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Strategic management of inter-firm technological cooperation: an empirical study of high-tech small and medium-sized enterprises in China

Chen, Dan

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Strategic Management of Inter-firm Technological Cooperation: An Empirical Study of High-tech Small and Medium-sized Enterprises in China

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Dan Chen (B.A. and M.A. in Economics)

Bangor Business School

University of Wales, Bangor

UK

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DEDICATION

This work is dedicated to my husband Shanqing and my son Zheng for their unconditional support and love over the past few years.

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ABSTRACT

The objective of this study is to investigate inter-firm technological cooperation through the theoretical lenses of transaction cost, competitive forces, and the resource-based view of the firm. High-tech small and medium-sized enterprises (SMEs) are targeted for examinations as to why high-tech SMEs initiate cooperation with other firms, how they cooperate with each other, what is the impact on innovation, and what are the critical factors for successful cooperation. This study is based on a comprehensive questionnaire and semi-structured interviews with CEOs or senor managers in SMEs in China. Sample firms are randomly selected from three national high-tech industrial development zones. To control for exogenous industrial variance, sample firms are confined within the information and communications industry that is the fast growing and main export industry in China.

The study concludes that successful cooperative practices do improve firms' economic performance, which meets primary motives for engaging in cooperation in the first place. However, cooperation does not have significant impact on innovation in smaller firms. High-tech SMEs are primarily motivated to cooperate for new market access, economies of scale or scope, technology transfer, and learning from partners. High-tech SMEs cooperate mainly by means of customer-supplier R&D contracts, joint R&D agreements, and joint ventures. The larger a firm's size is, the more likely the firm engages in cooperation for technology transfer and learning, and the more likely the firm cooperates with partnering firms by joint ventures. Firm size is the only influential factor on propensity of firms to cooperate. Resource complementarity, communication and reciprocity based trust, and contributing as promised are considered the fundamental success factors by all surveyed firms. Firms that are successful in their cooperative practices put more emphasis on 'trust, communication and reciprocity' than firms that are not yet.

The findings implicate that compared to their larger counterparts high-tech SMEs have distinctive motives for cooperation which are determined by their resource-constrained nature and their particular growth strategy. Managers should consider these factors in formulating an effective cooperation strategy. Simple involvement in inter-firm cooperation does not guarantee improvement in innovation, and only successful cooperative activities make a difference.

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Chapter One: Introduction

This thesis is an empirical study of inter-firm technological cooperation in high technology small and medium-sized enterprises (SMEs) in China. The study explores how high-tech SMEs cooperate with partner firms for the sake of technological innovation. The empirical investigation in China's high-tech SMEs was conducted to test proposed hypotheses and address derivative research questions. The objective is to contribute both to business management and policy-makers' decision-making, and also to academic research by providing new insight into the bases of inter-firm cooperative activities intended to increase innovation.

1.1 Background of the Study

While resourced-based firms have their core capabilities, it is impossible for a small firm to house all the resources necessary for product innovation. SMEs are resource constrained to a higher extent compared with their larger counterparts. It is argued that cooperating with partner firms can bring SMEs the competitive force which a small firm can never achieve by itself. Studies of inter-firm cooperation have been well documented among large firms, especially multinational companies. However, far less attention has been paid to SMEs. The role of high-tech SMEs has attracted researchers' attention in recent decades, and theoretical and empirical studies in this field have become more popular than ever before. This study aims to bridge the gap between high-tech SMEs' cooperative practices and theoretical explanations to and effective strategic management of this phenomenon.

1.1.1 High-tech SMEs' Technological Cooperation

This study focuses on the phenomenon of technological cooperation in high-tech SMEs. Due to size limitations, SMEs often do not house the resources to carry out desired product innovation. Recourse to external resources to develop new products seems to have become a requisite solution for many SMEs. According to Audretsch (2001), the paradox that high degrees of innovative activity combine with relatively low levels of research suggests that small firms rely on external sources of knowledge.

Previous studies (Hergert and Morris, 1988; Smith et al., 1991; Leverick and Littler, 1993; Barley et al., 1992) document that the most frequent motivation for alliance formation is the development of new technologies. Teubal et al. (1991) argue that the network approach to innovation enables us to supersede the methodological individualism of Schumpeter's 'heroic' entrepreneur. Their study stresses that in addition to the entrepreneur and the initial innovation, and beyond bilateral supplier-user relationships, networks are a required form to ensure the success of an innovation. As noted by Audretsch (2001), many small biotechnology firms have successfully commercialised their new technology by allying with big pharmaceutical companies. In recent decades, various forms of collaboration, such as sub-contracting, licensing, joint venture, strategic alliance, research consortia and regional clusters have been prevalent among firms seeking innovation, particularly in high-tech sectors.

1.1.2 Technological Cooperation for Product Innovation

Technological cooperation for product innovation is the target area of this study. According to OECD (1997), technological innovation refers to technological product innovation and technological process innovation. Hoffman et al. (1998) state that across industrial sectors, SMEs tend to exhibit broadly similar characteristics in their innovative activities. One of the common features is that SMEs are more likely to engage in product innovation than process innovation. Stalk and Hout (1990) stress that in industries populated by entrepreneurial high-tech firms a primary determinant of enterprise success is the rate of new product development. Schoonhoven et al. (1990) further argue that the ability to rapidly develop new products and bring them to market is important in order to gain cash flow, market share, external visibility and legitimacy as soon as possible, and to increase the likelihood of survival. Moreover, the faster a firm develops new products and brings them onto the market, the more likely it is to capture first-mover advantages.

1.1.3 High-tech SMEs in China

This empirical study investigates inter-firm cooperative phenomena in China's high-tech SMEs. Before the 1980s, technological innovation in China was mostly initiated by the government, and conducted by research institutes, universities and state-owned large enterprises. With the transition of the economic system from the early 1980s, China's national innovation system has been transformed into a market-oriented economy, and major players in technological innovation have gradually transferred to business firms. High-tech SMEs have emerged since then and the number of firms has increased dramatically as has the number of employees and value added to GDP. By 2004, there were 120,000 technology-based SMEs with 9,600,000 employees in China. As a small proportion of overall SMEs, technology-based SMEs create 65% of patented inventions, 75% of technological innovations, and 80% of new product developments. Arguably, technology-based SMEs have played a significant role in technological innovation. Prior empirical studies (e.g. Gomes-Casseres, 1996 and 1997; Audretsch, 2001) have reported that high-tech SMEs have resorted to cooperative strategy in a major way. The current study, undertaking a comprehensive investigation and analysis on the phenomenon of high-tech SMEs' technological cooperation, aims to address the foremost challenging management issues.

1.2 Rationale of the Study

From October 2002 to October 2003, the researcher undertook a one-year visiting research project at the University of Reading in England. This period of time gave the researcher a chance to learn common practices in business research in the UK. The researcher found that research projects and units focusing on entrepreneurship, SMEs and technology innovation were widespread and productive in universities. More importantly, there were many dedicated researchers in this field. This encouraging picture inspired the researcher to carry out a doctoral research in this country. For this, the researcher greatly appreciates the opportunity provided by the University of Wales, Bangor which offered the researcher a studentship to fulfil her ambition of further investigating this field.

The researcher's personal interest in SMEs and their innovation activities began in the late 1990s when entrepreneurial start-ups, high-tech innovative SMEs were booming in China. To create a favourable environment for SME growth, numbers of high-tech development zones and science parks have been built across Mainland China. High-tech SMEs in the 21st century became a leading force in China's economic growth and exports, and greatly contribute to employment creation and especially product innovation. Meanwhile, it was found that high-tech SME innovation is faced with various difficulties due to its resource-constrained nature. To tackle resource constraints, many entrepreneurs in high-tech SMEs implement inter-firm cooperation strategies aimed at bringing their innovative products to market in competitive time frames. Cooperation for technological innovation has been a major strategy in high-tech firms. However, a variety of technological, business and relational factors prevent high-tech SMEs from cooperating successfully. The literature (e.g. Hagedoorn, 2002) on strategic alliances has shown that large companies, especially multinational companies collaborate with partner firms globally to enhance their global competitiveness. However, little attention has been paid to SMEs. The significance of cooperation strategy and the problems arising from SMEs' cooperation practices prompted me to undertake an investigation into this phenomenon theoretically and empirically. This study proposes to give fresh insight into the emerging theory of strategic alliance and the management effectiveness of strategic alliances in high-tech SMEs. This research project is also an expression of the researcher's personal gratitude towards her country and its dedicated entrepreneurs.

1.3 Research Questions and Objectives

This study will address the following five questions:

- What are the primary motives for high-tech SMEs engaging in inter-firm technological cooperation? Are firm age and firm size correlated with these primary motives?
- What are the main modes of cooperation preferred by high-tech SMEs? Are firm age and firm size correlated with these main modes?
- Do resource capabilities influence the propensity of high-tech SMEs to cooperate?
- Does inter-firm technological cooperation influence a firm's innovation performance?
- What are the critical success factors in inter-firm technological cooperation?

The objectives of the study are:

- To investigate the primary motives which lead to high-tech SMEs involvement in inter-firm technological cooperation and to examine the dynamics of motives for cooperation with the change of firm age and firm size.
- To investigate the main modes of cooperation which high-tech SMEs prefer and to examine the dynamics of modes with the change of firm age and firm size.
- To identify the determinants of firms' propensity to cooperate.
- To examine whether and how inter-firm technological cooperation enhances SMEs' innovation.
- To identify the discriminating factors between firms that cooperate and firms that do not and between firms that are successful in cooperating practices and firms that are not.

The overall objectives of this study are to provide insights into the academic research in strategic management of inter-firm cooperation, and provide business managers with suggestions for helping them improve their inter-firm cooperative practices.

1.4 Methodology

The context of this empirical study is high-tech SMEs in the information and communication technology industries in China. The reason for choosing these industries is that their technologies have been evolving dramatically, thereby creating opportunities for new ventures and innovation. As noted by Rothwell (1991), new technologies open up many new opportunities for SMEs. The literature (see e.g. Tether and Store, 1998; Tidd et al., 2001) documents that SMEs constitute a large proportion of these technology sectors. In China, SMEs account for a large portion of value added in high-tech industries. In 2003, SMEs contribute 58.9% of total value added of high- tech industries. Of all high-tech industries, SMEs account for 55.6% in the electronic and telecommunications equipment industry, and 39.2% in the computers and office equipments industry (National Bureau of Statistics of China et al., 2004). Many entrepreneurial firms are spin offs from universities, research institutions and public laboratories. The founders are experts in science, engineering and management. These people and these firms are among the most active innovators in China.

Methods employed to collect data are a combination of questionnaire, interview and secondary data sources. Secondary data is mainly from official publications. For example, the National Bureau of Statistics of China publishes the *China Statistical Yearbook* annually, which provides the data with the most comprehensive coverage of industries. In addition, the National Bureau of Statistics of China, the National Development and Reform Commission, and the Ministry of Science and Technology of China have started to publish the *China Statistics Yearbook on High Technology*

Industry annually in recent years, which provide the most detailed data of high-tech industries. However, the secondary data are inadequate to achieve the proposed research objectives. A set of broader and more in-depth data, both quantitative and qualitative, is required. Therefore, a postal questionnaire and semi-structured interviews are used as the main data sources. To ensure the survey is cost efficient and practical, a pilot study was undertaken in advance.

To collect data by questionnaire, three national high-tech development zones in Shandong province of China are selected. The study "population" refers to all SMEs in the information and communication technology industry in the selected high-tech development zones. The sample firms are subjected to SME classification standards issued by the State Economic and Trade Commission of China et al. (2003). Face-to-face interviews with CEOs or senior managers responsible for R&D were conducted. The interview method supplements the questionnaires, and more importantly, provides background or embedded information which other methods do not access.

Based on collected data, research variables are defined and measured for testing proposed hypotheses and addressing research questions. Statistical analyses are conducted by using SPSS. The employed analysis methods include descriptive analysis, Pearson correlation analysis, independent-samples t test, binary logistic regression and multiple regression models.

1.5 Structure of the Thesis

This thesis is organised into eight chapters. Chapter One is an introduction to the current study, and chapter Eight contains the conclusions of the entire study. Chapter Two through to Chapter Seven contain the main body of research, including the literature review of theoretical and empirical studies, the conceptual framework of the current study, methodologies and research design, data analyses, and discussion.

Chapter One introduces the background of this study, the rationale for the study, research questions and objectives, methodologies, and the structure of the thesis.

Chapter Two provides a critical review of theories in relation to inter-firm technological cooperation. This chapter discusses the rationale for firms engaging in cooperation from the perspectives of competitive forces, transaction cost, and resource-based theory. It also reveals the nature of technology change cycle, the impacts on and the implications for technology strategies of high-tech SMEs, and presents an introduction to technological innovation. The review of theoretical studies establishes the basis and direction of the current empirical research.

Chapter Three reviews other research on motives for engaging in inter-firm technological cooperation, the modes of cooperation, the determinants of a firm's propensity to cooperate, the impact of cooperation on a firm's innovation, and critical success factors for inter-firm cooperative relationships. Gaps and inconsistencies in explaining the phenomenon of cooperation are examined, and the purpose and direction of conducting the current study is consolidated.

Chapter Four provides an introduction to high-tech SMEs in China. Information and communications technology sectors from which the sample firms of this study are derived are specified. Consequently, the chapter builds up a research framework by proposing research questions and hypotheses.

Chapter Five presents research design and methodology in detail. The chapter states the research strategy, presents the postal questionnaire for this study, describes the sample design for data collection, and defines research variables and their measurements used for data analysis in the following chapter.

Chapter Six presents the entire process of data analysis and hypothesis testing. The chapter provides a profile of respondents and surveyed firms, investigates primary motives for high-tech SMEs initiating cooperation and the main modes of their cooperative activities, and it also examines the relationship of primary motives and main modes with firm age and firm size. Furthermore, the chapter presents the statistical analysis of what make a difference in a firm's propensity to cooperate, and how cooperation impacts on firms' innovation performance. Finally the chapter analyses critical success factors in inter-firm technological cooperation.

Chapter Seven discusses the results of data analyses and interprets implications of research results. The chapter describes the five research questions in five separate sections respectively. The results of this study are compared with results of prior studies. While consistent results are confirmed, inconsistent results are highlighted in an attempt to provide new insights into cooperation theory and cooperation management.

Chapter Eight concludes the whole study by presenting findings, implications for theory and practice, limitations of the study, and suggestions for future research.

1.6 Summary

This chapter is an introduction to the whole thesis. The chapter introduces the background and the rationale of the study. The personal motivation for conducting this study is addressed to declare the researcher's commitment to this research work. The chapter also outlines the research questions, objectives and methodologies, and presents the structure of the thesis.

Chapter Two: Theoretical Perspectives on Strategic Management in Inter-firm Technological Cooperation

This chapter provides a critical review of theories in relation to inter-firm technological cooperation to establish the direction of the current empirical research. The chapter is divided into four sections. The first section discusses the rationale for firms engaging in cooperation from the perspectives of competitive forces, transaction cost, and resource-based theory. The subsequent section reveals the nature of technology change cycles, the impact of technological discontinuities on a firm's competence, technological paradigms and trajectories, and their implications for technology strategies of high-tech SMEs. The third section introduces the concept of technological innovation, the sources of a firm's technological innovation, and the measurements of the output of innovation and the impact of innovation on a firm's performance. The fourth section provides a summary of discussion in this chapter.

2.1 Overview of Strategic Management Theories in Relation to Inter-firm Technological Cooperation

Three theoretical approaches are relevant in explaining motivations for inter-firm cooperation. One approach focuses on competitive forces developed by Porter (1980) in which strategic motivation is driven by maximizing profits through improving a firm's competitive position vis-à-vis rivals. The second approach is derived from the theory of transaction cost developed by Williamson (1975, 1985) where arguments are driven by cost-minimization considerations. The last approach is derived from resource theory which calls for exploiting existing internal resources and building resource capabilities through organizational learning. Though these three theories differ, they are considered complementary rather than as alternatives. As prior studies (e.g. Kogut, 1988; Sachwald, 1998) suggest, the analysis of cooperative relationships should be a combination of competitive forces, transaction cost, and resource-based perspectives.

2.1.1 Competitive Forces

During the 1980s, the dominant paradigm in the study of strategy was based on competitive forces. Porter (1980) develops five industry-level forces, which are, threat of new entrants, threat of substitute products or services, bargaining power of buyers and suppliers, and rivalry among existing firms. The competitive forces approach views the essence of competitive strategy formulation as "relating a company to its environment…the key aspect of the firm's environment is the industry or industries in which it competes. Industry structure strongly influences the competitive rules of game as well as the strategies potentially available to firms" (Porter, 1980, p.3). The ability for a firm to gain competitive advantage, according to Porter (1980, 1985, 1986), rests mainly on how well it positions and differentiates itself in an industry. The collective effects of the five forces determine the ability of firms in an industry to make profits.

According to Teece (1984), economic rents in a competitive forces framework are monopoly based. Firms earn rents when they are somehow able to impede competitive forces in either factor markets or product markets. Competitive strategies aim at altering a firm's position in the industry vis-à-vis competitors and suppliers. Industry structure plays a central role in determining and limiting strategic action. The perspective of strategic behaviour is developed from competitive forces theory. From the view of strategic behaviour, Kogut (1988) explains that reasons for firms building joint ventures range from tying downstream distributors to depriving competitors of raw materials and to stabilizing oligopolistic competition. Sachwald (1998) notes that R&D cooperation may be used to build or reinforce barriers. This could be the case in the field of standards or if firms resort to alliances in order to develop 'technological oligopolies'. Vickers (1985) posits that joint ventures in research can be a way to deter entry through pre-emptive patenting. Especially for small innovations, as Vickers (1985) suggests, a joint venture is an effective mechanism to guarantee an entry-deterring investment. More generally, Vernon (1983) sees joint ventures as a form of defensive investment by which firms hedge against strategic uncertainty.

Sachwald (1998) also points out that firms widely resort to cooperative agreements as a means to lower entry or mobility barriers. For example, in the case of innovation, the resource barrier is often considered to be the cost of R&D, and average cost is increased by risks of failure. Besides, first mover advantages imply that short innovation and development cycles are fundamental assets in the competitive game. Inter-firm cooperation is often used to circumvent barriers to entry. DeBresson and Amesse (1991) declare that belonging to a network not only reduces the cost of information, but also avoids being subject to subsequent exclusion and entry barriers. Furthermore, belonging to a network reduces entry cost while minimizing exit costs by limiting internal irreversible sunk investments. The case study by Bresnahan and Salop (1986) examines the cooperation between Toyota and GM, explores the motivations of each partner and assesses the results of the venture. They generally conclude that the cooperative agreement has been instrumental in assuring a stronger entry of Toyota in the American market, and thus to an increase in competition.

Eisenhardt and Schoonhoven (1996) examine alliance formation from a strategic behaviour perspective and conclude that firms in vulnerable strategic positions (i.e. emergent markets, innovative technologies, and high competition) are more likely to form alliances. In the same vein, Hagedoorn et al. (2000) see collaboration as a means of shaping competition by improving a firm's comparative competitive position. They explain that coalitions involve coordinating or sharing value chains with partners that broaden the effective scope of the firm's own activities. By using coalitions, a firm can benefit from a broader scope of activities without spending precious resources to enter new market segments. Inter-firm technical collaboration permits firms to react swiftly to market needs and allows them to bring technology to the marketplace faster.

As noted by Teece et al. (1997), competitive forces theory recognizes economic scale as firm-specific assets that establish differences among firms. From this view, Gomes-Casseres (1997) explains why small firms are motivated to enter strategic alliances. In a context with high economies of scale, larger players dominate the market and size bestows a competitive advantage. To compensate for this size-inherent cost disadvantage, small firms then have a clear incentive to engage in a strategic alliance to effectively increase their scale and scope. Sachwald (1998) points out the technical potential for economies of scale or economies of scope does not imply that a single firm should undertake the total amount of production necessary to exhaust these economies. Cooperation agreements could be an efficient solution. In the case studies of the Aluminium industry, Stuckey (1983) finds joint ventures enable firms to share intermediate inputs, such as bauxite or alumina, without supporting the full cost for acquiring all the necessary assets. The choice of joint ventures is a result of consideration on economies of scale or economies of scope. Joint production allows both partners to reach lower unit costs and only support part of the necessary initial investment.

Smith et al. (1991) state that small/large firm collaboration can reduce inequalities between the smaller and larger firms. Furthermore this inter-firm collaboration can change market structures as small firms are able to operate effectively in large firm arenas through their relationships with larger partners. Technological expertise, coupled with increased resources through collaboration, also allows smaller firms to compete directly with larger firms. A consequence of inter-firm collaboration is, therefore, that competition is taking on a more organized pattern in which firms of different sizes are integrated into coherent networks.

Kogut (1988) stresses that though transaction cost and strategic behaviour theories share several commonalities, they differ fundamentally in the objectives attributed to firms. Two important differences in the implications of transaction cost and strategic behaviour analysis are in the motives for cooperation and in the selection of partners. "Transaction costs theory posits that firms transact by the mode which minimizes the sum of production and transaction costs. Strategic behaviour posits that firms transact by the mode which maximizes profits through improving a firm's competitive position vis-à-vis rivals" (Kogut, 1988, p.322). Whereas transaction costs theory predicts that the matching of partnership should reflect minimizing costs, the strategic behaviour perspective predicts that the partners should be chosen to improve the competitive positioning of the parties. Kogut (1988) warns that the common confusion is in treating the two theories as substitutes for one another rather than as complementary.

2.1.2 Transaction Costs

Coase (1937) and Williamson (1975, 1985) formulate the transaction cost economics which seek to explain why organizations exist. The basic premise of transaction costs is that markets and hierarchies are alternative governance mechanisms for completing transactions. In the transaction cost framework, the unit of analysis is the firm-level dyadic transaction, wherein minimization of transaction costs is the efficient outcome. Entrepreneurs try different ways to organize a transaction, including arm's length markets and market displacements through internalisation or mergers & acquisitions (M&As). The primary goal of this theory is to know whether a firm should 'make or buy' a good or a service, which depends on two kinds of costs: production costs and transaction costs. According to Kogut (1988) and Das and Teng (2000), production costs come from coordinating activities in-house, in terms of organizing and managing production. For example, learning, proprietary knowledge, and economies of scale and scope will make a difference between firms in their production costs. Transaction costs refer to the expenses incurred for an exchange activity, including writing and enforcing a contract, haggling over terms and contingent claims, deviating from optimal kinds of investments in order to increase dependence on a party or to stabilize a relationship, and administering the transaction. The boundary between the market and the firm will then be determined by the relative costs of carrying out a transaction under each organizational structure. The optimal transaction is the minimization of the sum of production costs and transaction costs.

