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**NEW PRODUCT DEVELOPMENT, COOPERATION AND SPECIALIZATION
IN THE CANADIAN TELECOMMUNICATIONS INDUSTRY**

by

NICHOLAS L N TRUDEL, B COMM.

A thesis submitted to
the Faculty of Graduate Studies
in partial fulfillment of
the requirements of the degree of

Master of Management Studies

Carleton University

Ottawa, Ontario

January 16, 1998

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Thesis Supervisor

Director, School of Business

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ABSTRACT

This thesis is an empirical study of the relationship between inter-firm cooperation, the degree of cooperation among firms; intra-firm functional specialization, the degree of specialization within functional areas of the firm; and new product development success in the Canadian telecommunications industry as moderated by firm size. A theoretical model was developed to generate hypotheses which were tested using correlation analysis and comparisons of means of data gathered in a nation-wide mail survey of new product development projects. Based on the responses of fifty one survey respondents the research validates the theoretical model and concludes that financial success of new product development projects is correlated to intra-firm functional specialization. Small and large firms were not differentiable by perceived success, technical success or financial success and the degree of intra-firm specialization did not vary significantly with firm size.

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LITERATURE REVIEW

The importance of new product development (NPD) for the success of firms competing in advanced markets is widely accepted (Prahalad and Hamel, 1989; Zirger and Maidique, 1990; Dougherty, 1992; Eisenhardt and Tabrizi, 1995). New product development is characterized by speedy, flexible innovation of new technologies and applications to create new economical products that satisfy customer needs. Firms competing in advanced markets often rely on new product development to extend and preserve competitive advantage and to create new markets and opportunities. Identifying and explaining strategies that contribute to new product development success or failure is therefore important.

External factor explanations such as the state of the economy, foreign competition, market size and growth, and lack of funding were not found to be major contributors to new product failure (Cooper, 1979; Maidique and Zirger, 1985). This is indicative of the importance internal processes of the firm on new product development outcomes. A firm's strategy choices are one such internal process and are the topic of this thesis.

Strategies affect a firm's performance but the strength and rational behind this relationship are poorly understood (Williamson, 1985). Strategies have evolved from line and staff organizations, to forward integration, divisionalized corporations, conglomerates, and multinational enterprises without any clear understanding of the relationship between strategy and new product development success. This evolution has

been influenced by transaction cost minimization, profit maximization and organizational and task complexity. As firms engage in more complex competitive activities, more sophisticated strategies are required. Developing a detailed understanding of whether and under which circumstances new product development strategies contribute to new product development success can increase the competitiveness of the firm.

The relationship between a firm's activities and new product development success has been studied. Research to date has identified cross functional input as an important contributing strategy to new product development success. Cross functional input can be defined as involvement in the new product development process from all functions. These have been identified as engineering/ design, manufacturing, planning/ budgeting, marketing and sales (Dougherty, 1992). Research and development and customer input may also be important sources of input to new product development.

The size of a firm can also play a role in new product development success. Smaller companies are often more successful at developing new products than larger companies. Small firms can be generalized as more inventive while large firms can be generalized as experienced and financially powerful (Forrest and Martin, 1992). However, smaller companies are less likely to be able to generate adequate internal cross functional input to new product development. This inability is in part the result of being a smaller firm with fewer human, technological and financial resources.

A conflict between a small company's ability to generate cross functional input and its ability to develop new products successfully is evident. If small companies are unable to generate cross functional input to new product development but are still more successful than their larger counterparts then some unexplored phenomena must exist to explain their success.

Differences between small firms and large firms have already been identified. Small firms have different success factors than large firms (Rothwell and Dogson, 1991; Ballantine, Cleveland and Koeller, 1992), but these differences do not explain differing new product development results. Some other strategies must play a role in new product development successful. This thesis study explored two such strategies:

- intra-firm functional specialization: where firms specialize internally in a given functional area in order to concentrate their resources and expertise.
- inter-firm cooperation: where firms cooperate closely with other firms in the new product development process to gain input they cannot generate internally.

The focus of this study is whether a strategy of inter-firm cooperation and intra-firm functional specialization will help achieve new product development success and

whether firms size plays a role in new product development success. Other strategies will be briefly explained and compared to a strategy of inter-firm cooperation and intra-firm functional specialization and areas of accordance, contention and contradiction will be discussed.

Emphasize Core Competencies

Core competencies can be defined as a consolidation of skills and technologies that allow firms to adapt to changing opportunities and environments in order to yield competitive advantage (Prahalad and Hamel, 1989). Core competencies comprise collective learning, coordinated skills, and integrated technology. This combination provides access to many markets, has a significant impact on customer benefits, and is difficult to imitate.

Core competency emphasis has been identified as an important strategy for firms competing in advanced markets. Firms competing in today's dynamic business environment need to develop core organizational capabilities that will distinguish them from their competitors and deliver value to customers.

For a strategy of core competency emphasis to be successful, new product development teams must work across organizational boundaries, must evoke skills and knowledge from all functions, and must learn from cooperation. A shared understanding of customer needs and market possibilities is necessary. If a strategy of core competency emphasis is to remain effective, the competencies must be used. The use of core competencies updates and improves them.

Alliances between firms serve to increase and improve core competencies while reducing costs. Alliances should be viewed by firms that emphasize core competencies as opportunities to multiply internal resources and to internalize new skills. Alliances help to develop a portfolio of skills that focus on core products. By leveraging core competencies, small firms can compete with larger firms while using fewer resources. Core competencies allow firms to benefit from economies of scale (by specializing in a core product) and economies of scope (by applying core products to a wide variety of end products).

A strategy which emphasizes core competencies and a strategy of inter-firm cooperation and intra-firm functional specialization are not mutually exclusive. Both stress the importance of alliances and resource concentration to maximize competitiveness. Where they differ is in the nature of resource concentration. Strategies that emphasize core competencies aim at maximizing knowledge across functions to lead in the production of a core product with many applications to thereby gain competitive advantage. Inter-firm cooperation and intra-firm functional specialization aim to maximize knowledge within a function and gain competitive advantage via that avenue. Whether core competency emphasis or inter-firm cooperation and intra-firm functional specialization is a more effective strategy for a given company may depend on firm size. Smaller firms may be better off focusing more narrowly, on few or even a single function (inter-firm cooperation and intra-firm functional specialization) while larger firms may be able to adopt a more functionally broad-based strategy (core competency emphasis).

Strategic Alliances and Partnering

Strategic Alliances and Partnering are methods of inter-firm cooperation. One reason these strategies may help improve a firm's chances of success is that they help overcome resource constraints which limit the growth and performance of technology based entrepreneurial companies (Hull, Slowinski, and Collins: 1988). Resource constraints are not limited to financial challenges. Indeed, highly specialized human resources and unique organizational resources often cannot be readily purchased on the open market. Inter-firm cooperation, be it through strategic alliances, partnering or other methods, is a logical strategy to overcome this barrier. Further, strategic alliances and partnering do not inhibit intra-firm specialization, rather they facilitate it. Consequently, strategic alliances and partnering can be adopted by the firm in conjunction with inter-firm cooperation and intra-firm specialization.

Vertical Integration

Although vertical integration can serve a variety of purposes, its main purpose is to economize on transaction costs (Williamson, 1985). He proposes that vertical integration is an organizational means by which complex products and services are efficiently produced and brought to market. Only under limited circumstance would firms choose to purchase sub-components from outside suppliers (e.g. patent protection, vast economies of scale, etc.) and rarely is vertical integration motivated by technological acquisition. In the absence of these unusual circumstances 'there is no compelling neoclassical reason to prefer integration to market procurement.'

However, any benefits provided by vertical integration are lost if products are almost unique. It is also important to note that as asset specificity increases vertical integration becomes more favorable. This is caused by economies of scale and bureaucratic and organizational needs opposing vertical integration at low levels of assets specificity and bilateral (supplier-manufacturer) dependency and low adaptability encouraging it at high levels of asset specificity. By these arguments larger firms are more likely to be vertically integrated since they are able to realize economies of scale and already possess bureaucratic and organizational structures.

By Williamson's theories, inter-firm cooperation and intra-firm specialization should be less common where high asset specificity is required and within large firms. Logically one would therefore expect more inter-firm cooperation and intra-firm specialization among smaller firms with less asset specificity.

Intra-firm Functional Specialization and Inter-firm Cooperation

Exploration of these strategies is important for firms engaged in new product development and cooperative alliances. Smaller firms face challenges that are not faced to the same degree by their larger, less specialized counter parts (Butcher, 1986). In the past, product line specialization and production flexibility were once identified as important contributors to success that helped achieve competitiveness (Doeringer, 1987). Typically, large firms focused on capital intensive mass production and small firms on labor intensive customization. However, with modern production capabilities and

techniques this is no longer the case (Melcher and Booth, 1988). Small firms now sustain their competitive advantage through new product development facilitated by strategies of specialization and cooperation. In fact even though a strategy of specialization and cooperation can be limiting it may be the only way a small firm can succeed (Maldonado, 1996). In addition to theoretical speculation (Borys and Jemingson, 1989; Oliver, 1990; Rind and Van de Ven, 1992), increases in the number of cooperative alliances in the recent past and expected future are testimony to their importance (Anderson, 1990; Geringer and Herbert, 1991; Parkhe, 1993).

In order to address this topic a study of Canadian telecommunications suppliers was undertaken. The study aimed to determine whether inter-firm cooperation and intra-firm functional specialization are related to new product development success and whether the relationships are moderated by firm size. To this end, a model to represent the relationships between inter-firm cooperation, intra-firm functional specialization and new product development success as moderated by firm size was developed and the hypothesized relationships were tested.

PROBLEM STATEMENT

In advanced markets, new product development success requires managerial excellence and commitment, manufacturing and technical proficiency and flexibility, market knowledge and marketing proficiency, unique and superior products that provide value, and speedy product innovation (Cooper, 1979; Takeuchi and Nonaka, 1986; Butcher, 1986; Zirger and Maidique, 1990). These requirements for new product development success span various areas of functional specialization and demand a high level of commitment and expertise in each function. Meeting the functional demands of the new product development process requires significant human and financial resources allocation to each function. Consequently, the requirements may encourage strategies of inter-firm cooperation and intra-firm functional specialization particularly among firms with fewer human and financial resources.

Because of the lack of human and financial resources, it is difficult for small firms competing in an advanced market to sustain a high level of commitment and expertise in a functional area. In these markets, achieving the required high level of commitment and expertise in all functional areas is even more difficult. Overcoming resource constraints is an obstacle to new product development success.

Most small firms competing in advanced markets face greater human and financial resource constraints (Latimer, 1994) and yet are known to have successful new product development (Forrest and Martin, 1992). Hence, resource constraints cannot be used to

predict new product development success. Conversely, the strategies that firms choose to adopt to overcome these constraints may be useful for such a prediction (Prahalad and Hamel, 1989).

Successful new product development in advanced markets requires a different strategy than the traditional emphasis on high quality, low cost and product differentiation. It requires a cross functional approach to new product development where close knit, autonomous project teams turn concepts into products. These cross functional teams achieve project goals, as opposed to functional ones, through learning with parallel or overlapping development phases and with transfers of knowledge between functions. The result is products that are of value to customers (Takeuchi and Nonaka, 1986; Nonaka, 1990; Bailetti and Guild, 1991; O'Connor, 1994). These products incorporate technological and market possibilities into new product design thereby satisfying customer needs (Dougherty, 1992; Maidique and Zirger, 1985) and increasing product quality (Dean and Bowen, 1994).

One cannot overlook the evidence that advanced market new product development is often more successful and effective when product development teams consisting of functionally diverse individuals work together, when information is shared by all parties in the development process, and when interdepartmental barriers have been reduced. This evidence is particularly strong in studies of larger firms (Nonaka, 1990; Dougherty, 1992).

It is logical to assume that barriers between firms are more difficult to overcome than barriers within them. Hence, if all else was equal, firms would be expected to prefer internal cross functional input to cooperation with other firms. Additionally, there are risks that are unique to cooperative projects which should discourage external cooperation further (Lei and Slocum, 1992).

Since cross functional input into new product development is important, smaller, more functionally limited firms should be at a disadvantage compared to larger, more functionally diverse firms. This may be demonstrated by the fact that smaller firms that focus on product innovation cannot always secure enough of the economic benefits that arise from new products to ensure long term financial success (Rosenbloom and Cusumano, 1987).

As product designs become dominant in the marketplace, infrastructures become more developed and new product development strategy begins to play an important role in new product development success (Weiss and Birnbaum, 1989; Zirger and Maidique, 1990). Increasing infrastructure development increases human and financial resource requirements and resource constraints become more of a barrier to new product development success. This may in turn increase the importance and effectiveness of intra-firm functional specialization and inter-firm cooperation especially for small firms.

Smaller firms may have no way of overcoming resource constraints on their own.

Without cooperation and specialization, it is unlikely that smaller firms could achieve the scale of resource allocation that is necessary to overcome resource constraints and compete in advanced markets. When cooperating with other small firms, they enjoy more symmetric alliances and greater inter-organizational learning than large firms (Hara and Kanai, 1989). For these reasons, some small firms have chosen to specialize in a given functional area and to rely on other firms to cooperate with them in the successful completion of new product development. Examples of this are a firm's choice to specialize in product design or engineering and to allow other firms to specialize in the manufacturing and marketing of these products (Pita, 1992; Mulqueen, 1996). These examples raise doubts over the universal importance of internal cross functional integration for new product development and suggest that small firms may be an exception to the current findings that are based on large firm results.

The problem statement can be expressed as follows:

Is a new product development strategy based on intra-firm functional specialization and inter-firm cooperation likely to contribute to successful new product development for smaller firms competing in advanced markets?

