3c (External Sourcing).

7.33 Organizational Capability: Staffing-Related Factors. In general, organizational-capability antecedents had a stronger influence on the speed of innovation than strategic-orientation antecedents. There were many important findings in this area. Looking first at staffing-related variables, Table 7-1d illustrates that, contrary to predictions, neither the presence nor the influence level of product champion(s) influenced the speed of innovation. Possible explanations for this non-finding are that champion presence, in addition to the predicted positive effects on speed, also brought with it inhibitive effects. For example, perhaps the existence of a champion(s) created an overly political environment which diverted time from value-added activities. One can observe in the previously described actions of champions -- such as "overcoming resistance", "getting resources", and "selling the project" -- a strong political component to the role of champion. These and related actions can also be referred to with more clearly political terminology, such as controlling information, coopting management, and building coalitions (Drazin, 1990; Frost & Egri, 1991; Page, 1995). These initiatives of champions can increase the frequency of political activity in the development of an innovation (Page, 1995), which has been shown to have such undesirable side-effects as increasing secrecy and the strategic withholding of information (which acts to inhibit rather than facilitate communication) (Feldman, 1988) and increasing the resistance of an innovations by some individuals or subgroups (under the presumption that the successful completion of the project will increase the power of competing individuals or subgroups) (Drazin, 1990). Subsequently, champion activity may have mixed effects on innovation speed.

Also, it may be the case that a greater champion presence tends to promote technical elegance over timely pragmatism. Champions often have an intense personal identification with a project (Chakrabarti, 1974; Howell & Higgins, 1990; Maidique, 1980). This identification, combined with a natural inclination of R&D professionals towards product quality and performance -- that is, they are concerned more with the questions of "can we do it" and "how long will it take" versus "can it work" and "how long do we have" (Burgelman, Maidique, & Wheelwright, 1996; Burgelman & Sayles, 1986) -- might bias champions to focus their influence on keeping a project in the organization longer to improve its technical performance rather than on bringing the product to market quickly. As a result, *their* criteria (and, through their efforts, perhaps the criteria of their projects) may have influenced the projects toward elegance and not towards timeliness. Indeed, this scenario of powerful members directing a project towards elegance versus speed was observed by researchers during the development of Microsoft's LAN Manager 3.0 (Cross, Kosnik, Seecharen, & Maidique, 1996).

Regarding project team leaders, multiple regression analysis revealed that leaders having shorter tenures with their firms tended to push products out faster. However, because of the marginal level of significance, one should refrain from drawing any strong conclusions. Notwithstanding, the direction of this marginal relationship is inconsistent with the predictions of this study presented in Chapter 3. However, this is in general consistent with Katz and Allen's (1982) research into the Not-Invented-Here syndrome, which showed that an increased comfortableness with both personnel and information sources inside ones organization can lead to a growing isolation from external scientific and professional developments, thereby influencing one to discount the effect new ideas and technologies which originate outside the organization. In other words, longer leader tenure may be associated with less external monitoring and subsequently less up-to-date knowledge. Because of the importance of the project leader in assimilating and applying external information to development activities (Allen, Lee, & Tushman, 1980; Cohen & Levinthal, 1990), this can be especially problematic to timely product development.

A second explanation for the marginal result that longer leader tenure slowed down innovation involves findings related to the career paths of R&D professionals in organizations. It may be that longer leader tenure is associated with lower rather than greater technical and managerial proficiency, to the contrary of arguments expressed earlier. For example, Cordero, DiTomaso, and Farris (1994) reported that R&D professionals with greater opportunities for technical advancement were more likely to leave their organization and R&D professionals with greater opportunities for managerial advancement were more likely to leave their area of the company. This suggests that those individuals who remain as project leaders for a long duration have the fewest opportunities for advancement. This is consistent with Jain and Triandis' (1990) argument that R&D professionals who remain in this type of assignment for a long period of time are less likely to rise in the organization and to be considered "successful".

Related to this reasoning, tenure may be a surrogate measure for *age* (which was not measured), which has been shown to be related to lower organizational turnover (Porter & Steers, 1979; Davies, Mathews, & Wong, 1991). This might be because of fewer job opportunities generally available to older employees or more satisfactory levels of compensation achieved by them, both of which may be related to exhibiting more conservative behaviors. This is contrasted to high levels of risk taking, which many argue is essential to accelerate the speed of innovation (Cordero, 1991; Dumaine, 1989).

Also contrary to predictions, neither leader position, leader power, nor leader involvement significantly influenced innovation speed. This could be because of the general overstatement of the importance of a leader's influence upon performance measures (e.g., Meindel, Ehrlich, & Dukerich, 1985; Pfeffer, 1981). That is, it is possible that too much emphasis was placed on the characteristics of the project leader when in fact the importance of this individual is more symbolic than substantive.

Alternatively, these non-findings may be because, in this type of situation (i.e., new product development project team), there are "substitutes" for the effects of the project leader on team performance (in this case, speed of innovation) (Kerr & Jermier, 1978). For example, these types of teams are typically characterized by educated R&D professionals who are given a higher degree of autonomy from bureaucratic controls than the typical operating employee, and who are more sensitive to intrinsic versus extrinsic reinforcement (Burgelman, Maidique, & Wheelwright, 1996) -- these characteristics have been shown to substitute for or neutralize the effect of task-related behaviors of leaders (Kerr & Jermier, 1978). This is also consistent with research by Andrews and Farris (1967), Farris (1982), and Jain and Triandis (1990), which point to the effectiveness of a collaborative style of project leadership rather than a dominant, directing one. Whereas this study emphasized the task dimensions of leadership in its propositions and measurement scales, it might be useful to investigate the effect of participation-oriented leadership styles as well.

Regarding project team members, multiple regression analysis revealed that staffing projects with members having broader ranges of functional experience (versus narrow, "functional-silo" backgrounds) tended to push products out faster. This is consistent with the predictions of this study presented in Chapter 3. This is also consistent with previously discussed arguments voiced by Galbraith (1982), Meyer (1993), Purser, Pasmore, & Tenkasi (1994), Smith and Reinertsen (1991), Van de Ven (1986), and Wheelwright and Clark (1992). However, because of the marginal level of significance, one should refrain from drawing any strong conclusions. Thus, one could interpret the results to say that a wider degree of project members' exposure to *other functional aspects* of development might have sped up innovation.

Additionally, backward-elimination MLR analysis revealed that staffing projects with members having longer tenures with their firms tended to push products out faster. This is consistent with the predictions of this study presented in Chapter 3. This is also consistent with the previously discussed works of Burkart (1994) and Donovan (1994). Thus, one could interpret the results to say that a greater degree of project members' exposure to *their organization* sped up innovation.

It is interesting to note that longer tenure of project members facilitated innovation speed while longer tenure of project leaders inhibited innovation speed. Perhaps this is because of the different roles each plays in group problem solving generally (e.g., Maier, 1967) and in the innovation process specifically (e.g., Ancona & Caldwell, 1990; Roberts & Fusfield, 1988). That is, in light of the previous discussions, it might be the case that (a) less entrenched leaders can more easily defer power and adopt a collaborative (versus overly directing) and risk-taking (versus overly conservative) style whereas (b) more entrenched, experienced members can bring greater ranges of technical and other relevant information to the project.

Regarding project team representativeness, multiple regression analysis revealed that representing a variety of interests groups to a greater (versus lesser) extent tended to slow down innovation. Further, finer-grained analysis reported that high degrees of engineering representativeness (marginally significant) and supplier representativeness (highly significant) tended to slow down innovation. These findings are inconsistent with the predictions of this study presented in Chapter 3.

Possible explanations for the representativeness finding in general are that, quite simply, the presence of "too many cooks" slowed the process. In other words, larger groups tended to make decisions at a slower pace than smaller groups (e.g., Hill, 1982; Maier, 1967). Following from this logic, perhaps there is an optimum degree of representation below which there is too little input/information and above which there is too much -- that is, the relationship between representativeness and speed may be curvilinear rather than linear.

Related to this point, it may be the case that there are more appropriate and less appropriate times when various functions should be represented. For example, Bommer, Jalajas, and Boyer (1993) found that, instead of blanketly representing all interest groups, adding team members as their expertise was needed resulted in an efficient, on-time innovation process. Thus it might be the case that the *form* of representation (i.e., who is represented when), rather than just the raw amount of representation, effects innovation speed. Moreover, it is also a possibility that, in general, there may be some functions whose representation slows down the pace of innovation more so than others. Indeed, the results from the finer-grained regressions (see Table 6-8 and discussion below) support this interpretation.

Possible explanations for the direction of the engineering-related finding are twofold. First, it stands to reason that the greater the presence of engineers on the project team throughout the innovation process, the more likely it is that there will be a greater number of design changes and modifications. In other words, more engineer representativeness might signal a higher probability of failure to freeze product specifications. This is similar to the argument regarding "creeping elegance" (Gupta & Wilemon, 1990) or "features creep" (Stalk & Hout, 1990), whereas failing to freeze specifications delays projects because it forces development teams to constantly make design adjustments and requires constant re-tooling and start-ups in production. Thus, more opportunities for engineers' input might increase the likelihood of project-delaying design changes occurring.

Alternatively, this finding may be the result of a reverse-effect. That is, a slower process might require engineering to become more intensely involved in the project rather than the other way around. For example, the existence of more problems in the early stages (i.e., difficult design) or later stages (i.e., mistakes, poor forecasts, poor fit with downstream functions) of the innovation process may necessitate that engineers be involved in the project to a greater extent. If this were the case, making the argument that the increased presence of engineers slows down innovation is akin to the argument that increased presence of firefighters causes buildings to burn more intensely.