Transaction cost logic is premised on a set of assumptions about human behaviour and attributes of transactions that affect transactions between two firms: bounded rationality, opportunism, uncertainty, small number bargaining, and asset specificity. The transaction cost approach is different from the industrial economics approach which largely focuses on industry structure that affects firm behaviour and performance.

With the increasing wave of hybrid forms of organization, transaction cost theorists have begun to incorporate the hybrid forms into the transaction cost framework along a continuum of markets and hierarchies (Williamson, 1991a, 1991b and 1996; Mendard, 1996a and 1996b). 'Hybrid' refers to the various organizing modes between the two polarities of markets and hierarchies, such as joint venture, cooperation agreement, and licensing. Regarding the transaction decision choice among arm-length markets, hybrid forms and hierarchical integrations, Williamson (1991a, p.83) describes integration as a choice of last resort, and suggests that "try markets, try long-term contracts and other hybrid modes, and revert to hierarchy only for compelling reasons".

Transaction cost theorists (e.g. Kogut, 1988; Sachwald, 1998; Hadgedoorn et al., 2000) have explained the reason why market transactions are not chosen rests on potential exploitation of one party when assets are dedicated to the relationship and there is uncertainty over redress. Therefore market transactions are too fraught with opportunistic risk. The partnerships build a mechanism to turn the expected hostage situation in the market transaction into a mutual hostage situation in a cooperative agreement through the commitment of resources by partners to the common cause. The case study in the aluminium industry by Stuckey (1983) shows that bauxite and alumina are often not traded at arm's length market because the characteristics of the transaction would require very detailed long-term contracts to protect from opportunistic behaviour on thin market. Firms resort to production joint ventures where common assets constitute an incentive for firms to cooperate with each other by guaranteeing their dedication to a long-term relationship.

Theorists also explain why the partnerships are preferable to the market displacements. According to Kogut (1988), the answer lies in the diseconomies of acquisition due to the costs of divesting or managing unrelated activities or the higher costs of internal development. Kogut argues that the technological uncertainty makes firms favour the cooperation to share the high risk and high cost. Gulati (1995, p.87) suggests that cooperative relationships are preferred "when the transaction costs associated with an exchange are intermediate and not high enough to justify vertical integration . . ." According to Ramanathan et al. (1997, p.57), alliances can be justified when market exchange is costly and internalisation is more cost efficient "but constraints of various kinds prohibit full internalisation".

Researchers have been developing transaction cost theory with regard to inter-firm cooperation. Madhok (1998, p.1) separates transaction cost (TC) into two types. "Type I TC entails the search, selection, evaluation, bargaining and enforcement costs traditionally associated with TC theory, assuming potential opportunism. Type II TC refers broadly to the costs dedicated towards persuading, training, teaching and learning, and generally "educating" one another." According to Modhok, Type I TC is primarily oriented towards protection against opportunistic behaviour and the Type II TC is of a more entrepreneurial nature and is more explicitly oriented towards the active and actual creation and realization of value through inter-firm collaborative relationships. Modhok provides insights into transaction cost theory, suggesting that costs dedicated towards persuading, training, teaching and learning and generally "educating" one another are transaction-specific investments and these expenditures in the form of money, time, effort, and sheer managerial energy are dedicated towards reducing cognitive differences and creating cognitive convergence in the pursuit of value.

Additionally, Madhok (1998) undertakes a comparison analysis between transaction cost theory and resource-based theory. In Madhok (1998, p.5), "The two theories, TC and RB, were originally developed to address different questions: governance and competitive advantage respectively. Accordingly, the TC perspective addresses the firm primarily in terms of its governance rather than its productive attributes while, on the other hand, the primary interest of the RB perspective is in the productive attributes of firms, and the associated competitive advantage, rather than the governance attributes." Consequently, as Madhok (1998) states, if a firm selected an inter-firm relationship under strict TC criteria, it would suggest that the inter-firm relationship is characterized by lower costs than alternative modes.

Notwithstanding the transaction cost perspective provides an analytical scheme for the study of networks, Bougrain and Haudeville (2002) point out that several limits remain. One is that the transaction cost approach puts too much emphasis on opportunism. However, recurrent transactions lead partners involved in a network to gradually trust one anther. As Lundvall (1993) posits, collaborative relationships entail learning. Another one is that as one of the "four contemporary paradigms in the theory of the firm" (Winter, 1991, p.187), transaction cost theory is first and foremost a matter of exchange and bounded rationality. Production is secondary. Consequently, as Foss (1996, p.12) says, it fails to "examine how new resource uses are discovered, how resources are accumulated, how firms learn, which governance structures best promote learning, etc."

2.1.3 Resource-based View of the Firm

Pioneered by Penrose (1959) and developed by Wernerfelt (1984), the resource-based view (RBV) of the firm emerged as "an important new conceptualisation in the field of strategic management" and is "one of the most important redirections of the strategic research in this decade" (Zajac, 1995, p.169). Chandler (1977), Nelson and Winter (1982), Barney (1986), Teece (1988a, 1989) and Teece et al. (1997) all have made their own remarkable contribution to this theory. The founding idea of RBV is to view a firm as a bundle of resources. The central promise of RBV addresses the fundamental question of why firms are different and how firms achieve and sustain competitive advantage. Accordingly, as Grant (1996a, 1996b) and Teece (1988a) suggest, a firm's advantage arises from two sources: its ownership and access to knowledge and complementary resources, and its ability to create value by integrating and applying these resources; and a firm's primary function is to create value from the knowledge residing within individuals, including combining internal knowledge with outside sources.

Extending the original work, researchers have attempted to explain more specifically how differences in firms' resources realize superior firm performance. Barney (1991) presents a concrete and comprehensive framework to identify the needed characteristics of firm resources in order to generate sustainable competitive advantage. Four criteria are proposed to assess the economic implications of the resources: value, rareness, inimitability and substitutability. Value refers to the extent to which the firm's combination of resources fits with the external environment so that the firm is able to exploit opportunities and/or neutralize threats in the competitive environment. Rareness refers to the physical or perceived physical rareness of the resources in the factor markets. Inimitability is the continuation of imperfect factor markets via information asymmetry such that resources cannot be obtained or recreated by other firms without a cost disadvantage. Finally, the framework also considers whether the organizations are substitutable by competitors.

Developing Barney's (1991) resource construct, Das and Teng (2000) contend that the formation of strategic alliances depends on the characteristics of resources. They propose that "the more a firm's resources are characterized by imperfect mobility, imperfect imitability, and imperfect substitutability, the more likely the firm will get involved in strategic alliances (p.41)." Das and Teng (2000) take alliances in pharmaceutical industry as an example, arguing that small biotechnology firms allying with large pharmaceutical companies are not just to have access to financial resources, but also to intangible resources such as marketing and operations know-how - which are far less mobile, imitable, and substitutable.

Researchers have been dedicated to exploring the resource-based view of alliances, although using different names, such as the property right perspective (Ramanathan et al., 1997) and the organizational capability perspective (Madhok, 1997). The work more recently and more systematically applying the resource-based view of the firm to strategic alliances is Das and Teng (2000). Das and Teng (2000) put forward a general resource-based theory of strategic alliances. Their study synthesizes the various findings on alliances from a resource-based view in the literature. The proposed theory covers four major aspects of strategic alliances: rationale, formation, structural preferences, and performance. Das and Teng examine the rationale for entering into strategic alliances by comparing resource-based view with transaction cost perspective. Instead of focusing on minimizing the sum of production and transaction costs derived from transaction cost perspective of alliances, resource-based theory suggests firms going to cooperate aim at maximizing existing internal resource value by combining external resources.

As Eisenhardt & Schoonhoven (1996) suggest, when resources can be exchanged efficiently in market "firms are more likely to continue alone" and choose market transaction strategy rather than market displacement or alliances. However, efficient exchanges are often not possible in imperfect market, and certain resources are not fully tradable, as they are either un-separated with other resources or embedded in organizations (Chi, 1994). Hence, mergers, acquisitions, and strategic alliances are reasonable alternatives. Thus, Das and Teng (2000) conclude that, from the resource-based perspective, strategic alliances and mergers/acquisitions are strategies used to access other firms' resources for the purpose of gaining otherwise unavailable competitive advantages and values to the firm.

The reason that firms favour strategic alliances over internalisation (M&As or internal development) can be explained from two perspectives. Following Kogut's (1988) organizational learning model, Das and Teng (2000) argue that, to obtain other's resources, strategic alliances have more viable options than M&As when not all the resources possessed by the target firm are valuable to the acquiring firm. When non-desired assets are not easily separable, strategic alliances allow partner firms to access only the assets each desires while bypassing non-desired ones, thereby augmenting overall value. Thus, the distinct advantage of strategic alliances is to have access to precisely those resources that are needed, with minimum unneeded assets. For retaining currently under-utilized resources, Das and Teng (2000, p.38) posit that "the possible advantage of strategic alliances over M&As is that the firm only temporarily relinquishes its resources, which remain available for future internal deployment. Thus, strategic alliances will be preferred only when discounted present value of the deployment of its resources in the future is greater than the realized value of selling its resources in the present."

2.1.3.1 Strategic Leadership

Strategic leadership is one of sub-streams emerging from the RBV because leadership is considered an important resource. Hambrick and Mason (1984) present a formal theoretical framework based on the upper echelon perspective, proposing that senior executives make strategic choices on the basis of their cognitions and values. They argue that an organization is a reflection of its top managers. Hambrick and Finkelstein (1987) outline the concept of "managerial discretion", which links the individual characteristics of strategic leaders with organizational and environmental factors. In the same vein, Johnson and Scholes (2002) and Analoui and Karami (2003) contend that decisions on competitive strategies are likely to be strongly influenced by the valuable experience of senior executives in small businesses. Based on empirical studies on SMEs' strategic human resource management in electronics industry in the UK, Karami et al. (2004) and Karami et al. (2006) conclude that CEOs in SMEs play a significant role in formulation of the business strategy and the firm's performance. From this view, a top leader plays an irreplaceable role in SMEs' innovation strategy and successful collaboration.

2.1.3.2 Knowledge-based View

The knowledge-based view (KBV) of the firm is an extension of the RBV by conceptualising firms as heterogeneous, knowledge-bearing entities. Polanyi (1966) classifies knowledge into two categories: explicit or codified knowledge which refers to knowledge that is transmittable in formal, systematic language; and tacit knowledge which has a personal quality and, thus, is difficult to formalize and communicate. Zander and Kogut (1995) operationalise the construct of knowledge into five dimensions: codifiability, teachability, complexity, system dependence and product observability.

From the knowledge-based view of the firm, some intangible assets, like know-how, culture, value, and reputation, and organization routine, are tacit knowledge. Firms' interactions through arm-length contracts are not able to capture these assets due to their "people dependent" and "learning by doing" nature (Hall, 1993, p.609).

Sachwald (1998) points out that tacit knowledge cannot be embodied in formulae, designs or other types of specifications. As a result, it cannot be transferred in a codified form such as patent. Thus, Teece (1980, 1982) and Hennart (1988) posit that firms have to resort to governance structures which facilitate know-how transfers. In the same vein, Kogut (1988) declaims that 'tacit knowledge' is a rational explanation for joint venture. Kogut proposes that a joint venture is chosen because the very knowledge being transferred is organizationally embedded and joint ventures are a vehicle by which tacit knowledge is transferred. Therefore, inter-firm cooperative relationships are often portrayed in the resource-based framework as devices that are instrumental to knowledge transfer from one firm to another.

Sachwald (1998) analyses the question why firms look for complementary resources. By observing the sectors where cooperative agreements have been numerous such as semiconductors, computers, pharmaceuticals and automobiles, Sachwald (1998) finds the answer is in a growing gap between firms' strategies and their internal resources. The increasing role of innovation in competition has induced firms to set up specific strategies in order to foster product or process innovations. In such a context, cooperative agreements have been used as a way of complementing internal R&D resources. Firms in high-tech sectors have logically been very active in cooperation. For example, in semiconductors, cooperative agreements have organized technology transfers from American to European firms, as a means of addressing the technological gap; large pharmaceutical companies have resorted to various types of agreements with small biotechnology firms in order to enter this new research area.

2.1.3.3 Skill-based View of the Firm

Consistent with the knowledge-based view of the firm, Hamel (1991) proposes a skill-based view of the firm. The study conceives a firm as a portfolio of core competencies and disciplines, suggesting that inter-firm competition is essentially concerned with the acquisition of skills. In this view, global competitiveness is largely a function of the firm's pace, efficiency, and extent of knowledge accumulation. Hamel (1991) points out that the traditional 'competitive strategy' paradigm (e.g. Porter, 1985) provides the means for computing product-based advantages at a given point in time in terms of cost and differentiation. However, the paradigm provides little insight into the process of knowledge acquisition and skill building. Hamel (1991) argues that core competencies and value creating disciplines are not distributed equally among firms. Expansion-minded competitors, exploiting such firm-specific advantages, bring the skill deficiencies of incumbents into stark relief. The case study in Hamel (1991) depictures how the collaborative process leads to a reapportionment of skills between the partners, and how a firm's capacity to learn changes its strategic position inside and outside alliance. The study concludes that where global competitors are rapidly building new sources of competitive advantages, as well as enhancing existing skills, a go-it-alone strategy could confine a firm to permanent also-ran status. Alliances may be seen as a way of short-circuiting the process of skills acquisition and thus avoiding the opportunity cost of being a perpetual follower.

2.1.3.4 Dynamic Capabilities

The theory of dynamic capabilities is an extension of resource-based view of the firm as well. Teece et al. (1997) define dynamic capabilities as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments. Dynamic capabilities thus reflect an organization's ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions (Leonard-Barton, 1992).

A firm's knowledge is not boundless as it is constrained in its knowledge development by path dependencies. "A firm's previous investments and its repertoire of routines constrain its future behaviour" (Teece et al., 1997, p.522). The path of developing firm knowledge is also constrained by a firm's complementary assets. Firms have an established asset base from prior activities. Any new products or processes which require radically different complementary assets, particularly in terms of manufacturing and downstream activities, can enhance or destroy the value of previously established assets. Consequently, because of path dependencies and complementary assets, organizational capabilities, though dynamic, are constrained in their direction. In Sachwald (1998), path dependency in knowledge-building results in firm-idiosyncratic technological trajectories. Firms progressively construct their competences and then depend on them; in other words, competences are both constituents of competitiveness and constraints which may impede future changes. From this perspective, competences may be considered a specific kind of barriers to entry, representing sunk costs.

According to dynamic capabilities theory, firms can accumulate knowledge, expertise, and skills through organizational learning to overcome the inherent constraints. There are expanding stream of literature focusing on corporate learning and organizational modes that facilitate such learning. The studies (Hamel and Prahalad, 1989; Prahalad and Hamel, 1990; Hamel, 1991; Dodgson, 1991; Mody, 1993) view inter-firm collaboration as a vehicle for organizational learning, and moreover view knowledge accumulation and internalisation via organizational learning as the motives, process and outcomes of strategic technical alliance.

The exploration of cooperative agreements shows that firms do not merely use them to exchange resources, but often to learn and enhance their competences. A firm's competence building requires specific learning devices. Sachwald (1998) states that when American carmakers wanted to learn better production techniques from their Japanese competitors, they could not just read a manual or take a license and change a couple of isolated steps in their factories. They had to really understand a different approach and review their whole organization in order to implement it, which of course implied extensive training of personnel. In such a sweeping process, American firms certainly benefited from their relationships with their Japanese partners.

2.1.4 Combined Theoretical Perspectives on Inter-firm Cooperation

In summary, to account for the emergence of cooperation as well as its operation, a number of theories and models have been proposed. As discussed above, competitive forces (including strategic behaviour), transaction costs, and resource-based view (including its extension theories) complementarily contribute to the rational explanations of this phenomenon. Studies also examine the logic of strategic decision on three alternative governance modes – internalisation, market transaction and cooperative agreement. To clarify the discussion, drawing on Das and Teng (2000), the rationales of a firm's strategy option on governance mode based on competitive forces theory, transaction cost theory, and resource-based theory are summarized and presented in Table 2-1.

Although theorists tend to explain firms' cooperative efforts by applying one specific theory, empirical studies have found that firms that cooperate may be motivated by more than one sole reason. As Kogut (1988) reports, joint ventures have been found to be a form of strategic behaviour to increase market power, a form of transaction cost minimization to increase efficiency, and an instrument for transfer of organizational knowledge and learning. Stuckey (1983), an investigation of the aluminium and bauxite industry, specifically analyses whether joint ventures are motivated by transaction costs or strategic motivations. The study concludes that transaction cost based explanations appear more relevant to aluminium production, whereas strategic behaviour is more prevalent in the upstream stages. The study by Berg and Friedman (1981) provides support for the use of joint ventures as instruments for the transfer of organizational knowledge as opposed to the means by which to enhance market power. Among the studies on the choice of international ventures for entry, Kogut (1988) notes that, theoretically, there has been significant work in understanding entry decisions as a question of minimizing transaction costs, most studies have empirically investigated the strategic motivation hypothesis.

Prior studies demonstrate that any single one theory cannot fully explain cooperation phenomena, suggesting that a comprehensive study on cooperation requires a combination of discussed theories to address the research questions fully.

Table 2 - 1: Rationales for choice of governance mode based on competitive forces theory, transaction cost theory and resource-based theory

	Competitive forces theory	Transaction cost theory	Resource-based theory
Logic of decision making	"Firms transact by the mode which maximizes profits through improving a firm's competitive position vis-à-vis rivals" (Kogut, 1988, p.322).	"Firms transact by the mode which minimizes the sum of production and transaction costs" (Kogut, 1988, p.322).	Firms adopt a suitable governance mode to maximize value creation through combining internal resources with external valuable resources (Das and Teng, 2000).
Mergers/ Acquisitions/ Internal development	Firms are dedicated to undertaking radical technological innovation to appropriate monopoly rents through pre-emptive patenting (e.g. Vickers, 1985).	Firms operate in the market with high transaction costs (i.e., high asset specificity, uncertainty, and frequency of the transactions, and high costs for controlling opportunistic behaviour) and/or low production costs (i.e. economies of scale) (Kogut, 1988).	"A firm will favour acquisitions over joint ventures when the assets it needs are not commingled with other unneeded assets within the firm that holds them, and hence can be acquired by buying the firm or a part of it." (Hennart & Reddy, 1997, p.1) The firm is pursuing a strategy for which it has extensive resource capabilities (Eisenhardt & Schoonhoven, 1996).
Market transaction	The firm enjoys a comparative competition advantage vis-à-vis its rivals.	Firms operate in the market with low transaction costs and/or high production costs.	When efficient market exchange of resources is possible, firms are more likely to continue alone and rely on the market (Eisenhardt & Schoonhoven, 1996).

Table 2-1: Rationales for choice of governance mode based on competitive forces theory, transaction cost theory and resource-based theory (Cont.)

	Competitive forces theory	Transaction cost theory	Resource-based theory
Cooperative agreements	Firms have widely resorted to cooperative agreements as a means to either lower barriers to entry or mobility barriers, or to build or reinforce barriers (Sachwald, 1998). Coalitions involve coordinating or sharing value chains with partners that broaden the effective scope of the firm's own activities (Hagedoorn et al., 2000). Inter-firm collaboration can change market structures as small firms are effectively operating in large firm sectors through their relationships with larger partners (Smith et al., 1991).	A mutual hostage under cooperative agreements may reduce opportunistic risk compared to market transaction (e.g. Stuckey, 1983). For the question why firms choose joint ventures, "the answer lies in the diseconomies of acquisition due to the costs of divesting or managing unrelated activities or the higher costs of internal development" (Kogut, 1988, p.320). "JVs are formed when transactional hazards suggest that internalisation is efficient . . . , but constraints of various kinds prohibit full internalisation . . . ." (Ramanathan et al., 1997, p.57). "The situational characteristics best suited for a joint venture are high uncertainty over specifying and monitoring performance, in addition to a high degree of asset specificity" (Kogut, 1988, p.320).	Alliances are preferred "when the critical inputs required to pursue the opportunity are owned by different parties and when these inputs are inseparable from the other assets of the owner firms" (Ramanathan et al., 1997, p.65). "Collaborations are a useful vehicle for enhancing knowledge in critical areas of functioning where the requisite level of knowledge is lacking and cannot be developed within an acceptable timeframe or cost" (Madhok, 1997, p.43). "The substantial tacit element of the technology means that its exchange has to rely on intimate human contact" (Tsang, 2000).

Source: adapted from Das and Teng (2000).

2.2 The Nature of Technology Change

Literature has well documented that the technology factor facilitates inter-firm cooperation. The wave of inter-firm cooperation has been attributed to the present rapid changes in technological development, the necessity of quick pre-emption strategies, complexities and uncertainties surrounding technological developments, and the necessity for firms to monitor a wide spectrum of technologies.

According to Scott (1998), technology is the means by which inputs are transformed to outputs by the firm. Rosenberg (1972) defines technology as those tools, devices, and knowledge that mediate between inputs and outputs (process technology) and/or that create new products or services (product technology). Since the new economy era is characterized by technology innovation and the industrialization of high technology, better understanding the nature of technological change and newly emerging technologies should be greatly beneficial to strategic management theory and practice. Due to the discussion in last section focused on economical and organizational views of innovation based cooperation, this section emphasizes the impact of technological factor on inter-firm cooperation.

2.2.1 Technology Cycles

As noted by Rothwell (1991), one reason for the dramatic increase in new technology-based firms formation in Europe since the early 1970s is the nature of several emerging 'technology clusters' (Table 2-2). In the information technology and biotechnology areas, especially, innovation is knowledge intensive, rather than capital and scale intensive. Entry costs for firms appear to be relatively low in these areas. Therefore, information technology and biotechnology in particular have opened up many new market niches suitable for entry for small firms.