OBJECTIVES

The aim of this study was to determine if inter-firm cooperation and intra-firm functional specialization are correlated with new product development success and if the relationship is affected by firm size in the Canadian telecommunications industry. To accomplish this goal, inter-firm cooperation, intra-firm functional specialization and new product development success were defined and a model was developed to represent the relationships between them as moderated by firm size. Specifically, the research objectives can be stated as follows:

1. The research is to determine if strategies of inter-firm cooperation and intra-firm functional specialization are advantageous for firms engaged in new product development for advanced markets. This study of the degree of association aimed to determine if inter-firm cooperation and intra-firm functional specialization affect the new product development success of firms competing in the Canadian telecommunications industry. This industry was taken to be an advanced market. The study also sought to express the strength of the relationship through correlation analysis. A positive correlation of inter-firm cooperation and intra-firm functional specialization with new product development success was considered indicative of a link between inter-firm cooperation and intra-firm functional specialization and new product development success (hypothesis 1). Achieving this objective helps professionals and academics understand optimal new product development processes.

2. The research is also to determine if strategies of inter-firm cooperation and intra-firm functional specialization differ between smaller firms and larger firms in the Canadian telecommunications industry. The differences were evaluated using statistical testing of differences in means of large and small firm sub-groups of the total sample group. The importance of inter-firm cooperation and intra-firm functional specialization was expressed by comparing findings from small sized firms to those of large sized firms. These comparisons aimed to indicate whether inter-firm cooperation and intra-firm functional specialization are more important strategies for new product development success for small firms or large firms (hypothesis 2). The comparison facilitates managerial decision making.

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The principal concern of this thesis is whether intra-firm functional specialization and inter-firm cooperation affect new product development success at the project level and whether this influence varies with firm size.

Few studies have addressed the relationships described in the theoretical model. Fewer still have presented unique new product development models. The bulk of recent new product development research suggests that input from multiple functions contributes to new product development success (Takeuchi and Nonaka, 1986; Nonaka, 1990; Baiietti and Guild, 1991; O'Connor, 1994) without addressing the related issues of inter-firm cooperation, intra-firm functional specialization and firm size. No research was found that contradicted the model.

HYPOTHESES

The first hypothesis is that inter-firm cooperation and intra-firm functional specialization are correlated to new product development success for firms that compete in the Canadian telecommunications industry. This hypothesis seems reasonable in that firms may experience difficulties developing new products because of their inability to overcome resource constraints. Inter-firm cooperation and intra-firm functional specialization may be important strategies that can be used to overcome resource constraints, attain new product development success, and gain competitive advantage.

The second hypothesis addresses the importance of a strategy of inter-firm cooperation and intra-firm functional specialization for smaller firms versus larger firms. It is hypothesized that, in the case of small firms, inter-firm cooperation and intra-firm functional specialization have a greater correlation to new product development success than in the case of larger firms. Consider the arguments that a positive correlation should exist between intra-firm functional specialization, inter-firm cooperation and new product development success. Given these arguments, intra-firm functional specialization and inter-firm cooperation should be more correlated to new product development success of smaller firms than of larger firms. Despite barriers to economic success, smaller companies are known to have higher growth rates than their larger counterparts. This suggests that intra-firm functional specialization and inter-firm cooperation may help smaller firms to overcome resource constraints and achieve new product development success.

The hypotheses are as follows:

- 1 a.i. Inter-firm cooperation is positively correlated to NPD perceived success for firms competing in the Canadian telecommunications industry.
- 1 a.ii. Inter-firm cooperation is positively correlated to NPD technical success for firms competing in the Canadian telecommunications industry.
- 1 a.iii. Inter-firm cooperation is positively correlated to NPD financial success for firms competing in the Canadian telecommunications industry.
- 1 b.i. Functional specialization is positively correlated to NPD perceived success for firms competing in the Canadian telecommunications industry.
- 1 b.ii. Functional specialization is positively correlated to NPD technical success for firms competing in the Canadian telecommunications industry.
- 1 b.iii. Functional specialization is positively correlated to NPD financial success for firms competing in the Canadian telecommunications industry.
- 2 a. A strategy of inter-firm cooperation is a more important contributor to NPD success in smaller firms competing in the Canadian telecommunications industry than in larger firms.
- 2 b. A strategy of intra-firm functional specialization is a more important contributor to NPD success in smaller firms competing in the Canadian telecommunications industry than in larger firms.

METHODOLOGY

Correlation analysis of new product development project data collected through a mail survey of the Canadian telecommunications industry was the method chosen for hypothesis testing in this thesis study. This method addresses the need to obtain empirical data on the theoretical model. It also provides enough data to produce meaningful results and employs a methodology that is easily replicated. Examples of single industry statistical studies of new product development include Masten's (1984) study of the aerospace industry, Parkhe's (1993) study of strategic alliance structuring and Dyer's (1996) study of specialized supplier networks.

Cooper (1979) used mail surveys in his study of new product successes and failures. Questionnaires were also used by Masten (1984) and by Parkhe (1993). Parkhe targeted higher level executives in his study as did Dougherty (1992). Cooper sought "functionally neutral respondents with an overall knowledge of total new product efforts." Use of similar techniques is desirable for three reasons:

- Comparability of findings will not be jeopardized by use of a different method.
- The academic validity of the method has been established.
- There is a lack of empirical findings at the project level.

Sample Selection

A single industry was selected for this study for several reasons. Firstly, economic factors affecting specific industries can be ignored. An example of industry specific

macro economic effect is the a weak domestic currency coupled with a strong export market. Under these circumstances export industries are more successful than other firms.

A second reason to study a single industry is the difference that may exist in the competitive nature of particular industries. For example, consider firms competing in a zero growth industry. In such a market, success by one firm can only come at the expense of another. Conversely, in a high growth industry where demand greatly exceeds supply, all competitors may be relatively successful in comparison to those in a zero growth industry. These differences in success may occur regardless of intra-firm functional specialization and inter-firm cooperation. Additionally, a given industry may have fewer participants, resulting in less opportunity for cooperation. Clearly these differences would have had an impact on the results on this study.

Another reason to study only one industry is that aggregation of data from a single industry makes more sense than aggregation of data from many industries. Arguments that product development time, gross margins and other measures cannot be aggregated from more than one industry are well established (Palay, 1984; Monteverde and Teece, 1982; Masten 1984).

Dyer (1996) studied the automotive industry to determine if specialized supplier networks are a source of competitive advantage. He chose the automotive industry for

two reasons: 1) the market was large enough for him to make the desired comparisons of his study and 2) the product was complex and required that components work together as a system and demanding mutual adjustment and coordination throughout the network. Masten (1984) also used complexity as one of the justifications of his study of make-or-buy decisions in the aerospace industry.

Size and complexity are important in this study because if an industry has too few players, cooperation is hampered and if products are simple cooperation is unnecessary. Both the size and complexity of the Canadian telecommunications industry meet these criteria. The telecommunications sector has been identified as one of the world's largest (Seidenberg, 1996) and was used by Bailetti and Guild (1991) in their study of new product development. The telecommunications sector was also chosen because it produces many new products with input from a variety of functional areas. These criteria are necessary so that new product development specialization and cooperation are viable alternatives.

Participants of the study were asked to provide questionnaire responses based on their most recently completed new product development project for which results are available. Most recently completed projects were used in an effort to minimize problems of recall and to eliminate selection biases on behalf of managers being surveyed.

Pretest of Survey Instrument

Pretests of the survey instrument were conducted to detect weaknesses in the design of the instrument in measuring the relevant phenomena and to refine its design. The objectives of pretesting the data collection instrument were to improve clarity of survey questions, to ensure that respondents understood questions and to ensure that responses reflected reality (Dilman, 1978). Initially pretesting consisted of informal discussions with colleagues and concluded with testing of actual respondents. In the pretests, questionnaires were delivered to respondents without any additional instructions. Respondents in the National Capital region were selected for the pretests so that they could be contacted for feedback. Once the questionnaires were returned pretest subjects were informally interviewed to determine if they understood the questions and if their responses reflected reality. The only difference between the pretests and the survey was that the pretest was hand delivered and was followed up to ensure accuracy.

The level of interest and sensitivity to some questions demonstrated by pretest respondents raised some concerns. It was often difficult to get completed questionnaires returned, let alone constructive feedback on survey design. Some pretest respondents were apprehensive that financial information may become public despite clear written statements ensuring confidentiality. Feedback from pretest respondents provided little additional information on continuity and flow of the questionnaire, on timing of the survey or on clarity of instructions. Exhaustive academic consultation with experienced researchers at Carleton University addressed these issues. Pretest respondents

understood the meaning of questions, found the question sequence logical and length of the questionnaire acceptable. Respondents indicated that their primary concern was preservation of anonymity and ease of completion of the questionnaire.

Survey Instrument Design

The survey instrument was designed to be as short and simple as possible while maintaining clarity. This approach was developed in consultation with the faculty at Carleton University and from feedback from professionals in the telecommunications industry. The chosen design was expected to yield the highest response rate possible from the sample population while accurately collecting the required data. These considerations were deemed important because of the number of surveys underway in the industry and because of the availability of respondents.

Data Collection

On September 15th, 1997, three hundred and seventy managers of companies selected from the Canadian telecommunications industry were each mailed a survey questionnaire. The mailing list was generated from national telecommunications directories provided by the Information Technology Industry Branch of Industry Canada and the Register of Telecom Resellers of the Canadian Radio Telecommunications Commission and was comprised of Canadian companies from accross Canada.

Data measuring firm size, new product development project success, inter-firm cooperation and intra-firm functional specialization pertaining to the most recently completed new product development project was collected from respondents. Only one new product development project was studied per firm. The survey questions and cover letter employed are included in Appendix B.

No reminders or follow-ups were sent because of concerns over anonymity expressed by respondents in the pretests. These concerns were confirmed by the fact that the majority of respondents chose not to identify themselves. Obviously reminders and follow-ups cannot be sent to potential respondents without wasting efforts on existing anonymous respondents. Nevertheless, reminders and follow-ups were seriously considered but a postal disruption and the costs and expected effectiveness suggested that such efforts were not warranted and may have required a different methodology.

Response

A total of 64 responses were received before November 7th, 1997. Of these, 13 were discarded because they were deemed unusable due to incompleteness of at least 90% of the questionnaire. The remaining 51 responses were used for hypothesis testing and analysis. This amounts to a gross response rate of 17.3% and a net response rate 13.8%. The net response rate exceeds the minimum of 10% outlined in the research proposal for this study and is sufficient to meet the minimum statistical requirements of this study. The resulting sample consists of functionally diverse group of managers from firms in

the Canadian telecommunications industry who chose to respond to the initial mailing.

Although contentious, this group was considered to be a random sample for the purposes of statistical analysis. Table 1 summarizes survey responses:

Table 1: Summary of Survey Responses		
Total surveys sent	370	100%
Pretests Received	5	1.4%
Total surveys received	59	15.9%
Total responses received	64	17.3%
Responses deemed unusable due to incompleteness	13	3.5%
Total usable responses	51	13.8%

VARIABLES AND DATA

Data on firm size, intra-firm functional specialization, inter-firm cooperation and success was collected and evaluated to determine if new product development success is related to intra-firm functional specialization and inter-firm cooperation for firms competing in advanced markets and to discover if this relationship is moderated by firm size. This section defines the variables used in this study, outlines the data collected and shows all calculations done for hypothesis testing. A summary of instrument measures is provided in Appendix D.

Firm Size

Data was gathered on firm size because it was a variable of interest that played a moderating role in the theoretical model and because it was necessary to separate the sample into groups of large and small sized firms for hypothesis testing.

Variables

In order to measure firm size, data was collected for the following two variables:

h_1 : size of work force measured by the number of employees
(measures human resources)

h_2 : value of assets measured in hundreds of thousands of dollars
(measures financial resources)

Assets were chosen to delineate size because assets are congruent with the difficulties of overcoming barriers that are created by a lack of financial resource dependent new product development capabilities. The number of employees was chosen because it is congruent with the difficulties of overcoming barriers that are created by a lack of human resource dependent new product development skills. These two measures were used to differentiate between smaller firms facing resource constraints and larger firms facing other challenges.

Larger firms, with more assets and personnel, are more likely to have adequate resources to overcome resources constraints and perform in many functional areas. Theoretically, this permits larger firms to emphasize a given functional area while still being able to operate effectively in other functional areas. Smaller firms with fewer resources may not be able to operate as effectively in as many functional areas and therefore stand to gain more from inter-firm cooperation and intra-firm functional specialization than their larger counterparts.

Sales were not chosen as a measure of size for three reasons. Firstly, measures of sales do not have the theoretical reasoning that measures of the number of employees and of assets have with respect to resource constraints. Measures of the number of employees and of assets are clearly linked to resource constraints however this link does not necessarily exist for measures of sales. Secondly, measures of sales would probably have been highly correlated to measures of sales growth and market share which are

being used to measure success. In this context, a measure of sales is a measure of both size and success and its use would have corrupted research findings. Thirdly, in the interest of parsimony the fewest number of measures should be used when they can accurately capture all the information desired (Stevens, 1992). Those aspects of measures of sales that relate only to size were most likely captured in measures of the number of employees and of assets.

Although some of these arguments, such as correlation and parsimony, could be applied to either the number of employees or value of assets of the firm, in the context of this study these two variables are important in the differentiation of size and should both be considered. Consequently, a firm with fewer assets and employees was considered smaller than a firm with many assets and numerous employees.

Data

Table 2 summarizes the size data collected.

Table 2: Summary of Size Data		
	h_1 (Number of employees)	h_2 (Assets in \$100,000's)
Mean	1710.13	6,325.79
Standard deviation	8840.13	22,907.12
Minimum	10.00	2.00
Maximum	60,000	100,000
Kurtosis	44.793	14.561
Skewness	6.656	3.914
Number of respondents	46	38

The size data collected for a firm's number of employees (h_1) and the value of its assets (h_2) has a non-linear distribution and has a correlation coefficient of 0.7168 at significance level greater than 0.001.