The finding that greater (versus lesser) supplier involvement lengthened innovation time, while counter to the predictions of this study, is nevertheless consistent with similar findings by Tabrizi and Eisendardt's (1993) among computer firms -- incidentally, they too predicted the opposite effect, that supplier involvement would speed up innovation. One possible explanation for this result is that the benefits assumed to accrue to project teams from supplier involvement (e.g., brings in information regarding new technologies, development of a co-developer mentality) were not gained in this sample. For example, if a co-developer mentality was not fostered among suppliers, then including them may detract from the pace of innovation because their potentially incongruous set of objectives (e.g., cost-minimization) is added throughout the process. In this sense, the case of Chapparal Steel and its development of beam-blank casting (Preuss & Leonard-Barton, 1996) represents a "best-case" scenario where suppliers were willing to work with the firm and develop new technologies to speed innovation. However, even Chapparal initially met with some resistance from its suppliers, whose actions at first resembled those of independent, for-profit entities rather than co-developers, and who seemed less willing to develop newer technologies than to rely on older ones.

Another possible explanation for this finding is that these types of productive innovator-supplier relationships are easier to forge in industrial contexts like Japan (Mansfield, 1988) than in the U.S., because of the different institutional relationships between firms and sub-contractors in the two nations. This is similar to a potential explanation advanced for the external-sourcing finding.

In sum, there is no support for Proposition 4a (Champion Presence). There is partial support for Proposition 4c (Member Experience). There is some evidence to suggest a partial reversal of Proposition 4b (Leader Strength) and Proposition 4d (Team Representativeness).

7.34 Organizational Capability: Structuring-Related Factors. Table 7-1e illustrates that there were many significant relationships, by far the most of the four categories of antecedents, between decisions regarding project-structure and the subsequent pace of new product development. First, split-sample analysis reported that empowering project teams tended to speed up innovation -- however, this applied only to highly radical innovations. This is consistent with the predictions of this study presented in Chapter 3. Generally, the positive relationship between autonomy and speed is consistent with the previously discussed works of Ancona and Caldwell (1990), Blackburn (1992), Damanpour (1991), Deschamps and Nayak (1992), Dumaine (1989), Eisenhardt (1989), Emmanuelides (1991), Hall (1991), King and Penlesky (1992), Meyer (1993), Rosenthal (1992) Stalk and Hout (1990), Zangwill (1993), and Zirger and Hartley (1993). Thus, in this limited range, one can say that the speed of projects involving highly complex, uncertain tasks was increased when decision making authority was transferred from top management to the development team.

One possible explanations for this finding being specific to radical innovations is that there is a greater need to decentralize and delegate authority when the tasks are less clear. To recall, radical (versus incremental or moderate) innovation is relatively newer to the focal organization and represents a greater departure from existing practices (Damanpour, 1991; Ettlie et al. 1984; Henderson & Clark, 1990; Meyers & Marquis, 1969). Subsequently, decentralization might be most appropriate when the tasks are more of a departure from existing practices (i.e., more radical in nature). When change is more radical, there is less likely to be precedents on which to rely, and thus it will be less clear what are the appropriate activities, tasks, resources, and the like. This is consistent with the underlying logic that innovation in general, because of the higher degree of uncertainty and complexity it faces, requires a higher degree of decentralization than standard business activities (Burns & Stalker, 1961; Damanpour, 1991; Spender & Kessler, 1995). It is also consistent with research in the decision making literature that suggests that the degree of rationality or imposed structure in problem solving (e.g., centralization, formalization) should match the degree of certainty or programmability of circumstances surrounding that problem (e.g., Fredrickson, 1984; March & Simon, 1958). Thus, it stands to reason that if an innovation is highly uncertain and complex, than a high degree of project team empowerment is most appropriate.

It is also reported in Table 7-1e that obtaining a high degree of overlap (i.e., parallel processing, concurrent engineering) tended to speed up innovation. This effect was found in the main-effect analysis for all innovations, split-sample-analysis for highly radical innovations, and backward-elimination analysis for all innovations. This is consistent with the predictions of this study presented in Chapter 3. This is also consistent with the previously discussed research of Brown and Karagozoglu (1993), Clark & Fujimoto (1991), Handfield (1994), Millson and colleagues (1992), Rosenthal (1992), Smith and Reinertsen (1991). Takeuchi and Nonaka (1986), Vesey. 1991. and Zahra and Ellor (1993). Thus it appears that innovation speed is greater when there is a higher degree of parallel (versus sequential) processing of tasks.

The results regarding project integration were mixed. Consistent with the predictions of this study presented in Chapter 3. a low degree of turf-guarding tended to speed up innovation -- however. this applied only to highly radical innovation. In general. the negative relationship between turf-guarding and time is consistent with the previously discussed work of Brockhoff and Chakrabarti (1988), Clark and Fujimoto (1991). Larson and Gobeli (1988), Meyer (1993), and Stalk and Hout (1990). Thus it appears that, for radical projects. strong functional norms slowed down development while weak functional norms sped up development.

A possible explanations for this finding being specific to radical innovations is that there is a greater need for a more integrated, project-oriented perspective (versus several loosely-connected, functionally-oriented perspectives) to speed work on a new product development team when the task is less clear (i.e., the innovation is more radical). That is, a more "organic" versus "bureaucratically-specialized" context is appropriate for solving less familiar problems (Burns & Stalker, 1961; Spender & Kessler, 1995). In this vein, this result seem consistent with the notion that there is an increased importance of communication and integration between functional concerns when there is a higher degree of complexity and uncertainty surrounding a task (e.g., Lawrence & Lorsch, 1967; Thompson, 1967).

Also consistent with the predictions of this study presented in Chapter 3, a high degree of physical proximity tended to speed up innovation -- however, this applied only to moderately radical innovations (note: excessive tolerance forced this variable out of the highly radical model). In general, the negative relationship between proximity and time is consistent with the previously discussed work of Allen (1977), Jain and Triandis (1990), Katz and Tushman (1979), Keller (1994), Meyer (1993), Mabert and colleagues (1992), Peters (1987), Rosenthal (1992), Slade (1993), Stalk and Hout (1990), Takeuchi and Nonaka (1986), Zangwill (1993), and Zirger and Hartley (1993). Thus the results indicate that, for moderately radical projects, spreading out members of a project team lengthened development time.

One possible explanation for this finding applying to moderate and not incremental innovations is similar to that above for turf-guarding; specifically, the importance of communication is greater for less familiar tasks which represent a greater departure from existing practices. Thus, comparing moderately radical to incremental innovations, the former "more innovative" innovations needed the higher quality (Katz & Tushman, 1979) and quantity (Keller, 1986, 1994; Meyer, 1993) of information which results from closer proximity between project team members. This finding is also consistent with the more general notion that more complex problems require more "information rich" communication channels (e.g., face-to-face communication) (Daft & Lengel, 1984). Therefore, it stands to reason that a project team would require more face-to-face communication when an innovation is less familiar.

Inconsistent with the predictions of this study presented in Chapter 3, a high degree of design-for-manufacturing tended to slow down innovation. This was revealed for all innovations in the backward-elimination analysis and for highly radical innovations in the split-sample analysis. A possible explanations for this finding is that the added criteria of manufacturability was inappropriately applied too early or too frequently in the processes. In this vein, perhaps manufacturability provided a status-quo incentive; after all, it is easier to manufacture a product for which designs are either already adapted to machine specifications or are similar to existing machine specifications. This is consistent with the argument that, when established programs exist (i.e., solutions to problems), they tend to be relied upon (Ford, 1996; March & Simon, 1958). In other words, the input from a manufacturing representative(s) may have inhibited the innovation process.

Related to this reasoning, the slowing-effect of manufacturing representation may stem from poor integration. Contrary to an implicit assumption of the study, it may be that a greater presence of a manufacturing representative on a project team did not translate into manufacturing concerns being harmonized with those of other functions. That is, representation does not guarantee integration because it does not address *how* the functional representatives interacted (e.g., Hayes & Wheelwright, 1984). Instead, if manufacturing concerns (such as ease of production and few design changes) are not integrated with other issues (such as customer-needs and technological sophistication), the greater inclusion of a manufacturing representative might simply provide the opportunity for more frequent, and subsequently more time consuming, politicking and disagreements.

The results regarding process organization were also mixed. Split-sample analysis reported that a frequent development milestones tended to speed up highly radical innovations (consistent with the predictions of this study presented in Chapter 3) but tended to slow down moderately radical innovations (inconsistent with the predictions of this study presented in Chapter 3). Needless to say, these results were not expected. However, reflecting back upon what frequency of milestones represents, they are not altogether surprising.

One possible explanation for this finding is that, quite simply, radical innovations are the most in need of milestones. A primary reason why milestone frequency was argued to speed innovation was that it structured the process by separating an otherwise formidable task into manageable parts. Thus it stands to reason that the most formidable tasks (i.e., highly radical innovations) would accrue the most benefits of frequent milestones . Alternatively, moderately radical innovations may not need this "benefit" of frequent milestones and, instead, more milestones may merely represent more artificial hurdles which slow down the development process without conveying any real speed-based benefits. However, the natural extension of this reasoning would be that incremental innovations would be aided the least when in fact the results indicate that milestone frequency has no effect on their speed. This may be because the time-frame for incremental innovations is sufficiently short that milestones are almost meaningless. Also, it might be because incremental innovations involve a much lower degree of uncertainty than other types, making milestones easier to meet and less of an issue.

Results from main-effect analysis, backward-elimination analysis, and split-sample analysis (for highly radical innovations) revealed that a high percentage of development time spent in testing tended to slow down innovation. This is inconsistent with the predictions of this study presented in Chapter 3. However, a this finding may be interpretable when the purpose of testing is more closely examined. Testing is intended to evaluate working models, prototypes or computer-generated images of products against previously established guidelines or criteria (Wheelwright & Clark, 1996). Insofar as testing is used to this end, it might influence members of a project team to become overly concerned with the quality of their product and less so with its speed. That is, a greater percentage of time spent in testing may indicate that speed is being traded off for quality.

The typical product development approach adopted by Microsoft illustrates this point. Microsoft has a record of releasing initial versions of products (too?) early, which are subsequently revealed by users to frequently possess problems in design and overall quality (Cross, Kosnoik, Seecharan, & Maidique, 1996). It seems as if their approach to development is to let the users in the market test a "satisfactory" product rather than to release a superior, albeit later, product. However, Microsoft typically follows up with a next-generation product which addresses these shortcommings. This is reminiscent of Simon's (1976) concept of "satisficing", whereby the product is brought to market when it is seen as 'good-enough' rather that when it is seen as 'perfect'. Thus firms might be able to reduce the number of design-build-test iterations (Wheelwright & Clark, 1996) and innovate faster when design improvements are carried out in the marketplace as successive generations rather that in the laboratory as successive iterations.