Table 2 - 2: Emerging technologies

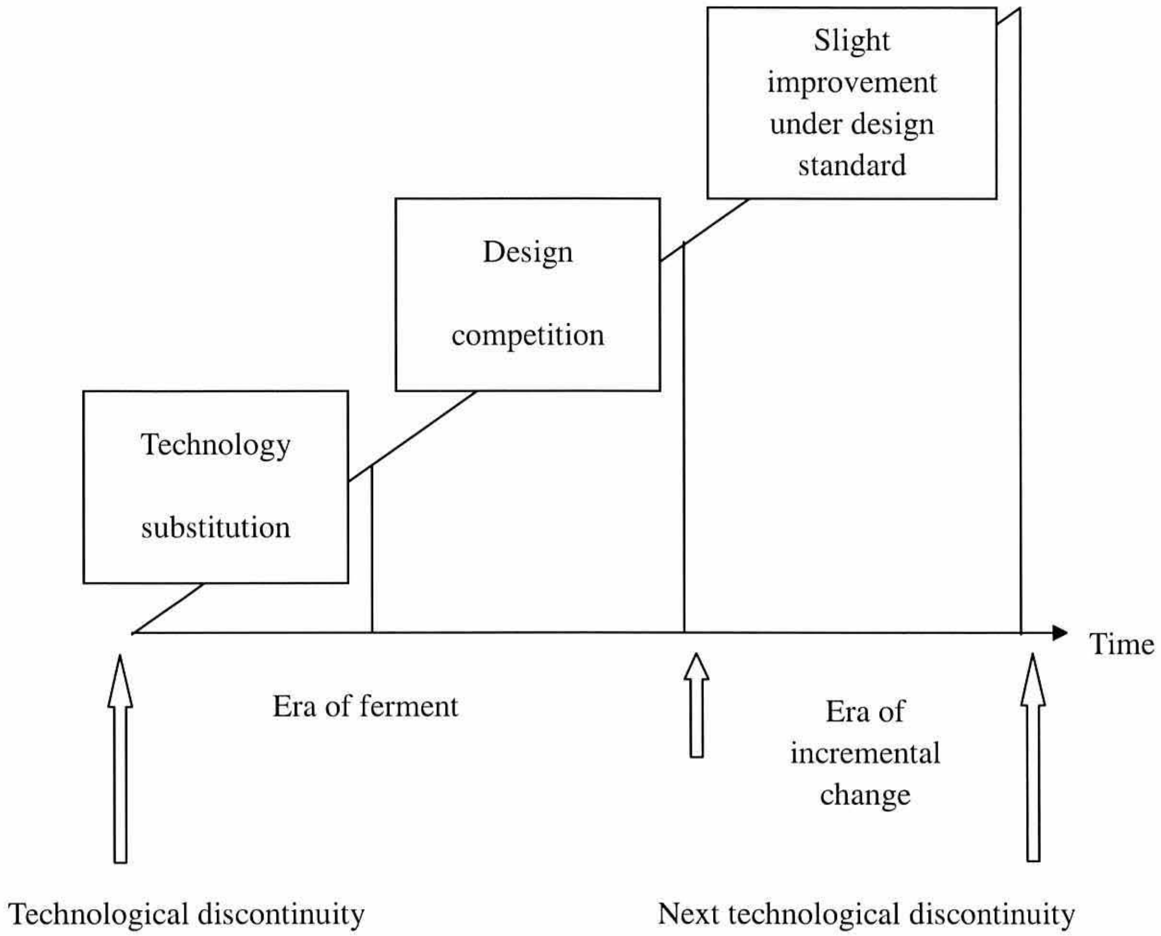
Biotechnology	Single cell protein Bio-engineering Biomass Diagnostic kits Pharmaceuticals
Energy technologies	Heat pumps Solar energy devices Coal gasification and liquefaction Renewable energy sources Monitoring and control equipment
Advanced materials technology	Biocompatible materials (implants) Advanced composite material Advanced electronics materials Superconducting materials
Information technologies	Electronic office equipment Fibre optic systems Satellite communications Scientific and medical instruments Advanced computing Software developments IT in the home etc. (IT for existing and new applications)

Source: Rothwell (1991, p.95).

Tushman and Anderson (1986) and Anderson and Tushman (1991) indicate, from the view of the nature of technologies, some of emerging technologies provide opportunities for numerous new entrants but others do not. Also their studies depict that the technological processes happen in a series of cycles, hinging on technological discontinuities and the emergence of dominant designs.

According to Anderson and Tushman (1991), discontinuities are breakthrough innovations that advance by an order of magnitude the technological state-of-the-art which characterizes an industry. They are based on new technologies whose technical limits are inherently greater than those of the previous dominant technology along economically relevant dimensions of merit. Each technological discontinuity inaugurates a technology cycle. The sketch of this process is given in Figure 2-1. The breakthrough initiates an era of ferment, characterized by two processes. The first process is an era of substitution in which the new technology displaces its predecessor. The second process, partly overlapping the first, is an era of design competition. In this era, more refined versions replace the initial products or processes of radical innovations. Typically, several competing designs emerge and each embodies the fundamental breakthrough advance in a different way. The design competition culminates in the appearance of 'dominant design' (also called 'technological guidepost'). This design is a single basic architecture and becomes the accepted market standard. As Anderson and Tushman (1991) state, dominant designs are not necessarily better than competing designs; rather, they represent a combination of features that sets a benchmark to which all subsequent designs are compared.

Figure 2 - 1: Technology change cycle



Source: adapted from Anderson and Tushman (1991)

The emergence of a dominant design marks the end of the era of ferment and the beginning of a period of incremental change. The rate of design experimentation drops sharply, and the focus of competition shifts to market segmentation and lowing costs via design simplification and process improvement. Once a design becomes a standard, it establishes a trajectory for future technical progress and changes the basis of competition in the industry. The era of incremental change continues with slight improvements on a standard design until the next technological discontinuity emerges to kick off a new technology cycle.

Furthermore, Anderson and Tushman (1991) demonstrate how technology discontinuities influence competence. They declare that the nature of the technology cycle is dramatically affected by the cutting dimension of competence. Some discontinuous innovations are competence-destroying which make obsolete existing know-how. Established firms have to embark on a new learning curve to master the new technology, for example, technical professionals require new training. Other discontinuous innovations are competence-enhancing. These breakthroughs push forward the state of the art by an order of magnitude, but build on existing know-how instead of obsolescing it.

The above discussion on the nature and character of technology cycle leads to the following implications:

(1) Firm failure rates are remarkably higher during eras of ferment than in any other period. Small research-intensive firms, though with first-comer's advantages, struggle for survival. Challenges come from markets and competitors. As Anderson and Tushman (1991) argue, established firms will improve older technology markedly in response to the competitive threat. Therefore small firms are motivated to ally with relevant partners, for example partnering with large counterparts, to

enhance their capabilities for innovation commercialisation. The veterans in an industry have much stronger capabilities in manufacturing and marketing than technology-based start-ups.

(2) Competence-destroying discontinuities create opportunities for new entrants to high-technological industry. Competence-destroying discontinuities break the existing order. Barriers to entry are lowered; new firms enter previously impenetrable markets by exploiting the new technology. These discontinuities favour new entrants at the expense of entrenched defenders. New entrants take advantage of fundamentally different skills and expertise, and gain sales at the expense of formerly dominant firms burdened with prior technologies and ways of operating. This manifests the situation SMEs have dramatically developed in such as information and biotechnology sectors since the late 1970s.

(3) As Anderson and Tushman (1991) observe, the original discontinuous innovation never became a standard. Although competence-destroying innovations are pioneered by newcomers, newcomers rarely become standard-setters since industry standards care much more for market demand than for the state of the art. It explains why high-tech SMEs have strong incentives to partner with large firms for participating in standard setting. These strategies have been practiced in many cases.

There are rich analysis about how the nature of technological change forces firms to collaborate on R&D (see e.g. Contractor and Lorange, 1988; Mowery, 1988; Mytelka, 1991; OECD, 1992; Hadgedoorn, 1993 and 1996; Nooteboom, 1999; Dussauge and Garetti, 1999). Important industrial and technological changes in the 1980s and 1990s led to increased complexity in scientific and technological development, higher uncertainty surrounding R&D, increasing costs of R&D projects, and shortened innovation cycles. Link and Bauer (1989), Mytelka (1991), Hadgedoorn (1993), and Dussauge and Garetti (1999) also indicate that R&D partnerships are mainly concentrated on high-tech sectors or R&D intensive sectors.

2.2.2 Technological Paradigms and Technological Trajectories

Technological paradigms and technological trajectories are proposed by Nelson and Winter (1977), and extended by Dosi (1982). A 'technological paradigm' is a 'model' and 'pattern' of solutions of selected technological problems, based on selected principles derived from natural sciences and on selected material technologies. A 'technological trajectory' is the pattern of 'normal' problem solving activity (i.e. of 'process') on the ground of a technological paradigm. A technological trajectory is a cluster of possible technological directions whose outer boundaries are defined by the nature of the paradigm itself. From this viewpoint, Dosi (1982) explains both continuous changes and discontinuities in technological innovation. Continuous changes are often related to progress along a technological trajectory defined by a technological paradigm, while discontinuities are associated with the emergence of a new paradigm.

Tidd et al. (2001) distinguish five major technological trajectories, each with its own distinctive nature and sources of innovation, and with its distinctive implications for technology strategy and innovation management. Amongst the five major technological trajectories, science-based firms accumulate technologies mainly from R&D laboratories. These firms are heavily dependent on knowledge, skills and techniques emerging from academic research. Tidd et al. (2001) identify chemical and electronics as typical core sectors of science-based firms in which fundamental discoveries (electromagnetism, radio waves, transistor effect, synthetic chemical, and molecular biology) open major new product markets over a wide range of potential applications. The major direction of technological accumulation in these firms is a horizontal search for new and technologically related product markets. Thus, the main tasks of technology strategy are to monitor and exploit advances emerging from basic research, to develop technologically related products and acquire the complementary assets (e.g. production and marketing) to exploit them, and to reconfigure the operating divisions and business units in the light of challenging technological and market opportunities.

Organizational theorists, especially those who advocate a dynamic capabilities perspective, have found technological trajectories are explanations why core competences could be transformed into core rigidities within a firm over time. As

Leonard-Barton (1995) states, core competences can become core rigidities in the firm when established competencies become too dominant. Core competences are central to today's market, which may blind managers so that they neglect or underestimate new technological trends. To break through this inherent path-dependence, strategic alliance and other network modes enable a dynamic learning that builds competence.

2.3 Technological Innovation in Firms

According to Drucker (1974, 1985), from the business management point of view, firms only have two main tasks: marketing and innovation. Whereas the marketing function is to satisfy current needs of the consumers, innovation goes further to satisfy consumers' future needs. Without ability for constant innovation, enterprise disappears in the moment when the consumers' needs, technology or competition are changed. Since the last decade, the pace of change has been constantly accelerating, innovation has been used as a strategic element of competition in business.

2.3.1 Definition of Innovation

Schumpeter (1934) describes innovation as the motor of economic development. He distinguishes five different types of innovation. These are new products, new methods of production, new sources of supply, the exploration of new market, and new ways to organize business. This definition offers a broad perspective with regard to innovation.

The European Commission Communication (COM, 1995: 688) presents a broad and more detailed definition: "innovation is the renewal and enlargement of the range of products and services and associated markets; the establishment of new methods of production, supply and distribution; the introduction in changes in management, work organization, and the working conditions and skills of workforce."

A broad US innovation definition, developed by the 21'st Century Innovation Working Group (2004, p.21), states "innovation is a process through which the nation creates and transforms new knowledge into useful products, services and processes for national and global markets – leading to both value creation for stakeholders and higher standards of living."

When innovation refers to technological innovation in firms, the definition of innovation made by OECD (1997) is the particularly suitable. In 1997, Organization for Economic Cooperation and Development (OECD), European Commission and Eurostat published a document titled *Oslo Manual: The Measurement of Scientific and Technological Activities – Proposed Guidelines for Collecting and Interpreting Technological Innovation Data.* In the Oslo Manual, innovation is referred to 'technological product and process (TPP)' innovation.

"Technological product and process (TPP) innovations comprise technologically implemented new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organizational, financial and commercial activities. The TPP innovating firm is one that has implemented technologically new or significantly technologically improved products or processes during the period under review" (OECD, 1997, p.31).

According to Szmytkowski (2005), OECD's (1997) "innovation definition" consists of the object, the process, the subject, the results, and the time frame of TPP innovation.

(1) The object of TPP innovation is technological product and process innovation. The term "product" is used to cover both goods and services. Other changes in the firm such as organizational innovation are excluded from the definition of OECD (1997).

(2) The process of TPP innovation is the action of technologically new implementations or technologically significant improvements. In OECD (1997, p.32), "A technologically new product is a product whose technological characteristics or

intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge...A technologically improved product is an existing product whose performance has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher-performance components or materials, or a complex product which consists of a number of integrated technical sub-systems may be improved by partial changes to one of the sub-systems."

(3) The subject of TPP innovation covers all levels of innovation with "new to the firm" as the minimum entry level. When a new or improved product or process is implemented in the very first time, a worldwide TPP innovation occurs. When a firm implements a new or improved product or process which is technologically novel for the unit concerned but is already implemented in other firms and industries, a firm level innovation occurs. According to OECD (1997, p.34), between the two levels "come degrees of diffusion of technologically new or improved products and processes."

(4) The results of TPP innovation are not expressed directly in Oslo Manual. However, the suggested measurements for the impact of innovations on the performance of the enterprise, such as percentage share of sales due to

commercialised new products or improved products, indicate that TPP innovation is market oriented.

(5) The time frame of TPP innovation is defined as "the period under review" (OECD, 1997, p.31).

2.3.2 Sources of Innovation

Commission of the European Communities (2003, p.5) states that "Enterprises are spurred to innovate by pressures and challenges, notably competition and the desire to create new market space." From this view, Commission of the European Communities (2003) proposes a set of diverse routes for firms' technological innovation.

(1) Exploitation of invention arising out of the research laboratory. Research is a major contributor to innovation, generating a flow of technical ideas and continually renewing the pool of technical skills.

(2) Taking an idea from another business sector and adapting it for use in its own production processes or market.

(3) The search for new, untapped, market space. This may rely on technological innovation, or on reconfiguring existing products and services so as to present a

radical change that will be perceived by customers as offering more or better value.

(4) The emergence of new firms. In fast-moving sectors it is the new enterprises with growth potential that are often the most innovative, forcing established enterprises to respond to the challenge by themselves becoming more innovative.

(5) Entrepreneurial action. While research is a major contributor to innovation, if there is no entrepreneurial action there is no value creation. With the shortening of product cycles, enterprises face the need for more capital-intensive investment and must put more emphasis on the ability to react quickly.

(6) The occupational and geographical mobility of the workforce. Through the forces of competition and imitation, an initial innovation is developed and improved so that the impact on the economy is many times greater than that brought about by the first application of the innovation. The process requires the constant reallocation of resources to activities that lead to more efficiency or greater economic value.

(7) The fast follower. Leaders in technology development are not necessarily leaders in technology adoption. The most important economic contribution does not necessarily come from the "early adopter" but from the "fast follower" who adopts the innovative design that captures the international market.

OECD (1997) refers to the complex system of factors shaping innovation at the firm level as the “innovation dynamo”, and categorizes these factors into three kinds of activities: strategic activities, R&D activities and non-R&D activities. These activities are options open to a firm who wants to innovate.

(1) Strategic activities: making decisions about the types of markets they serve or seek to create, and the types of innovations they will attempt there.

(2) R&D activities: undertaking basic research to extend its knowledge of fundamental processes related to what it produces; engaging in strategic research to broaden the range of applied projects that are open to it, and applied research to produce specific inventions or modifications of existing techniques; developing product concepts to judge whether they are feasible and viable, a stage which involves (i) prototype design, (ii) development and testing, and (iii) further research to modify designs or technical functions.

(3) Non-R&D activities: identifying new product concepts and production technologies (i) via its marketing side and relations with users, (ii) via the identification of opportunities for commercialisation resulting from its own or others’ basic or strategic research, (iii) via its design and engineering capabilities, (iv) by monitoring competitors, and (v) by using consultants; developing pilot and then full-scale production facilities; buying technical information, paying fees or royalties for

patented inventions, or buying know-how and skills through engineering and design consultancy of various types; developing or purchasing human skills relevant to production; investing in process equipment or intermediate inputs which embody the innovative work of others; reorganizing management systems and the overall production system and its methods, including new types of inventory management and quality control, and continuous quality improvement.

2.3.3 TPP Innovation Activities

OECD (1997) states innovation is a complex process, and the scale of activity required for a TPP innovation in a firm may vary considerably. Innovation activities may be carried out within the firm or may involve the acquisition of goods, services or knowledge from outside sources. Thus a firm may acquire external technology in disembodied or embodied form.

As OECD (1997, p.40) suggests, the following activities are included in TPP innovation activities:

(1) Acquisition and generation of relevant knowledge new to the firm.

(a) Research and experimental development: R&D; construction and testing of a prototype; software development.

Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

Construction and testing of a prototype is often the most important phase of experimental development. A prototype is an original model (or test situation) which includes all the technical characteristics and performances of the new product or process. The acceptance of a prototype often means that the experimental development phase ends and the other phases of innovation process begin.

Software development is classified as R&D as long as it involves making a scientific or technological advance and/or resolving scientific/technological uncertainty on a systematic basis.

(b) Acquisition of disembodied technology and know-how: acquisition of external technology in the form of patents, non-patented inventions, licenses, disclosure of know-how, trademarks, designs, patterns and computer and other scientific and technical services related to the implementation of TPP innovations, plus the acquisition of package software that is not classified elsewhere.

(c) Acquisition of embodied technology: acquisition of machinery and equipment with improved technological performance (including integrated software) connected to technological product or process innovations implemented by the firm.

(2) Other preparations for production

(a) Tooling up and industrial engineering: changes in production and quality control procedures, methods and standards and associated software required to produce the technologically new or improved product or to use the technologically new or improved process.

(b) Industrial design n. e. c.: plans and drawings aimed at defining procedures, technical specifications and operational features necessary to the production of technologically new products and the implementation of new processes.

(c) Other capital acquisition: acquisition of buildings, or of machinery, tools and equipment – with no improvement in technological performance – which are required for the implementation of technologically new or improved products or processes.

(d) Production start-up: product or process modifications, retraining personnel in the new techniques or in the use of the new machinery, and any trial production not already included in R&D.

(3) Marketing for new or improved products: activities in connection with the launching of a technologically new or improved product. These may include preliminary market research, market tests and launch advertising, but will exclude the building of distribution networks to market innovations.

When an innovation activity mentioned above is undertaken through inter-firm cooperation under certain agreement, it becomes the concern of this study.

2.3.4 Measuring the Impact of Innovation on the Performance of a Firm

By incorporating the suggestions of Tidd et al. (1996), Souitaris (2001) and Bedssant (2003) into OECD (1997), the output of innovation and the impact of innovation on the performance of a firm can be measured as follows:

(1) The output of innovation: number of technologically new products introduced in the past three years; number of technologically improved products introduced in the passed three years; number of innovative manufacturing processes introduced in the past three years; number of patents acquired in the last three years.

(2) The proportion of sales due to technologically new or improved products: percentage share of sales due to technologically new products commercialised during

the last three years; percentage share of sales due to technologically improved products commercialised during the last three years.

(3) The results of innovation effort: sales year t and t-2; exports year t and t-2; employees year t and t-2; operating margin year t and t-2; profitability year t and t-2; market share year t and t-2.

(4) The impact of innovation on the use of factors of production: average cost reductions due to technological process innovations.

2.4 Summary

This chapter, firstly, outlines the underlying assumptions of the main extant theories with respect to inter-firm cooperation. A great deal of research has been developed to explain the rationale of inter-firm cooperation. This remarkable body of work has been done in the view of competitive forces theory, transaction cost theory, and resource-based theory. This literature review recognizes that no single theory dominates, and competitive forces, transaction cost and resource-based perspectives provide an irreplaceable complementarity for explaining the phenomenon of inter-firm cooperation. Therefore, the conceptual framework of the current study is fundamentally built on a combination of competitive forces, transaction cost and resource-based theories. The aim of the current empirical study is to contribute to the more general inter-firm cooperation theory.

Following a discussion of economic and organizational views of technological cooperation in the first section, the second section discusses the impact of technological factors on inter-firm cooperation. In contrast with competence-enhancing technological discontinuities, competence-destroying technological discontinuities open up opportunities for new entrants. In many high-tech industries, SMEs are the first movers by bringing in cutting edge technologies. They compete with veterans in the industries. SMEs go to cooperate with other firms, particularly with larger firms, with incentives that vary with the stage of a technology cycle the firm operates in. From the viewpoint of technological paradigms and trajectories, a firm's core competence may be shifted to core rigidity over time. Therefore, as suggested by dynamic capabilities advocators, inter-firm cooperation is a learning mechanism for a firm to capture the technology change trend and upgrade its core competence.

The third section briefly demonstrates technology innovation theory. Technological innovation is referred to as technological product innovation and technological process innovation, comprising technologically implemented new products and processes and significant technological improvements in products and processes (OECD, 1997). While research is a major contributor to innovation, entrepreneurial action is the key to filling the gap between promising technology and potential markets. Innovative firms initiate innovation activities by internal R&D, and acquisition of technology externally. The process of providing new or improved product is complicated and very often it is beyond a firm's existing capability. Inter-firm cooperation oriented to technological innovation is a strategic option for entrepreneurial firms. In the final part of this section, measurements of the impact of innovation on performance of a firm are reviewed. The literature suggests that the impacts of innovation on the performance of a firm should be examined from multiple aspects, ranging from output of new products and patents due to technological product innovation to the cost reduction due to technological process innovation, from growth of sale, profit and export to increase of R&D employees. The discussion of definition, sources, activities and performance assessments of technological innovation lays the ground for defining inter-firm technological cooperative activities, and designs the assessment system for technological cooperation performance for the current study.

Chapter Three: Empirical Study of Inter-firm Technological Cooperation

This chapter reviews the literature on motives for engaging in inter-firm technological cooperation, modes of cooperation, determinants of a firm's propensity to cooperate, impact of cooperation on a firm's innovation, and the critical success factors in inter-firm cooperative relationships. Gaps and inconsistencies in explaining the phenomenon of cooperation are examined by critically reviewing a considerable body of work, and the purpose and direction of conducting the current study is thereby consolidated.