Calculation of Firm Size

The high Kurtosis and skewness values and the P-P plots of the data gathered for measuring firm size show that the data gathered for h_1 and h_2 is not normally distributed. Further, the P-P plots of h_1 and h_2 showed non-linear distributions.

Because firm size variables were found to be non-linear, transformations of h_1 and h_2 were necessary. The purpose of the transformation was to produce as normal and linear a distribution as possible. Logarithms and square roots were applied to h_1 and h_2 and the resulting data was evaluated. Measures of Kurtosis and skewness and P-P plots indicated that the logarithmic transformations of h_1 and h_2 produced the most normal and linear distributions.

The high correlation between h_1 and h_2 necessitated an additional calculation on measures of size. The purpose of which was to produce a single composite measure of size that accurately reflected the data collected for h_1 and h_2 . Calculation of a single composite measure of firm size was made using the following formula:

$$S = \log (h_1) + \log (h_2)$$

Where higher scores are indicative of greater size.

The above measure of size (S) was used to split the sample into two groups: large and small sized firms. The number of firms in the sample does not permit further meaningful division of the sample on the basis of size. Firms with size values below the sample mean were considered small sized firms and firms with size values above the sample mean were considered large.

This division of firms into small and large size groupings was chosen because it rates the size of a given firm relative to the average size of firms in the sample. In this case, there were a few large firms in the sample and many smaller firms. Hence, a first group consisting of a few large firms with S values above the mean size and a more numerous second group of small firms with S values below the mean size were generated.

This method of division seems to accurately reflect reality and produced results that were quite similar to size division based on either $\log(h_1)$ or $\log(h_2)$ alone. The results of the calculations and transformations of measures of size and the correlation matrix of the resulting measures are summarized in tables 3 and 4. Anonymity of respondents prevented the completion of size data through public information sources or direct contact with respondents.

Table 3: Summary of Size Calculations

	$\log (h_1)$	$\log (h_2)$	$S = \log (h_1) - \log (h_2)$
Mean	2.03	2.06	4.01
Standard deviation	0.79	1.07	1.62
Minimum	1.00	0.30	1.41
Maximum	4.78	5.00	8.70
Kurtosis	2.296	2.026	2.257
Skewness	1.356	1.262	1.345
Number of respondents	46	38	35
Number of small firms	29	23	23
Number large firms	17	15	12
Non respondents	5	13	16
Total	51	51	51

Table 4: Correlation Matrix of Size Data

	h_1	h_2	$\log (h_1)$	$\log (h_2)$	S
h_1	1.000 (46) P = *				
h_2	0.7168 (35) P = 0.000	1.000 (38) P = *			
$\log (h_1)$	0.5947 (46) P = 0.000	0.6004 (35) P = 0.000	1.000 (46) P = *		
$\log (h_2)$	0.6972 (35) P = 0.000	0.7420 (38) P = 0.000	0.7604 (35) P = 0.000	1.000 (38) P = *	
S	0.7844 (35) P = 0.000	0.7472 (35) P = 0.000	0.9011 (35) P = 0.000	0.9668 (35) P = 0.000	1.000 (35) P = *

Intra-firm Functional Specialization

The terminology used to identify and describe functions may vary from firm to firm and from researcher to researcher but the roles each function assumes in the new product development process will remain consistent. Intra-firm functional specialization is a measure of the involvement of important functions within the firm in the new product development project being evaluated.

Variables

Dougherty (1992) studied functional areas of product innovation within large firms. Interview data about innovation gathered from many subjects, from different functional areas within a few firms was used to produce five thought worlds that are relevant for new product development:

1. business issues
2. customer issues
3. selling issues
4. technical issues
5. manufacturing.

A glaring omission to this list is research and development. Research and development has been identified as important and has been observed quite frequently in the context of inter-firm cooperation (Nonaka, 1990; Brockhoff, 1991).

Dougherty may have chosen to omit research and development because it may not have been differentiated from technical issues by interview subjects in the author's study. A second possible reason for the omission is that, as with this study, establishing a conclusive list of functions was not the objective of the research. This and Dougherty's studies seek to measure the degree of involvement in the new product development process of important functional areas. This has been done in Dougherty's research without demonstrated efforts to enumerate and define every possible functional area of each potential respondent and without creating an exhaustive or conclusive list of functions. Dougherty adopted a sufficient list of important functional areas instead.

Conversely, an accurate overview of the most important functional areas is required so that respondents are not forced to guess appropriate responses or omit relevant information. Hence, an inclusive approach to developing a list of important functions was adopted and research and development was included as a functional area in this study.

A list of important functional areas allows an accurate picture of the degree of concentration within each function to be derived. Adding research and development to

Dougherty's list of functions forms an accurate functional outline of important functional areas of the new product development process of Canadian telecommunications firms.

This list is summarized in table 5.

Table 5: Functional Outline of the New Product Development Process		
Function	Role Focus	Variable
research and development	innovation and technology discovery	a_1
engineering/design	product technology and design issues	a_2
manufacturing	manufacturing (plant, suppliers, materials)	a_3
planning/budgeting	segments, competition, forecasts	a_4
marketing	customer issues such as needs and problems	a_5
sales	distribution or selling issues	a_6

A firm that concentrates on one or few specific functions can be characterized as more specialized than a firm that uses a broad, participatory, multi-functional approach to new product development. The degree of intra-firm functional specialization was measured by the number of functions involved in the new product development project and the degree of involvement of each function. Functional involvement (a_n) was measured on a 0-4 scale.

Data

Tables 6 and 7 summarize functional involvement data collected:

Table 6: Summary of Degree of Functional Involvement Data						
	a_1	a_2	a_3	a_4	a_5	a_6
Mean	3.51	3.29	2.06	2.14	1.78	1.65
Standard deviation	0.86	1.06	1.38	1.39	1.30	1.28
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	4.00	4.00	4.00	4.00	4.00	4.00
Kurtosis	5.571	3.741	-1.178	-1.126	-0.934	-1.073
Skewness	-2.212	-1.975	-0.396	-0.162	0.078	0.226
Number of respondents	51	51	51	51	51	51

Table 7: Correlation Matrix of Degree Functional Involvement Data						
	a_1	a_2	a_3	a_4	a_5	a_6
a_1	1.000 (51) $P = *$					
a_2	0.4683 (35) $P = 0.001$	1.000 (51) $P = *$				
a_3	0.3468 (51) $P = 0.013$	0.3838 (51) $P = 0.005$	1.000 (51) $P = *$			
a_4	0.1083 (51) $P = 0.450$	0.2705 (51) $P = 0.055$	0.3101 (51) $P = 0.027$	1.000 (51) $P = *$		
a_5	0.2082 (51) $P = 0.143$	0.0901 (51) $P = 0.529$	0.4984 (51) $P = 0.000$	0.5935 (51) $P = 0.000$	1.000 (51) $P = *$	
a_6	0.1310 (51) $P = 0.359$	-0.0398 (51) $P = 0.782$	0.4439 (51) $P = 0.001$	0.5700 (51) $P = 0.000$	0.6992 (51) $P = 0.000$	1.000 (51) $P = *$

Calculation of Intra-firm Functional Specialization

For calculation of the degree of intra-firm functional specialization let:

F = degree of intra-firm functional specialization of a given NPD project

n = number of functional areas participating in the NPD project

a_n = degree of involvement in functional area 'n'

A new product development project in which fewer functions participate is more functionally specialized than a project in which many functions participate. Therefore, the number of functions participating in a new product development project (n) can be used as the denominator when calculating F .

Similarly, a new product development project with greater involvement (a_n) from each participating function (n) is more functionally specialized than a new product development project with a lesser involvement of each participating function (a higher average involvement versus a lower average involvement). Therefore, average involvement of participating functions (a_n/n) can be used as the numerator of F . The calculation of the degree of intra-firm functional specialization can therefore be made using the following formula:

$$F = \sum \frac{\text{average involvement of participating functions}}{\text{total number of functions participating}} = \sum \frac{a_n/n}{n} = \sum \frac{a_n}{n^2}$$

This formula, with the average involvement of participating functions as the numerator and the number of functions participating as the denominator, was used for calculating intra-firm functional specialization (F).

A second equation for calculating intra-firm functional specialization (F) was also considered:

$$F = \sum a_n/n$$

This second equation does not yield accurate results because firms with different numbers of functions participating in new product development with the same average involvement would have the same F value. For example, a firm with six highly involved functions participating in new product development ($F = 3+3+3+3+3+3/6 = 3$) would have the same F value as a firm with only one highly involved function participating ($F = 3/1 = 3$). In fact, there would be no way to differentiate between firms with equal average involvement regardless of the number of functions participating. Clearly, a firm with six functions participating in new product development is less specialized than a firm with a single function participating. If average involvement is used as the numerator, as in the first equation, this problem is corrected. Hence, the first equation was used to calculate F.

In the first equation, higher values of F are the result of greater intra-firm functional specialization and lower values of F are the result of lesser intra-firm functional specialization. The following provides examples of calculations of intra-firm functional specialization (F) using the first equation:

Only one function that is very involved:	$F = 4/1 = 4$
Two functions that are highly involved:	$F = 6/4 = 1.5$
Three functions with different levels of involvement:	$F = 9/9 = 1$
Four functions with different levels of involvement:	$F = 8/16 = 0.5$

The following table summarizes intra-firm functional specialization calculations:

Table 8: Summary of Intra-firm Functional Specialization Calculations	
	$F = \sum \frac{a_n}{n^2}$
Mean	0.68
Standard deviation	0.42
Minimum	0.31
Maximum	2.00
Kurtosis	3.335
Skewness	1.966
Number of respondents	51

Inter-firm Cooperation

Variables

Physical asset specificity was one of the measures used to estimate inter-firm cooperation in this study. This measure was used in Dyer's (1996) study of supplier networks. Dyer operationalized this measure as the percentage of the supplier's total capital investments which would be scrapped if the supplier were prohibited from conducting any future business with its current partner divided by the percentage of total sales that went to that partner (normalized sunk costs). This data was expected to be too difficult to obtain by mail survey and would require in-depth formal interviews. In this study data was gathered to measure unrecoverable sunk costs of the new product development project that were directly attributable to cooperation with other firms in thousands of dollars (c_1). The strong point of using this variable is that it accounts for issues identified in the literature review such as resource constraints, resource commitment and risk of cooperation. It can also be easily applied to new product development projects, the unit of analysis for this study.

Dyer used person days of direct contact between a firm and its partner normalized for firm size as a measure of human asset specificity, a measure of cooperation in his study. Data was collected for person days of direct contact between the responding firm and its cooperators (c_2) as a second measure of inter-firm cooperation in this study.

Dyer also measured the number of collocated employees (working at the same site) to estimate human asset specificity. This measure was not used in this study because it was expected to be highly correlated to person days of contact and because it was expected to be difficult to accurately collect this information by mail survey.

Dyer's last measure of cooperation used was information sharing. Although data collection by mail survey was not feasible for all elements of Dyer's measures of information sharing some of the elements can be used. The elements of measures of information sharing that were selected for this study are:

- c_3 : the intended duration of cooperation.
- c_4 : the extent to which suppliers shared confidential information.
- c_5 : the extent to which they received information to lower product costs.
- c_6 : the extent to which they received information to improve quality.

Information sharing was also measured by gathering data on management's perception of cooperation (c_7). This information provides an overall picture of intra-firm cooperation from a managerial perspective. As with Dyer's study, information sharing data was gathered using a response scale.

Calculation of Inter-firm Cooperation

The Kurtosis and Skewness values and the P-P plot of sunk costs of new product development projects (c_1) showed a non-linear distribution. For this reason logarithmic and square root transformations of non-zero sunk costs of cooperation were calculated in order to obtain a linear distribution. Logarithmic transformation provided the most normal linear distribution. The data was also normalized for firm size. These calculations permit accurate comparisons between large and small sized cooperating firms as required for testing hypothesis 2. Calculations on data from respondents with non-zero sunk costs (c_1) were made using the following formula:

$$C_1 = \frac{\log(c_1)}{\log(h_1) + \log(h_2)}$$

where h_1 : size of work force measured by the number of employees
 h_2 : value of assets measured in hundreds of thousands of dollars

As with sunk costs of new product development projects (c_1), the Kurtosis and Skewness values and the P-P plot of person days of direct contact of new product development projects (c_2) also showed a non-linear distribution. Similarly, logarithmic and square root transformations of non-zero person days of direct contact were calculated in order to obtain a linear distribution. Again logarithmic transformation provided the most normal

linear distribution and the data was also normalized for firm size as required for testing hypothesis 2. Calculations on data from respondents with non-zero number of person days of direct contact (c_2) were made using the following formula:

$$C_b = \frac{\log(c_2)}{\log(h_1) + \log(h_2)}$$

As in Dyer (1996), information sharing data was aggregated into a single measure of information sharing by averaging responses.

$$C_c = \frac{(c_3 + c_4 + c_5 + c_6 + c_7)}{5}$$

Sunk costs, person days of direct contact, and information sharing were chosen for this study because they apply well to new product development projects (the unit of analysis) and addresses human resource constraints, and risk and reward issues that arise from inter-firm cooperation. The resulting measures of inter-firm cooperation (C_a , C_b , C_c) were found to be highly correlated. Therefore, the measures were grouped into a single measure of inter-firm cooperation (C).

$$C = C_a + C_b + C_c$$

Note that logarithms were only calculated for non-zero c_1 and c_2 responses. Where respondent provided a zero response for c_1 or c_2 a zero was used instead of a logarithm of c_1 or c_2 . Table 11 and 12 summarize inter-firm cooperation calculations.