Results from main-effect analysis, backward-elimination analysis, and split-sample analysis (for highly radical and moderately radical innovations) revealed that a more frequent use of CAD systems tended to slow down innovation. This is inconsistent with the predictions of this study presented in Chapter 3. However, this is consistent with

Tabrizi and Eisendardt's (1993) similarly unexpected finding among computer firms that use of CAD systems lengthened innovation time Tabrizi and Eisenhardt posited several reasons why this was found to be the case, and these explanations may also be applicable to this study. First, the CAD systems may have been implemented inappropriately; that is, there may have been a overly long time required to learn and use them effectively. Additionally, whereas CAD systems can eliminate may sources of delay from the innovation process, they can also create new types of delays; for example, a preoccupation with the computer, or computer "hacking". A third reason is that CAD systems often, by nature, direct activities towards automating well-known calculations and facilitating re-use of old designs; that is, they may be poorly suited for the creation of new designs and testing them. Overall, this result is consistent with those who caution against the "technological fix", or relying upon newer means of executing the same old process (e.g., Dumaine 1989; Goldratt & Cox, 1986; Takeuchi & Nonaka, 1986).

In sum, there is partial support for Proposition 5a (Team Empowerment). There is mixed support (i.e., some consistent evidence and some contrary evidence) for Proposition 5b (Project Integration). There is some evidence to suggest a partial reversal of Proposition 5c (Process Organization).

7.35 Summary of Antecedent Factors. Overall, the antecedent analysis yielded mixed, but some very interesting, findings. One interpretation of these results, especially those involving the structuring-related antecedents (Model 5), is that they in part suggests a contingency answer to the question on how to speed up innovation. This is supported by the fact that the main-effect MLR models (Table 6-5) accounted for an average of 16% of the variance in innovation speed whereas the split-sample MLR models (Table 6-7), which took into consideration differences in innovation radicalness, accounted for an average of 45% of the variance in innovation speed. Contingency theory argues that there is not one "best answer" to an particular problem; instead, the appropriateness of managerial interventions is dependent on the prevailing conditions which surround that problem (e.g., Lawrence & Lorsch, 1967; Thompson, 1967). Thus, for example, results regarding Model 5 suggest a contingency theory insofar as different structural arrangements are more or less effective at speeding up innovation for projects differing in degree of radicalness. Therefore, depending upon the level of uncertainty -- ranging from radical (high) to moderate to incremental (low) -- there may be different sets of answers to the second research question regarding ways to speed up innovation.

Another insight which can be derived from the antecedents results is that organizational capability (i.e., actual strategy) may have a greater effect on the speed of innovation than strategic orientation (i.e., espoused strategy). An examination of the variance explained by the different antecedent models (i.e., their R^2 s) reveal that, on the average, organizational capability factors accounted for more variance in innovation speed than did strategic orientation factors. For the main-effect MLR models, strategic orientation factors accounted for an average of 6% of the variance in innovation speed whereas organizational capability factors accounted for an average of 26% of the variance in innovation speed; for the split-sample MLR models, strategic orientation factors accounted for an average of 23% of the variance in innovation speed whereas organizational capability factors accounted for an average of 68% of the variance in innovation speed. Additionally, backward elimination MLR analysis selected four organizational capability factors to only two strategic orientation factors for the final, parsimonious model. All together, these results suggest that the innovation strategy espoused by top management affects speed less than the actual characteristics of the infrastructure in which new products are developed. This is consistent with the argument that a firm's espoused and actual strategies can be quite different (e.g., Burgelman, Maidique, & Wheelwright, 1996; Christensen & Kessler, 1995), and that a firm's actions, rather than its rhetoric, reflect its actual innovation strategy.

Finally, the parsimonious antecedent model resulting from the backward-elimination stepping procedure was highly significant (at the .01 level) and included the factors clarity of time goal (sped up), tenure of project members (sped up), degree of process overlap (sped up), design for manufacturing (slowed down), percentage of development time spent in testing (slowed down), and use of CAD systems (slowed down). One may interpret this to suggest that, when all antecedent factors are considered at once -- and in reality they are operating simultaneously in the innovation process (e.g., at any given time there are leaders, reward systems, culture, competing projects in the stream, milestones, etc.) -- these six variables have the greatest impact on innovation speed as derived from a sample of seventy-five diverse new product innovations from ten firms in a variety of industries.

7.4 Outcome Factors (Research Question #3)

Regarding the third component of the model, the results were relatively strong and consistent regarding the outcomes of a fast innovation process. That is, there emerged a fairly clear, predicted answer for the question of what happens when firms speed up innovations.

Table 7-1f reports that speeding up innovation lowered development costs -- however, this was true only for incremental innovations. This is consistent in direction with the predictions of this study presented in Chapter 3. In general, the positive relationship between time and costs (or, framed differently, the negative relationship between speed and costs) is consistent with previously described arguments articulated in the works of Clark and Fujimoto (1991), Graves (1989), and Page (1993). It also suggests that, if the relationship is curvilinear (e.g., Gupta et al., 1992; Murmann, 1994; Vincent, 1989), firms in the sample were operating to the right of the minimum (i.e., they were overly-slow) and thus speeding up projects reduced their costs.

There are a few possible explanations for this result being specific to incremental innovations. Perhaps speed is more vital to reducing costs for improvements of existing products because its effects are more resonant (e.g., in reducing overhead and capping man-hours) on the types of tasks involved in the process. For incremental innovations, much of the conceptual and design work has already been done (by definition, these innovations are minor improvements on existing products and technologies) -- thus, a shorter process limits only relatively simple design extensions and implementation. The same cost reductions may not be realized for radical innovations because time frames are more indeterminant and there are usually a greater number of design iterations and conceptual exploration required (e.g., Tabrizi & Eisenhardt, 1993). Thus shorter development times may or may not result in increased efficiency for these types of projects because the economies derived from a faster innovation process are not as great for more abstract creativity and exploration than they are for more concrete extensions.

Results from main-effect analysis (all innovations) and split-sample analysis (highly radical and moderately radical innovations) reveal that speeding up innovation increased product quality. This is consistent with the predictions of this study presented in Chapter 3. This is also consistent with previously discussed arguments by Clark (1989b), Cordero (1991), Deschamps and Nayak (1992), Eisenhardt (1989), Flynn (1993), Gomory and Schmidt (1988), Meyer (1993), Page (1993), Patterson and Lightman (1993), Sonnenberg (1993), and Wheelwright and Clark (1992). Thus it appears that faster innovation was generally associated with higher (as opposed to lower) product quality.

Results from main-effect analysis (all innovations) and split-sample analysis (moderately radical innovations) reveal that speeding up innovation increased project success. This is consistent with the predictions of this study presented in Chapter 3. This is consistent with previously discussed arguments by Cordero (1991), Dumaine (1989), Gee (1978), Gomory (1989), Meyer (1993), Reiner (1989), Smith and Reinertsen (1991), Stalk and Hout (1990), and Vesey (1991). Thus it appears that faster innovation was generally associated with greater (versus lesser) degrees of project success.

In sum, there is partial support for Proposition 6a (Cost of Development). There is fairly strong support for Proposition 6b (Product Quality) and Proposition 6c (Project Success). Overall, these findings suggests that the positive "hoopla" surrounding innovation speed (Crawford, 1992) appears to be justified.

CHAPTER 8
SUMMARY AND CONCLUSIONS

8.1 Introduction

In this chapter I summarize the conceptual and empirical aspects of the dissertation, trace its implications for both scholars and practicing managers, and, based upon the limitations of the study, offer directions for future research.

8.2 Summary of Conceptual Arguments and Empirical Findings

I have argued that, despite a growing recognition that innovation speed can be important to competitive advantage, there are several shortcomings in the literature which constrain our ability to understand conceptually as well as systematically validate important relationships. An analysis of the innovation speed literature revealed that different units of analysis are adopted by authors, which presents problems in applying some variables from one study to the conclusions of another. Different types of analyses are also undertaken, which reveals different degrees of rigor and objectivity underlying their conclusions. Factors at different stages of the innovation process are focused upon by different studies, often to the neglect of other important variables. Moreover, a general lack of theoretical development, especially at the project level, and variability in both the conception and measurement of speed provide additional barriers to comparing the lessons of one study with another. As a result of these limitations, inconsistencies exist in assessments of the contextual applicability of speed, in prescriptions regarding methods which could be used to increase speed, and in predictions about the outcomes of innovation influenced by speed.

In this dissertation, I have developed a theoretically-based model of innovation speed at the project level which integrates the findings of other studies into conceptual categories relating to need, antecedents, and outcomes. I have also advanced specific, testable propositions to provide a foundation for empirically validating conclusions within these three broad areas and reducing some of the above inconsistencies. Specifically, I have explored the relationships between innovation speed and: (a) need factors relating to economic, technological, demographic, and regulatory conditions; (b) antecedent factors relating to strategic orientation (both criteria- and scope-oriented) and organizational capability (both staffing- and structuring-oriented), and; (c) outcome factors relating to cost, quality, and ultimate project success.

Empirical tests of the model's three sections revealed some interesting findings, some expected and some surprising, which provided differential levels of support for the need, antecedent, and outcome propositions. As discussed previously, one should interpret the results of the study with an appreciation of its context -- the dissertation is more of a broad-based, early attempt to pull together various types of studies relating to innovation speed and empirically test inferred relationships than it is an incremental, specialized extension of a small area of an established literature.

With this in mind, the results suggest that innovation speed (a) is motivated by still uncertain external circumstances, (b) has its origins in an often complex set of interrelated variables, though some factors seem to exert a stronger influence upon it than others, and

(c) results in relatively consistent, positive project outcomes.

First, regarding the need for speed, the results are mainly in the predicted direction but are inconclusive in magnitude. Thus, the model may be on to something but not yet fine-grained enough (or the sample is too small) to show relationships between external context and the pace of innovation with any degree of certainty. In short, the results are weakest in this part of the model. However, it was found that:

1-1 Technologically dynamic contexts seem to motivate faster development of incremental innovations than contexts with a static rate of technological advance.