3.1 Review Definitions of Inter-firm Technological Cooperation

According to Smith et al. (1995), cooperation is a topic of interest in disciplines such as economics, sociology, anthropology, psychology, and political science as well as in organizational behaviour, organization theory, and strategic management. They suggest definitional categories to the topic of cooperation would be helpful for informing the analysis of current research topic and trend. An overview of definitions of inter-firm cooperation is presented here. All of reviewed definitions are based on aforementioned three theoretical perspectives – competitive forces, transaction cost and the resource-based view of the firm.

A variety of terms regarding inter-firm cooperative practices have been used, such as network, coalition, collaboration, alliance, partnership, cooperation, and the like.

Some researchers consider them as synonymous, while others focus on specific inter-firm relationship in their studies. Considering that inter-firm cooperation in this study is orientated to technological innovation, only the terms relevant to this study are discussed below.

As noted by Harbison and Pekar (1998), inter-firm cooperation consists of a broad range of cooperative relationships, ranging from short-term projects to long-lasting supplier-manufacturer relationships, and to broad strategic alliances where partners tap into and learn from each other's capabilities. To clarify the various definitions of inter-firm cooperation, the concerned literatures are reviewed from two points of view: motivation and governance mode.

Many researchers emphasize a firm's strategic motivation for initiating cooperative agreements. Maynard (1996) proposes that strategic alliances are the outcome of a firm's consideration of potential synergies and complementary strengths that enable the partners to share risks and exploit opportunities. Gulati (1995) describes strategic inter-firm alliances as a variety of agreements in which two or more firms agree to pool their resources to pursue specific market opportunities. In Chan et al. (1997, p.199), a strategic alliance "enables a firm to focus resources on its core skills and competencies while acquiring other components or capabilities it lacks from the marketplace." PricewaterhouseCoopers (2000, p.4) defines an alliance as "any situation where there is an explicit agreement to leverage combined resources to achieve competitive advantage." Ahwireng-Obeng (2001, p.3) defines strategic alliances as "agreements utilizing resources from two or more organizations in such a way that strategic position of each is enhanced beyond what they could accomplish individually."

More specifically, many studies focus on jointly technological innovation or R&D activities. According to Dodgson (2001), strategic research partnerships (SRPs) are understood to essentially involve shared commitment of resources and risk by a number of partners to the agreed complementary research aims. SRPs can occur 'vertically' throughout the design, production and assembly of parts, components and systems, to their distribution and service. 'Horizontal' SRPs, on the other hand, occur between partners at the same level in the value chain. Hagedoorn et al. (2000) define SRPs as "an innovative relationship that involves, at least partly, a significant effort in research and development..." This perspective places and recognizes that R&D is an important element embedded within a larger strategic framework. Brokhoff et al. (1991) use the term 'inter-firm R&D co-operation' and define it as inter-organizational arrangements through which organizations jointly acquire technological knowledge. More related to the current study, Hagedoorn and Schakenraad (1994) and Robertson and Gatignon (1998) refer to alliances as joint innovative activities to develop new products and technologies or to exchange technologies.

From the view of organizational arrangement (governance mode), Gomes-Casseres (1997, p.34) defines alliances as "an administrative arrangement to govern an incomplete contract between separate firms in which each partner has limited control." In Sachwald (1998, p.204), cooperative agreements or alliances are defined as "the types of transactions undertaken by two or more independent partners and which were an intermediary between spot transactions on a market and mergers or acquisitions, that is, between market and hierarchy." In the same vein as Sachwald (1998), Hagedoorn (2002, p.478) defines R&D partnerships as "part of a relatively large and diverse group of inter-firm relationships that one finds in between standard market transactions of unrelated companies and integration by means of mergers and acquisitions." According to Imai and Baba (1991), innovation networks can be viewed as an inter-penetrated form of market and organization. Empirically they are loosely coupled organizations having a core with both weak and strong ties among constituent members. Their study emphasizes the importance of cooperative relationships among firms as a key linkage mechanism of network configurations.

Literature review suggests that a well-defined inter-firm cooperation concept requires considerations of (1) the range of inter-firm relationships; (2) the aim to be achieved by approaching potential partners; (3) the means by which to cooperate and benefit from one another; (4) the organizational arrangements or governance structures for functioning in cooperative relationships.

3.2 Overview of Motives for Inter-firm Technological Cooperation

According to Love and Roper (1999), the simple Schumpeterian hypothesis, which asserts a positive link between firm size (or monopoly power) and innovative activity, is insufficient to explain the extent of innovation at the establishment level, and technology transfer and networking may be important alternatives to R&D as an input into the innovation process. Evolutionary models of the innovation process (Freeman, 1991; Todtling, 1992) also suggest the potential importance of inter-firm networks as sources of new technical knowledge, in addition to an enterprise's own R&D effort.

Motives for firms cooperating in their efforts to innovate have a wide range, such as economic explanations (e.g. cost reduction and efficiencies), and strategic competitive relationships between firms (e.g. standards creation, competitor exclusion or locking-in key players, and entry into foreign markets). Some address technological issues (e.g. uncertainty, multi-disciplinarity, and shortening life-cycle of technology), while other explanations are less instrumental and focus on qualitative issues such as organizational learning.

Gain access to complementary assets. Deeds and Hill (1996) note that in order to develop a new product a number of complementary assets have to be integrated. Partnership is an effective way of quickly assembling the required set of complementary assets. Considering that a firm has developed a body of technological know-how with the commercial promise of a viable product, the firm has to assemble assets that include complementary technological know-how, market know-how, manufacturing know-how, and financing. Complementary technological know-how is important because increasingly new product development is an interdisciplinary task that requires the integration of know-how from different areas. Thus, to develop a new product, the firm's know-how may have to be combined with complementary know-how possessed by other firms. Marketing know-how may also be important, for if new products are to succeed in the market, they have to be designed to best serve customer needs. Manufacturing know-how is important for firms to understand how to efficiently manufacture a new product while minimizing the time it takes to move the product to market. And finally, access to financial resources is important, for without financing many entrepreneurial firms will be unable to transform their technological know-how into a commercial product. Harrigan (1985, 1988a) and Varadarajan and Cunningham (1995) points out that the missing resources in each of these complementary resource sets provide the motivation to consider an alliance. As noted by Sachwald (1998), high-tech firms have been very active in R&D cooperation because cooperative agreements have been used as one way of complementing internal R&D resources. Sachwald (1998) also finds, in the automobile industry, obtaining distribution channels and suppliers in the American market has been one motivation for joint ventures between Toyota and GM and between Honda and Rover.

Capture first-mover advantages. Hamel et al. (1989), Shan (1990), Pisano (1990), Stalk and Hout (1990), Mitchell and Singh (1992), Varadarajan and Cunningham (1995), and Deeds and Hill (1996) argue that given time and financial resources, a firm can develop internally the complementary technological, manufacturing, and marketing assets needed to transform new knowledge into a commercially viable product. However, by the time this has been achieved, the firm may have lost the ability to capture any first-mover advantages in order to be quicker than competitors. Alternatively, the firm may be able to quickly gain access to complementary assets through alliances. Thus, when minimizing time to market is an important competitive requirement, as is often the case, it can be argued that there should be a presumption in favour of strategic alliances.

Increase scale and scope of activities. Contractor and Lorange (1988) and Varadarajan and Cunningham (1995) point out that companies form alliances as a means of achieving economies of scale. Dodgson (2000) demonstrates that the outcomes of strategic research partnerships may be applicable to all partners' markets, and thus may expand an individual firm's customer bases (increased scale). Synergies between firms' different technological competencies may produce better, more widely applicable products (increased scope). Increasing the scale of resources dedicated to research programs can also raise entry barriers to other firms. Gomes-Casseres (1994, 1997) reveals how a strategic alliance generates compensating competitiveness for a small computer firm to compete against other firms and groups.

As noted by Smith et al. (1991), collaboration can reduce inequalities between small and large firms as a result of the complementary nature of the relationship. Technological expertise, coupled with increased resources through collaboration, allows smaller firms to compete directly with larger firms. A consequence of inter-firm collaboration is, therefore, that competition is taking on a more organized pattern between firms of different sizes which have been integrated into coherent networks.

Share costs and risks. In Contractor and Lorange (1988), Faulkner (1995), Hill and Jones (1995), Varadarajan and Cunningham (1995), Dodgson (2000), and Ritter and Gemunden (2003), strategic alliances are considered to be able to share high costs and risks involved in new product development, although they can also, of course, share future income streams from any subsequent innovations. As Ritter and Gemunden (2003, p.746) contend, "Nowadays, most companies face major problems related to new product and process development due to the shortening of the innovation cycle, the higher complexity and interconnectedness of technologies, and the higher costs of innovations. One solution to these problems is seen in using interorganizational relationships through which the 'burden' of innovation can be shared between several organizations." Many other studies, such as Berg et al. (1982), Auster (1987) and Harrigan (1988b), contend that reduction and sharing of costs of R&D are incentives for firms' cooperation.

Improve ability to deal with complexity. In Nooteboom (1996, 1999), the primary function of a firm may be cognitive as in a 'focusing device'. By focusing on one direction the firm runs the risk of missing out on opportunities and not seeing threats from other directions. To cover for this, the firm needs complementary outside sources of cognition: cognition by others which is relevant but different. Dunning (1995) points that alliance is the outcome of a series of landmark technological advances and of the globalisation of many kinds of value-added activity. From this view, Nooteboom (1999) proposes a new reason for alliance linkages between firms: when complexity and variability of technologies and markets increases, the need for complementary cognition from external partners increases. Many studies (e.g. Harrigan, 1985; OECD, 1986; Auster, 1987; Mowery, 1988; Hagedoorn and Schakenraad, 1990a and 1990b) all support the increased complexity and intersectoral nature of new technologies and the cross-fertilization of scientific disciplines and fields of technology are important motives that lead firms to cooperate with each other.

Cope with environmental uncertainty. An important contextual factor affecting the level of uncertainty is the increasing amount of scientific and technological integration occurring in various forms. For example, Kodama (1995) presents the increasing prevalence of 'technological fusion', such as the 'mechatronics' involves the fusion of mechanical technology with electrical and material technologies, and 'optoelectronics' involves the fusion of glass technology with cable and electronic device technologies. Meanwhile, increasingly sophisticated and demanding customers, growing competition in globalisation of markets place pressures on firms. Few firms, even big one, are capable of controlling these uncertainties. Faulkner (1995) proposes that external factors drive firms to form alliances, including issues surrounding globalisation or regionalisation, turbulence and uncertainty of international markets, and the need for coping with fast technological change and the shortening product life cycles. In the same vein, Dunning (1995) claims that international joint ventures and joint R&D agreements can circumvent geographical boundaries for foreign market entry. From this view, Dodgson (2000) believes that it will be often easier for firms to cooperate with partners than go it alone.

Benefit from flexibility and efficiency. Dodgson (2000) argues that strategic research partnerships may be an alternative to direct foreign investment, mergers, and acquisitions which are much less easily amended once entered into. As a governance structure, strategic research partnerships have advantages over the alternatives of arms' length transaction and vertical integration. They may allow firms to keep a watching brief on external technological developments without having to invest heavily. Dodgson and Rothwell (1994) determine that large/small firm interaction can be facilitated such that the resource advantages of the former are linked with the behavioural or creative advantages of the latter whilst maintaining their independence.

Learn through alliance. As noted by Hamel and Prahalad (1989), Hamel (1991), and Varadarajan and Cunningham (1995), a major reason for entering into alliance is to learn about the skills of other firms. Strategic alliances are a mechanism for learning valuable skills that can help improve the efficiency of a firm's own internal processes, including its new product development processes. In the same vein, Pavitt (1988) stresses that technological knowledge is not only tacit, but also firm-specific. It is, therefore, difficult to transfer easily or quickly. Alliances potentially provide a mechanism whereby close linkages among different organizations enable the development of sympathetic systems, procedures, and vocabulary which may encourage the effective transfer of technology. As Mowery (1988) suggests, alliances may allow partners to 'unbundle' discrete technological assets for transfer. Prahalad and Hamel (1990) and Hamel (1991) conceive of a firm as a portfolio of core competencies and disciplines. They posit that inter-firm competition is essentially concerned with the acquisition of skills, and globally competitiveness is largely a function of the firm's pace, efficiency and the extent of knowledge accumulation. Hamel (1991) further points out that core competencies and value creating disciplines are not distributed equally among firms. Strategic alliances play a role in effecting a partial distribution of skills among partners. Through partnerships, as noted by Hamel (1991), a firm may not only gain access to partners' skills but also actually acquire the partners' skills (internalisation).

It is worthy noting that Hagedoorn (1993) presents a spectrum of motives that go with the process of innovation. These range from developing science and performing R&D down to market entry and the joint introduction of new product.

Motives related to basic and applied research and some general characteristics of technological development. These are (1) increased complexity and the intersectoral nature of new technologies, cross-fertilization of scientific disciplines and fields of technology, monitoring of evolution of technologies, technological synergies, access to scientific knowledge or to complementary technology; and (2) reduction, minimizing, and sharing of uncertainty in R&D; (3) reduction and sharing of costs of R&D.

Motives related to concrete innovation processes. These are (1) capturing of partner's tacit knowledge of technology, technology transfer, and technological leapfrogging; and (2) shortening of product life cycle, reducing the period between invention and market introduction.

Motives related to market access and search for opportunities. These are (1) monitoring of environmental changes and opportunities; (2) internationalisation, globalisation, and entry to foreign markets; (3) new products and markets, market entry, and expansion of product range.

In sum, prior studies explain that motives for cooperation are mainly based on competitive forces, transaction cost and resource-based perspectives. It is assumed that SMEs in high technology industries have distinctive characteristics, and therefore they are motivated by reasons different from those of large firms or firms in non-high technology industries. Fully examining firms' motives for engaging in cooperation helps understand firms' choice of cooperative modes and enables assessment of their cooperation performance.

3.3 Empirical Studies on SMEs' Cooperative Practices

3.3.1 Providing Technology in Exchange for Finance through Strategic Research Partnerships

Audretsch (2001) studies strategic alliances between pharmaceutical firms and biotechnology firms. Strategic research partnerships between large corporations and biotechnology companies have been particularly important for biotech companies specializing in therapeutics. This is because the cost of developing a new drug, complying with the various layer of regulation, manufacturing the product, and then marketing the product, have required a level of finance that far exceeds the budgets of most small firms. Cullen and Dibner (1993) estimate the cost of bringing a therapeutic drug from basic research to the market is around $250 million. At the same time, the average budget for research and development of biotech firm is $12.5 million. To close this gap, biotech firms have engaged in a broad range of marketing and licensing agreements. Under these agreements, biotech firms provide access to cutting edge technology in exchange for an infusion of capital from their corporate partners.

In documenting the evolution of strategic alliances in biotechnology, Cullen and Dibner (1993) conclude that finding and developing alliances is the primary concern of small and medium-sized biotechnological companies in developing and marketing their new products. The obvious advantage of such strategic research partnerships is that they enable a small, new company to concentrate on its core mission - moving from basic research to commercialisation through technological innovation. The strategic alliances also enable biotech companies to reduce financial risks as well as operating costs. In addition, biotech firms are able to better offset the major liabilities associated with biotech start-ups - acquiring manufacturing capabilities, marketing and sales.

Established firms are generally quite active and supportive towards biotechnology firms. This is because a strong complementary relationship has evolved between established and biotechnology firms. The former have recognized that it may be a more efficient structure to engage in an inter-firm cooperative relationship to obtain new biotechnology products than to produce them internally. The reason for this involves agency problems in undertaking research that is highly uncertain and asymmetric. As Williamson (1991a, p.83) suggests, hierarchical integration is the last choice and firms "revert to hierarchy only for compelling reasons". In addition, the exposure to legal liabilities resulting from biotechnology research is reduced when that research is undertaken at a small firm with limited assets rather than in a large corporation with massive assets.

In Lerner and Tsai (2000), biotechnology firms have only modest financial resources. Their study estimates that, on average, a biotech firm had around $10 million in revenue in the year prior to the alliance. However, given the mean expenditures of over $21 million, mostly on R&D, virtually all of the biotech firms were making losses. The loss corresponded to about one-third of the mean firm's shareholder equity and one-half of its cash and equivalents. The final point is that the strategic partners - the large pharmaceutical companies provide finance, while the small biotechnology firms provide knowledge.

3.3.2 Reaching for Scale and Scope through Strategic Alliances

Gomes-Casseres (1994, 1996 and 1997) provides an example of how a strategic alliance generates compensating competitiveness for small firms. A relatively small computer firm, Mips Computer Systems ('Mips' hereafter), operated in the same market as IBM and Hewlett-Packard. Production scale economies and market penetration determined commercial success. Mips produced reduced instruction-set computing (RISC) processors, which required large-scale production. Because of these economies of scales, only a few of the producers in the market would ultimately survive. This meant that those designs with the greatest market penetration were likely to be among the survivors. Thus, it was crucial for Mips to obtain a large market share and influence the industry standard. Mips created a constellation including semiconductor partners and a number of systems vendors by the forms of equity investment, product supply, technology license, and agreement to use its chip. These partners contributed production capacity, market presence, technological competencies, and finance. Mips contributed a highly specialized and unique semiconductor design and coordinated the activities of the constellation. This strategy implied a transformation of the unit of competition. As Gomes-Casseres (1997, p.37) remarks, "Legally, Mips remained a small corporation. But, economically, it was part of a much larger whole, and it was this larger whole that competed against other firms and groups. Increasingly, the talk in the industry became one of how the Mips "camp" was faring versus the camps centred around other firms."

3.4 Overview of Modes of Inter-firm Cooperation

Inter-firm cooperation takes on a variety of modes or forms. It may be as simple as a licensing agreement for technology transfer or a more complex long-term commitment to work with one or more firms to develop and bring new leading-edge technology to market.

According to Baum et al. (2000), alliances between firms are formed in two ways: vertical alliances and horizontal alliances. Vertical alliances link firms to sources of complementary assets, commercialisation knowledge, and capital outside of the existing industry boundaries. These alliances tend to provide smaller firms with expertise that they have not yet developed or do not have the resources to develop. As observed by Baum et al. (2000), small biotechnology firms tend to partner with large pharmaceutical companies in order to gain expertise in the Food and Drug Administration's (FDA) drug testing policies and procedures. Horizontal alliances link a firm to other firms in the same industry. These alliances are very prevalent in high technology industries where resources are unique and costly to obtain. Joint research and development agreements, for example, help lower the cost and risk of enhancing or developing new products. In this case each company provides critical resources to the alliances that the other company does not have. Sachwald (1998) notes that the most striking type of cooperation is the cooperative agreements with competitors, for example joint programmes of pre-competition research.

Many studies (e.g. Osborn and Baughn, 1990; Tallman and Shenkar, 1990; Gulati, 1995; Baum et al., 2000) use the dichotomy of equity alliances vs. non-equity alliances as the category of alliance forms. Whereas equity alliances include equity joint ventures and minority equity alliances, non-equity alliances refer to all other contract-based cooperative arrangements that do not involve equity exchange.

Others categorize alliance modes by using multiple dimensions. For example, Das and Teng (2000) adopt the following four-part alliance typology: (1) joint ventures; (2) minority equity alliances; (3) bilateral contract-based alliances; and (4) unilateral contract-based alliances. Freeman (1991) uses the term of 'innovation network' and categorizes it as: (1) joint ventures and research corporations; (2) joint R&D agreements; (3) technology exchange agreements; (4) direct investment (minority holdings) motivated by technology factors; (5) licensing and second-sourcing agreements; (6) sub-contracting, production-sharing and supplier networks; (7) research associations; (8) government-sponsored joint research programmes; (9) computerised data banks and value-added networks for technical and scientific interchange; (10) other networks, including informal networks.

Although innovation has a variety of determinants, innovative firms are largely determined by their R&D level. Therefore, there are many studies focusing on R&D partnerships. Hagedoorn (1990, 1993) overviews the modes of cooperation in which technology transfer, technology-sharing, R&D collaboration or, more generally, innovation-motivated cooperation is an essential feature of the agreement. Hagedoorn (1990, 1993), Hagedoorn and Schakenraad (1994) and Hagedoorn (2002) line up the modes of R&D partnerships according to the logic of increasing organizational interdependency as technology licensing, second-sourcing agreements, customer-supplier relationships, joint R&D agreements, equity investments, and joint ventures and research corporations. These forms are discussed systematically in the following part in order to better understand firms' choice of cooperative modes.

3.4.1 Licensing

Licensing refers to agreements that provide unilateral technology access, frequently through patents, to a licensee in return for a fee. As Hagedoorn (1990, p.23) states, "standard licensing agreements are contracts whereby one company, which has proprietary rights, gives another company the right of use in return for payments." Since licensing provides speedy entry and relatively inexpensive technology access to the licensee (Hagedoorn, 1990), in most of licensing agreements small firms play the role of licensees and they license in the technologies from other firms, especially large firms. As Rothwell (1991, p.109) states, "This frequently involves technology that the large company does not wish to exploit in-house but which it wishes to gain a financial return on." Unilateral licensing usually concerns the transfer of somewhat older technologies and products (Killing, 1983; Bonin, 1986).

Cross-licensing is considered the way of licensing for reciprocity which is a bilateral form in which companies exchange licences to supplement their own research with licensed technology or to avoid patent protection. Compared with unilateral licensing, this bilateral form of technology transfer regulates the relocation of more advanced technology (Hagedoorn, 1990).

Licensing agreements are one of the most widely used methods for acquired technology. The main attraction is that it enables firms rapidly to establish positions in new technical areas, particularly in those which complement existing core skills. For example, Eli Lilly licensed in basic cephalosporin technology from the National Research and Development Corporation. Using its in-house skills, Eli Lilly was able to produce a wide range of these antibiotics, hence adding value to the licensed technology (Tidd et al., 2001). From the resource-based perspective, Tsang (2000) points out that if the technology is mature, well codified and protected by a patent, its functioning is more or less independent of the firm's idiosyncratic routines. In this case, Tsang posits that licensing is the preferred mode of technology transfer. Differently put, if the technology to be transferred is newly developed by a firm and consists of a substantial tacit element, it is very firm-specific and licensing is not a suitable option.