Table 11: Summary of Inter-firm Cooperation Calculations						
	$\log c_1$	$\log c_2$	C_a	C_b	C_c	C
Mean	1.04	0.93	0.30	0.24	2.18	2.59
Standard deviation	0.97	0.99	0.38	0.35	1.08	1.68
Minimum	0.00	0.00	0.00	0.00	1.00	1.00
Maximum	3.00	3.00	1.54	1.54	4.00	6.08
Kurtosis	-1.529	-1.049	2.942	5.205	-1.472	-1.213
Skewness	0.125	0.566	1.607	2.137	0.209	0.503
Number of respondents	51	51	44	44	51	43

Table 12: Correlation Matrix of Inter-firm Cooperation Data						
	$\log c_1$	$\log c_2$	C_a	C_b	C_c	C
$\log c_1$	1.000 (51)					
$\log c_2$	0.7820 (51)	1.000 (51)				
C_a	0.8208 (44)	0.5844 (44)	1.000 (44)			
C_b	0.7039 (44)	0.8017 (44)	0.8744 (43)	1.000 (44)		
C_c	0.8639 (51)	0.7504 (51)	0.7421 (44)	0.6336 (44)	1.000 (51)	
C	0.9301 (43)	0.7825 (43)	0.9180 (43)	0.8193 (43)	0.9576 (43)	1.000 (43)
All correlations are significant at 0.000						

C_a and C_b could not be calculated for respondents that did not provide the required size data needed for normalization.

New Product Development Success

Variables

Previous studies have either measured the degree of success of new product development projects or have classified projects into categories of success. Cooper's (1979) study of new product successes and failures defined new product development success as the degree to which a product's profitability exceeded or fell short of the minimum acceptable profitability for this type of project or investment (as determined by management), regardless of how the firm measured profitability. Data for the study was gathered by interviews from responding managers but no effort was made to measure the degree of success as Cooper had defined it. Cooper analyzed data on a wide range of variables relating to 102 new product successes and 93 new product failures. The resulting methodology omits information that can be derived from measuring the degree of success. Classifying new product development projects as simply successes or failures seems to oversimplify analysis.

Similarly, in a study of barriers to successful product innovation in large firms, Dougherty (1992) simply grouped new product development projects into three classes of success without measuring the degree of success:

1. successful products: at least as much profitable as planned.
2. failed products: canceled after introduction.
3. uncertain products: not canceled but falling short of projections.

Although Dougherty's classification is useful and facilitates analysis, it relies extensively on interviews for data collection, present difficulties in classifying marginal cases and loses information that can be derived from measuring the degree of success. It is also very difficult to accurately gather adequate data as required by her classification system using a mail survey. Therefore, data collection in this study focused on measuring the degree of new product development project success.

Geringer and Herbert (1991) confirm that there is no consensus in the literature on which success variables should be measured. They go on to separate variables into two broad classes: objective and subjective. Their subjective variables, such as manager's satisfaction and manager's perception of success, are listed in Appendix C.

The theoretical link between objective variables measuring success and cooperation and specialization has already been established (Dyer, 1996). Objective variables (usually economic; including: profitability, growth, costs, and development time) have also been used in previous research to measure various types of success (Tomlinson, 1970; Lecraw, 1983; Eisenhardt and Tabrizi, 1995; Dyer, 1996) despite difficulties acquiring data (Dess and Robinson, 1984). Unfortunately, objective variables are often not representative of successful goal achievement (i.e., to develop new technology or gain market share), are often not available at the project level and do not necessarily reflect the success of a given new product development project within the firm. Furthermore, objective

variables do not always reflect short and long term goals (Killing, 1983; Artisien and Buckley, 1985). The weaknesses of objective variables to evaluate success, even at the firm level, are demonstrated by the inability of traditional accounting variables to statistically differentiate between excellent and ordinary firms (Chakravarthy, 1986). Because objective variables reflect only one dimension of performance (Anderson, 1990) both objective and subjective variables were used to measure new product development success in this study. However, measures of similar concepts were grouped to produce meaningful results that can be more easily interpreted. The three groupings of variables measuring the degree of success used in this study are:

1. degree of perceived success (PS)
2. degree of technical success (TS)
3. degree of financial success (FS)

Subjective variables have been used in previous studies to determine if the goals of international joint ventures were being met (Killing, 1983). Subjective variables were used to measure perceived new product development project success in this study for two reasons. Firstly, subjective variables can be easily and accurately applied to measuring perceived new product development success at the project level. This is particularly useful where inter-firm cooperation makes data collection of financial data at the project level difficult and inaccurate and where respondents are uncomfortable or unwilling to disclose financial information.

Secondly, subjective variables, which aim to compensate for external forces, were found to be correlated to objective variables (Dess and Robinson, 1984; Geringer and Herbert, 1991). This confirms their usefulness for obtaining new product development project level data when objective data is not available. The following subjective variables measuring perceived success (PS) were used:

- s_1 : satisfaction with the new product development project relative to expectations.
- s_2 : satisfaction with sales of the new product relative to expectations.
- s_3 : satisfaction with the reputation of the new product relative to expectations.

Subjective variables were also used to measure product quality, termed technical new product development project success in this study. The most pervasive definition of quality currently in use is the extent to which a product or service meets and/or exceeds a customer's expectations (Reeves and Bednar, 1994). Dimensions of product quality that fit Geringer and Herbert's subjective category of measures of success are performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality (Garvin, 1987). Garvin's research has indicated that commercial success is often dependent on product quality variables rather than financial variables. Moreover, commercial success can be independent of external factors like economic cycles which can have an impact on financial variables. The competitive aspects and independence from external factors of Garvin's variables make them good measures of technical new product development success. However, in this study product quality was not measured

with the same rigor as Garvin used because product quality is not the focus of this study.

Instead the following subjective variables measuring technical success (TS) were used:

- s_4 : overall new product quality relative to expectations.
- s_5 : technical performance relative to expectations.
- s_6 : technical design relative to expectations.

Despite the effectiveness of subjective variables at measuring success some objective measures were also used. The following objective variables measuring financial success (FS) were used:

- s_7 : gross profit margin of new product.
- s_8 : annual rate of sales growth of new product.
- s_9 : percentage of market share captured by new product.

Additional variables were not used because they were expected to be correlated to the selected variables, would add little or no information to the study, and would make findings difficult to interpret.

Table 14: Correlation Matrix of New Product Development Success Data									
	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9
s_1	1.000 (51)	(51)	(51)	(51)	(51)	(51)	(39)	(38)	(32)
s_2	0.6608 P= 0.000	1.000 (51)	(51)	(51)	(51)	(51)	(39)	(38)	(32)
s_3	0.5793 P= 0.000	0.6417 P= 0.000	1.000 (51)	(51)	(51)	(51)	(39)	(38)	(32)
s_4	0.5935 P= 0.000	0.3671 P= 0.008	0.4774 P= 0.000	1.000 (51)	(51)	(51)	(39)	(38)	(32)
s_5	0.4871 P= 0.000	0.4371 P= 0.001	0.3842 P= 0.005	0.7026 P= 0.000	1.000 (51)	(51)	(39)	(38)	(32)
s_6	0.2902 P= 0.039	0.2737 P= 0.052	0.1770 P= 0.214	0.5180 P= 0.000	0.5140 P= 0.000	1.000 (51)	(51)	(38)	(32)
s_7	0.3060 P= 0.058	0.5143 P= 0.001	0.3371 P= 0.036	0.2548 P= 0.117	0.2541 P= 0.118	0.2205 P= 0.177	1.000 (39)	(38)	(32)
s_8	0.3826 P= 0.018	0.3403 P= 0.037	0.3565 P= 0.028	0.0986 P= 0.556	0.0998 P= 0.551	0.1603 P= 0.336	0.2191 P= 0.221	1.000 (38)	(32)
s_9	0.3516 P= 0.048	0.0790 P= 0.667	0.2515 P= 0.165	0.1957 P= 0.283	0.0251 P= 0.892	-0.0463 P= 0.801	-0.0848 P= 0.674	0.1647 P= 0.384	1.000 (32)

Calculation of Success

Success was calculated using the following equations:

$$\text{Perceived success} = \text{PS} = \frac{(S_1 + S_2 + S_3)}{3}$$

$$\text{Technical success} = \text{TS} = \frac{(S_4 + S_5 + S_6)}{3}$$

$$\text{Financial success} = \text{FS} = \frac{(S_7 + S_8 + S_9)}{3}$$

Table 15: Summary of Success Calculations			
	PS	TS	FS
Mean	3.18	3.25	47%
Standard deviation	0.68	0.60	27%
Minimum	1.00	1.67	10%
Maximum	4.00	4.00	100%
Kurtosis	0.792	0.048	-0.718
Skewness	-0.796	0.636	0.544
Number of respondents	51	51	25

VALIDITY

In social sciences, measurement of concepts using variables can be complex. This is because of difficulties in defining and operationalizing variables to measure a concept that may be abstract and difficult to define. The relationship between concepts and variables becomes crucial. Hence, theory specifying the relationship between concepts and variables is as important as the theoretical model linking concepts to one another.

Criterion-related Validity

Criterion-related validity is used to demonstrate that a given relationship found in a study can predict the results of future cases. Criterion-related validity is usually measured by correlation. A correlation between expected results based on findings and actual results is measured. The correlation coefficient between expected results and actual results is the validity coefficient (Carmines and Zeller, 1979). There are two forms of criterion-related validity tests: concurrent validity and predictive validity.

Predictive validity testing was not used for validation because it requires additional data collection which has already proven to be costly and arduous. Concurrent validity testing was used to evaluate the relationship between variables and concepts. The high correlations between the various measures of each concept suggest that they are indeed measuring a single concept.

Evaluation of the correlations between the survey measures of firm size (h_1 and h_2) and the calculated value of size suggests that S is a valid measure of size. The correlations coefficients between h_1 , h_2 and S range from 0.7168 to 0.7844 and all are significant at 0.0005.

The calculation of intra-firm functional specialization (F) from survey measures of functional involvement (a_n) is not as simple as other calculations. Because involvement in more functions is a characteristic of a less functionally specialized firm, a negative correlation between involvement and specialization is an indication of validity. Table 16 shows the correlation coefficients between survey measures of functional involvement (a_n) and intra-firm functional specialization (F). These indicate that F is a valid measure of specialization.

Table 16: Correlation coefficients Between Involvement (a_n) and Specialization (F)					
a_1	a_2	a_3	a_4	a_5	a_6
-0.1482 $P = 0.299$	-0.2070 $P = 0.145$	-0.5063 $P = 0.000$	-0.3564 $P = 0.010$	-0.5128 $P = 0.000$	-0.3570 $P = 0.010$
Sample size of 51 in all cases					

Correlations between measures of inter-firm cooperation (c_n) were analyzed for validity in using the following procedure. First, the correlation between C_3 and $\log c_1$ was evaluated. A correlation coefficient of 0.8208 at a significance level of 0.0005 indicated the validity of C_3 . Second, the correlation between C_6 and $\log c_2$ was evaluated. A

correlation coefficient of 0.8017 at a significance level of 0.0005 indicated the validity of C_b . Third, the correlation coefficients between C_c and $c_{3,4,5,6,7}$ were evaluated. These ranged from 0.8723 to 0.9343 at a significance level of 0.0005 and confirmed the validity of C_c . Lastly, the correlation coefficients between C and all the above survey measures and calculated measures of cooperation were evaluated. These coefficient, contained in table 17, confirm the validity of C as a measure of cooperation.

Table 17: Correlation Coefficients Between Survey and Calculated Measures Cooperation									
$\log c_1$	$\log c_2$	c_3	c_4	c_5	c_6	c_7	C_a	C_b	C_c
0.9301	0.7825	0.8934	0.9091	0.8100	0.8512	0.9126	0.9180	0.8193	0.9576
P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000
Sample size of 43 in all cases									

The validity of perceived success (PS) was established by its correlation coefficients with survey measures of perceived success ($s_{1,2,3}$). These ranged from 0.5793 to 0.6608, all at a significance level of 0.0005.

Similarly, the validity of technical success (TS) was established by its correlation coefficients with survey measures of technical success ($S_{4,5,6}$). These ranged from 0.5140 to 0.7026, all at a significance level of 0.0005.

Lastly, the validity of financial success (FS) was evaluated by its correlation coefficients with survey measures of financial success ($s_{7,8,9}$). These ranged from -0.084 to 0.2191,

were not significant and failed to confirm the validity of calculations of financial success (FS). This is likely the result of the high standard deviations observed for financial measures of success. Consequently, the validation of calculations of financial success relies on theory, which has already been discussed in detail, and on other validation techniques.

Content Validity

Content validity is the extent to which an instrument reflects a specified domain of content. In practical terms this is the extent to which the variable measures all the dimensions of a concept. To test content validity all the dimensions of the concept and all alternative measure must be know. Consequently, application of content validity testing beyond simple theoretical reasoning is difficult to apply to new or abstract concepts. A theoretical evaluation of measures and calculations has already been detailed in this thesis and it has show no reason to suspect that any are not valid. Specifically, the survey measures and calculations used to derive FS were subjected to a rigorous theoretical assessment. The calculation of FS is simply an averaging of survey responses for profit margin, growth rate and market share. Again, no theoretical evidence was found to indicate that the calculation of financial success is not valid.

Construct Validity

Construct validity refers to the extent to which a variable relates to other variables that are consistent with the theoretical model's estimation of the concept being measured.