Second, regarding the antecedents to speed, the results are mixed in direction as well as in level of significance. Overall, it was found that new product development projects are faster for the *entire range* of innovations when:

2-1 Project team members are punished as a group for schedule slippage.

2-2 Teams are staffed with members with relatively long tenures in the firm.

2-3 Teams are staffed with fewer representatives from various interest groups, especially engineers and suppliers.

2-4 They are undertaken in parallel.

2-5 They are not designed for manufacturing.

2-6 They spend a lower percentage of time in the testing phase of development.

2-7 They do not make extensive use of CAD systems.

Additionally, it was found at a marginal level of significance[1] that new product development projects are faster when:

(2-8) There are clear, specific schedules.

(2-9) There is a greater reliance on internal ideas and technologies.

(2-10) Teams are staffed with a leader with a relatively short tenure in the firm.

(2-11) Teams are staffed with members with broad functional experience.

However, different answers to the second research question emerged when projects of different degrees of radicalness were examined. It was found that a new product development project is faster for *radical* innovations when:

2-1a Teams are given a high degree of autonomy.

2-2a They are undertaken in parallel.

2-3a There are strong project (versus functional) norms, or little turf-guarding.

2-4a They are not designed for manufacturing.

(2-5a) There are frequent development milestones.

2-6a They spend a lower percentage of time in the testing phase of development.

2-7a They do not make extensive use of CAD systems.

It was found that a new product development project is faster for *moderately radical* innovations when:

[1] Conditions in parenthesis were only marginally significant (p<.10), so one should be careful in interpreting them too strongly.

2-1b There are not frequent development milestones.

2-2b Team members are located in close physical proximity.

2-3b They do not make extensive use of CAD systems.

It was found at a marginal level of significance that a new product development project is faster for *low radical (i.e., incremental)* innovations only when:

(2-1c) There are clear, specific schedules.

Third, regarding the <u>outcomes</u> for speed, the results are both consistent in direction and significant in magnitude. In general, it can be said that faster innovation is associated with:

3-1 Lower development costs, but only for incremental innovations.

3-2 Higher product quality, both in general for all innovations and most notably for highly radical and moderately radical innovations.

3-3 Greater project success, both in general for all innovations and most notably for moderately radical innovations

8.3 Implications for Scholars

This thesis contributes to our understanding of innovation speed and hence our ability to successfully manage it in several ways. First, regarding theory-based contributions, this study represents an important step in establishing the conceptual groundwork for rigorous, empirical hypotheses testing. The challenge, of course, is to cumulatively build upon the works of others to investigate and further clarify some of these issues without losing a focus upon the "big picture" and complex relationships relating to the context, antecedents, and outcomes of speed. Indeed, there are significant overlaps and implications of these areas which span such rich literatures as (a) organizational theory, for instance environmental contingency theory (e.g., Duncan, 1972; Lawrence & Lorsch, 1967) and organizational design (e.g., Galbraith, 1982; Kanter, 1988); (b) technology and innovation strategy (e.g., Brockhoff & Chakrabarti, 1988; Clark, 1989b; Lengnick-Hall, 1992); (c) time-based competition (e.g., Eisenhardt, 1990; Stalk & Hout, 1990), and; (d) project/team management (e.g., Ancona & Caldwell, 1990; Keller, 1994). However, research drawing from these literatures should be undertaken while taking into account the need for consistency in the unit of analysis adopted, the stage(s) of the process studied, and the definition and measurement of speed.

Second, regarding empirical-based contributions, this study has broadened our knowledge of innovation speed in several important areas. It has raised some important questions as well. This is especially meaningful given that innovation speed is one of the least studied areas in new product development (Montoya-Weiss & Calantone, 1994) and, as a relatively new field of study, is in its early stages of development. Need for speed results do not offer scholars a strong basis for understanding the contextual characteristics which motivate fast product development. However, the relative consistency in the direction of effects may suggest that there is some underlying logic to the idea of positing need for speed relationships. Antecedents to speed results offer scholars important insights into several variables that tend to speed up (i.e., act as facilitators) or slow down (i.e., act as barriers) innovation for a wide variety of product innovations in a wide variety of industries. Moreover, these results suggest that slightly different sets of variables tend to act as facilitators or barriers, depending on the radicalness of innovation. Outcomes of speed results offer scholars relatively clear information regarding the "hoopla" surrounding innovation speed, specifically that is appears to be largely justified. However, it is also suggested that the consequences of a fast innovation process may also vary slightly with innovation radicalness.

8.4 Implications for Practitioners

From the practitioner's point of view, the contributions of the thesis are useful in terms of its (a) discussion of the merits of innovation speed and the situations where it is most appropriately (and least appropriately) pursued, (b) delineation of ways in which planned interventions can be appropriately applied to address specific opportunities and pitfalls affecting fast-paced innovation, and; (c) exploration of the bottom-line implications of speed.

Regarding applicability, the theoretical model and empirical results seem to be at odds. On the one hand, the model argues that, contrary to the bias that faster is always better, speed is not equally appropriate in all environmental contexts. Thus, a practical prescription of the theoretical model is that firms carefully determine the need for speed for different innovations within different task and regulatory environments before blindly pursuing faster development; It is this need that determines the relative utility of speed. On the other hand, as discussed previously, results are not particularly strong here regarding environmental factors and the need for speed. In fact, the results from the outcome part of the model suggest that speed is good -- for quality, success (and possibly costs) --in all kinds of environmental conditions. Thus, a practical prescription of the empirical results is that firms pursue speed on all development projects. In summary, although the first part of the theoretical model points out potentially-important boundary conditions for speed and asks an important question, the results do not offer a clear answer to this question and may in fact run counter to it.

The model also indicates that speeding up innovation is a complex process which involves factors related to both orientation and capability. That is, it is argued that firms need to align their strategic orientation (or that of their relevant divisions) with the objectives of speed, including the criteria applied to projects as well as the scope of projects, and they need to build the organizational capability for speed through appropriate staffing as well as structuring considerations. To this end, the results offer managers several concrete factors related to both orientation and capability which exert a statistically significant influence on innovation speed (see the above lists) -- The methods which have the largest effects on innovation speed are summarized in Table 8.1. They also suggest that organizational capability may be more important than strategic orientation and that a contingency approach to increasing the speed of innovation (based upon the degree of innovation radicalness) might be most appropriate. Specifically, it follows from the data that emphasis should be placed on increasing speed indirectly through methods to improve organizational capability, especially for radical projects.

More fundamentally, the model and results imply that actually speeding up

TABLE 8-1
Methods Which Speed Up Development Projects[a]

ALL PROJECTS	HIGHLY RADICAL PROJECTS	MODERATELY RADICAL PROJECTS	INCREMENTAL PROJECTS
Modest CAD	Modest CAD	Modest CAD	
High Overlap	High Overlap	Few Milestones	
Modest DFM	Modest DFM	Co-Location	
Modest Testing	Modest Testing		
Modest Representativeness	High Autonomy		
	Modest Turf-Guarding		

[a] The table is comprised of factors which were statistically significant at the .05 level in the main-effect analysis (all projects) and the split-sample analysis (radical, moderate, and incremental projects).

innovation requires that organizations break away from traditional developmental approaches and address fundamental strategic orientation as well as organizational capability factors that can influence the pace of project development. This is because, "the worst way to speed up a company ('s innovation processes) is by trying to make it do things just as it does, only faster. The machinery, and certainly the workers, will simply burn out" (Dumaine, 1989: 55). Alternatively, the propositions voiced here, and to some extend the results found, advocate an approach similar to Goldratt and Cox's (1986) logic on improving the efficiency of manufacturing processes, that organizations systematically address the factors which can constrain the speed of development so that they promote rather than inhibit innovation speed.

This is related to a third practical implication, that speed affects other important project outcomes such as cost, quality and ultimately success in positive ways. More specifically, the results inform managers that pursuing speed in innovation need not be at the sacrifice of lower cost or higher quality; in fact, there does not seem to be a tradeoff between the objectives -- speed tends to increase quality and may in some instances lower costs. However, it is probably better to strain for speed not as an end in itself but rather as a means towards improved cost and quality performance. That is, companies should pursue focused improvements in speed as opposed to blind haste. This is similar in spirit to Deming's insight that pursuing higher quality need not be at the sacrifice of lower costs (Gitlow & Gitlow, 1987). Further, and perhaps most importantly, the speed of a new product innovation is shown to be significantly, positively related to its eventual success. Again, this was true for a wide variety of new product innovations in several industries.

8.5 Limitations and Suggestions for Future Research

As in any research study, tough decisions were made regarding trade-offs in adopting various conceptual, methodological, and analytical approaches. This was also the case partly because of the relatively embryonic nature of the field and subsequently the need to draw boundary conditions to keep an already large project manageable. Thus, there are several limitations to this study which suggest future areas of research.

Some conceptual limitations of the study, which were manifest in the delineation of propositions and the selection of an appropriate research sample, are that it (a) considered only *product* innovations, and (b) considered only *U.S.* firms or affiliates. This bears upon the generalizability of findings. It might be the case that there are different need, antecedent, and outcome relationships for the speed of process, administrative, or service innovations. It might also be the case that the nature of these relationships varies between different national cultures, as some of the previous discussion suggests, where a more global perspective is required. Thus subsequent research can explore these slightly different conceptual issues and investigate them in a broader research sample.

Some methodological limitations of the study, which were manifest in the collection of data, are that it (a) adopted a *cross-sectional* design of study (i.e., time-specific), (b) pursued a less than random selection of *research sites*, and (c) utilized retrospective, *questionnaire* responses. Future research may pursue a real-time strategy of data collection, where agreater depth of investigation can explore the nuances of projects and their variables otherwise untested in this study (e.g., the nature of managerial support, the different types of rewards and punishers used). Another option would be to undertake a longitudinal strategy of data collection, where relationships can be explored over various time intervals to detect any time-lag effects. Future research may also try to confirm these results in a larger, more comprehensively or randomly-selected sample base. A larger sample would also increase the ability to probe deeper into industry differences regarding innovation speed.