According to Schilling (2005), firms as licensers can broaden the scope of technology application to market without being limited by their internal capacity. Licensing also can be a market strategy as Schilling describes, i.e. a firm is willing to license its technology before its rival successfully develops the competing technology. The first mover may harvest as a dominant technology setter once the licensing technology is accepted by market.

Licensing agreements usually impose many restrictions in order to keep licensed technology under licensers' control. Tidd et al. (2001) note that many firms express concerns regarding the constraints imposed by licensing agreements, specifically the common requirement to 'grant-back' any improvements made to the technology. For these reasons an increasing number of firms are careful to license only components of any process or product in order to allow scope for subsequent improvement and differentiation. For example, Mitsubishi Chemical licensed a well-established process technology from a US competitor, but chose not to license the catalyst or polymer design. This allowed the company to avoid having to grant-back its subsequent improvements to the catalyst and polymer design to the American competitor. However, as Tidd et al. (2001) point, this approach to licensing is only viable where the technology can be easily 'unbundled'. For the complex interrelated technology patents and skills, companies prefer the more interdependent cooperative forms.

Studies (e.g. Tidd et al., 2001) have identified the other potential drawbacks of licensing-in, including loss of control of operational issues such as pricing, production volume and production quality, and the potential transaction costs of search, negotiation and adaptation. Schilling (2005) adds that acquiring technology through licensing can not be the source of competitive advantage since the same technology can be licensed to more than one user.

3.4.2 Subcontracting

Subcontracting, also termed second-sourcing or outsourcing, has become a popular technology strategy in recent times. According to OECD (1985, p.52), "Second-sourcing involves a transfer of product technology, often including masks or technical specifications, which allows one firm to make an exact copy of another firm's product...Although second-sourcing will result in loss of market share for the originator of the product, the compensating advantage is the market growth resulting from many suppliers..." OECD (1985) explains the dense network of second-source agreements as the result of complex production processes and dependency of sophisticated end product on the design of a single component. Hagedoorn (1990) contends that advantages of second-sourcing are in secure and overall growth of supply for one side and secured and regulated demand for the other. Mutual second-sourcing, according to Hagedoorn (1990), reflects the preference of companies to minimize the risk of opportunistic behaviour by its second-sourcing partner through a reciprocal arrangement.

Firms usually subcontract their non-core technology to seek cost-savings because suppliers are likely to have lower overheads and variable costs. The most popular form is to use contract manufacturers. Contract manufacturing can help firms realize their innovation without investing in manufacturing, and therefore achieve cost-saving benefit from outsourcing. Additionally, Schilling (2005) suggests that firms can outsource technical design, product distribution, or marketing. The advantage comes from where firms build their competences upon core technology, and remain a key part of the value chain. Although large firms tend to outsource part of their business, smaller research-intensive firms may favour this business model as well. For example, they may focus on research-based activities and outsource manufacturing and marketing of products to other firms. There are drawbacks in doing it this way. From a long-term view, this may limit firms in future product development since firms lose the learning opportunities due to outsourcing. Another drawback can be a potential risk of core technology leakage. It is reasonable to anticipate that contract manufacturers might grasp key technology to develop their own innovative products.

3.4.3 Customer-supplier Relationships

Customer-supplier relationships refer to the partnerships between vertically-related, but independent companies, basically in the forms of co-production contracts, co-makers relations, and R&D contracts (Hagedoorn, 1993). Customer-supplier R&D contracts are relationships where one company is sub-contracted by another company to perform particular R&D projects. For example, large computer companies or automobile manufacturers fund R&D in small software companies or design houses.

Hagedoorn (1990) states that there are advantages and disadvantages for small R&D-intensive companies engaged in contract research. Small firms benefit from secure R&D funding and ensured cooperation with experienced partners. The potential disadvantages can be loss of capital if R&D is unsuccessful; low profit margins from licensing technology; short-term relationships and revenues as well. Furthermore, OECD (1987) notes these small research companies have few commercial rights to any inventions they developed under contract and they frequently end up with few or no benefits.

The seminal work of Von Hippel (1988) and the subsequent works by others encourage firms to identify and form relationships with a 'lead' user. Nishiguchi (1994) observes that the perception of the practice of Japanese manufacturers has led many firms to form closer relationships with suppliers. It is expected that closer links between suppliers and customers may help to reduce the cost of components, through specialization and sharing information on costs. Traditionally, such relationships have been short-term, contractual arm's-length agreements focusing on the issues of the cost, with little supplier input into design or engineering. In contrast, the 'Japanese Model' is based on long-term relationships, and suppliers make a significant contribution to the development of new products. The latter approach increases the visibility of cost-performance trade-offs, reduces the time to market and improves the integration of component technologies. According to Tidd et al.'s (1997) observation, in certain sectors, particular machine tools and scientific equipment, there is a long tradition of collaboration between manufacturers and lead users in the development of new products.

However, Leonard-Barton and Sinha (1993) warn that factors such as the selection of suppliers and users, the timing and mode of their involvement, and the novelty and complexity of the system being developed may reduce or negate the benefit of close supplier-user links. The quality of relationship with suppliers and the timing of their involvement in development are critical factors.

3.4.4 Joint R&D Agreements

Joint R&D agreements (non-equity joint venture), including joint research pacts and joint development agreements, are contractual relationships through which companies perform jointly funded R&D projects, or in the case of joint development agreements, jointly work on the development of new products or processes. Auster (1987, p.4) posits that companies engage in joint R&D activities "to reduce costs, minimize risk, and allow synergy among firms pursuing similar innovations". According to Rothwell (1991), large firms may collaborate with small firms in the development of an innovative new product containing technology new to the larger partners. The large firm provides financial, manufacturing and marketing resources, and the small firm provides specialist technological know-how and entrepreneurial dynamism. Generally the new products are complementary to the large firms' product range.

Studies (e.g. Osborn and Baughn, 1990; Hagedoorn, 1996; Narula and Hagedoorn, 1999) have established that non-equity forms, such as joint R&D pacts and joint development agreements, have become very important modes of inter-firm collaboration as their numbers and share in the total of partnerships have far exceeded that of joint ventures. According to Hagedoorn (2002), these contractual agreements cover technology and R&D sharing between two or more companies, implying the sharing of resources, usually through project-based groups of engineers and scientists from each parent-company, and the sharing of costs for capital investment, such as laboratories, office space, equipment, etc. However, as noted by Hagedoorn (1993), compared to joint ventures, the organizational dependence between companies in an R&D partnership is smaller and the time-horizon of the actual project-based partnerships is almost by definition shorter.

Joint research pacts and joint development agreements cover a wide variety of legal and organizational arrangements. These contractual R&D partnerships are to be seen as incomplete contracts for which it is impossible to specify the concrete results of the joint effort. Companies favour the form of joint R&D agreements due to its flexibility and the low costs of both intended and unintended termination compared to equity-based agreements like a joint venture. From a resource-based point of view, Das and Teng (2000) contend that contract-based alliances will be preferred over equity joint ventures and minority equity alliances when the purpose of the alliance is project or learning-oriented. Bilateral contract-based alliances, such as joint R&D, provide more opportunities for learning than unilateral contract-based alliances such as licensing and subcontracting. Contractor and Lorange (1988) find that large companies tend to undertake joint R&D agreements as experiments for exploring possible benefits of co-operation before entering into more far-reaching agreements such as joint ventures.

3.4.5 Minority Equity Alliances

Minority equity alliances, according to Pisano (1989), Gulati (1995), and Das and Teng (2000), are defined as one of the partners takes a minority equity position in the other partner or partners. According to Hagedoorn (1990, 1993), equity investments can be seen as a form of cooperation between companies because in the long run this equity-based relationship could affect the technological performance of at least one 'partner'. The strategic motivation for taking minority stakes in another firm is to achieve some control of another company although this control is limited by the extent of equity investment. Hagedoorn (1990) observes a large company would cooperate with a smaller high-tech company by holding minority stakes, in particular the minority sharing is coupled with research contracts. OECD (1987) reports this practice has been popular specifically in the field of biotechnology.

Das and Teng (1996) argue that shared ownership helps control opportunistic behaviours. Since equity arrangements are rather complicated to implement as well as to get out of, they are usually entered into for longer time periods, compared to alliances without equity investments. A long duration for an alliance provides an incentive to partners to behave honestly and curb opportunistic behaviour. In the context of the so-called "shadow of the future" effect, firms that expect a relatively lasting relationship will be more careful about taking advantage of their partners (Axelrod, 1984; Heide and Miner, 1992; Joskow, 1987). Should a partner be found appropriating others' knowledge-based resources to an undue extent, its equity stake may be held as hostage. Thus, equity investments provide some protection against the unintended transfer of partners' tacit knowledge.

Hagedoorn (1990) doubts minority sharing is an effective strategic option for acquiring technological achievements of another company because of limited participation and limited rights in decision-making, and argues that "if a smaller 'high-tech' company is of any interest to a larger company, the more favourable options are probably either majority sharing (integration), joint ventures, technology exchange agreements or research contracts" (Hagedoorn, 1990, p.24).

3.4.6 Joint Ventures and Research Corporations

Joint ventures and research corporations are the combinations of the economic interests of at least two separate companies in a distinct organizational entity, where profits and losses are usually shared in accordance with the equity investments by the 'parent' companies (Hagedoorn, 1993). R&D-related joint ventures occur in those companies that have shared R&D as a specific company objective in addition to production, marketing, sales etc. Research corporations are joint R&D ventures with distinctive research programmes (Hagedoorn, 1990). Compared to research corporations, R&D joint ventures undertake joint work more focused on innovation commercialisation and less on basic research tasks. OECD (1986) reports joint ventures of the pure R&D type are not very common and the agreements usually include manufacturing and marketing.

According to Berg et al. (1982), Hladik (1985), and Hagedoorn (1990, 1996), joint ventures are one of the older modes of inter-firm partnering and have become well-known during recent decades. Hagedoorn (2002) argues that although joint ventures do approach hierarchical organizational structures as parent companies share control over the joint venture, joint ventures can also act as semi-independent units that perform standard company functions such as R&D, manufacturing, sales, marketing, etc. Harrigan (1988b) contends that joint ventures are used by parents companies in a broader strategic setting where companies enter into new markets, reposition themselves in existing markets or exit from declining markets.

As noted by Das and Teng (2000), one key problem in strategic alliances is that firms may be opportunistic in maximizing their own particular interests at expense of their partners. Such opportunistic behaviour tends to be more severe when it involves tacit knowledge and skills that are not protected by property laws. When the partners work shoulder to shoulder in the same entity for an extended period, it becomes difficult to keep others from accessing one's tacit know-how (Hamel, 1991). Consequently, equity joint ventures provide the best opportunities to acquire partners' tacit knowledge and other knowledge-based resources. Researchers note that partners often use alliances as a cover for appropriating knowledge-based resources (Inkpen and Beamish, 1997). Among various alliance forms, equity joint ventures are the most instrumental in the transfer of tacit knowledge between the partners, because of the significant extent to which partners are exposed to each other (Kogut, 1988). As Hennart and Reddy (1997, p.11) report, "a joint venture is primarily a device to obtain access to resources which are embedded in other organizations."

Applying transaction cost theory, Kogut (1988, p.320) argues, "The situational characteristics best suited for a joint venture are high uncertainty over specifying and monitoring performance, in addition to a high degree of asset specificity. It is uncertainty over performance which plays a fundamental role in encouraging a joint venture over a contract."

Kogut and Singh (1988) demonstrate that R&D related joint ventures appear to be concentrated in R&D-intensive industries. Berg and Friedman (1978) and Harrigan (1988b) conclude that R&D joint ventures are particularly established in high-tech industries, such as information technology-related sectors in electronics and communications, and pharmaceuticals. However, this does not suggest that R&D joint ventures are a preferred method of governance for achieving core research activities or major strategic activities of their parent companies. Researchers have found that technologically inspired joint ventures are used to overcome shortcomings of in-house R&D rather than building one's own core technological capabilities (Harrigan, 1985; OECD, 1986; Hagedoorn, 1990). As Harrigan (1985, p.326) claims, "the higher a product line or area of technology was in strategic importance, the more reluctant firms were to use cooperative strategies to leverage their competitive positions." Hagedoorn (1990) observes that sometimes joint ventures are established with smaller, but promising, companies. He warns that a take-over strategy probably remains a 'hidden' option in case the larger partner becomes critically interested in the activities of the joint venture. Take-overs which emerged in the partnerships between pharmaceutical companies and biotechnological companies have demonstrated this trend.

Hadgedoorn (1996, 2002) and Narula and Hadgedoorn (1999) point out that equity-based joint ventures have become gradually less popular compared to other forms of partnering, e.g. contractual partnerships. Studies (see e.g. Hladik, 1985; Harrigan, 1985 and 1988b; Poter, 1987; Kogut, 1988; Dussauge and Garette, 1999; Nooteboom, 1999) explain that this decreasing popularity is probably due to the organizational costs of setting up joint ventures, high failure rates, the risk of sharing proprietary knowledge, and the 'appetite for control' by one partner or a variety of different strategic objectives.

3.5 Determinants of Firms' Propensity to Cooperate and the Impact of Cooperation on Firms' Economic Performance

3.5.1 Determinants of Firms' Propensity to Cooperate

Many works have been dedicated to exploring the variables that influence firms' propensity to cooperate. The variables examined in prior studies include: firm age (e.g. Shrader 2001); firm size (e.g. Berg et al., 1982; Riedle, 1989; Kleinknecht and Reijnen, 1992; Hagedoorn and Schakenraad, 1994; Shrader, 2001; Fritsch and Lukas, 2001); innovation input, such as R&D intensity (e.g. Kleinknecht and Reijnen, 1992; Shrader, 2001; Fritsch and Lukas, 2001); innovation output, such as patent intensity (e.g. Hagedoorn and Schakenraad, 1994); and economic performance, such as sales growth (e.g. Shrader, 2001).

Kleinknecht and Reijnen (1992) use a logit model to estimate which of various independent variables have a systematic influence on the probability that a firm cooperates on R&D. The studied independent variables are collected from both firm and sector levels. By comparing the firms that engage in cooperation with those that do not, the results demonstrate that firm size has no significant influence on inter-firm R&D cooperation, confirming observations by Riedle (1989). In respect to the impact of R&D intensity on cooperation, Kleinknecht and Reijnen (1992) show that the R&D intensity of a firm has no impact on the probability to cooperate in general, which is contradictory to Fusfeld and Haklisch (1985). By separately examining this relationship in different sectors, Kleinknecht and Reijnen (1992) find significant positive correlation in biotechnological firms but not in information firms or new material firms.

Taking collaboration as a dichotomous independent variable, Shrader (2001) analyses what variables influence a firm's decision regarding whether or not to collaborate for foreign market entry. The results of logistic regression for collaboration use show that collaboration is positively related to firm size and negatively related to the overall sales growth of a firm in foreign markets. Firm age at foreign entry and R&D intensity is not related to collaboration among the firms in the sample.

Fritsch and Lukas (2001) use a logit-poisson hurdle model to analyse the impacts of a set of variables on the propensity of a firm to cooperate and on the number of a firm's cooperative relationships. Their regression analyses are implemented separately in innovative firms and non-innovative firms. The regression analyses show that firms that engage in R&D cooperation tend to be relatively large, have a comparatively high share of R&D employees, spend resources for monitoring external developments relevant to their innovation activities ('Gatekeeper') and are characterized by a relatively high aspiration level of their product innovation activities.

Berg et al. (1982) find that firm size has positive effect on joint venture participation. This correlation is explained by larger firms having more and better opportunities to seek external linkages through economies of scope. Hagedoorn and Schakenraad (1990c) find a J-shape relation between size and strategic partnering and posit that smaller size of Japanese companies in 'Triad' sample can explain the lower Japanese cooperation propensity. As Hagedoorn and Schakenraad (1994, p.299) state, "despite our attempt to reduce the large firm bias, large firm size is still associated with higher strategic partnering rates. In other words, firm size reflects the degree to which firms actively seek and find external opportunities in strategic linkages."

Hagedoorn and Schakenraad (1994) argue that innovative firms are attracted to technological cooperation. Therefore, patent intensity, measured by total number of assigned U.S. patents 1982-1986 set against average turnover 1982-1986, is expected to affect the propensity to cooperate. Their study demonstrates that a high patent intensity produces a strong positive impact on the propensity to establish strategic alliances. Therefore they conclude that patent intensive companies are heavily involved in strategic partnering.

3.5.2 Impact of Cooperation on Firms' Economic Performance

There are numbers of studies that give consideration to the relationship between inter-firm technological cooperation and firms' economic performance. Berg et al. (1982) is an earlier comprehensive study on the relationship between corporate performance and inter-firm cooperation. The effect of joint venture activity on profitability is measured with cross-firm and cross-industry empirical tests. At the cross-firm level, results from regression analysis show that joint venture activity tends to have a significant negative impact on profitability in chemicals and mechanical engineering but insignificant effects in the resource-proceeding sector.

No significant long-term effects of joint venture activity on profitability are found in any industrial sector. At the cross-industry level, regression analyses demonstrate that R&D oriented joint ventures produce a negative impact on the industry-average rate of return, whereas non-R&D driven joint ventures on average have a positive impact on rates of return.

In Bougrain and Haudeville (2002), results from the logistic analyses do not support the finding that technological cooperation increases the chance of success of innovative projects. And R&D intensity does not have significant influence on a successful rate of cooperative projects. In Hagedoorn and Schakenraad (1994, p.100), "for European and American process industries there is a positive association between R&D-driven cooperation and profitability."

Shrader (2001) uses moderated multiple regression models to examine the relationship between collaboration and performance. Profitability and sales growth are indicators of firms' economic performance. Collaboration neither significantly contributes to profitability nor to sales growth. R&D intensity has a positive direct relationship to both profitability and sales growth. However, the interaction of R&D intensity with collaboration is negatively related to profitability and sales growth. According to the results from regression analyses, Shrader (2001) suggests that R&D intensity is a quasi-moderator both to profitability and sales growth. Consistent with previous research, Shrader (2001) concludes there is no direct relationship between collaboration and performance. However, the study provides strong evidence that the key to understanding how collaboration affects performance is to examine other factors that moderate the relationship. Taking into account that the positive impact of some moderators appears to mask the negative impact of others, the overall relationship between collaboration and performance may become not significant. Recent studies (e.g. Dickson et al., 2006) suggest considering firm size as a moderator when examining the partnerships which SMEs involved.

In sum, the literature reports contradictory findings of determinants of firms' propensity to cooperate and effects of cooperation on firms' performance. Riedle (1989) and Kleinknecht and Reijnen (1992) conclude that firm size has no significant influence on inter-firm R&D cooperation while Berg et al. (1982), Hagedoorn and Schakenraad (1990c, 1994), Shrader (2001), and Fritsch and Lukas (2001) posit that collaboration is positively related to firm size. While R&D intensity in Fusfeld and Haklisch (1985) and Fritsch and Lukas (2001) appears to be positively correlated with the likelihood of cooperation, Kleinknecht and Reijnen (1992) and Shrader (2001) show that the R&D intensity of a firm has no impact on the probability of cooperation. Berg et al. (1982) conclude that joint venture activity tends to have a significant negative impact on profitability in chemicals and mechanical engineering but insignificant effects in the resource-proceeding sector. However, Hagedoorn and Schakenraad (1994) find a positive association between R&D-driven cooperation and profitability in the firms from European and American process industries.

The inconsistent research results imply the following. Firstly, the fundamental elements which determine firms' propensity to cooperate and the effect of cooperation on firms' performance still remain unclear. The relevant issues are much more complicated and exceed the expectation of most managers, and therefore call for in-depth investigation. Secondly, prior studies appear to target a broad industrial range. For example, Kleinknecht and Reijnen (1992) use a large sample including manufacturing and service firms from all industries in Netherlands. Hagedoorn and Schakenraad (1994) employ a sample of European, American and Japanese manufacturing firms from three industrial sectors. The advantages of these studies are attributed to the level of aggregation and generalization and at the same time these studies suffer from lack of depth in and representative to a specific industrial context. Hagedoorn and Schakenraad (1994) have noted that technological opportunities and competitive environments vary with industries and these variances largely explain differences in innovative performance. It is suggested that conducting an empirical study on firms coming from a specific sector under a common market and technology environment, rather than from cross sectors, may produce more precise conclusions and therefore provide more constructive advice for management practices.

3.6 Critical Success Factors for Inter-firm Technological Cooperation

While a great number of studies have their focus on the rationales of cooperation formation from different theoretical perspectives, many researchers have turned their attention to more practical issues, i.e. the high failure rate of cooperative relationships and the efficient management of strategic alliances. Attempts have been made to examine and discriminate the critical success factors for increasing the likelihood of successful cooperation. Conclusions in the literature are reviewed in the following section. The discussion builds a framework for investigating the influential factors for successful cooperation in high-tech SMEs in China.

3.6.1 Resource Complementarity

The resource-based view of strategy sees inter-organizational relationships as resource linkages that provide synergies by sharing and transferring resources (Eisenhardt and Schoonhoven, 1996). Forming a partnership rather than developing resources internally allows for faster strategy implementation, and therefore firms seek strategically complementary skills and knowledge in their partners (see e.g. Inkpen, 2001; Sampson, 2002). Regarding small/large firm partnerships, Meyer and Alvarez (1998) conclude that entrepreneurs seek to access the larger firm's skill in order to increase their firms' likelihood of success. Audretsch (2001) studies the strategic alliances between pharmaceutical firms and biotechnology firms. He demonstrates small biotechnology firms provide technology in exchange for finance through strategic research partnerships. Hagedoorn (1993) demonstrates that large firms seek small partners that can provide complementary edge-cutting technology, reducing their innovation time and cost. Numbers of studies propose that complementary resources are one of most basic determinants for a successful inter-firm cooperation (see e.g. Florin, 1997; Doz and Hamel, 1998; Alvarez, 1999; Hoffmann and Schlosser, 2001).