For example, consider a theoretical model that states that concept A and concept B are related. In order to test the validity of the variable measuring concept A, a measure of the correlation between the variable measuring concept A and concept B is used. If the correlation findings fit the theoretical model then the some evidence exists supporting the validity of the instrument. If an unexpected relationship is found there are at least 3 possible explanations:

- (a) the variable measuring concept A is not valid;
- (b) the variable measuring concept B is not valid;
- (c) the theoretical model's link between concept A and concept B is not valid.

The correlation coefficients between success variables shown in table 18 are all positive and the correlation coefficient between financial success (FS) and perceived success (PS) is significant. These findings suggest that financial success is a valid measure of new product development success.

Table 18: Correlation Coefficients Measures of Success			
	FS	PS	TS
FS	1.000 (25) P = *		
PS	0.5511 (25) P = 0.004	1.000 (51) P = *	
TS	0.2116 (25) P = 0.310	0.5332 (51) P = 0.0005	1.000 (51) P = *

RELIABILITY

The following section reviews various methods to assess the reliability of measures used in this study.

Test-retest and Alternative-form Method

Test-retest and alternative-form methods of reliability testing were not be used because they require additional data collection. Additional data collection has already been considered in this study and has been ruled out. Based on current results and pretest feedback, additional data collection would probably encounter little success, would necessitate unacceptable delays, would require methodological alterations and would introduce new problems such as changes of the variables over time and recall problems.

Split-halves Method

The split-halves method for reliability testing was not used in this study because it was judged to be inappropriate for the nature of the data and the available sample. The split-halves method requires a statistical corrections to compensate for the fact that a applying half the sample to predict the other half is inevitably less reliable than use of the entire sample. Hence a large sample size is required to effectively use this method. Further, because the sample was divided into two groups for theoretical reasons an even larger sample is necessary to test the reliability within sub-groups. The data collection obstacles encountered in this study have resulted in an inadequate sample size in this respect and therefore use of this method would have been ineffective. The split-halves

method also suffers from the drawback that depending on which way the sample is divided, slightly different correlations between the halves can be produced and hence different reliability estimates will result.

Internal Consistency Method

Among internal consistency methods of reliability testing, the most popular is Cronbach's alpha. Cronbach's alpha is a conservative measure, the true reliability is always greater than or equal to alpha. Cronbach's alpha can be explained in a several ways:

- In terms of comparability with a split-halves test, alpha for an instrument with N items is equal to the average value of the alpha coefficients obtained for all possible combinations of items into two half-tests.
- In terms of alternative-form testing, alpha is an estimate of the expected correlation of variables with a hypothetical alternative form that has the same number of items.

Because the Cronbach's Alpha test of reliability was applied to non-standardized variables the test used the average covariance among variables. The value of alpha depends on the average inter-variable covariance and on the number of variables in the scale. Alpha increases with both of these but reaches a point of diminishing values as the number of variables being tested increases. If variables are added to the test and the new

additions have lower inter-variable covariance than those previously in the test, then alpha is reduced.

Cronbach's alpha can vary between 0 and 1. The more the variables being tested vary together (a higher alpha) the greater the likelihood that they are measuring the same concept. The following table summarizes Cronbach's Alpha reliability analysis:

Table 19: Summary of Cronbach's Alpha Reliability Analysis				
Variables	mean	standard deviation	number of cases	Alpha
Technical success (TS)	3.25	0.60	25	0.6470
Perceived success (PS)	3.18	0.68		
Financial success (FS)	0.47	0.27		
Cooperation (C)	2.59	1.68	43	0.8289
C _a	0.30	0.38		
C _b	0.24	0.35		
C _c	2.18	1.08		
Specialization (F)	0.68	0.42	51	0.6947
a ₁	3.51	0.86		
a ₂	3.29	1.06		
a ₃	2.06	1.38		
a ₄	2.14	1.39		
a ₅	1.78	1.30		
a ₆	1.65	1.28		
Size (S)	4.01	1.62	35	0.8998
log h ₁	2.03	0.79		
log h ₂	2.06	1.07		

These results confirm the reliability of the chosen variables and their operationalization to the extent that each group is probably measuring a single concept. They also imply

the that the calculations of new product development success, inter-firm cooperation, intra-firm functional specialization and size outlined in the Variables and Data section are accurate and reliable.

HYPOTHESIS TESTING

Prior to analysis, the distribution of data was examined to ensure that it met the necessary assumptions for statistical analysis. Specifically, sample size, normality and linearity were examined (Tasbachnick and Fidell, 1990). The variables required for hypothesis testing met the necessary assumptions although number of respondents was slightly low particularly among large firms and with respect to financial success.

Histograms, measures of skewness and measures of kurtosis of the data for size (S), inter-firm cooperation (C), intra-firm functional specialization (F), perceived success (PS), technical success (TS), and financial success (FS) are found in Appendix E.

The P-P plots, histograms and skewness and kurtosis values of size, inter-firm cooperation, perceived success, technical success, and financial success follow a distribution that is fairly linear and normal. The exception is intra-firm functional specialization. In order to improve the distribution of this data a logarithmic transformation was used. This transformation was superior to a square root transformation and resulted in improved linearity, skewness and kurtosis. The correlation coefficient between F and log F was 0.9674 at a significance level of 0.0005 base on 51 respondents.

Data for perceived success and technical success is slightly negatively skewed while data for financial success and cooperation is slightly positively skewed. Size and specialization data were more strongly positively skewed.

Data for cooperation and financial success is slightly platykurtic while data for perceived success, technical success and log F is slightly leptokurtic. Size data is the most leptokurtic due to the high number of small firms responding to the survey.

Every reasonable effort has been made to transform the data into form that is suitable for hypothesis testing. Despite these efforts some slight deviations from linearity and normality remain. These slight deviations are acceptable and do not necessarily violate the required assumptions of linearity.

Hypothesis 1

Correlation analysis studies the degree of association between variables. This method was used for testing hypothesis 1. With correlation both dependent and independent variables must be random and their joint distribution must be bivariate normal.

The correlation between dependent success variables (PS, TS, FS) and independent variables of inter-firm cooperation (C) and intra-firm functional specialization (F) was tested. The average correlation coefficient for social science research is 0.40 (Nonnally, 1978) and a correlation of 0.50 is considered 'large' (Cohen, 1977). Cooper (1979) stated that variables with inter correlations in excess of 0.50 are highly inter-correlated. Coefficients greater than 0.35 were considered indicative of a true hypothesis.

Hypothesis 1 a.i.

Inter-firm cooperation (C) is positively correlated to new product development perceived success (PS) for firms competing in the Canadian telecommunications industry.

Test

Table 20 shows the correlation coefficients between the various measures of inter-firm cooperation (C_a , C_b , C_c , C) and perceived success (PS).

Table 20: Correlation between Inter-Firm Cooperation and Perceived Success			
C_a	C_b	C_c	C
0.1531 (44) P = 0.321	0.0797 (44) P = 0.607	0.0983 (51) P = 0.492	0.1543 (43) P = 0.323

These findings, consistent across all measures, indicate that hypothesis 1 a.i. is false.

Hypothesis 1 a.ii.

Inter-firm cooperation (C) is positively correlated to new product development technical success (TS) for firms competing in the Canadian telecommunications industry.

Test

Table 21 shows the correlation coefficients between the various measures of inter-firm cooperation (C_a , C_b , C_c , C) and technical success (TS).

Table 21: Correlation between Inter-Firm Cooperation and Technical Success			
C_a	C_b	C_c	C
0.1214 (44) P = 0.432	0.0859 (44) P = 0.579	-0.0408 (51) P = 0.776	0.0661 (43) P = 0.674

These findings, consistent across all measures, indicate that hypothesis 1 a.ii. is false.

Hypothesis 1 a.iii.

Inter-firm cooperation (C) is positively correlated to new product development financial success (FS) for firms competing in the Canadian telecommunications industry.

Test

Table 22 shows the correlation coefficients between the various measures of inter-firm cooperation (C_a , C_b , C_c , C) and financial success (FS).

Table 22: Correlation between Inter-Firm Cooperation and Financial Success			
C_a	C_b	C_c	C
-0.0767 (21) P = 0.741	-0.2499 (22) P = 0.262	0.2544 (25) P = 0.220	0.0197 (21) P = 0.932

These findings, consistent across all measures, indicate that hypothesis 1 a.iii. is false.

Hypothesis 1 b.i.

Intra-firm functional specialization (log F) is positively correlated to perceived success (PS) for firms competing in the Canadian telecommunications industry.

Test

The correlation coefficient between intra-firm functional specialization (log F) and new product development perceived success (PS) is 0.2670 at a 0.058 significance level based on 51 completed responses. This finding indicates that hypothesis 1 b.i. is false.

Hypothesis 1 b.ii.

Intra-firm functional specialization (log F) is positively correlated to technical success (TS) for firms competing in the Canadian telecommunications industry.

Test

The correlation coefficient between intra-firm functional specialization (log F) and new product development technical success (TS) is 0.1857 at a 0.192 significance level based on 51 completed responses. This finding indicates that hypothesis 1 b.ii. is false.

Hypothesis 1 b.iii.

Intra-firm functional specialization (log F) is positively correlated to financial success (FS) for firms competing in the Canadian telecommunications industry.

Test

The correlation coefficient between intra-firm functional specialization (log F) and new product development financial success (FS) is 0.5943 at a 0.002 significance level based on 25 completed responses. This finding indicates that hypothesis 1 b.iii. is true.

Table 23 summarizes hypothesis testing results, correlation coefficients used to test hypothesis 1 and significance of results.

Table 23: Correlation Coefficients for Testing Hypothesis 1					
Hypothesis	Variables	Result	Respondents	Correlation Coefficient	2 Tailed Significance
1 a.i.	C & PS	False	43	0.1543	0.323
1 a.ii.	C & TS	False	43	0.0661	0.674
1 a.iii.	C & FS	False	21	0.0197	0.932
1 b.i.	Log F & PS	False	51	0.2670	0.058
1 b.ii.	Log F & TS	False	51	0.1857	0.192
1 b.iii.	Log F & FS	True	25	0.5943	0.002

Hypothesis 2

The second hypothesis was evaluated using a t-test to determine whether the differences between the means of the variables of large firms and small firms was statistically significant. Statistical analysis of differences in the means was chosen because it is a simple, widely accepted, academically valid method of hypothesis testing in the study of new product development (Eisenhardt and Tabrizi, 1995; Cooper, 1979; Zirger and Maidique, 1990).

For hypothesis testing concerning the difference between means where population variances are unknown but assumed to be equal, the standard deviation used should be pooled from the samples to provide a combined point estimate of the population

variance. The pooled variance is given by:

$$S_p = \sqrt{\frac{(n_L - 1) s_L^2 + (n_S - 1) s_S^2}{(n_L - 1) + (n_S - 1)}}$$

where: n_L = sample size of large sized firm group

n_S = sample size of small sized firm group

s_L^2 = sample variance for large sized firm group

s_S^2 = sample variance for small sized firm group

and S_p is the weighted mean of s_L^2 and s_S^2 .

The Z standardized test statistic used for testing against a single population mean can no longer be used because the population variance had to be estimated. Instead the standardized test statistic for a test of equality of two means was used (Pfaffenberg and Patterson, 1987).

$$t = \frac{(\text{mean}_L - \text{mean}_S) - D_0}{S_p \sqrt{(1/n_L + 1/n_S)}}$$

with $n_L + n_S - 2$ = degrees of freedom and where:

D_0 = hypothesized value of the difference between the means taken as 0

mean_L = sample mean of large sized firm group

mean_S = sample mean of small sized firm group

Preliminary Analysis of Hypothesis 2

An independent sample two tailed t-test was used to determine whether the difference between the means of the small firm and large firm groups is statistically significant. For the purposes of the t-test the null hypothesis was that the difference between the means is zero [$H_0: D = D_0$]. The alternate hypothesis was that the difference between the means is not zero [$H_a: D \neq D_0$].

Prior to testing hypothesis 2, the groups were tested to determine if differences in size (S), perceived success (PS), technical success (TS) and financial success (FS) were statistically significant.

An independent sample one tailed t-test was used for testing statistical significance of size difference because it is hypothesized that the first group of firms is larger than the second. For the two size groups:

Table 24: Test of Difference in Size						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	3.1625	0.731	0.152	-2.4665	F= 11.245 P= 0.002
Large firm	12	5.6290	1.634	0.472		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	
Equal	-6.20	33	0.000	0.398	(-3.275; -1.658)	
Unequal	-4.97	13.34	0.000	0.496	(-3.535; -1.398)	

The mean sizes of the two groups were found to be statistically different and there is virtually no chance that these means could come from groups with an equal mean size.

This result was expected since the size groups were intentionally created.

An independent samples two tailed t-test was also used for testing statistical significance of differences in the degree of success. Tables 25, 26 and 27 summarizes t-test results :

Table 25: Test of Difference in Financial Success (FS)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	14	0.5121	0.290	0.078	0.1755	F= 3.804 P= 0.068
Large firm	5	0.3367	0.125	0.056		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	
Equal	1.29	17	0.214	0.136	(-0.111; 0.462)	
Unequal	1.84	15.99	0.085	0.096	(-0.027; 0.378)	

Table 26: Test of Difference in Perceived Success (PS)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	3.3696	0.624	0.130	0.1196	F= 0.638 P= 0.430
Large firm	12	3.2500	0.553	0.160		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	

Equal	0.56	33	0.580	0.214	(-0.316; 0.555)	
Unequal	0.58	24.95	0.567	0.206	(-0.304; 0.544)	

Table 27: Test of Difference in Technical Success (TS)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	3.3333	0.503	0.105	-0.0556	F= 0.230 P= 0.635
Large firm	12	3.3889	0.547	0.158		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	
Equal	-0.30	33	0.765	0.184	(-0.431; 0.320)	
Unequal	-0.29	20.79	0.772	0.190	(-0.450; 0.339)	

The two size groups were not found to be significantly different with respect to perceived success (PS), financial success (FS) or technical success (TS). This preliminary finding suggest that firm size does not play a significant role in determining the degree of success in the Canadian telecommunications industry. However, the mean perceived success and mean financial success were higher among small firms than among large firms and these results were still fairly unlikely if the groups share the same mean levels of success.