Some analytical limitations of the study, which were manifest in the statistical procedures applied to the data, are that it (a) tested mostly *main-effect* relationships of individual variables, although split sample analysis was used to explore the moderating effects of innovation radicalness, and (b) examined effects over the *entire innovation process*, as opposed to making distinctions between effects for different stages of the process. Future research may examine the possibilities of interactions and other moderated relationships between variables. It may also test the effects various factors specific to certain stages of the innovation process. This approach may lend itself to a slightly more sophisticated way of understanding and managing innovation speed because, if one discovers that different factors facilitate and impede speed in different stages of the innovation process, then appropriate managerial interventions can be applied more effectively.

Overall, though the research questions addressed by this dissertation remain unanswered in an absolute sense, the development of a conceptually-based model and the systematic, deductive testing of its propositions offer several interesting insights that increase our understanding of the many relationships surrounding innovation speed. Thus, this study can be seen to contribute to both theoretical integration and empirical validation with respect to an important phenomena, innovation speed, which has implications for scholars as well as R&D managers. As research into these issues continues to grow, and this literature continues to develop, researchers will come closer to answering these questions in a more authoritative fashion.

APPENDIX A-1
Questionnaire Instrument - Project Leader Version

A SURVEY ON MANAGING THE INNOVATION PROCESS

Please return completed questionnaire to:

NJIT
New Jersey Institute of Technology
Professor Alok K. Chakrabarti
School of Industrial Management
New Jersey Institute of Technology
Newark, New Jersey 07102

RUTGERS

Graduate School of Management • University Heights • 180 University Avenue • Newark • NJ 07102-1895

Researchers at the Graduate School of Management at Rutgers University and the New Jersey Institute of Technology are studying the development of a variety of innovations in a cross-section of organizations. The purpose of this research is to better understand how to manage the innovation process and learn what factors influence the successful development of innovations.

Your organization has been selected for this study, and you specifically have been selected to participate by your organization's coordinator. We would appreciate your cooperation by completing this survey. It should take less than 30 minutes. Most questions can be answered simply by circling, checking off, or writing a number that reflects your best judgment on an answer scale. All answers are straightforward and there are no right or wrong answers.

You will receive a feedback report on the findings of this survey. We promise that the information you provide will remain confidential. Data will be averaged across individuals and organizational units, and no individual or organization will be identified in any of the study findings.

Thank you.

Alok Chakrabarti
Project Co-Director

School of Industrial Management
New Jersey Institute of Technology
Newark, New Jersey 07102

(201) 596-3256 (Phone)
(201) 596-3074 (Fax)

Eric Kessler
Project Co-Director

Graduate School of Management
Rutgers University
Newark, New Jersey 17102

(201) 648-1650 (Phone)
(201) 648-1664 (Fax)

Code Number: ________ Project: ____________________

THE FIRST SECTION COMPRISES QUESTIONS #1 THROUGH #15.

IT FOCUSES UPON THE MAJOR OUTCOMES OF THE PROJECT.

When did product development activities **begin** (mm/yy)? ___/___

When did product development activities **end** (mm/yy)? ___/___

Please place a check next to the statement that indicates the extent to which the **time goal** for the project was achieved.

We were **ahead** of schedule by:	__0-25%	__26-50%	__51-75%	__76-100%	__>100%
We were **behind** schedule by:	__0-25%	__26-50%	__51-75%	__76-100%	__>100%
We had met our schedule:	__				

Please place a check next to the statement that indicates the extent to which this project was faster or slower than similar past projects in your organization.

Faster than similar past projects by:	__0-25%	__26-50%	__51-75%	__76-100%	__>100%
Slower than similar past projects by:	__0-25%	__26-50%	__51-75%	__76-100%	__>100%
About the same as similar past projects:	__				

Please place a check next to the statement that indicates the extent to which this project was faster or slower than similar competitor projects.

Faster than similar competitor projects by:	__0-25%	__26-50%	__51-75%	__76-100%	__>100%
Slower than similar competitor projects by:	__0-25%	__26-50%	__51-75%	__76-100%	__>100%
About the same as similar competitor projects:	__				

If the following stages of development were undertaken, when did they begin and end (mm/yy)?

a. **PRE-DEVELOPMENT/PLANNING**: Begins with the start of the project and ends with the completion of basic product requirements.

Was this stage undertaken (circle one)? Yes / No If so: Start Date___/___ End Date___/___

b. **CONCEPTUAL DESIGN**: Begins with the basic concepts and ends with final specifications of the product.

Was this stage undertaken (circle one)? Yes / No If so: Start Date___/___ End Date___/___

c. **PRODUCT DESIGN**: Begins with the engineering work to take the specifications to a fully designed product and ends with final release to system test.

Was this stage undertaken (circle one)? Yes / No If so: Start Date___/___ End Date___/___

d. **TESTING**: Begins with component and system test and ends with the release of the product to production.

Was this stage undertaken (circle one)? Yes / No If so: Start Date___/___ End Date___/___

e. **PROCESS DEVELOPMENT**: Begins with the first process design and ends at the completion of the first pilot run.

Was this stage undertaken (circle one)? Yes / No If so: Start Date___/___ End Date___/___

f. **PRODUCTION START-UP**: Begins with production ramp-up and ends with the stabilization of production.

Was this stage undertaken (circle one)? Yes / No If so: Start Date___/___ End Date___/___

6 How much **money** was devoted to the development and commercialization of the new product (This includes but is not limited to expenses incurred due to man-hours, materials, and equipment utilization)?

$______

7 Please place a check next to the statement that indicates the extent to which the **budget goal** for the project was achieved.

We came in **under** budget by:	__0-25% __26-50% __51-75% __76-100% __>100%
We came in **over** budget by:	__0-25% __26-50% __51-75% __76-100% __>100%
We came in **right on budget**.	__

8 **Please place a check next to the statement that indicates the extent to which this project was more or less expensive than similar past projects in your organization.**

More expensive than similar past projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
Less expensive than similar past projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar past projects.	__

9 **Please place a check next to the statement that indicates the extent to which this project was more or less expensive than similar competitor projects.**

More expensive than similar competitor projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
Less expensive than similar competitor projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar competitor projects.	__

10 **Please place a check next to the statement that indicates the extent to which this product was of a higher or lower quality than pre-set performance standards.**

Superior to pre-set standards by:	__0-25% __26-50% __51-75% __76-100% __>100%
Inferior to pre-set standards by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as pre-set standards.	__

11 **Please place a check next to the statement that indicates the extent to which this product was of a higher or lower quality than similar past projects in your organization.**

Superior to similar past products by:	__0-25% __26-50% __51-75% __76-100% __>100%
Inferior to similar past products by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar past products.	__

12 **Please place a check next to the statement that indicates the extent to which this product was of a higher or lower quality than similar competitor products.**

Superior to similar competitor products by:	__0-25% __26-50% __51-75% __76-100% __>100%
Inferior to similar competitor products by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar competitor products.	__

13 To what extent were the customers or users of this product **satisfied** with it - - i.e., to what extent did it meet their needs?

Not at all Satisfied		Somewhat Satisfied		Completely Satisfied
1	2	3	4	5
☐	☐	☐	☐	☐

14 To what extent did this product **meet expectations** and attain organizational goals?

Not at all		Somewhat		Completely
1	2	3	4	5
☐	☐	☐	☐	☐

15 To what extent was this product a **marketplace success** - - i.e. to what extent did the product "win" in competitive situations?

Product Flop		Somewhat Successful		Completely Successful
1	2	3	4	5
☐	☐	☐	☐	☐

THE SECOND SECTION COMPRISES QUESTIONS #16 THROUGH #22.

IT FOCUSES UPON THE ORGANIZATIONAL CONTEXT OF THE PROJECT.

16 Please rank the following performance criteria in terms of their importance to top management (1=most important performance dimension and 3=least important performance dimension):

___ Fast development time

___ Low development cost

___ High product quality

17 How would you describe the **clarity and specificity** of the project's time goal?

a. Clarity:

Very Ambiguous		Moderate		Very Clear
1	2	3	4	5
☐	☐	☐	☐	☐

b. Specificity:

Very General		Moderate		Very Specific
1	2	3	4	5
☐	☐	☐	☐	☐

18 How would you describe the **clarity and specificity** of the project's product concept?

a. Clarity:

Very Ambiguous		Moderate		Very Clear
1	2	3	4	5
☐	☐	☐	☐	☐

b. Specificity:

Very General		Moderate		Very specific
1	2	3	4	5
☐	☐	☐	☐	☐

19 How would you characterize the extent of **top management interest** in the project?

Very Low		Moderate		Very High
1	2	3	4	5
☐	☐	☐	☐	☐

20 How well do <u>each</u> of the following statements characterize your organization's reward system?

		Disagree Strongly	Disagree Somewhat	Neutral	Aggree Somwhat	Agree Strongly
		1	2	3	4	5
a.	When schedules are met, development personnel are rewarded or recognized.	☐	☐	☐	☐	☐
b.	When schedules are met, rewards or recognition are given collectively to all those involved as a group.	☐	☐	☐	☐	☐
c.	When schedules are <u>not</u> met, development personnel are punished or reprimanded.	☐	☐	☐	☐	☐
d.	When schedules are <u>not</u> met, punishment or reprimand are given collectively to all those involved as a group.	☐	☐	☐	☐	☐

21 How well do <u>each</u> of the following statements characterize your organization's culture?

		Disagree Strongly	Disagree Somewhat	Neutral	Aggree Somwhat	Agree Strongly
		1	2	3	4	5
a.	When a person tries something new and fails, it will be considered a serious blight on the individual's career in the organization.	☐	☐	☐	☐	☐
b.	This organization seems to place a high value on taking risks, even if there are occasional mistakes.	☐	☐	☐	☐	☐
c.	In this organization, a high priority is placed on learning and experimenting with new ideas.	☐	☐	☐	☐	☐

22 How much did your project have to compete with other projects for <u>each</u> of the following resources?

		None	Little	Some	Much	Very Much
		1	2	3	4	5
a.	Financial Resources	☐	☐	☐	☐	☐
b.	Materials, Space, Equipment	☐	☐	☐	☐	☐
c.	Management Attention	☐	☐	☐	☐	☐
d.	Personnel	☐	☐	☐	☐	☐

THE THIRD SECTION COMPRISES QUESTIONS #23 THROUGH #26.