Some studies also suggest that firms may look for similar resources to enhance their resource capacity. For example, Das and Teng (2000, p.52) state that "the more individual firms contribute supplementary resource to an alliance, the more they accumulate." Challenging this view, Harrison et al. (2001) argue that "while two firms with highly similar resources may be able to achieve economies of scale and greater power…these companies may not be able to develop other valuable potential synergies as a result of their integration". Based on the data from questionnaire and interview, Arizel (2003) concludes that "young start-up and early growth firms seek relationships with firms that can supply resources that they do not have, rather than provide supplemental resources."

3.6.2 Geographical Proximity

An early work, Marshall (1920), has recognized that the spatial clustering or agglomeration of firms with related interests might yield agglomerative economies and an industrial atmosphere. Deeds et al. (1999) develop a model of new product development which is tested on a sample of 94 pharmaceutical biotechnology companies. One of important implications is that entrepreneurs/managers need to view the choice of geographic location as an important strategic decision which will impact their firms' access to the skilled technical personnel and the streams of the knowledge. Being dependent on emerging new knowledge, biotechnology companies cannot rely solely on internal knowledge development. They also need to absorb relevant knowledge from external sources. A firm located in a geographic area with a high concentration of similar firms will have access to knowledge which is unavailable to firms which are geographically isolated. Romijn and Albu (2002) analyse the effectiveness of small high-tech firm industry clusters, showing that frequency in external interactions with suppliers and scientific institutions and proximity of these actors is associated with higher innovative capabilities in the sample firms. They propose that a region can be an 'innovative milieu' in which small firms' innovative capabilities are fostered through local contacts with business, support agencies and institutions that are complementary to what small firms possess.

With ever-advancing communication technology, more and more firms no longer consider the geographical proximity an important factor in building and maintaining cooperative relationship. However, industry clusters' success, such as Silicon Valley in America, inspires a new wave that firms tend to be based in industry cluster regions and ally with nearby firms (see e.g. Saxenian, 1994; Keeble et al., 1999). Taking this tendency into account, it is assumed that geographical proximity still plays a significant role in cooperative efforts.

3.6.3 Deliberate Agreement

Belussi and Arcangeli (1998) point out that every launch of an innovation represents a chance for firms to revise their networking strategy. Old strategic alliances may be confirmed or, alternatively, revised. As a consequence, an internal instability emerges in the architecture of networks. Innovation activity is a major source of network reversibility: in high-tech sectors, network reversibility is quite a widespread phenomenon.

Leverick and Littler (1993, p.32) quote one of their surveyed respondents, saying that "Collaboration is a risky venture that has value in a limited and focused range of activities. In general it needs to be very specific and targeted. Vague long term research projects are a recipe for disaster." Lynch (1990) also contends, "Clarity of focus is vital. Ambiguous goals, fuzzy directions, and uncoordinated activities are the primary causes of failure of cooperative ventures." Therefore, a deliberate agreement to lay ground rules for dynamic cooperative activities becomes a prerequisite. Lynch (1991), Lyons (1991) and Farr and Fisher (1992) all stress the importance of clearly establishing the ground rules for the collaboration. This way is to ensure that there are clearly defined goals, objectives and responsibilities for the collaboration which are fully understood by all parties involved. Gyenes (1991) emphasizes the necessity of preparing detailed and binding initial collaboration agreements in order that future ambiguity is avoided.

According to Hoffmann and Schlosser (2001), responsibilities and benefits should be stated clearly in the agreement. Sensitive issues, like 'who owns the intellectual property resulting from the collaborative product development', need to be given particular emphasis. From the perspective of transaction cost theory, the behaviour uncertainty and opportunism increase transaction costs, and therefore reduce the efficiency of cooperation. The precise definition of rights and duties for both parties aims to avoid potential disputes. Given the possibility of unexpected opportunist behaviour or termination, the agreement needs to enclose a provision of compensation for one party breaking the agreement.

Safeguards in place for protecting core technologies are suggested. Hamel and Prahalad (1989) advise collaborators to impose restrictions and exclusivity clauses in order to limit the transfer of core technologies. They state that "Companies must take steps to limit the scope of the formal agreement. It might cover a single technology rather than an entire range of technologies; part of a product line rather than the entire line ... the objective is to circumscribe a partner's opportunities to learn". Porter and Fuller (1985) argue that joint ventures involving technology transfer fail mostly because of opportunistic behaviour that induces unexpected leaks of replicable firm-specific assets. Thus, a joint venture characterised by an exchange of technologically specific know-how is more vulnerable than one that involves more discrete contributions, such as financing or physical resources (Teece, 1986).

Furthermore, the transfer of technology normally leads to asymmetric possession of information, and partners face difficulties in understanding what is transferred and how much to expect in return (Teece, 1980). Based on the arguments above, Park and Ungson (1997) hypothesize that joint ventures are more likely to dissolve when contributors involve technology transfer. The results of their study support the hypothesis.

As Hoffmann and Schlosser (2001) note, inter-firm cooperation is viewed as an organizational mode that facilitates quick and flexible learning of new capabilities. But what from one company's perspective is a successful effort to acquire new technologies can be seen by the other company as an undesirable drain of proprietary expertise to the partner, endangering its own competitiveness. High-tech SMEs can contribute to cooperative innovation with their specific technology advantage. However, they are vulnerable from their limited ability to prevent expertise from unexpected leakage. In the case that partners are large companies and have a strong technology background, SMEs' core technologies are exposed to the risk of 'outlearning' which is interpreted by Hoffmann and Schlosser (2001) as knowledge transfer beyond the cooperative agreement. According to Teece (1986), SMEs' situation might be more risky when their critical knowledge is in a 'weak appropriability regime'. Osborn and Baughn (1990) also contend that organizational size affects a partner's vulnerability to exploitation and the economic effectiveness of the transaction itself, implying that small firms are highly vulnerable when entering high-technology-based cooperative ventures because their sole technical cores are placed at risk. Thus, the necessary restriction for stopping partner 'outlearning' should be included in agreement.

Related to the establishment of clear ground rules for collaboration is the corresponding need for the monitoring of progress. One option for creating a monitoring mechanism is to establish collaboration 'milestones' in which progress can be measured and reviewed by significant points (Perlmutter and Heenan, 1986; Lorange, 1988).

3.6.4 Top Leader's Commitment

Hambrick and Mason (1984) argue that an organization is a reflection of its top manager. Lumpkin and Dess (1996) believe a small business firm is simply an extension of the individual who is in charge. Thus, it is believed that without top management commitment and support, many problems would emerge in the process of cooperation, such as time-consuming decision making, lack of continuous resource input, strategy goal distracted, staff morale depreciated, and so on. To get round these problems, many companies have senior executives take on the role of sponsor for strategically important cooperative projects. Smith (2005) shares the view of leadership commitment. He claims that management energy flows to where leadership attention goes. Leadership attention is typically on finances, sales and technology so most alliances either do not fulfil their promise or fail. Many of the best alliances have been based on a handshake and hereafter a lot of informal communication. Literature also suggests the important role of cooperation champions.

3.6.5 Trust, Communication and Reciprocity

Belussi and Arcangeli (1998) posit that the "relational and networking" firms, in order to preserve their own identity, have two kinds of basic needs. On the one hand, firms must continuously introduce tactical measures which protect their bargaining power within the network, enable them to appropriate as much of the value-added as possible and help them to preserve their central role in managing the web of relationships. On the other hand, firms must at the same time strengthen their cooperative behaviour and the basic trust between the partners which is necessary if the potential conflict inherent in networks is to be avoided.

Camagni (1990) argues that the objective of technological alliances is not just the control over a given technology or a given stock of complementary assets, but rather the control over the optimal development trajectory of these assets or technologies. Thus, giving changing economic circumstances and technological risks, firms may have to learn new rules of behaviour, if long-term collaboration is on the agenda. They may have to learn to work within a cooperative game paradigm. According to Aoki (1984), maximum gains come from mutual trust and reciprocity and not from a competitive two-player game which characterizes most commercial activities.

Van de Ven and Walker (1984) suggest that trust emerges as a result of the degree to which one party judges that another party will fulfil its commitments. Zucker (1986) and Friedman (1991) refer to trust as the confidence one has in the other's goodwill. Communication and reciprocity are elements for developing trust between partners. While the transaction cost perspective posits that trust reduces costs incurred for governing transactions, the resource-based perspective insists that trust helps to build a relationship by which partnering firms benefit from each other's contribution and enhance value creation in both sides. Therefore, developing trust and building good inter-firm relationships become an important part of the management of cooperation. As Hakansson (1987) notes, relationships are one of the most valuable resources that a company possesses.

Smith et al. (1991) stress the importance of personal relationships in collaboration. They state that personal relationships are not only an outcome of collaboration, but also a key element in its success. Collaboration itself may be an outcome of the personal and professional trust which exists at many layers within companies. They also suggest that the existence of informal, personal networks among the scientific and engineering elite is the key factor in the establishment of collaborative links. However, the downside of the key role which personal relationships play in collaborative ventures is over-dependence on certain individuals. Pointing to this problem, Dodgson (1993) argues that inter-organization trust-building is as important as interpersonal trust.

Smith (2005) states alliance is a relational phenomenon and while technical aspects are essential, technical fit is insufficient to support the "unstable" nature of alliances. Over time, the maintenance of trust is necessary for an effective alliance. Since, motivation for alliance formation is usually instrumental and business oriented, continuing and necessary attention to the bases of trust is often neglected. In practical terms, this relates to critical success factors in human behaviour and business culture, e.g. telling the truth, honouring one's word, co-inventing solutions to problem and communication.

3.6.6 Adjusting to External Changes

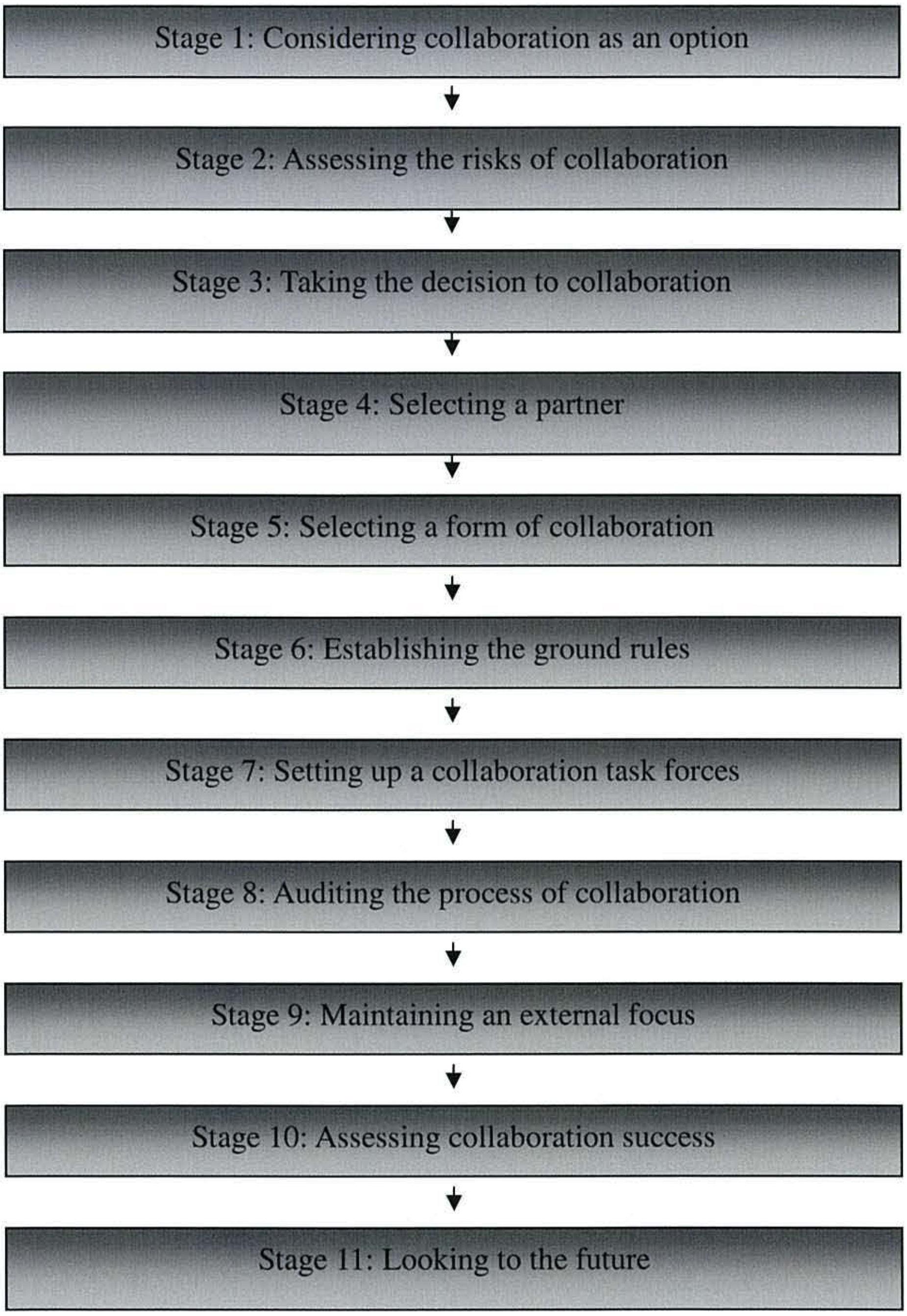
Collaboration will not work unless there is complementarity in technology and market access. Technological advancement may not fulfil customer needs. In Leverick and Littler (1993), a case study explains how an alliance achieved positive outcome on producing innovative product, but failed in market performance. Both parties devoted to managing alliance internally, however, neglected the changed market. Devlin and Bleackley (1988) perceive that circumstances change and suggest that there may be a need for frequent appraisal of the collaboration and making room for adaptability. As noted by Bruce et al. (1995), the broader context within which the collaboration takes place is likely to have a significant bearing on a collaborative outcome. Changes in the wider economic environment and in the various partners' markets, and redefinitions of the collaborators' missions and objectives, can affect collaboration. Lynch (1990) comments: "Alliances are established to tackle inherently risky environments. Neglecting contingency plans to deal with the unpredictable and unknown will leave the venture on shaky ground. …failures result from dramatically changing strategic conditions." Therefore, Sachwald (1998, p.212) suggests "the organizational structure of cooperation should be flexible in order to permit adaptation to shifting environments and strategies."

As a new product diffuses through the economy, the network structure might display a life-cycle as the product itself matures. In order to counteract decay in profitability, Belussi and Arcangeli (1998) suggest dematuration efforts for the readjustments of the scope of the network itself.

Kogut (1987) reveals cooperative and competitive incentives have influence on stability of cooperative relationship. Franko (1971) contends that if the incidence of joint venture is related to industry characteristics or strategies, then changes in the values of these parameters affect survival rates.

It is worth mentioning that the comprehensive studies on critical success factors of inter-firm cooperation are conducted by Leverick and Littler (1993) and Hoffmann and Schlosser (2001). Leverick and Littler (1993) study the role of collaboration in product development by conducting their survey in over 100 UK companies which are involved in the manufacture and supply of information and communication technology products. Their study finds that while companies enter into collaborations hoping to reduce the risks and costs of product development, collaboration often has a negative effect on product development. Skilful management is vital for realizing the full benefits of collaboration. The suggested key factors include an initial agreement of clearly defined collaboration objectives and responsibilities, frequent consultation, regular audits of progress, and the presence of a 'collaboration champion'. Based on these findings, they developed a stage model of product development collaboration as a guide for collaboration management (see Figure 3-1). Hoffmann and Schlosser (2001) propose 24 potential important factors from relevant theories and categorize the alliance evolution as five stages. They examine the proposed factors by conducting an empirical survey in 164 Austrian SMEs. The study concludes that SMEs greatly underestimate a number of critical success factors, recommending that SMEs should pay more attention to strategic compatibility, governance mechanisms and alliance evolution.

Figure 3 - 1: A Stage Model of Product Development Collaboration



Source: Leverick and Littler (1993, p.52)

3.7 Summary

This chapter reviews definitions of inter-firm cooperation, motives for and modes of cooperation, determinants of firms' propensity to cooperate, effects of cooperation on firms' economic performance, and critical success factors for inter-firm cooperation. The literature review suggests a well-defined inter-firm cooperation concept requires taking into account: (1) the range of inter-firm relationships; (2) the aim to be achieved by approaching to partners; (3) the means by which to cooperate and benefit from one another; (4) the organizational arrangements or governance structures as functioning of cooperative relationships.

The motives for going to cooperate are combination of economic, competitive, technological and organizational learning. These motives include gaining access to complementary assets, capturing first-mover advantage, increasing scale and scope of activities, sharing costs and risks, improving ability to deal with complexity, coping with environmental uncertainty, benefiting from flexibility and efficiency, and learning through alliance.

The modes of cooperation are demonstrated in the order of their level of interdependency, which include licensing agreements, subcontracting agreements, customer-supplier R&D contracts, joint R&D agreements, minority holdings, and joint ventures and research corporations. Apart from differences in interdependency, each cooperative mode entails a specific method regarding how technologies are transferred, how resources are shared, and how opportunistic risks are suppressed. Although equity-based alliances are still a large percentage of all cooperative agreements, in general, the modes of equity-based cooperation have become less popular compared to contractual agreements. Reasons include considerations of the fast-changing pace of technology, diverse business strategic objectives, and protection of tacit knowledge.

With regard to the determinants of firms' propensity to cooperate, analyses among variables concerned, including firm characteristics, manager characteristics, and probability of cooperation report contradictory results. This calls for more empirical studies to be conducted for identifying the most relevant factors.

Concerning the effects of cooperation on firms' economic performance, the findings from prior studies are inconsistent with each other. It has been recognized that a further study which focuses on a specific technology field, such as information technology, would help understand the relationship between cooperation and its impact on economic performance, and thereby provide more precise input to theoretical development and business decision making.

Literature has provided considerable information to help make inter-firm cooperative relationships successful. Suggestions are oriented to, firstly, the prerequisites of successful cooperation, such as resource complementarity, compatible business strategies, well-documented agreements, and flexible organizational style; secondly, to maintaining and monitoring the process of cooperation, such as sufficient resource input, top leader commitment, trust based communication and reciprocity, and attention to external change; thirdly, the stepwise assessment, such as setting milestones and reward systems. Successful cooperation depends on the extent to which executive cooperation managers recognize these factors and practice them.

Research gaps exist in a number of respects. Firstly, there is no comprehensive empirical study covering a broad range of cooperative modes from the least dependent licensing agreements to highly interdependent equity-based joint ventures; secondly, while many studies have been undertaken in the context of high-tech industries, most analyses involve only large firms, and the results from large firms are often not likely to apply to small firms. High-tech small and medium-sized firms have been neglected, partly due to the lack of available data and the difficulty of access to systematic data; thirdly, a large portion of prior studies relates to alliances in North America, Japan and Europe. The empirical studies in developing countries are far fewer than in developed countries. The literature review concludes that the inter-firm cooperation phenomenon is industry-specific and country-specific which means decision making and process of cooperation can not be disassociated from the industry and country context firms operate in. China has been drawing attention in recent decades due to its dramatic economic growth and involvement in the global economy. Empirical study of China's high-tech SMEs and their growth strategies has significance for both theory development and business management practice. The identified gaps call for a further study.

Chapter Four: Research Context and Conceptual Framework

This chapter presents a framework for addressing the research questions. The first section provides an introduction to high-tech SMEs in China, in which classification standards of SMEs, identification of high technology industries and high-tech firms, and an overview of high-tech industries in China are presented. Specification is given to information and communications technology sectors in which the sample firms of this study come from. The second section depicts China's national innovation system with regard to high-tech SMEs. The third section builds up a research framework by proposing research questions and hypotheses. A summary of this chapter is presented in the last section.

4.1 Introduction to High-tech SMEs in China

4.1.1 Classification Standards of SMEs in China

Different countries and industries classify SMEs with different standards in accordance with their economic and technological contexts. These standards also vary with functional categories, such as support policy, taxation, statistics and law regulation. Since the target of this study is China's SMEs, the classification defined by China's authority agencies is adopted. The criteria for classifying a firm's size are number of employees, annual revenue, and total assets.

According to the Tentative Classification Standards on Small and Medium-sized Enterprises (State Economic and Trade Commission of China et al., 2003), small and medium-sized enterprises in industrial sectors must satisfy at least one of the following criteria:

(1) The number of employees is less than 2000;

(2) Annual sales revenue is less than ¥300 million (RMB);

(3) Total assets are less than ¥400 million (RMB).

A small-sized enterprise in industrial sectors must satisfy at least one of the following criteria:

(1) The number of employees is less than 300;

(2) Annual sales revenue is less than ¥30 million (RMB);

(3) Total assets are less than ¥40 million (RMB).

The current study uses the number of employees to classify sample firms' size. The number of employees is commonly used as one of criteria to classify SMEs. For example, in the UK, the Companies Act 1985, Regulations 2004 (Statutory Instrument 2004 No.16) defines SMEs as those with not more than 250 employees. The European Commission (2003) defines SMEs as those with less than 250 employees. By comparison, the number of employees in China's standard is much larger. It may be due to the labour-intensive attribute of industrial sectors. The decision to use this standard is to accord with the literature on SMEs in China, and to make use of secondary data. The disadvantage of using this standard is its difference in the number of employees from other countries' standards. The difference may somewhat limit the generalisability of research results. However, this study targets high-tech SMEs which are technology-intensive rather than labour-intensive. SMEs in high-tech industries have a smaller employment size on average than SMEs in other industries. Therefore, the disadvantage of the difference in employment size is lessened.

4.1.2 Identification of High-tech Firms in China

The Ministry of Science and Technology of China (2000a) defines high technologies as: (1) electronics and information technology; (2) bioengineering and new pharmaceutical technology; (3) new materials and their application technology; (4) advanced manufacturing technology; (5) aerospace and spaceflight technology; (6) modern agricultural technology; (7) new energy and high efficiency energy-saving technology; (8) new environmental protection technology; (9) ocean engineering technology; (10) nuclear application technology; and (11) others including new techniques and technologies applied to upgrade traditional industries.