Hypothesis 2 a.

A strategy of inter-firm cooperation (C) is a more important contributor to new product development success (PS, TS, FS) in smaller firms competing in the Canadian telecommunications sector than in larger firms.

Test

Hypothesis 2 a. was tested using an independent sample two tailed t-test. Tables 28, 29, 30 and 31 summarizes the results :

Table 28: Test of Difference in Inter-Firm Cooperation (C _a)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	0.4714	0.428	0.089	0.2932	F= 2.217 P= 0.146
Large firm	12	0.1782	0.212	0.061		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	
Equal	2.22	33	0.033	0.132	(0.025; 0.561)	
Unequal	2.71	32.97	0.011	0.108	(0.073; 0.513)	

Table 29: Test of Difference in Inter-Firm Cooperation (C _b)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	0.3661	0.431	0.090	0.1919	F= 2.826 P= 0.102
Large firm	12	0.1741	0.188	0.054		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	

Equal	1.46	33	0.153	0.131	(-0.075; 0.459)	
Unequal	1.83	32.35	0.077	0.105	(-0.022; 0.406)	

Table 30: Test of Difference in Inter-Firm Cooperation (C _c)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	2.4348	1.054	0.220	0.5181	F = 0.265 P = 0.610
Large firm	12	1.9167	1.120	0.323		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	

Equal	1.35	33	0.186	0.383	(-0.262; 1.298)	
Unequal	1.33	21.25	0.199	0.391	(-0.294; 1.331)	

Table 31: Test of Difference in Inter-Firm Cooperation (C)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	3.2722	1.706	0.356	1.003	F = 0.210 P = 0.650
Large firm	12	2.2690	1.505	0.434		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	
Equal	1.72	33	0.096	0.585	(-0.186; 2.193)	
Unequal	1.79	25.07	0.086	0.561	(-0.153; 2.159)	

Except for C_s , none of the mean levels of inter-firm cooperation had differences that were significant to a 0.05 level. The mean for C_s is based on sunk costs. For this measure, the difference is large relative to the means on the two size groups.

Interpretation of this finding suggests that large firms may have greater normalized sunk costs of inter-firm cooperation than small firms. However the majority of inter-firm cooperation findings suggest that hypothesis 2 a. is false and that inter-firm cooperation is no more important among small firms in the Canadian telecommunications industry than it is among large ones. This conclusion is deduced from the fact that there was no significant difference between mean levels of success of small and large firms and

between mean levels of inter-firm cooperation of small and large firms. The fact that small and large firms cooperate and succeed equally implies that a strategy of inter-firm cooperation (C) is not a more important contributor to new product development success (PS, TS, FS) in smaller firms competing in the Canadian telecommunications sector than in larger firms.

Hypothesis 2 b.

A strategy of intra-firm functional specialization (F) is a more important contributor to new product development success in smaller firms competing in the Canadian telecommunications sector than in larger firms.

Test

A two independent sample two tailed t-test was also used to test hypothesis 2 b. The following table summarized results:

Table 32: Test of Difference in Intra-Firm Functional Specialization (log F)						
	Number of cases	Mean	Stand. deviation	SE of Mean	Mean Diff.	Levene's Test for Equality of Variances
Small firm	23	-0.1964	0.208	0.043	0.0354	F= 0.003 P= 0.954
Large firm	12	-0.2318	0.208	0.060		
Variances	t-value	df	2-Tail Sig	SE of Diff.	95% CI for Diff.	

Equal	0.48	33	0.636	0.074	(-0.115; 0.186)	
Unequal	0.48	22.48	0.637	0.074	(-0.118; 0.189)	

The independent samples two tailed t-test indicates that if the means of the degree of intra-firm specialization of the two groups are equal, there is a 63.6% chance that there will be a difference of 0.0354 or greater between log F for small firms and log F for large firms. This seems quite probable. Hence small and large firms probably specialize equally. These findings direct to accept H_0 , therefore hypothesis 2 b. is false and there is no difference in the degree of intra-firm functional specialization. This conclusion is deduced from the fact that there was no significant difference between mean levels of success of small and large firms and between mean levels of intra-firm specialization of small and large firms. The fact that small and large firms specialize and succeed equally implies that a strategy of intra-firm specialization (F) is not a more important contributor to new product development success (PS, TS, FS) in smaller firms competing in the Canadian telecommunications sector than in larger firms.

DISCUSSION

A linear regression of variables was performed to confirm that the statistical methodology chosen for this thesis is the most appropriate. Linear regression equations were formed using theoretical reasoning because statistical selection methods did not produce any significant results. Based on the theoretical model two alternative linear regression equations were identified:

Alternative A	Alternative B
$F = \beta_1 C + e$	$F = \beta_1 C + \beta_2 S + e$
$\text{Success} = \beta_2 F + \beta_3 C + \beta_4 S + e$	$C = \beta_3 S + e$
$= \beta_2(\beta_1 C + e) + \beta_3 C + \beta_4 S + e$	$\text{Success} = \beta_4 F + \beta_5 C + e$
$= C(\beta_2 \beta_1 + \beta_3) + \beta_4 S + e$	$= \beta_4(\beta_1 C + \beta_2 S) + \beta_5(\beta_3 S) + e$
	$= \beta_4 \beta_1 C + (\beta_4 \beta_2 + \beta_5 \beta_3) S + e$

The two alternatives result in a linear regression equation where success (FS, PS, TS) is dependent on inter-firm cooperation (C) and firm size (S). The results of the regression were not significant and therefore help confirm that the statistical methodology selected is indeed the most suitable. The results of the linear regression for both size groupings and for the entire sample are contained in Appendix M.

Hypothesis Test Results

The correlation coefficients found between inter-firm cooperation and all types of success were positive but were of low magnitude and were not significant. As rationalized in the literature review, a lack of significant findings in this respect may have been caused by difficulties encountered by respondents in overcoming barriers between firms. However, since all the coefficients are positive it is unlikely that inter-firm cooperation hinders success.

The correlation coefficients found between intra-firm functional specialization and perceived success and technical success were also positive, of low magnitude and were not significant. However, the results were stronger than those of inter-firm cooperation. Further, intra-firm functional specialization is positively correlated to financial success (coef. = 0.6226) and was found to be significant ($P = 0.001$). This finding contributes to validating the theoretical model and to confirming the relationship between intra-firm functional specialization and success.

The fact that the two groups were not found to be significantly different with respect to success suggest that firm size does not play a significant role in determining the degree of new product development success in the Canadian telecommunications industry. However, the mean perceived success and mean financial success were higher among small firms than among large firms and these results were still fairly unlikely if the groups share the same mean levels of success. This is consistent with the research

outlined in the literature review of this thesis regarding the level of success of small firms relative to large firms. It also suggests that size may play a moderating role as outlined in the new product development theoretical model.

The discovery that small firms in the sample cooperate to a greater degree than large firms, although not significant, is also consistent with the rational developed in the literature review. The theory that is presented in the literature review is that smaller firms cooperate more in the new product development process in order to overcome resource constraints. Further validation of this finding by additional research of inter-firm cooperation and firm size is warranted.

The lack of a statistical difference between small and large firms with respect to intra-firm functional specialization is a surprising result given the apparent validation of the theoretical model by measures of correlation between other variables. This study found a correlation coefficient between intra-firm functional specialization and firm size of -0.1109 at a significance level of 0.526. This finding fails to validate the theoretical model or to confirm the deductions that were made based on the literature review. One possible explanation of this inconclusive finding is that the degree of involvement of each function at the new product development project level may not be an accurate measure of intra-firm functional specialization at the firm level. Large firms may be able to support an equal or greater degree of functional involvement at the project level than smaller firms that have fewer human and financial resources regardless of specialization

at the firm level. Further study of methods to measure intra-firm functional specialization and its relationship with firm size is warranted.

Another possibility is that large firms have a normalized degree of intra-firm functional specialization that is similar to that of their smaller counterparts in the Canadian telecommunications industry. If the telecommunications industry is among the largest in the world as stated in the literature review, it may be that all Canadian firms can be considered small with respect to new product development strategy alternatives. A second possibility is that sub-sectors affecting the measurement of relative size exist within the Canadian telecommunications industry. A third explanation may be that large firms have recognized the correlation between intra-firm functional specialization and financial success and have therefore adopted strategies of intra-firm functional specialization for new product development at the project level.

Comparison of Results to those of Other Authors

Zirger and Maidique (1990) sought to differentiate between successful and unsuccessful products in their study of over 330 new products in the electronics industry. Their research indicates that the quality of the research and development organization, the technical performance of the product, the product's value to the customer, the synergy of the new product with the existing competencies of the firm and the level of management support during new product development are factors that influence new product development success.

Zirger and Maidique found a correlation coefficient of 0.36 between the level of management support for a new product development project and technical performance at a 0.001 level of significance. Although this finding is relevant, no significant results that could be compared were found in this study. The correlation coefficient between technical success (TS) and planning/budgeting involvement (α_5) was -0.0493 at a 0.731 level of significance based on 51 responses.

Dougherty's (1992) study of new product development in 5 large firms from the chemicals, communications and computer industries concluded that differences in understanding of technology in each function inhibit new product development success. In Dougherty's study, this is attributed to 'thought world' and 'organizational routines'. Thought worlds are how concepts are understood within a functional area. Organizational routines are how tasks are accomplished in a functional area.

The author's study indicated that successful new product developers are able to overcome these interpretive barriers so that each function contributes to new product development success. Dougherty performed a two-way ANOVA to determine which functions played a more prominent role in new product development success. Dougherty concluded that successful developers emphasize customer issues more and technology and manufacturing issues less.

Dougherty's results imply that involvement of the marketing function (a_5) in new project development projects should be more correlated to new product development success than involvement in engineering (a_2) and manufacturing (a_3) functions. The correlation coefficients between involvement in functional areas and new product development success of this study are shown in table 33.

Table 33: Correlation Coefficients Between Involvement and Success						
	a_1	a_2	a_3	a_4	a_5	a_6
TS	0.2531 (51) P = 0.073	0.2891 (51) P = 0.040	0.1185 (51) P = 0.408	0.1339 (51) P = 0.349	-0.0493 (51) P = 0.731	0.1506 (51) P = 0.291
PS	0.2983 (51) P = 0.033	0.2120 (51) P = 0.135	0.0742 (51) P = 0.605	0.1436 (51) P = 0.315	0.0222 (51) P = 0.877	0.1441 (51) P = 0.313
FS	-0.2719 (25) P = 0.189	-0.0428 (25) P = 0.839	-0.4125 (25) P = 0.040	-0.2517 (25) P = 0.225	-0.3141 (25) P = 0.126	-0.3803 (25) P = 0.061

In comparison to Dougherty's conclusions, the only significant findings are that engineering involvement (a_2) is correlated to technical success, that research and development involvement (a_1) is correlated to perceived success and that manufacturing involvement (a_3) is negatively correlated to financial success.

The relationship between engineering involvement and technical success is easy to rationalize. Simply put, more involvement from engineers results in products that are more technically successful. This is more an indication of the competency of engineers

than anything else. The correlation between research and development and perceived success is more difficult to explain. The relationship may be the result of manager's perception of success being impacted by the application of new technologies to existing markets. Regardless of the explanations, the correlation coefficients between engineering involvement and technical success and research and development and perceived success are not high enough to be of great interest and do not contradict Dougherty's findings or those of this thesis.

The finding that manufacturing involvement is negatively correlated to financial success is consistent with Dougherty's conclusions. In the author's research, unsuccessful new product development projects had a greater degree of involvement of the manufacturing function than successful or uncertain projects. This result contributes to validating the methodology and findings of this thesis.

Parkhe (1993) examined the problems of maintaining inter-firm cooperation by studying 111 inter-firm alliances from the chemicals and allied products industry, the machinery industry, the electrical and electronics industry and the transport equipment industry (using Standard Industrial Classification definitions). The author concluded that a greater focus on structural dimensions and institutional responses to perceived opportunism is needed. Table 34 compares some of Parkhe's findings to those of this thesis.

Table 34: Comparison of Correlation Coefficients to Parkhe's Findings										
Parkhe (1993)				Current Findings						
	freeq. of interac.	sunk costs	firm size	cooperation				sunk costs	firm size	
				C _a	C _b	C _c	C			
fulfill major strategic needs	0.27	0.33	-0.04	0.153	0.080	0.98	0.154	0.009	-0.200	PS
				0.121	0.086	-0.041	0.066	-0.067	-0.051	TS
indirect perform. measures	0.18	0.18	0.18	-0.077	-0.250	0.254	0.020	-0.046	-0.204	FS
corr. > 0.18 are significant at P < 0.05				none of the findings are significant						

The only consistency between Parkhe's findings and those of this thesis, although not significant, is that firm size is negatively correlated to measures of success in both studies. The remaining comparisons are inconclusive. This may be attributable to differences in the operationalization of success (fulfill major strategic needs and indirect performance measures versus TS, FS, and PS). It may also be due to differences between industries used for the two studies. The lack of similarities between the two sets of results does not weaken the arguments of either study.

Eisenhardt and Tabrizi (1995) studied 72 new product development projects from European, Asian and U.S. computer industries. Their findings indicated that using a strategy of multiple design iteration, extensive testing, frequent milestones, strong leadership and cross functional involvement accelerates new product development.

Supplier involvement, computer-aided design and overlapping development were found to only be effective for new product development projects in mature industries.