IT FOCUSES UPON THE GENERAL CHARACTERISTICS OF THE PRODUCT PRODUCED.

23 Please place a check next to the statement that comes closest to describing the type of work that was being done on the project.

- ☐ Applications engineering
- ☐ A clever combination of mature technologies
- ☐ Applying state-of-the-art technology
- ☐ A minor extension of state-of-the-art technology
- ☐ A major extension of state-of-the-art technology
- ☐ Development or application of new technology

24 Please place a check next to the statement that comes closest to describing the degree of change involved in the project.

- ☐ Imitation of existing products
- ☐ Improvement of existing products
- ☐ Major improvement of existing products
- ☐ Radically new product

25 To what extent did the idea for this product come from internal sources (i.e., members of the research and/or development staff) as opposed to external sources (i.e., suppliers, licensing arrangements)?

Entirely from External Sources		50/50		Entirely from Internal Sources
1	2	3	4	5
☐	☐	☐	☐	☐

26 To what extent have technological developments for this product come from internal sources (i.e., members of the research and/or development staff) as opposed to external sources (i.e., suppliers, licensing arrangements)?

Entirely from External Sources		50/50		Entirely from Internal Sources
1	2	3	4	5
☐	☐	☐	☐	☐

THE FOURTH SECTION COMPRISES QUESTIONS #27 THROUGH #34.

IT FOCUSES UPON THE PEOPLE WHO WORKED ON THE PROJECT.

27 Did <u>you</u> report directly to the divisional manager?	Yes	No
	☐	☐

28 Where <u>you</u> the final decision maker for the following:	Yes	No
a. The project budget	☐	☐
b. Project team composition	☐	☐
c. Development timetables	☐	☐

29 How long have you been with the organization (mm/yy)? ___/___

30 How would you characterize your involvement with the project?

Full-time, with little or no other responsibility		Moderate		Part time, with many other responsibilities
1	2	3	4	5
☐	☐	☐	☐	☐

31 What was the highest educational degree, on the average, project team members earned (check one)?

- ☐ High School or Equivalent
- ☐ 1-3 Years College or Technical School
- ☐ Bachelor's Level (e.g., BS, BA)
- ☐ Master's Level (e.g., MS, MBA)
- ☐ Doctorate Level (e.g., Ph.D)

32 In how many of the following functions, on the average, did project team members have work experience (check all that apply)?

- ☐ Purchasing
- ☐ Manufacturing
- ☐ Marketing/Sales
- ☐ Engineering
- ☐ Finance/Accounting

33 How long, on the average, have project team members been with the organization (mm/yy)? ___/___

34 How would you characterize, on the average, project team members' involvement with the project?

Full-time, with little or no other responsibility		Moderate		Part time, with many other responsibilities
1	2	3	4	5
☐	☐	☐	☐	☐

THE FIFTH SECTION COMPRISES QUESTIONS #35 THROUGH #43.

IT FOCUSES UPON THE PROJECT DEVELOPMENT TEAM ON WHICH YOU WORKED.

35 Was there a product champion or champions for this project? Yes ☐ No ☐

If YES, how many champion(s) were there? ________

If YES, how influential or politically savvy was the champion or most active champion ?

Not Very Influential		Somewhat Influential		Very Influential
1	2	3	4	5
☐	☐	☐	☐	☐

36 How well do each of the following statements characterize your leadership style during the project?

	Disagree Strongly 1	Disagree Somewhat 2	Neutral 3	Agree Somewhat 4	Agree Strongly 5
a. I was very effective at providing freedom for project team members to explore, discuss, and challenge ideas on their own.	☐	☐	☐	☐	☐
b. Project team members made their own decisions about what technologies to pursue.	☐	☐	☐	☐	☐
c. Project team members made their own decisions about what problems needed to be solved.	☐	☐	☐	☐	☐
d. Project team members made their own decisions about what tasks to undertake.	☐	☐	☐	☐	☐

37 How much authority did the project team as a whole have, including yourself as the project leader, for each of the following decisions that may have been made during the project:

AUTHORITY LEVEL

	None 1	Little 2	Some 3	Quite a Bit 4	Very Much 5
a. Setting goals and performance targets for the project.	☐	☐	☐	☐	☐
b. Deciding what work activities to be performed on the project.	☐	☐	☐	☐	☐
c. Deciding on funding and resources for the project.	☐	☐	☐	☐	☐
d. Recruiting individuals to work on the project.	☐	☐	☐	☐	☐

38 Which of the following internal interest groups were represented on the project development team during the following stages of development, where representation is defined as having one or more employees as recognized members on the product development team including active participation in team meetings and design activities (Check all that apply)?

STAGE OF DEVELOPMENT

	Pre-Development and Planning 1	Conceptual Design 2	Product Design 3	Testing 4	Process Development 5	Production Start-up 6
a. Purchasing	☐	☐	☐	☐	☐	☐
b. Manufacturing	☐	☐	☐	☐	☐	☐
c. Marketing/Sales	☐	☐	☐	☐	☐	☐
d. Engineering	☐	☐	☐	☐	☐	☐
e. Finance/Accounting	☐	☐	☐	☐	☐	☐

39 Which of the following **external interest groups** were represented on the project development team during the following stages of development, where representation is defined the same as in the previous question (Check all that apply)?

STAGE OF DEVELOPMENT

	Pre-Development and Planning	Conceptual Design	Product Design	Testing	Process Development	Production Start-up
	1	2	3	4	5	6
a. Users/Customers	☐	☐	☐	☐	☐	☐
b. Suppliers	☐	☐	☐	☐	☐	☐
c. Distributors	☐	☐	☐	☐	☐	☐

40 How much **"turf guarding"** was there between different departments and professional groups connected with this project?

None at All		Some		Very Much
1	2	3	4	5
☐	☐	☐	☐	☐

41 **Were computer aided design (CAD) systems used during this project?** Yes ☐ No ☐

If YES, what was the percentage of design engineers on the product development team (electronic, mechanical, and manufacturing process) who used CAD systems when designing on this project? ______%

If YES, how often did these individuals use CAD systems?

Very Rarely		Sometimes		Very Often
1	2	3	4	5
☐	☐	☐	☐	☐

42 What was the average time between **milestones or goals** to be accomplished during the project?

____weeks

43 Which of the following statements best characterizes the **physical location** of the members of the product development team?

- ☐ In the same office.
- ☐ On the same floor but not in the same office.
- ☐ In the same building but not on the same floor.
- ☐ In the same city but not in the same building.
- ☐ In the same state but not in the same city.
- ☐ In the same country but not in the same state.
- ☐ Not in the same country.

THE SIXTH SECTION COMPRISES QUESTIONS #44 THROUGH #47.

IT FOCUSES UPON THE EXTERNAL ENVIRONMENT FOR THE PROJECT.

44 How would you characterize the **economic environment** of this innovation – e.g., levels of domestic and international competition – that may affect this innovation?

	1	2	3	4	5
a.	Very dynamic, changing rapidly		Moderate		Very stable, virtually no change
	☐	☐	☐	☐	☐
b.	Very unpredictable, hard to anticipate the nature or direction of changes		Moderate		Very predictable, easy to forecast the future state of affairs
	☐	☐	☐	☐	☐
c.	Very simple, few competitors		Moderate		Very complex, many competitors
	☐	☐	☐	☐	☐

45 How would you characterize the **technological environment** of this innovation – e.g., advances in research and development of new products, devices, and processes – that may affect this innovation?

	1	2	3	4	5
a.	Very dynamic, changing rapidly		Moderate		Very stable, virtually no change
	☐	☐	☐	☐	☐
b.	Very unpredictable, hard to anticipate the nature or direction of changes		Moderate		Very predictable, easy to forecast the future state of affairs
	☐	☐	☐	☐	☐
c.	Very simple, few other R&D efforts		Moderate		Very complex, many other R&D efforts
	☐	☐	☐	☐	☐

46 How would you characterize the **demographic environment** of this innovation – e.g., social trends, population shifts, income and educational levels – that may affect this innovation?

	1	2	3	4	5
a.	Very dynamic, changing rapidly		Moderate		Very stable, virtually no change
	☐	☐	☐	☐	☐
b.	Very unpredictable, hard to anticipate the nature or direction of changes		Moderate		Very predictable, easy to forecast the future state of affairs
	☐	☐	☐	☐	☐
c.	Very simple, few demographic factors affect this innovation		Moderate		Very complex, many demographic factors affect this innovation
	☐	☐	☐	☐	☐

47 How would you characterize the **legal/regulatory environment** of this innovation – e.g., government policies, regulations, incentives, and laws – that may affect this innovation?

	1	2	3	4	5
a.	Very dynamic, changing rapidly		Moderate		Very stable, virtually no change
	☐	☐	☐	☐	☐
b.	Very unpredictable, hard to anticipate the nature or direction of changes		Moderate		Very predictable, easy to forecast the future state of affairs
	☐	☐	☐	☐	☐
c.	Very hostile, adversarial		Moderate		Very friendly, supportive
	☐	☐	☐	☐	☐

THANK YOU for taking the time to complete this survey. We consider your participation very important to learning more about how to manage the innovation process and what factors influence the successful development of innovations. Please place your completed survey in the return envelope and drop it in the mail. If you have any questions please call either of the numbers listed on the cover letter of this survey.

APPENDIX A-2
Questionnaire Instrument - Project Member Version

A SURVEY ON MANAGING THE INNOVATION PROCESS

Please return completed questionnaire to:

Professor Alok K. Chakrabarti
School of Industrial Management
New Jersey Institute of Technology
Newark, New Jersey 07102

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS
Campus at Newark

Graduate School of Management • University Heights • 180 University Avenue • Newark • NJ 07102-1895

Researchers at the Graduate School of Management at Rutgers University and the New Jersey Institute of Technology are studying the development of a variety of innovations in a cross-section of organizations. The purpose of this research is to better understand how to manage the innovation process and learn what factors influence the successful development of innovations.