Although there is no single preferred method for identifying high technology industries, two measures are usually used to define them: the percentage of scientific and technical employment in a particular industry compared to all industries, and R&D spending as a percent of total sales, a measure of R&D intensity. The definition of high technology sectors suggested by OECD (Hatzichronoglou, 1997) has been adopted widely by countries and regions all over the world. Based on this definition, the National Bureau of Statistics of China (2002a) adjusted the prior statistical classification of high technology industries and issued a "Classification Index for High Technology Industries Statistics" in 2002. The adjusted statistical classification includes: (1) Nuclear fuel processing, (2) Info-chemical manufacturing, (3) Medical and pharmaceutical products manufacturing, (4) Aircraft and spacecraft manufacturing, (5) Electronic and telecommunications equipment manufacturing, (6) Computers and office equipments manufacturing, (7) Medical equipments, instruments and meters manufacturing, and (8) Public software service. For the convenience of comparing the high technology manufacturing sector across countries and regions, nuclear fuel processing, chemical information manufacturing and public software services are not included in some indicators in public data (National Bureau of Statistics of China, 2002a).

The identification standard of high-tech firms issued by Ministry of Science and Technology (2000a) has two subsections, orientated respectively to firms situated inside high technology industrial development zones and to firms situated outside high technology industrial development zones. Since the sample firms of this study all come from the industrial development zones, the identification standard for firms inside high technology development zones is presented as follows:

A company qualifies as a high technology company if it meets the following criteria:

(1) Undertaking research and development, production or technical services in at least one of the high technologies defined by Ministry of Science and Technology of China (2000a);

(2) Registered as a legal entity;

(3) The ratio of technical employees who are graduates from universities and institutes to total employees is more than 30%, and the ratio of specific R&D employees to total employees is more than 10%. In the high-tech firms undertaking labour intensive high technology production and service, the ratio of technical employees who have graduated from universities and institutes to all employees is more than 20%;

(4) The ratio of R&D expenditure to annual turnover is more than 5%;

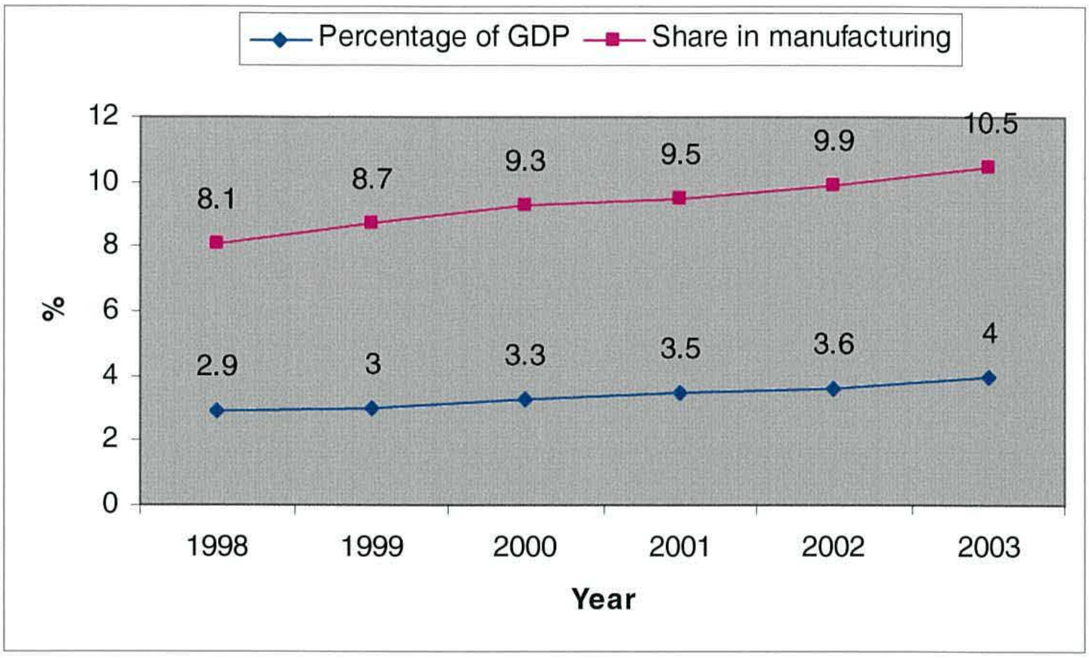
(5) The ratio of technological service income and technological product sales to total annual revenue is more than 60%; for newly founded firms, the ratio of investment in high technologies to total investment is more than 60%;

(6) The key executives in high-tech firms are familiar with R&D, production and management, and they place emphasis on technological innovation, and work as full time staff.

4.1.3 Analysis of China's High-tech Industries

Undoubtedly, high-tech industries play a leading role in the arena of technological innovation. The competencies of high-tech firms in technological innovation symbolize the innovativeness of a nation or a region. As the implementation of reforming and opening economic policies, China's high-tech industries have been developing with an accelerating pace. In 2003, high-tech industries accounted for 10.5% of value added of the manufacturing sector and held a 4.0% share in GDP (National Bureau of Statistics of China et al., 2004). Figure 4-1 demonstrates the share of value added of high-tech industries in the manufacturing sector and the value added of high-tech industries as a percentage of GDP from 1998 to 2003.

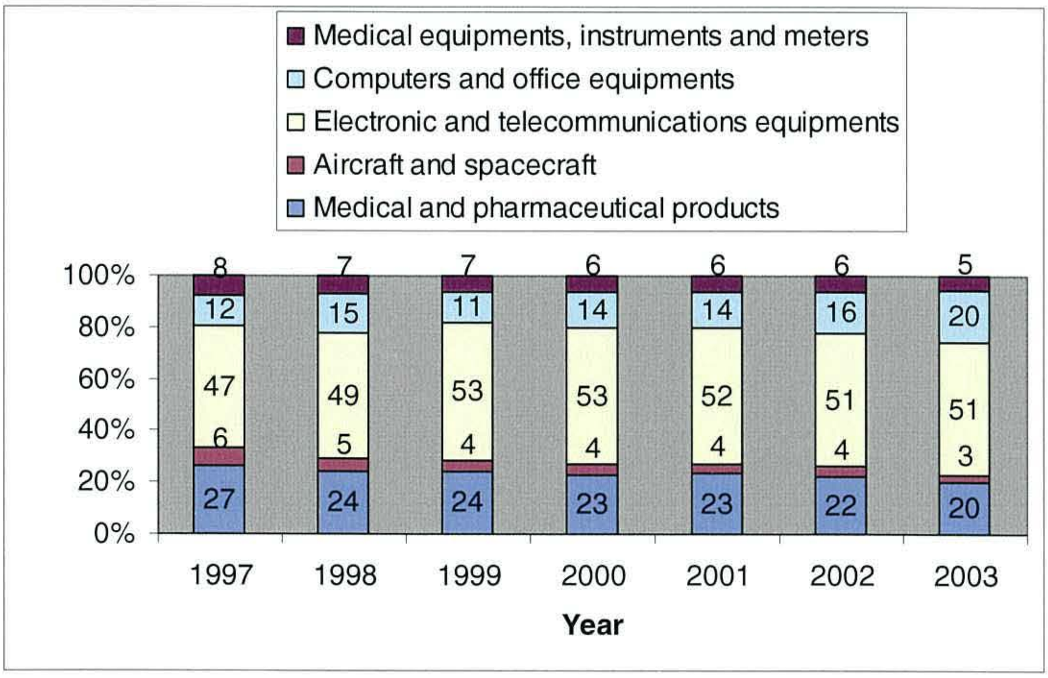
Figure 4 - 1: High-tech industries' share of value added in manufacturing and value added in high-tech industries as a percentage of GDP (unit: %)



Source: based on data obtained from National Bureau of Statistics of China et al. (2004)

The total value added of high-tech manufacturing in 2003 is reported as 503.4 billion RMB Yuan (National Bureau of Statistics et al., 2004). Of all, 102.5 billion Yuan comes from medical and pharmaceutical products, 14.1 billion Yuan from aircraft and spacecraft, 257.2 billion Yuan from electronic and telecommunications equipments, 102.2 billion Yuan from computers and office equipments, and 27.5 billion Yuan from medical equipments, instruments and meters. Compared with other high-tech industries, electronic and telecommunications equipments and computers and office equipments industries hold the highest growth rate from 1997 to 2003, being 23.38% and 33.44% respectively. Figure 4-2 presents a time series from 1997 to 2003, showing that the structure of value added within high-tech industries has been changing. The proportion of value added from computers and office equipment industries and electronic and telecommunication equipment industries has increased from 59.09% to 71.39%. The structure change of value added in high-tech industries leads to changes in exports. Exports of high-tech products from electronics and information technology reached 94.4% of total high-tech products exports in 2004 (National Bureau of Statistics et al., 2004). The commercialisation and industrialisation of electronics and information technology has significantly contributed to the rapidity of the economic growth of China.

Figure 4 - 2: Distribution of value added by high-tech industries (1997-2003)



Source: based on data obtained from National Bureau of Statistics of China et al. (2004)

A variety of determinants have an impact on technological innovation. R&D expenditures are a major innovation input, while there are other important innovation inputs. Table 4-1 presents expenditures of high-tech industries on new product development. The increased R&D input brings more new products to market. Figure

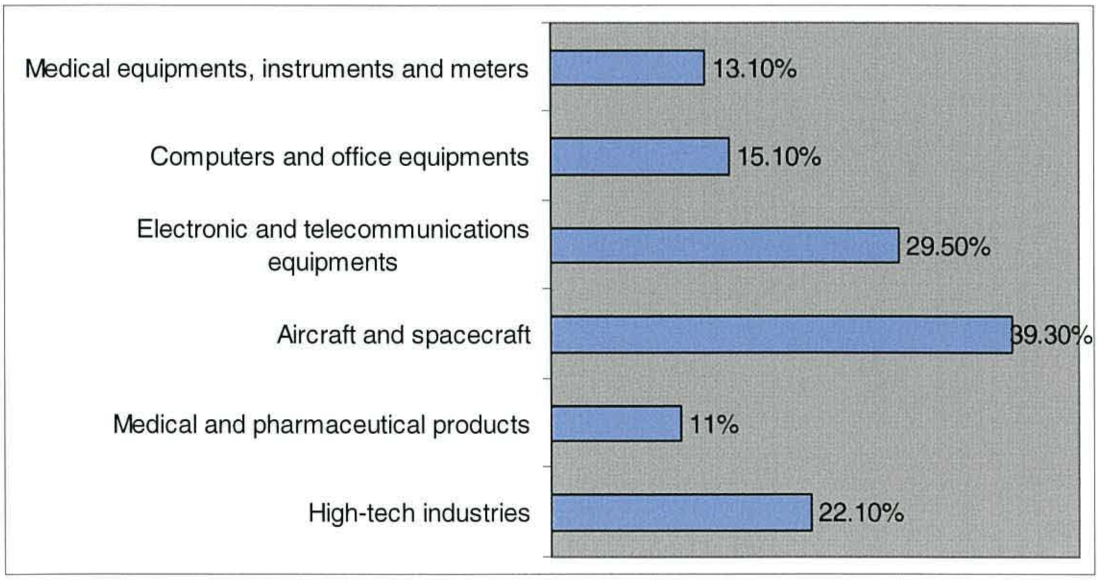
4-3 shows the ratio of sales from new products to sales from all products in each high-tech industry in 2003.

Table 4 - 1: Expenditures of high-tech industries on new product development (unit: 100 million Yuan)

	1997	1998	1999	2000	2001	2002	2003
Total	52.6	70.8	94.4	117.8	134.5	169.0	207.6
Medical and pharmaceutical products	7.7	7.6	10.0	14.8	14.1	19.0	22.9
Aircraft and spacecraft	9.9	11.5	12.4	11.4	10.4	19.5	19.9
Electronic and telecommunications equipments	23.3	42.2	51.4	73.7	88.1	101.1	118.8
Computers and office equipments	6.9	5.2	15.5	13.3	16.5	23.3	37.9
Medical equipments, instruments and meters	4.8	4.3	5.2	4.6	5.4	6.1	8.1

Source: based on data obtained from National Bureau of Statistics of China et al. (2004).

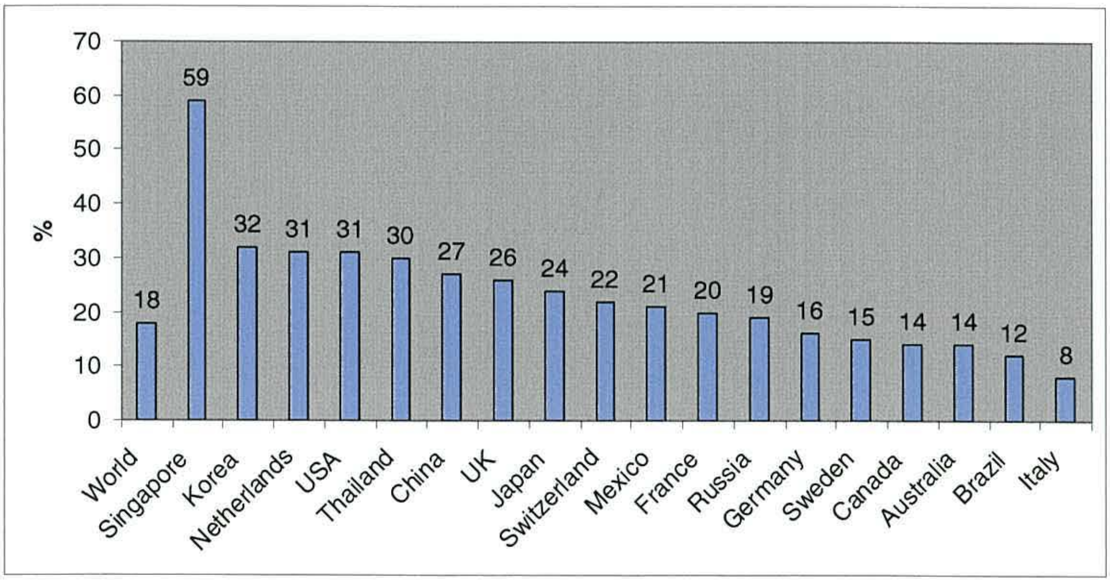
Figure 4 - 3: Ratio of sales from new products to sales from all products in each of high-tech industries (2003)



Source: based on data obtained from National Bureau of Statistics of China et al. (2004)

As a result of the transformation of the economic system, China has opened its huge domestic market to the world and has attracted a great deal of foreign capital investment. By 2003, value added created by foreign invested companies in high-tech industries was 289.5 billion Yuan, holding a 57.50% share in total value added in high-tech industries. Foreign invested companies' share of value added in the electronic and telecommunications industry was 64.54% and in the computers and office equipments industry was 85.13% (National Bureau of Statistics et al., 2004). Although the strategy of 'providing a market in exchange for technology' has been controversial in the recent decade, foreign invested companies are a leading force in high-tech product exports. Data from the World Bank (2005) reveal that exports of high-tech industries as a percentage of manufacturing in China is above the average world level and higher than the UK, Japan, Germany, and some other developed countries (see Figure 4-4).

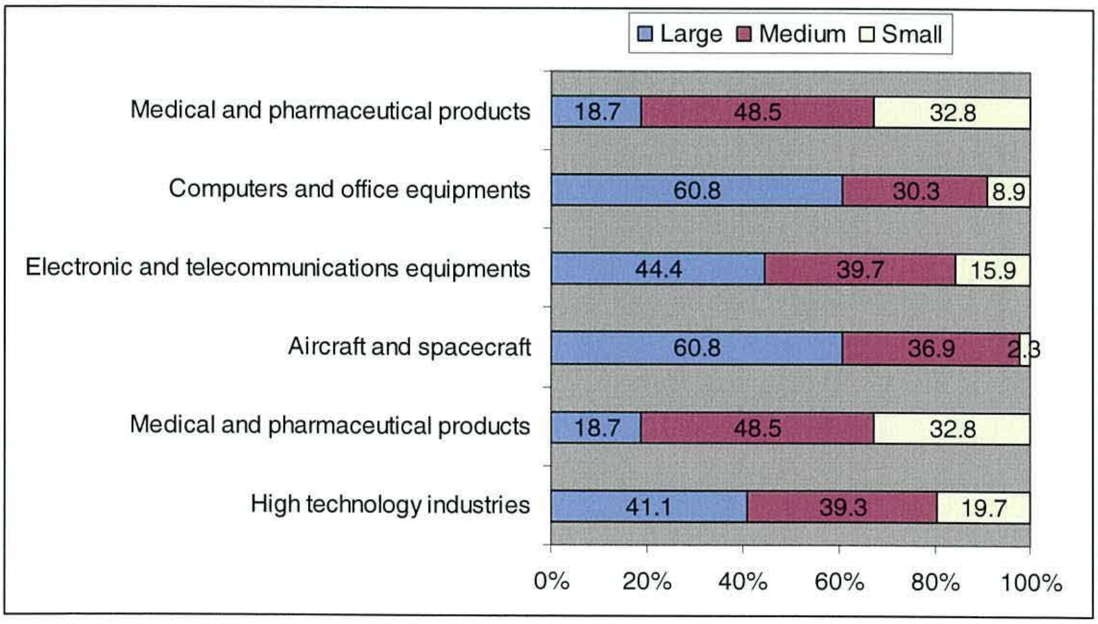
Figure 4 - 4: Exports of high-tech industries as a percentage of manufacturing in selected countries (2003)



Source: based on data obtained from World Bank (2005).

As Rothwell (1991) notes, new high technologies create a considerable number of opportunities for SMEs. High-tech SMEs account for a large portion of value added in high-tech industries. In 2003, SMEs contributed 58.9% of total value added of high- tech industries in China. Of all high-tech industries, SMEs accounted for 90.6% of total value added in the medical equipments, instruments and meters industry; 81.3% in the medical and pharmaceutical products industry; 55.6% in the electronic and telecommunications equipment industry; 39.2% in the computers and office equipments industry; and 39.2% in the aerospace and spacecraft industry (National Bureau of Statistics of China et al., 2004). The distribution of value added in each high-tech industry by firm size is depicted in Figure 4-5.

Figure 4 - 5: Distribution of value added in each high-tech industry by firm size (2003)



Source: based on data obtained from National Bureau of Statistics of China et al. (2004).

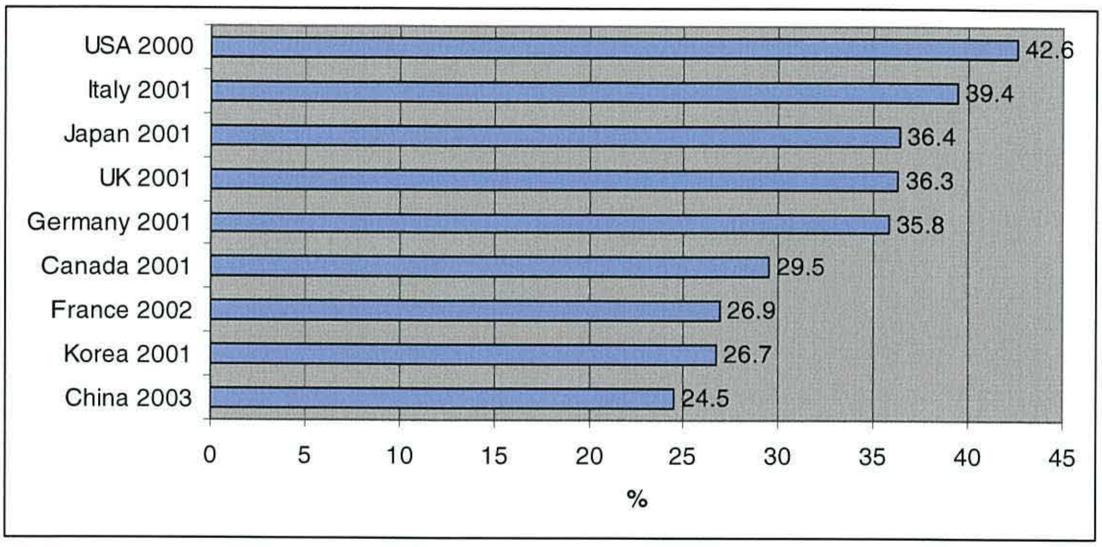
However, compared to developed countries, like the US and Japan, and leading developing countries, like Korea, the contribution of high-tech industries to the manufacturing sector in China stays at a lower level (see Table 4-2). The productivity of China's high-tech industries lags behind by comparison across countries (see Figure 4-6 and Table 4-3). The reason can be explained to a large extent by the fact that R&D intensity in China' high-tech industries is much lower than most of developed countries and some leading developing countries (see Table 4-4). The insufficient input of innovation leads to a lack of competence in pursuing radical technological innovation. Most of China's high-tech firms do not create or own intellectual property rights and valuable brands.

Table 4 - 2: Value added of high-tech industries as percentage of value added of manufacturing in selected countries (unit: %)

	1996	1997	1998	1999	2000	2001	2002
China	6.5	6.9	8.1	8.7	9.3	9.5	9.9
US	21.1	21.6	21.8	22.1	23.0	-	-
Japan	16.5	16.7	16.8	17.8	18.7	16.7	-
Germany	9.2	9.6	9.5	10.4	11.1	10.4	-
France	12.5	13.9	13.7	14.0	14.0	14.1	13.5
UK	14.3	15.0	15.5	16.3	17.0	17.0	-
Canada	9.3	9.6	9.0	10.3	10.5	8.4	-
Italy	8.7	8.5	8.6	8.9	9.8	10.0	9.6
Korea	18.0	17.4	21.3	22.6	24.4	22.2	-

Source: based on data obtained from National Bureau of Statistics of China et al. (2003) and OECD (2004).

Figure 4 - 6: Ratio of value added to total output value of high-tech industries in selected countries (%)



Source: based on data obtained from National Bureau of Statistics of China et al. (2003) and OECD (2004).

Table 4 - 3: Labour productivity of high-tech industries in selected countries* (unit: 1000 USD)

	China 2003	US 2000	Japan 2001	Germany 2001	France 2002	UK 2000	Italy 2002
Manufacture	8.5	80.4	71.2	47.5	62.4	54.2	41.6
High-tech industries	12.7	117	89.8	52.6	78.8	78.7	56.3
Medical and pharmaceutical products	10.8	212	236.2	75.8	131	127.7	93
Aircraft and spacecraft	5	94	95.6	70.3	109.3	68.4	80.5
Electronic and telecommunications equipments	13.9	127.8	79.4	44.5	41.9	82.6	40.6
Computers and office equipments	20.8	150.2	82.5	54.2	72.7	77.2	30.1
Medical equipments, instruments and meters	7.4	74.9	62.5	43.9	66.1	60.6	44

* Value added per capita.