If new product development time is considered a proxy for new product development success, their findings can be directly compared with those of this study. Eisenhardt and Tabrizi's findings suggest that cross functional involvement should be positively correlated to success and that cooperation should also be positively correlated to success if the Canadian telecommunications industry is considered a mature industry.

As already stated, research and development involvement is positively correlated to perceived success, engineering involvement is positively correlated to technical success and manufacturing involvement is negatively correlated to financial success. The degree of involvement of other functional areas was not found to be significant. Interfirm cooperation was not significantly correlated to new product development success.

With respect to cooperation, the differences between Eisenhardt and Tabrizi's findings and those of this study can be explained by the fact that the Canadian telecommunications industry is a rapidly growing and changing industry that is regulated by the Canadian Radio and Telecommunication Commission (CRTC). This suggests that it does not fit the standard definition of a mature industry.

With respect to functional involvement, there are many possible explanations. One is that new product development time is not as good a proxy for new product development success in the Canadian telecommunications industry as it is in the European, Asian and U.S. computer industries. This may be caused in part by regulatory delays caused by government involvement in the Canadian telecommunications industry. Another possible explanation is that with respect to functional involvement, new product development is simply not a good measure of success. After all, if no functions were involved, the new product development project would never be finished.

Kleinschmidt and Cooper (1995) studied 103 new product development projects from chemical firms in the United Kingdom, Germany, Canada and the United States. The following table compares the relevant results of their study with those of this thesis:

Table 35: Comparison of Correlation Coefficients to Kleinschmidt and Cooper's Findings				
Kleinschmidt and Cooper (1995)		Current Findings		
Variable	Correlation Coefficient with Rated Profitability	Perceived Success	Financial Success	Variable
technological success rating	0.57 P = 0.001	0.5332 P = 0.0005	0.2116 P = 0.310	technical success (TS)
product's sales and profit impact	0.73 P = 0.001	0.4636 P = 0.003	0.3737 P = 0.066	profit margin (s_7)
		0.4164 P = 0.009	0.9185 P = 0.0005	sales growth (s_8)
relative market share	0.25 P = 0.001	0.2468 P = 0.173	0.4587 P = 0.021	market share (s_9)

If rated profitability in Kleinschmidt and Cooper's study is compared to financial success, only the correlation with sales is significant. Although this finding concurs with those of Kleinschmidt and Cooper, it is of little relevance because financial success is derived in part from sales growth.

A more reasonable comparison is to evaluate the similarities between correlation coefficients of rated profitability in Kleinschmidt and Cooper's study and those of perceived success in this thesis. In this respect the findings of the two studies are nearly identical with respect to technical success and are very similar with respect to profit margin and sales growth. Correlation coefficients between market share and perceived success are also similar although not significant in this study. The striking similarities in results provides further evidence that the findings of this study are accurate.

Dyer's (1996) study of supplier networks in the Japanese and U.S. automobile industries examined the relationship between inter-firm asset specificity, a measure of inter-firm cooperation in this study, and performance. Among the author's findings was a positive relationship between asset specificity and return on assets. Dyer concluded that a tightly integrated production network will outperform a loosely integrated production network.

No significant correlation coefficients were found in this study between measures of success (TS, PS, FS) and measures of asset specificity (c_1 , c_2) or with other measures of inter-firm cooperation. The difference in findings has a number of possible explanations.

Firstly, the industries studied are very different. The two differ in that the auto industry is a mature industry dominated by a hand full of large firms while the telecommunications industry may be less mature and more open to new market entrants. It is possible that cooperation plays a much different role in the two industries.

A second possible explanation is the differences in sample selection and units of analysis of the two studies. Dyer chose to study performance at the firm level of large automakers and their related supplier networks. The author's analysis centered around groups of firms rather than individual new product development projects. This difference may indicate that the benefits of inter-firm cooperation do not necessarily manifest themselves at a project level. The benefits of inter-firm cooperation may also be different from those identified in this study in measurements of success. For example, interfirm cooperation may promote market stability and facilitate market forecasting.

Theoretical Model

The theoretical model identified and described the relationships that were hypothesized to exist between intra-firm functional specialization, inter-firm cooperation, new product development success, and firm size for cases of new product development by firms competing in advanced markets.

The relationship between intra-firm functional specialization ($\log F$) and inter-firm cooperation (C) as described in the model was confirmed for the Canadian

telecommunications industry by the collected data. A correlation coefficient of 0.4943 was found between these two variables at a significance level of 0.001. This study has helped identify and define the link between inter-firm cooperation and intra-firm functional specialization.

Results for the relationship between intra-firm functional specialization and new product development success are interesting but not as conclusive as those between intra-firm functional specialization and inter-firm cooperation. Correlation coefficients between intra-firm functional specialization (log F) and new product development success are not significant with the exception of the correlation coefficient of 0.5493 at a significance level of 0.002 between financial success (FS) and intra-firm functional specialization (log F). The results describing the relationship between financial success and intra-firm functional specialization are consistent with the theoretical model, are of value to managers and should not be ignored. The other success results are ambiguous but do not contradict the model.

Correlation coefficients found between inter-firm cooperation (C) and new product development success raises questions on the role of inter-firm cooperation in the theoretical model. Although positively correlated, no significant results were found in this study between inter-firm cooperation and financial success (correlation coefficient: 0.0197, significance: 0.932), perceived success (correlation coefficient: 0.1543, significance: 0.323) or technical success (correlation coefficient: 0.0661, significance:

0.674). This may be caused, as deduced in the literature review of this thesis, by difficulties in overcoming barriers between firms. Another possibility is that, as suggested in comparisons to other author's findings, the benefits of inter-firm cooperation are not found at the new product development project level. For example, interfirm cooperation may promote market stability and facilitate market forecasting. Further research on the role of inter-firm cooperation in advanced markets and on the impact of different inter-firm cooperation strategies is warranted.

The results found for firm size (S) were consistent with the theoretical model and the literature with respect to inter-firm cooperation. Among the firms studied, firm size was negatively correlated to inter-firm cooperation (coefficient of -0.3921, significance of 0.020) suggesting that small firms may indeed cooperate more than large firms in the Canadian telecommunications industry.

Among respondents, firm size was also negatively correlated to intra-firm functional specialization but results are not significant.

Firm size was also negatively correlated to perceived success, technical success, and financial success but again without an acceptable level of significance. Although none of these findings are significant, they are consistent with the literature and suggest that smaller firms in the Canadian telecommunications industry may be more successful than their larger counterparts.

Despite the lack of significance of most of these findings their consistency with each other and the literature suggests that the theoretical model is a valid one. that success is at least partially dependent on intra-firm functional specialization particularly in the case of financial success and that firm size plays a moderating role in the theoretical model.

A simple conclusion that can be drawn based on these empirical findings. It is that in the Canadian telecommunications industry, inter-firm cooperation among firms as measured in this study may be a "necessary evil" that permits or facilitates intra-firm functional specialization which ultimately may lead to greater new product development success.

Cooperation between many small functionally specialized firms may be more difficult to effectively implement than cooperation between many functional departments within one large firm. This may explain the low correlation between inter-firm cooperation and new product development success.

LIMITATIONS

Statistical Limitations

Statistical limitations were introduced to this thesis by the methodology used for data collection. Firstly, since nothing is known about non-respondents and since most respondents chose to remain anonymous, systematic differences between respondents and non-respondents cannot be evaluated. Additionally, because the Canadian telecommunications industry is poorly defined and is vast and dynamic, the entire population of firms may not have been identified in the solicitation of responses. Finally, the sample of firms that chose to respond was considered a random sample. These limitations are difficult to avoid in empirical research.

Correlation analysis assumes that both the dependent and independent variables are normally distributed and that cases are independently and randomly selected. The assumption of independent random selection is required because the population sizes were small. If the population sizes were larger ($n_{1,2} > 25$) this assumption would not be required. Independence of the random samples is necessary for testing the significance of differences in the means of variables. This assumption can be challenged on the basis that all the firms are competing in the Canadian telecommunications industry and that many cooperate with other firms and possibly each other. Despite these points, inter-firm cooperation, intra-firm functional specialization and new product development success are probably independent from one firm to another. Further, the academic validity of a single industry test of hypothesis has already been established in this paper.

The analysis also considers the variance of the two population's variables to be equal and that the variance of the difference between variables to be the sum of their respective variances. This means that a pooled sample variance can be used to estimate their common population variance. The pooled sample variance is the weighted mean of the sample variances. Even though no evidence was found to contradict this assumption, tests were duplicated under the assumption that variances were not equal. This had no impact on results.

Irrespective of the above, meeting the assumptions required for correlation analysis and for t-test of difference of means does not necessarily imply causation. Causation must be confirmed by theoretical reasoning.

Application Limitations

Arguably, similarities between the firms being studied may reduce the generalizability of the study beyond populations and industries that are very similar to that studied.

However, since the unit of analysis is the new product development project and not the firm, individual cases are more varied than the population suggests. Since only one project was studied per firm, the findings should be generalizable to new product development projects in advanced industries that are as diverse as Canadian firms competing in the telecommunications industry.

A second application limitation is the lack of significance and high variance of some of the findings. Although consistent with the theoretical model, some of the results of this study would not necessarily repeat themselves. Further, there may have been some degree of interpretation of the definition of the firm by respondents. This may have resulted in the high variance in responses for firm size. The impact of the high variance was tested by recalculating the findings while omitting the most extreme size responses. This had little impact on findings.

Analytical Limitations

The research intends to be accurate with respect to Canadian firms developing new products for advanced markets. The model being tested is a fairly simple representation of the real world. Therefore, by design, the results are not generalizable to the population of all firms, or even to all firms developing new products. Additionally, the statistical significance of some results is limited. This limitation may be caused by estimation error between the concepts and relationships being estimated and the variables that are being used to measure them. Additionally, because a mail survey was used for data collection some error may have been introduced by respondents interpretation of the data collection instrument. Because this research developed and tested a unique new product development model using empirical data these limitations are difficult to avoid.

BENEFITS

The principal benefit of this study is that it developed and tested a theoretical model using Canadian empirical data. Although the study was not conclusive with respect to whether intra-firm functional specialization and inter-firm cooperation are beneficial new product development strategies for firms operating in the Canadian telecommunications industry, it did provide some valuable insight into the topic and will serve as a guide to future research in this area. This thesis, in its tests of the theoretical model, indicated that small firms in the Canadian telecommunications industry are not significantly different from large firms with respect to inter-firm cooperation, intra-firm functional specialization and new product development success.

Additionally, the study explored the apparent contradiction that exists in the literature between the adoption of intra-firm functional specialization and inter-firm cooperation for new product development success and the generally accepted principles of internal functional integration for new product development success. The study also explored ways of operationalizing variables to measure cooperation and specialization.

Finally, the findings of this study are of value because they are among the few empirical studies of Canadian firms in the new product development field, because they are interesting for managers of new product development processes and because the results can easily be implemented to new product development strategy at the operational level.

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Appendix A: New Product Development Model

Appendix B: Cover Letter and Survey Instrument

Nicholas Trudel, B. Comm.
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K1S 5B6

Dear *ADDRESSEE*

As a recognized expert in the telecommunications industry your knowledge is extremely valuable. In order to apply this knowledge to educating future business leaders I ask your help in completing the short questionnaire attached. The information gathered will be used in a thesis study of new product development in the Canadian telecommunications industry. The aim of the study is to help explain new product development success. Participation in this study is easy. Simply provide responses to the short questionnaire attached based on your most recently completed new product development project. Once the questionnaire has been completed and mailed your participation in the study is complete.

Your anonymity will be protected in the following ways:

- at no time will questionnaire responses be linked to individual respondents;
- once entered into a database, original questionnaires will be destroyed;
- only aggregated findings will be published;
- information regarding the identity of respondents will NOT be recorded in the database or published in any way.

This study is required of me as part of my graduate work at Carleton University which will culminate with a Masters Degree in Management Studies. The findings of my study will be available through Carleton University or myself, the principal investigator. For further information please contact me by mail at my address above or by phone at (613) 236-2252. If you have any concerns or complaints regarding this study please contact me or Professor Vinod Kumar, Ph.D., P. Eng., Director School of Business, tel. (613) 520-2379 or contact the chair of the Carleton University Ethics Committee.

If you are willing to do me the service of participating in my study please complete the attached questionnaire and return it by mail in the prepaid envelope provided.

Thank you, your help is greatly appreciated.
Sincerely,

Nicholas Trudel

The purpose of the following questions is to collect data to measure the relationship between cooperation between your company and other companies, specialization within your company and new product development success. Please provide responses to the following questions based on your most recently completed new product development project for which results are available.

1. Please indicate the extent of involvement of the following departments in your most recently completed new product development project.

	not involved	somewhat involved	involved	very involved	extremely involved
Research and Development:	☐	☐	☐	☐	☐
Engineering/Design:	☐	☐	☐	☐	☐
Production /Manufacturing:	☐	☐	☐	☐	☐
Budgeting/Planning:	☐	☐	☐	☐	☐
Marketing/Advertising:	☐	☐	☐	☐	☐
Sales/Distribution:	☐	☐	☐	☐	☐

2. What was the number of person days of direct contact between your firm and cooperating firms, if any?

(days)

3. What were the unrecoverable sunk costs of this new product development project, if any, that were directly attributable to cooperation with other firms?