Your organization has been selected for this study, and you specifically have been selected to participate by your organization's coordinator. We would appreciate your cooperation by completing this survey. It should take less than 30 minutes. Most questions can be answered simply by circling, checking off, or writing a number that reflects your best judgment on an answer scale. All answers are straightforward and there are no right or wrong answers.

You will receive a feedback report on the findings of this survey. We promise that the information you provide will remain confidential. Data will be averaged across individuals and organizational units, and no individual or organization will be identified in any of the study findings.

Thank you.

Alok Chakrabarti
Project Co-Director

School of Industrial Management
New Jersey Institute of Technology
Newark, New Jersey 07102

(201) 596-3256 (Phone)
(201) 596-3074 (Fax)

Eric Kessler
Project Co-Director

Graduate School of Management
Rutgers University
Newark, New Jersey 17102

(201) 648-1650 (Phone)
(201) 648-1664 (Fax)

Code Number: ________ Project: ________________

THE FIRST SECTION COMPRISES QUESTIONS #1 THROUGH #15.

IT FOCUSES UPON THE MAJOR OUTCOMES OF THE PROJECT.

When did product development activities begin (mm/yy)? __/__

When did product development activities end (mm/yy)? __/__

Please place a check next to the statement that indicates the extent to which the time goal for the project was achieved.

We were ahead of schedule by:	__0-25% __26-50% __51-75% __76-100% __>100%
We were behind schedule by:	__0-25% __26-50% __51-75% __76-100% __>100%
We had met our schedule:	__

Please place a check next to the statement that indicates the extent to which this project was faster or slower than similar past projects in your organization.

Faster than similar past projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
Slower than similar past projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar past projects:	__

Please place a check next to the statement that indicates the extent to which this project was faster or slower than similar competitor projects.

Faster than similar competitor projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
Slower than similar competitor projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar competitor projects:	__

If the following stages of development were undertaken, when did they begin and end (mm/yy)?

a. **PRE-DEVELOPMENT/PLANNING:** Begins with the start of the project and ends with the completion of basic product requirements.
Was this stage undertaken (circle one)? Yes / No If so: Start Date__/__ End Date__/__

b. **CONCEPTUAL DESIGN:** Begins with the basic concepts and ends with final specifications of the product.
Was this stage undertaken (circle one)? Yes / No If so: Start Date__/__ End Date__/__

c. **PRODUCT DESIGN:** Begins with the engineering work to take the specifications to a fully designed product and ends with final release to system test.
Was this stage undertaken (circle one)? Yes / No If so: Start Date__/__ End Date__/__

d. **TESTING:** Begins with component and system test and ends with the release of the product to production.
Was this stage undertaken (circle one)? Yes / No If so: Start Date__/__ End Date__/__

e. **PROCESS DEVELOPMENT:** Begins with the first process design and ends at the completion of the first pilot run.
Was this stage undertaken (circle one)? Yes / No If so: Start Date__/__ End Date__/__

f. **PRODUCTION START-UP:** Begins with production ramp-up and ends with the stabilization of production.
Was this stage undertaken (circle one)? Yes / No If so: Start Date__/__ End Date__/__

6 How much money was devoted to the development and commercialization of the new product (This includes but is not limited to expenses incurred due to man-hours, materials, and equipment utilization)?

$____________

7 Please place a check next to the statement that indicates the extent to which the budget goal for the project was achieved.

We came in under budget by:	__0-25% __26-50% __51-75% __76-100% __>100%
We came in over budget by:	__0-25% __26-50% __51-75% __76-100% __>100%
We came in right on budget.	__

8 Please place a check next to the statement that indicates the extent to which this project was more or less expensive than similar past projects in your organization.

More expensive than similar past projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
Less expensive than similar past projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar past projects.	__

9 Please place a check next to the statement that indicates the extent to which this project was more or less expensive than similar competitor projects.

More expensive than similar competitor projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
Less expensive than similar competitor projects by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar competitor projects.	__

10 Please place a check next to the statement that indicates the extent to which this product was of a higher or lower quality than pre-set performance standards.

Superior to pre-set standards by:	__0-25% __26-50% __51-75% __76-100% __>100%
Inferior to pre-set standards by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as pre-set standards.	__

11 Please place a check next to the statement that indicates the extent to which this product was of a higher or lower quality than similar past projects in your organization.

Superior to similar past products by:	__0-25% __26-50% __51-75% __76-100% __>100%
Inferior to similar past products by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar past products.	__

12 Please place a check next to the statement that indicates the extent to which this product was of a higher or lower quality than similar competitor products.

Superior to similar competitor products by:	__0-25% __26-50% __51-75% __76-100% __>100%
Inferior to similar competitor products by:	__0-25% __26-50% __51-75% __76-100% __>100%
About the same as similar competitor products.	__

13 To what extent were the customers or users of this product **satisfied** with it - - i.e., to what extent did it meet their needs?

Not at all Satisfied		Somewhat Satisfied		Completely Satisfied
1	2	3	4	5
☐	☐	☐	☐	☐

14 To what extent did this product **meet expectations** and attain organizational goals?

Not at all		Somewhat		Completely
1	2	3	4	5
☐	☐	☐	☐	☐

15 To what extent was this product a **marketplace success** - - i.e. to what extent did the product "win" in competitive situations?

Product Flop		Somewhat Successful		Completely Successful
1	2	3	4	5
☐	☐	☐	☐	☐

THE SECOND SECTION COMPRISES QUESTIONS #16 THROUGH #22.

IT FOCUSES UPON THE ORGANIZATIONAL CONTEXT OF THE PROJECT.

16 Please rank the following performance criteria in terms of their **importance to top management** (1=most important performance dimension and 3=least important performance dimension):

___ Fast development time

___ Low development cost

___ High product quality

17 How would you describe the **clarity** and **specificity** of the project's time goal?

a. Clarity:

Very Ambiguous		Moderate		Very Clear
1	2	3	4	5
☐	☐	☐	☐	☐

b. Specificity:

Very General		Moderate		Very Specific
1	2	3	4	5
☐	☐	☐	☐	☐

18 How would you describe the **clarity** and **specificity** of the project's product concept?

a. Clarity:

Very Ambiguous		Moderate		Very Clear
1	2	3	4	5
☐	☐	☐	☐	☐

b. Specificity:

Very General		Moderate		Very specific
1	2	3	4	5
☐	☐	☐	☐	☐

19 How would you characterize the **extent of top management interest** in the project?

Very Low		Moderate		Very High
1	2	3	4	5
☐	☐	☐	☐	☐

20 How well do __each__ of the following statements characterize your organization's reward system?

	Disagree Strongly	Disagree Somewhat	Neutral	Aggree Somwhat	Agree Strongly
	1	2	3	4	5
a. When schedules are met, development personnel are rewarded or recognized.	☐	☐	☐	☐	☐
b. When schedules are met, rewards or recognition are given collectively to all those involved as a group.	☐	☐	☐	☐	☐
c. When schedules are __not__ met, development personnel are punished or reprimanded.	☐	☐	☐	☐	☐
d. When schedules are __not__ met, punishment or reprimand are given collectively to all those involved as a group.	☐	☐	☐	☐	☐

21 How well do __each__ of the following statements characterize your organization's culture?

	Disagree Strongly	Disagree Somewhat	Neutral	Aggree Somwhat	Agree Strongly
	1	2	3	4	5
a. When a person tries something new and fails, it will be considered a serious blight on the individual's career in the organization.	☐	☐	☐	☐	☐
b. This organization seems to place a high value on taking risks, even if there are occasional mistakes.	☐	☐	☐	☐	☐
c. In this organization, a high priority is placed on learning and experimenting with new ideas.	☐	☐	☐	☐	☐

22 How much did your project have to compete with other projects for __each__ of the following resources?

	None	Little	Some	Much	Very Much
	1	2	3	4	5
a. Financial Resources	☐	☐	☐	☐	☐
b. Materials, Space, Equipment	☐	☐	☐	☐	☐
c. Management Attention	☐	☐	☐	☐	☐
d. Personnel	☐	☐	☐	☐	☐

THE THIRD SECTION COMPRISES QUESTIONS #23 THROUGH #26.

IT FOCUSES UPON THE GENERAL CHARACTERISTICS OF THE PRODUCT PRODUCED.

23 Please place a check next to the statement that comes closest to describing the **type of work** that was being done on the project.

- ☐ Applications engineering
- ☐ A clever combination of mature technologies
- ☐ Applying state-of-the-art technology
- ☐ A minor extension of state-of-the-art technology
- ☐ A major extension of state-of-the-art technology
- ☐ Development or application of new technology

24 Please place a check next to the statement that comes closest to describing the **degree of change** involved in the project.

- ☐ Imitation of existing products
- ☐ Improvement of existing products
- ☐ Major improvement of existing products
- ☐ Radically new product

25 To what extent did the idea for this product come from **internal sources** (i.e., members of the research and/or development staff) as opposed to **external sources** (i.e., suppliers, licensing arrangements)?

Entirely from External Sources		50/50		Entirely from Internal Sources
1	2	3	4	5
☐	☐	☐	☐	☐

26 To what extent have technological developments for this product come from **internal sources** (i.e., members of the research and/or development staff) as opposed to **external sources** (i.e., suppliers, licensing arrangements)?

Entirely from External Sources		50/50		Entirely from Internal Sources
1	2	3	4	5
☐	☐	☐	☐	☐

THE FOURTH SECTION COMPRISES QUESTIONS #27 THROUGH #34.

IT FOCUSES UPON THE PEOPLE WHO WORKED ON THE PROJECT.