_____\$
(thousands)

4. What was the intended duration of cooperation between your firm and other cooperating firms?

none	initial stages	occasional	life of the project
☐	☐	☐	☐

5. To what extent did your firm share confidential information with other cooperating firms?

no sharing	little sharing	moderate sharing	intense sharing
☐	☐	☐	☐

6. To what extent did you receive assistance from other cooperating firms to reduce product costs?

no assistance	moderate assistance	ample assistance	extensive assistance
☐	☐	☐	☐

7. To what extent did you receive assistance from other cooperating firms to increase product quality?

no assistance	moderate assistance	ample assistance	extensive assistance
☐	☐	☐	☐

8. How would you characterize the extent to which your firm cooperated with other firms in developing this new product?

no cooperation	moderate cooperation	ample cooperation	extensive cooperation
☐	☐	☐	☐

9. How satisfied were you with this new product development project relative to your expectations?

not satisfied	somewhat satisfied	satisfied	highly satisfied
☐	☐	☐	☐

10. How would you characterize the sales of your new product relative to your expectations?

not satisfied	somewhat satisfied	satisfied	highly satisfied
☐	☐	☐	☐

11. How would you characterize the reputation of your new product relative to your expectations?

not satisfied	somewhat satisfied	satisfied	highly satisfied
☐	☐	☐	☐

12. How would you characterize the overall quality of your new product relative to your expectations?

not satisfied	somewhat satisfied	satisfied	highly satisfied
☐	☐	☐	☐

13. How would you characterize the technical performance of your new product relative to your expectations?

not satisfied	somewhat satisfied	satisfied	highly satisfied
☐	☐	☐	☐

14. How would you characterize the technical design specifications of your new product relative to your expectations?

not satisfied	somewhat satisfied	satisfied	highly satisfied
☐	☐	☐	☐

15. What is the gross profit (loss) margin of your new product? _____%
(indicate if loss)

16. What was the annual rate of sales growth (decline) of your new product over the last fiscal year? _____%
(indicate if decl.)

17. What percentage of market share did your new product capture? _____%

18. How many employees were in your company at the time of completion of the new product? _____

19. What was the value of your companies' assets at the end of the last fiscal year? _____\$
(millions)

20. What were the total sales of your firm for the last fiscal year? _____\$
(millions)

If you would like a summary of the findings of this research please complete the following:

Company name : _____

Contact : _____

Address : _____ E-mail : _____

Telephone : _____ Fax : _____

Thank you for your participation! Please return by mail in the prepaid envelope provided.

Appendix C: Subjective Measures of Success

Geringer & Herbert (1991) used manager's responses to subjective scale measures of the following variables:

Managers Satisfaction

Managers Perception of Success

Sales

Market Share

Profitability

Cost Control

Management

Technological Development

Product Design

Manufacturing/Quality Control

Labor Productivity

Marketing

Distribution

Reputation

Customer Service

Overall Performance

Appendix D: Summary of Survey Instrument Measures

No.	Question	Variable	Measure
Measures of intra-firm functional specialization			
1.	Please indicate the extent of involvement of the following departments in your most recently completed new product development project.	a _n involvement	0-4 scale
Measures of inter-firm cooperation			
2.	What was the number of person days of direct contact with cooperating firms for your most recently completed new product development project?	c ₁ person/days	# of days
3.	What were the unrecoverable sunk costs of this NPD project that were directly associated to cooperating with other firms?	c ₂ sunk costs	dollars
4.	What was the intended duration of cooperation between your firm and other cooperating firms in your most recently completed new product development project ?	c ₃ intended duration	1-4 scale
5.	To what extent did your firm share confidential information with other firms that cooperated in the development of your most recently completed new product?	c ₄ information sharing	1-4 scale
6.	To what extent did you receive assistance from other to reduce the costs of your most recently completed new product?	c ₅ assistance - cost	1-4 scale
7.	To what extent did you receive assistance from other to increase the quality of your most recently completed new product?	c ₆ assistance - quality	1-4 scale
8.	How would you characterize the extent to which your firm cooperated with other firms in the development of your most recently completed new product?	c ₇ perceived cooperation	1-4 scale
Measures of Perceived Success (PS)			
9.	How satisfied were you with your most recently completed new product development project relative to your expectations?	s ₁ satisfaction	1-4 scale
10.	How would you characterize the sales of your most recently completed new product have been relative to your expectations?	s ₂ product sales	1-4 scale

No.	Question	Variable	Measure
11.	How would you characterize the reputation of your most recently completed new product relative to your expectations?	s ₃ product reputation	1-4 scale
Measures of Technical Success (TS)			
12.	How would you characterize the overall quality of your most recently completed new product relative to your expectations?	s ₄ product quality	1-4 scale
13.	How would you characterize the technical performance of your most recently completed new product relative to your expectations?	s ₅ technical performance	1-4 scale
14.	How would you characterize the technical design specifications of your most recently completed new product relative to your expectations?	s ₆ technical design	1-4 scale
Measures of Financial Success (FS)			
15.	What is the gross profit/loss margin of your most recently completed new product?	s ₇ profit margin	percent
16.	What is the annual rate of sales growth of your most recently completed new product over the last fiscal year?	s ₈ growth rate	percent
17.	What percentage of the market share did your most recently completed new product capture?	s ₉ market share	percent
Measures of firm size			
18.	How many employees were in your company upon completion of most recently completed new product?	h ₁ number of employees	# employed
19.	What was the value of your company's assets at the end of the last fiscal year?	h ₂ assets	dollars
20.	What were the total sales of your firm for the last fiscal year?	total sales	dollars

Appendix E: Histograms, Kurtosis and Skewness of Key Variables

The following histograms of data distributions were produced using SPSS software:

Histogram of financial success (FS)

Kurtosis = -0.718, Skewness = 0.544

The above distribution is slightly platykurtic and slightly positively skewed. These deviations from normality were not considered a violation of the required assumptions.

Histogram of cooperation (C)

Kurtosis = -1.213, Skewness = 0.503

The above distribution is slightly platykurtic and positively skewed. These deviations from normality were not considered a violation of the required assumptions.

Appendix F: Summary of All Variables

The following table contains SPSS output summarizing data for all variables.

Variable	mean	std. dev.	kurt.	S.E. kurt	skew.	S.E. skew	min.	max.	valid obs.
INTRA-FIRM FUNCTIONAL SPECIALIZATION									
a_1	3.510	0.857	5.571	0.656	-2.212	0.333	0.00	4.00	51
a_2	3.294	1.064	3.741	0.656	-1.975	0.333	0.00	4.00	51
a_3	2.059	1.377	-1.178	0.656	-0.396	0.333	0.00	4.00	51
a_4	2.137	1.386	-1.126	0.656	-0.162	0.333	0.00	4.00	51
a_5	1.784	1.301	-0.934	0.656	0.078	0.333	0.00	4.00	51
a_6	1.647	1.278	-1.073	0.656	0.226	0.333	0.00	4.00	51
F	0.683	0.420	3.335	0.656	1.966	0.333	0.31	2.00	51
$\sqrt{F}$	0.798	0.218	1.752	0.656	1.534	0.333	0.55	1.41	51
log F	-0.514	0.481	0.506	0.656	1.079	0.333	-1.19	0.69	51
INTER-FIRM COOPERATION									
c_1	70.196	153.492	27.554	0.656	4.788	0.333	0.00	1000	51
log c_1	1.045	0.969	-1.529	0.656	0.125	0.333	0.00	3.00	51
$\sqrt{c_1}$	5.421	6.452	4.067	0.656	1.647	0.333	0.00	31.62	51
c_2	87.382	213.074	12.493	0.656	3.486	0.333	0.00	1000	51
log c_2	.927	0.995	-1.049	0.656	0.566	0.333	0.00	3.00	51
$\sqrt{c_2}$	5.304	7.774	3.925	0.656	1.999	0.333	0.00	31.62	51
c_3	2.529	1.286	-1.708	0.656	-0.156	0.333	1.00	4.00	51
c_4	2.314	1.241	-1.600	0.656	0.218	0.333	1.00	4.00	51
c_5	2.039	1.166	-1.002	0.656	0.710	0.333	1.00	4.00	51
c_6	1.922	1.074	-0.780	0.656	0.766	0.333	1.00	4.00	51
c_7	2.118	1.177	-1.255	0.656	0.529	0.333	1.00	4.00	51
CA	.295	0.379	2.942	0.702	1.607	0.357	0.00	1.54	44
CB	.239	0.355	5.205	0.702	2.137	0.357	0.00	1.54	44
CC	2.184	1.084	-1.472	0.656	0.209	0.333	1.00	4.00	51
C	2.593	1.683	-1.213	0.709	0.503	0.361	1.00	6.08	43

Variable	mean	std. dev.	kurt.	S.E. kurt	skew.	S.E. skew	min.	max.	valid obs.
FIRM SIZE									
h_1	1710.130	8840.130	44.793	0.688	6.656	0.350	10.00	60000	46
$\sqrt{h_1}$	18.838	37.22	31.54	0.688	5.299	3.50	3.16	244.95	46
$\log h_1$	2.027	0.792	2.296	0.688	1.356	0.350	1.00	4.78	46
h_2	6325.789	22907.117	14.561	0.750	3.914	0.383	2.00	100000	38
$\sqrt{h_2}$	31.850	73.857	11.157	0.750	3.431	0.383	1.41	316.23	38
$\log h_2$	2.062	1.068	2.026	0.750	1.262	0.383	0.30	5.00	38
Size S	4.008	1.619	2.257	0.778	1.345	0.398	1.41	8.70	35
NEW PRODUCT DEVELOPMENT SUCCESS									
s_1	3.196	0.693	0.775	0.656	-0.657	0.333	1.00	4.00	51
s_2	3.147	0.896	-0.085	0.656	-0.832	0.333	1.00	4.00	51
s_3	3.196	0.749	0.078	0.656	-0.638	0.333	1.00	4.00	51
PS	3.180	0.677	0.792	0.656	-0.796	0.333	1.00	4.00	51
s_4	3.176	0.740	0.124	0.656	-0.605	0.333	1.00	4.00	51
s_5	3.255	0.796	0.797	0.656	-0.993	0.333	1.00	4.00	51
s_6	3.314	0.583	-0.563	0.656	-0.164	0.333	2.00	4.00	51
TS	3.248	0.603	0.048	0.656	-0.636	0.333	1.67	4.00	51
s_7	44.4%	37.9%	5.815	0.741	-0.986	0.378	-100%	200%	39
s_8	71.2%	68.5%	-0.348	0.750	0.847	0.383	0%	200%	38
s_9	27.4%	25.2%	0.608	0.809	1.255	0.414	0%	100%	32
FS	47.1%	27.5%	-0.718	0.902	0.544	0.464	10%	100%	25

Appendix G: P-P Plots of c_1 and $\log c_1$

Appendix H: P-P Plots of c_2 and $\log c_2$

Appendix I: P-P Plots of h_1 and $\log h_1$

Appendix J: P-P Plots of h_2 and $\log h_2$

Appendix K: Summary of Correlations Between Key Variables

Correlation Matrix of Key Variables									
	C _a	C _b	C _c	C	F	S	TS	PS	FS
log F	0.3624 (44) P=0.016	0.2784 (44) P= 0.067	0.5340 (51) P= 0.000	0.4943 (43) P= 0.001	0.9674 (51) P= 0.000	-0.1235 (35) P= 0.480	0.1857 (51) P= 0.192	0.2670 (51) P= 0.058	0.5943 (25) P= 0.002
C _a	1.0000 (44) P= *	0.8744 (43) P= 0.000	0.7421 (44) P= 0.000	0.9180 (43) P= 0.000	0.3218 (44) P= 0.033	-0.5326 (35) P= 0.001	0.1214 (44) P= 0.432	0.1531 (44) P= 0.321	-0.0767 (21) P= 0.741
C _b		1.0000 (44) P= *	0.6336 (44) P= 0.000	0.8193 (43) P= 0.000	0.2227 (44) P= 0.146	-0.3679 (35) P= 0.030	0.0859 (44) P= 0.579	0.0797 (44) P= 0.607	-0.2499 (22) P= 0.262
C _c			1.0000 (51) P= *	0.9576 (43) P= 0.000	0.5023 (51) P= 0.000	-0.2899 (35) P= 0.091	-0.0408 (51) P= 0.776	0.0983 (51) P= 0.492	0.2544 (25) P= 0.220
C				1.0000 (43) P= *	0.4398 (43) P= 0.003	-0.3921 (35) P= 0.020	0.0661 (43) P= 0.674	0.1543 (43) P= 0.323	0.0197 (21) P= 0.932
F					1.0000 (51) P= *	-0.1109 (35) P= 0.526	0.1295 (51) P= 0.365	0.2418 (51) P= 0.087	0.6226 (25) P= 0.001
S						1.0000 (35) P= *	-0.0509 (35) P= 0.772	-0.2000 (35) P= 0.249	-0.2035 (19) P= 0.403
TS							1.0000 (51) P= *	0.5332 (51) P= 0.000	0.2116 (25) P= 0.310
PS								1.0000 (51) P= *	0.5511 (25) P= 0.004
FS									1.0000 (25) P= *

(Coefficient / (Cases) / 2-tailed Significance)

" * " is printed if a coefficient cannot be computed

Appendix L: P-P Plots of Key Variables for Hypothesis Testing

Normal P-P Plot of intra-firm functional specialization (F)

Normal P-P Plot of Log F

Normal P-P Plot of technical success (TS)

Normal P-P Plot of perceived success (PS)

Normal P-P Plot of financial success (FS)

Appendix M: Linear Regression Results

Linear Regression Results					
Firm Size	Independent Variables	Dependent Variables	F	Significance of F	R ²
All Firms	Inter-firm Cooperation (C) and Firm Size (S)	FS	0.34775	0.7115	0.04166
		PS	0.75121	0.4799	0.04485
		TS	0.11674	0.8902	0.00724
Large Firms		FS	8.21937	0.0606	0.84567
		PS	3.23703	0.0873	0.41838
		TS	0.47683	0.6356	0.09581
Small Firms		FS	0.26830	0.7695	0.04651
		PS	1.96351	0.1665	0.16412
		TS	1.21794	0.3169	0.10857

IMAGE EVALUATION TEST TARGET (QA-3)

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