27	Yes	No
Did the project leader report directly to the divisional manager?	☐	☐

28 Was the project leader the final decision maker for the following:	Yes	No
a. The project budget	☐	☐
b. Project team composition	☐	☐
c. Development timetables	☐	☐

29 **How long has the project leader been with the organization (mm/yy)?** ___/___

30 **How would you characterize the project leader's involvement with the project?**

Full-time, with little or no other responsibility		Moderate		Part time, with many other responsibilities
1	2	3	4	5
☐	☐	☐	☐	☐

31 **What was the highest educational degree <u>you</u> earned (check one)?**

- ☐ High School or Equivalent
- ☐ 1-3 Years College or Technical School
- ☐ Bachelor's Level (e.g., BS, BA)
- ☐ Master's Level (e.g., MS, MBA)
- ☐ Doctorate Level (e.g., Ph.D)

32 **In how many of the following functions do <u>you</u> have work experience (check all that apply)?**

- ☐ Purchasing
- ☐ Manufacturing
- ☐ Marketing/Sales
- ☐ Engineering
- ☐ Finance/Accounting

33 **How long have <u>you</u> been with the organization (mm/yy)?** ___/___

34 **How would you characterize <u>your</u> involvement with the project?**

Full-time, with little or no other responsibility		Moderate		Part time, with many other responsibilities
1	2	3	4	5
☐	☐	☐	☐	☐

THE FIFTH SECTION COMPRISES QUESTIONS #35 THROUGH # 43.

IT FOCUSES UPON THE PROJECT DEVELOPMENT TEAM ON WHICH YOU WORKED.

35 **Was there a product champion or champions for this project?** Yes ☐ No ☐

If YES, how many champion(s) were there? ________

If YES, how influential or politically savvy was the champion or most active champion ?

Not Very Influential		Somewhat Influential		Very Influential
1	2	3	4	5
☐	☐	☐	☐	☐

36 How well do each of the following statements characterize the **leadership style** of the project leader during the project?

	Disagree Strongly 1	Disagree Somewhat 2	Neutral 3	Agree Somewhat 4	Agree Strongly 5
a. He/She was very effective at providing freedom for project team members to explore, discuss, and challenge ideas on their own.	☐	☐	☐	☐	☐
b. Project team members made their own decisions about what technologies to pursue.	☐	☐	☐	☐	☐
c. Project team members made their own decisions about what problems needed to be solved.	☐	☐	☐	☐	☐
d. Project team members made their own decisions about what tasks to undertake.	☐	☐	☐	☐	☐

37 How much **authority** did the project team as a whole have, including the project leader, for each of the following decisions that may have been made during the project:

AUTHORITY LEVEL

	None 1	Little 2	Some 3	Quite a Bit 4	Very Much 5
a. Setting goals and performance targets for the project.	☐	☐	☐	☐	☐
b. Deciding what work activities to be performed on the project.	☐	☐	☐	☐	☐
c. Deciding on funding and resources for the project.	☐	☐	☐	☐	☐
d. Recruiting individuals to work on the project.	☐	☐	☐	☐	☐

38 Which of the following **internal interest groups** were represented on the project development team during the following stages of development, where representation is defined as having one or more employees as recognized members on the product development team including active participation in team meetings and design activities (Check all that apply)?

STAGE OF DEVELOPMENT

	Pre-Development and Planning 1	Conceptual Design 2	Product Design 3	Testing 4	Process Development 5	Production Start-up 6
a. Purchasing	☐	☐	☐	☐	☐	☐
b. Manufacturing	☐	☐	☐	☐	☐	☐
c. Marketing/Sales	☐	☐	☐	☐	☐	☐
d. Engineering	☐	☐	☐	☐	☐	☐
e. Finance/Accounting	☐	☐	☐	☐	☐	☐

39 Which of the following **external interest groups** were represented on the project development team during the following stages of development, where representation is defined the same as in the previous question (Check **all** that apply)?

STAGE OF DEVELOPMENT

	Pre-Development and Planning	Conceptual Design	Product Design	Testing	Process Development	Production Start-up
	1	2	3	4	5	6
a. Users/Customers	☐	☐	☐	☐	☐	☐
b. Suppliers	☐	☐	☐	☐	☐	☐
c. Distributors	☐	☐	☐	☐	☐	☐

40 How much "turf guarding" was there between different departments and professional groups connected with this project?

None at All		Some		Very Much
1	2	3	4	5
☐	☐	☐	☐	☐

41 Were computer aided design (CAD) systems used during this project? Yes ☐ No ☐

If YES, what was the percentage of design engineers on the product development team (electronic, mechanical, and manufacturing process) who used CAD systems when designing on this project? ______%

If YES, how often did these individuals use CAD systems?

Very Rarely		Sometimes		Very Often
1	2	3	4	5
☐	☐	☐	☐	☐

42 What was the average time between milestones or goals to be accomplished during the project?

____weeks

43 Which of the following statements **best** characterizes the physical location of the members of the product development team?

☐ In the same office.
☐ On the same floor but not in the same office.
☐ In the same building but not on the same floor.
☐ In the same city but not in the same building.
☐ In the same state but not in the same city.
☐ In the same country but not in the same state.
☐ Not in the same country.

THE SIXTH SECTION COMPRISES QUESTIONS #44 THROUGH #47.

IT FOCUSES UPON THE EXTERNAL ENVIRONMENT FOR THE PROJECT.

44 How would you characterize the **economic environment** of this innovation – e.g., levels of domestic and international competition – that may affect this innovation?

a. Very dynamic, changing rapidly — Moderate — Very stable, virtually no change

1	2	3	4	5
☐	☐	☐	☐	☐

b. Very unpredictable, hard to anticipate the nature or direction of changes — Moderate — Very predictable, easy to forecast the future state of affairs

☐ ☐ ☐ ☐ ☐

c. Very simple, few competitors — Moderate — Very complex, many competitors

☐ ☐ ☐ ☐ ☐

45 How would you characterize the **technological environment** of this innovation – e.g., advances in research and development of new products, devices, and processes – that may affect this innovation?

a. Very dynamic, changing rapidly — Moderate — Very stable, virtually no change

1	2	3	4	5
☐	☐	☐	☐	☐

b. Very unpredictable, hard to anticipate the nature or direction of changes — Moderate — Very predictable, easy to forecast the future state of affairs

☐ ☐ ☐ ☐ ☐

c. Very simple, few other R&D efforts — Moderate — Very complex, many other R&D efforts

☐ ☐ ☐ ☐ ☐

46 How would you characterize the **demographic environment** of this innovation – e.g., social trends, population shifts, income and educational levels –that may affect this innovation?

a. Very dynamic, changing rapidly — Moderate — Very stable, virtually no change

1	2	3	4	5
☐	☐	☐	☐	☐

b. Very unpredictable, hard to anticipate the nature or direction of changes — Moderate — Very predictable, easy to forecast the future state of affairs

☐ ☐ ☐ ☐ ☐

c. Very simple, few demographic factors affect this innovation — Moderate — Very complex, many demographic factors affect this innovation

☐ ☐ ☐ ☐ ☐

47 How would you characterize the **legal/regulatory environment** of this innovation -- e.g., government policies, regulations, incentives, and laws -- that may affect this innovation?

	1	2	3	4	5
a.	Very dynamic, changing rapidly		Moderate		Very stable, virtually no change
	☐	☐	☐	☐	☐
b.	Very unpredictable, hard to anticipate the nature or direction of changes		Moderate		Very predictable, easy to forecast the future state of affairs
	☐	☐	☐	☐	☐
c.	Very hostile, adversarial		Moderate		Very friendly, supportive
	☐	☐	☐	☐	☐

THANK YOU for taking the time to complete this survey. We consider your participation very important to learning more about how to manage the innovation process and what factors influence the successful development of innovations. Please place your completed survey in the return envelope and drop it in the mail. If you have any questions please call either of the numbers listed on the cover letter of this survey.

APPENDIX B

REPORT OF THE COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS OF N.J.I.T FOR REVIEW OF PROCEDURES FOR THE USE OF HUMAN SUBJECTS

Review of Proposal entitled: Innovation Speed

Principal Investigator: Alok Chakrabarti

The Committee met this date to review the subject proposal and reached the following conclusions:

1. The proposed program involves little or no physical, psychological, sociological or other risk to the participants. ☐
2. The rights and welfare of the individual participants are protected. ☐
3. The methods to be used to obtain consent from participants are adequate and appropriate. ☐
4. The risk to any individual is greatly outweighed by the potential benefits and the importance of the knowledge to be gained. ☐
5. The program will be reviewed by the Committee once during its progress; one year after its inception, unless unexpected circumstances warrant more frequent reviews by the Board. ☐
6. The project has been submitted to the Institute, Committee for the Protection of Human Subjects, but review is still pending. ☐
7. The Project has been reviewed and subsequently disapproved by Institute, Committee for the Protection of Human Subjects. ☐
8. An expedited review has been performed by the Chair of the Committee for the Protection of Human Subjects. Items 1-5 above were found to be applicable. ☒

[signature] 8/4/95
Date

________ Date

________ Date

________ Date

________ Date

________ Date

________ Date

________ Date

________ Date

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ERIC H. KESSLER

1967	Born July 7 in Brooklyn, New York.
1985	Graduated from Raritan High School, Hazlet, New Jersey.
1985-1989	Attended St. Lawrence University, Canton, New York; double-majored in Economics and Psychology.
1989	B.A., St. Lawrence University.
1990-1996	Attended Rutgers University, Newark, New Jersey.
1993	M.B.A., Rutgers University.
1993-1995	Instructor, Faculty of Management, Rutgers University.
1995	Article: Spender, J.-C. & Kessler, E.H. "Managing the uncertainties of innovation: Extending Thompson (1967)." *Human Relations*, 48 (1):35-56.
1995	Article: Christensen, E.W. & Kessler, E.H. "A toolbox metaphor for navigating the strategic discourse." In L.W. Foster (Ed.) *Advances in Applied Business Strategy*, 4: 171-202. Greenwich, CT: JAI Press.
1995-1996	Instructor, School of Industrial Management, NJIT.
1996	Article: Kessler, E.H., Ford, C.M., & Bailey, J.R. "Object valence as a moderator of the framing effect on risk preference." To appear in the *Journal of Economic Behavior and Organization*, 30 (2).
1996	Article: Kessler, E.H. & Chakrabarti, A.K. "Innovation speed: A conceptual model of context, antecedents and outcomes." To appear in the *Academy of Management Review*, 21 (4).
1996	Ph.D. in Organization Management, Rutgers University.