Source: based on data obtained from National Bureau of Statistics of China et al. (2003) and OECD (2004).

Table 4 - 4: R&D intensity of high-tech industries and R&D intensity of total manufacturing in selected countries* (%)

	China 2003	US 2000	Japan 2001	Germany 2001	France 2002	UK 2001	Canada 2001	Italy 2002	Korea 2003
Manufacturing	2.0	8.2	9.9	7.6	7.4	6.5	4.6	2.3	7.3
Total high-tech industries	4.4	22.5	26.3	23.8	28.6	23.1	41.1	11.6	18.3
Medical and pharmaceutical products	2.7	20.2	22.9	22.7	27.2	50.0	23.9	6.6	4.4
Aircraft and spacecraft	15.8	20.8	22.3	23.7	29.4	21.2	15.3	23.4	-
Electronic and telecommunications equipments	5.4	18.6	18.6	43.7	57.2	18.5	71.5	19.4	23.4
Computers and office equipments	2.5	30.7	59.5	19.7	15.8	4.2	71.8	8.8	4.4
Medical equipments, instruments and meters	3.0	30.2	28.7	14.8	16.1	8.8	-	6.4	10.7

* R&D intensity is calculated by R&D expenditure as a percentage of value added.

Source: based on data obtained from National Bureau of Statistics of China et al. (2003) and OECD (2004).

Besides electronic equipment, telecommunications equipment and computer manufacturing, software development is an important part of the electronics and information technology industry. Table 4-5 presents the major economic indicators of software development companies. The Ministry of Science and Technology of China (2000b) issued the "Identification and Administration of Software Companies", in which the criteria of a qualified software company are defined. According to the report "Statistics of Software Development Activities 2002" (National Bureau of Statistics of China, 2002b), by 2002 there were 3470 software development companies with 184290 employees in China. Overall, the ratio of number of professional technicians to the number of total employees was 68.85%, the ratio of R&D expenditures on software technology and products to software sales was 19.93%, and the ratio of software sales to annual turnover was 39.65%. These three major indicators were all higher than the identification standard (Ministry of Science and Technology of China, 2000b) which is 50%, 8% and 35% respectively. There were 7063 software development projects in 2002 (only including the projects with a budget of more than RMB 50000 Yuan), of which 25% of projects were developed through cooperating with partner organizations, including universities, research institutes and business firms from domestic and overseas. Software development companies have been attempting to explore the opportunities by inter-organizational cooperation to enhance their technological innovation.

Table 4 - 5: Major indicators of software development companies (2002)

Number of Companies	3740
Number of employees	184290
Professional technicians	126890
Annual turnover (million Yuan)	58557.42
#Software sales (million Yuan)	23220.1
##Software exports (million Yuan)	1201.67
Profit (million Yuan)	4265.36
Number of R&D employees	112015
#Scientists and engineers	97653
R&D expenditures (million Yuan)	4626.85
Number of applied patent	1792
#Invention patent	633
Number of granted patents	801

Source: based on data obtained from National Bureau of Statistics of China (2002).

A number of empirical studies have concluded that the likelihood of inter-firm technological cooperation is higher in high-tech industries than in other industries. Data from China's high-tech firms and comparison across countries reveal that, on the one side, China's high-tech firms have increasingly contributed to the domestic and global markets, and, on the other side, high-tech firms are severely constrained by the shortage of R&D input. The pressures of innovation input and new product development might be an important incentive for high-tech firms engaging in innovation cooperation as many studies have claimed, suggesting that the effort of conducting a research on this phenomenon in China would be a valuable contribution to business strategy theory and practice.

4.2 National Innovation System with Regard to High-tech SMEs

China's national innovation system has been transforming to adapt to a market oriented economy since the 1980s. More efforts than ever before have been made to encourage business firms to be major players in technological innovation. Favourable policies, grants, and infrastructure investment are provided to facilitate firms' initiatives in technological innovation. The national innovation system creates an innovative milieu in which high-tech SMEs are nurtured. High-tech industrial development zones, the Innovation Fund for Small Technology-based Firms, SME Promotion Law, and the SME Board of Shenzhen Stock Exchange are the most important supportive means related to high-tech SMEs.

4.2.1 High-tech Industrial Development Zones

To speed up the pace of emerging high technology development, numbers of high technology development zones have been set up across the country in China. According to the National Bureau of Statistics of China et al. (2005), there were 53 national high-tech industry development zones by 2004, which have accommodated 38565 firms with 4.48 million employees, achieving total revenue of 2744.63 billion Yuan and total exports of 82.38 billion USD (see Table 4-6).

Table 4 - 6: Basic information of national high-tech industrial development zones (1996-2004)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total number of companies	13722	13681	16097	17498	20796	24293	28338	32857	38565
Employment (10000 person)	129.1	147.5	183.7	221.0	250.9	294.3	348.7	395.4	448.44
Gross output (billion Yuan)	214.23	310.95	433.36	594.36	794.20	1011.68	1293.71	1725.74	2263.89
Value added (billion Yuan)	-	-	106.07	147.62	197.88	262.13	328.61	436.14	554.21
Revenue (billion Yuan)	230.03	338.78	483.96	677.48	920.93	1192.84	1532.64	2093.87	2744.63
Net profit (billion Yuan)	14.05	20.66	25.62	39.87	59.70	64.46	80.11	112.92	142.28
Taxes (billion Yuan)	9.77	14.33	22.08	33.86	46.02	64.04	76.64	99.00	123.96
Exports (billion USD)	4.30	6.48	8.53	11.91	18.58	22.66	32.92	51.02	82.38

Source: based on data obtained from National Bureau of Statistics of China et al. (2005).

High-tech industrial development zones encompass a variety of functioning divisions, such as university science parks, software parks, returning overseas students business pioneering parks, and hi-tech business pioneering service centres (business incubators). High-tech firms situated in development zones benefit not only from favourable policies and services provided by central government and local governments and implemented through the administration centres of development zones, but also the networking synergy derived from the cluster of high-tech firms.

The major economic indicators of 53 national industrial development zones are presented in Table 4-7.

Table 4 - 7: Major economic indicators by 53 national high-tech industrial development zones (2004)

Development Zone	Number of Enterprises (Unit)	Number of Employees (Person)	Gross Output (million Yuan)	Revenue (million Yuan)	Exports (million USD)
Total	32857	3953621	1725743.45	2093873.07	51016.90
Beijing	12030	488561	160775.49	288641.55	3292.99
Tianjin	1530	125282	48208.61	56363.96	1485.73
Shijiazhuang	491	56645	18281.57	23795.93	141.62
Baoding	140	31167	10632.38	10598.28	80.31
Taiyuan	532	86639	23625.07	26680.95	41.40
Baotou	266	58803	16111.21	16367.93	237.98
Shenyang	1552	57657	25386.27	50042.02	853.01
Dalian	1085	107601	25173.10	33998.98	664.75
Anshan	284	62122	13058.22	15418.78	22.06
Changchun	676	113812	62379.33	62538.00	507.03
Jilin	567	89371	41016.02	42002.39	50.45
Harbin	247	91567	27816.70	32590.21	195.22
Daqing	218	43256	18852.43	20244.77	24.31
Shanghai	550	115009	123615.33	161098.07	6634.50
Nanjing	213	76014	80821.92	88145.97	2101.37
Changzhou	336	57125	18557.66	19031.35	374.46
Wuxi	460	103413	64674.52	87296.73	3428.41
Suzhou	410	107254	75586.55	75091.90	4731.87
Hangzhou	423	48275	35582.74	47826.16	613.00
Hefei	198	45433	20700.76	21139.87	149.19

Table 4-7: Major economic indicators by 53 national high-tech industrial development zones (2004) (Cont.)

Development Zone	Number of Enterprises (Unit)	Number of Employees (Person)	Gross Output (million Yuan)	Revenue (million Yuan)	Exports (million USD)
Fuzhou	158	34343	17972.67	18331.40	809.11
Xiamen	88	27394	33786.51	35280.15	2455.40
Nanchang	172	59018	10754.08	12826.49	147.57
Ji'nan	323	86825	36749.94	38361.13	190.13
Qingdao	175	65498	50009.23	54771.45	925.19
Zibo	145	66804	25560.35	27753.69	321.07
Weifang	202	49528	23853.50	24981.82	142.05
Weihai	153	40601	18164.22	18433.64	870.81
Zhengzhou	342	53249	14284.73	18781.06	189.42
Luoyang	243	55054	10652.55	13763.27	81.41
Wuhan	600	115512	37681.94	48129.06	253.57
Xiangfan	88	65474	12668.25	16154.36	28.30
Changsha	732	89188	35219.28	40391.43	254.74
Zhuzhou	152	50526	14143.46	15081.29	214.04
Guangzhou	918	89211	42304.55	58819.22	1699.44
Shenzhen	273	82716	89579.96	83301.15	5219.70
Zhuhai	266	65194	38655.55	38089.83	3295.15
Huizhou	85	48389	36913.31	45394.98	2596.48
Zhongshan	432	97092	32640.42	32525.10	2670.15
Foshan	46	27794	22813.57	21123.99	917.84
Nanning	273	32589	10730.71	14886.94	48.85
Guilin	230	51603	10543.09	10801.08	81.72
Hainan	109	16655	12057.26	11731.38	44.36
Chongqing	539	113025	51157.66	59033.72	122.00
Chengdu	372	108444	24013.12	27539.55	371.57
Mianyang	89	45907	20517.76	19206.63	696.18
Guiyang	93	46317	10149.96	9558.67	79.90
Kunming	157	31516	9821.42	13189.85	182.14
Xi'an	2537	167390	40214.02	62647.43	333.63
Baoji	121	47938	8047.11	7895.02	33.74
Yangling	70	8838	1793.62	2393.88	57.57
Lanzhou	366	38711	8930.83	10226.95	23.19
Urumqi	100	10272	2502.98	3553.73	30.86

Source: based on data obtained from National Bureau of Statistics of China (2005).

Technology business incubators in high-tech industrial development zones are the functional division specific to technology-based start-ups. By 2004, 464 technology-based business incubators had been set up within 53 national high-tech industrial development zones. Graduated tenants had accumulated to11718 firms. Table 4-8 presents an overview of technology-based business incubators.

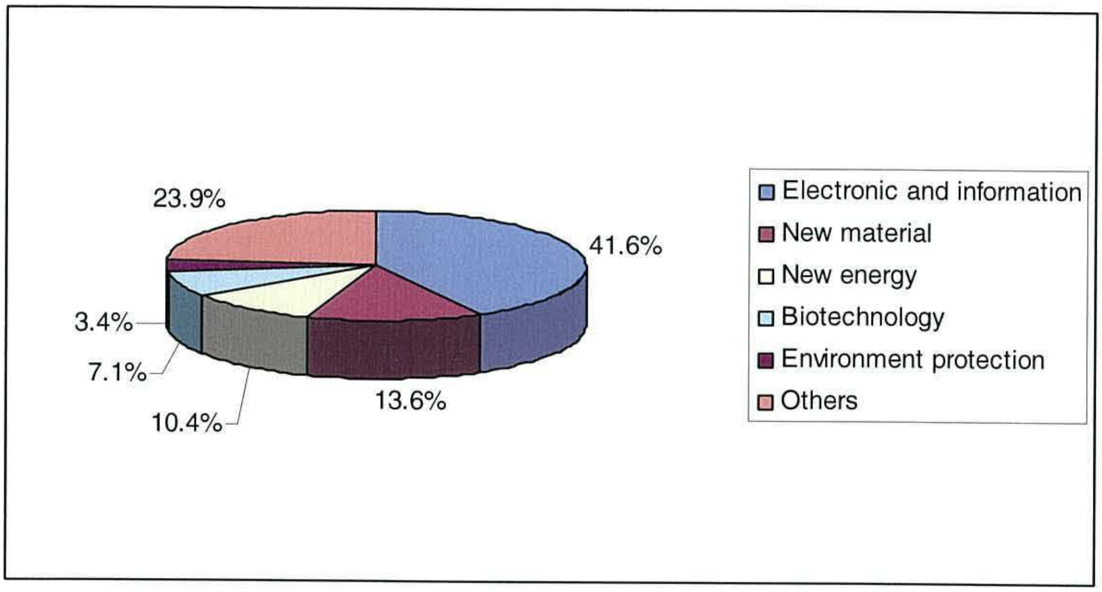
Table 4 - 8: Overview of technology-based business incubators in national high-tech industrial development zones (1997-2004)

	1997	1998	1999	2000	2001	2002	2003	2004
Number of incubators	80	77	110	164	324	378	431	464
Incubation space for tenants (10000 square meters)	77.4	88.4	188.8	339.5	634.7	632.6	1358.9	1515.1
Number of tenants	2670	4138	5293	8653	14270	20993	27285	33213
Number of new tenants each year	807	1244	1711	2866	5686	7635	8792	8933
Number of employees in tenants	45600	68975	91600	143811	283551	363419	482545	552411
Accumulated number of graduated tenants	825	1316	1934	2790	4281	6207	8981	11718

Source: based on data obtained from National Bureau of Statistics of China et al. (2005).

It is worth mentioning that electronic and telecommunications equipment, computers and software development are the dominant industries in high-tech industrial development zones. Sales from the electronics and information technology field account for 41.60% of total sales revenue. This is the rationale for this study choosing sample firms which operate in the electronic and information technology field and which are situated in high-tech industrial zones. The distribution of sales by technology field in 2004 is presented in Figure 4-7.

Figure 4 - 7: Distribution of sales by technology field (2004)



Source: based on data obtained from National Bureau of Statistics of China et al. (2005).

4.2.2 Innovation Fund for Small Technology-based Firms

The Innovation Fund for Small Technology-based Firms (Innofund) is a government-sponsored fund established in 1999. Adhering to the principle of 'market-oriented, supporting innovation, and encouraging entrepreneurship', Innofund supports the technological innovation activities of technology-based SMEs and the commercialisation of their R&D results in the forms of fiscal appropriation, loan interest subsidy and equity investment.

The implementation process of Innofund demonstrates the following characteristics: (1) Supporting technological innovations. The project applicants are required to have major innovations or substantial improvements in terms of technology, manufacturing technique or product performance. The level of technology should at least reach the leading state of the art technology across the country. Prioritised supportive funds have been given to those projects which hold the proprietary intellectual properties. (2) Encouraging venture establishments. Innofund supports technology-based start-ups, especially the start-up companies that are founded or led by the well-educated technological/engineering professionals or returning overseas students. (3) Accelerating commercialisation of science and technology achievements. Innofund continues its efforts in facilitating the commercialisation of advanced science and technology achievements which have potential promising markets. (4) Guiding the direction of investment. Inofund mobilizes a broader range of investment to technology-based SMEs from local governments, corporations, venture capitals and financial institutions. (5) Assisting the development of western regions and promoting national economic growth. Distinguished from other non-governmental funds or commercial venture capitals, Innofund pursues the growth of high technology-based SMEs, job creation and the transformation of economic systems rather than profit-making.

According to the Innovation Fund for Small Technology-based Firms 2003 Annual Review (Administration Centre for Innovation Fund for Small Technology-based Firms, 2003), the central fiscal budget appropriated for Innofund was 500 million RMB Yuan in 2003. Companies undertaking the projects in 2003 have multiple concurring characteristics as follows: 70.5% of enterprises are high-tech enterprises entitled by the local governments; 6.19% of enterprises are those originally founded by universities and colleges; 6.54% of enterprises are spin-offs from research institutions; 9.27% of enterprises are those established by returning overseas students; 3.37% of enterprises are those transformed from research institutions; 39.15% enterprises are located in national high-tech development zones; 10.51% of enterprises are tenants in national high-tech innovation service centres (business incubators).

4.2.3 SMEs Promotion Law

The SMEs Promotion Law was approved by the Standing Committee of the 9th National People's Congress in 2002 and put into effect in 2003. The basic principle of the law is to improve the environment which SMEs operate in, facilitate the development of SMEs, enlarge employment in both urban and rural areas, and exploit their significance in the national economy and social development.

The law puts forward specific provisions to promote technological innovation in SMEs. For example, loan interest subsidies are set up for SMEs' innovation projects; supportive policies are provided for assisting in establishing technical service centres, productivity promotion centres and technology-based business incubators; and the priority of favourable policies are given to those SMEs who engage in technological cooperation with research institutions, universities and colleges to industrialise the science and technology achievements.

4.2.4 SME Board in Shenzhen Stock Exchange

To boost the development of SMEs and lessen their financial bottleneck problems, the board for small and medium-sized enterprises (SME board) was launched on the Shenzhen Stock Exchange in 2004. 50 securities are listed on the SME board and the total issued capital is 6,012,933,957 RMB Yuan. Of these, 24 SMEs are high-tech firms (Shenzhen Stock Exchange, 2006). The SME board creates a direct financing platform for SMEs, especially for high-tech SMEs to initiate technological innovation.

4.3 Research Framework of Inter-firm Technological Cooperation in China's High-tech SMEs

4.3.1 Defining Inter-firm Technological Cooperation

To clarify the object of this study, the term 'inter-firm technological cooperation' is chosen to be used throughout this study. Inter-firm technological cooperation is defined as a set of inter-firm cooperative relationships by which technology transfer or joint innovative activities to develop new products and technologies are pursued under agreements between two or more firms. The cooperative relationships which solely entail manufacturing or marketing of existing products or processes are excluded from this study. To help the understanding of the studied phenomenon, several points about what is and what is not 'inter-firm technological cooperation' are presented as follows:

(1) This study targets inter-firm cooperative relationships. These relationships are part of a wide and diverse group of inter-organizational cooperative relationships. Firms may have partnerships with different organizations, such as business firms, universities, research institutions and public laboratories. This study, however, only focuses on inter-firm relationships.

(2) An inter-firm technological cooperative agreement can consist of multidimensional efforts. As Kline and Rosenberg (1986) state, successful technological innovation cannot be achieved without continuous communication with and feedback from marketing and production. Therefore, co-production efforts or co-marketing efforts may be intertwined with joint innovation effort. This study focuses on technological cooperative relationships in which technology transfer or new product development is at least a part of the cooperative agreement. Cooperative relationships which are solely oriented to manufacturing or marketing of existing products or processes are excluded. In agreement with Hagedoorn (1993), cooperative agreements that regulate no more than the sharing of production facilities, the setting of standards, collusive behaviour in price-setting and raising entry barriers are also excluded.

(3) This study observes inter-firm cooperation from the aspect of high-tech SMEs. The partner firms that high-tech SMEs ally with could be firms of different size, from different countries or regions, located in different sections in the value chain, or even competitors in the same market.

(4) In contrast to cooperation among giant companies in which joint effort may be a basic research programme with the expectation of a long-term promising market, the inter-firm cooperative relationship in which SMEs are involved is market-oriented by definition.

(5) This study only takes into account formal cooperative relationships under certain cooperative agreements which are reached by all parties involved through negotiation. Inter-firm or inter-personal interactions without formal agreements are not included in this study.

4.3.2 Research Questions and Hypotheses – An Outline of Research Framework

This study considers the issues from five aspects: the motives for high-tech SMEs engaging in inter-firm technological cooperation, the modes which firms prefer to choose, the capabilities for firms cooperating, the impact of cooperation on firms' technological innovation and the critical success factors in inter-firm technological cooperation. To address these issues, five research questions and eight hypotheses are proposed which are discussed in the following three sub-sections. Table 4-9 presents an outline of research framework of this study.

4.3.3 Motives for and Modes of Inter-firm Technological Cooperation

Hagedoorn (1990, p.17) states that "Organizational design of cooperation can be expected to be related to the strategies and economic performance of companies, reflecting their ability to model their inter-firm relationships." Considering SMEs' advantages and disadvantages in technological innovation compared with large companies, it is assumed that high-tech SMEs are motivated to engage in technological cooperation by their distinctive growth strategies and, therefore, their choices of cooperative modes are different from large companies. To investigate how high-tech SMEs formulate effective cooperation strategies, identifying the most significant motives and modes of SMEs' technological cooperation and the dynamics of these motives and modes as firm age and size changes become the fundamental questions.

Question 1: What are the primary motives for high-tech SMEs engaging in inter-firm technological cooperation? Are firm age and firm size correlated with these primary motives?

Based on the literature and the nature of SMEs, it is assumed that high-tech SMEs engage in inter-firm technological cooperation in order to obtain complementary resources such as financing, manufacturing, marketing, or specific experts; to enter new markets; to benefit from economies of scale/scope; to share costs/risks with partners; to tap advanced technology through technology transfer; or to learn from partners.

Table 4 - 9: An outline of research framework – research questions and hypotheses

Research questions	Hypotheses
Question 1: What are the primary motives for high-tech SMEs engaging in inter-firm technological cooperation? Are firm age and firm size correlated with these primary motives?	(1) H1a: The motives for high-tech SMEs engaging in technological cooperation are correlated to firm age. (2) H1b: The motives for high-tech SMEs engaging in technological cooperation are correlated to firm size.
Question 2: What are the main modes of cooperation preferred by high-tech SMEs? Are firm age and firm size correlated with these main modes?	(3) H2a: The choice of a cooperative mode is associated with firm age. (4) H2b: The choice of a cooperative mode is associated with firm size.
Questions 3: Do resource capabilities influence the propensity of high-tech SMEs to cooperate?	(5) H3: A firm's resource capabilities are positively correlated with the propensity of the firm to cooperate.
Question 4: Does inter-firm technological cooperation influence a firm's innovation performance?	(6) H4a: Firms that have been involved in cooperation have better innovation performance than those that have not. (7) H4b: Cooperation is positively correlated to a firm's innovation performance. (8) H4c: The number of cooperative projects is positively correlated to innovation performance.
Question 5: What are the critical success factors in inter-firm technological cooperation?	

Literature in business strategy suggests that firms of different ages and sizes pursue different market and technology strategies which have an impact on their cooperation strategy. To have an in-depth insight into motives for cooperation, the study conducts the analysis of motives of firms in general and in groups by age and size. Therefore, two hypotheses are proposed as follows:

Hypothesis 1a: The motives for high-tech SMEs engaging in technological cooperation are correlated to firm age.

Hypothesis 1b: The motives for high-tech SMEs engaging in technological cooperation are correlated to firm size.

Question 2: What are the main modes of cooperation preferred by high-tech SMEs? Are firm age and firm size correlated with these main modes?

Following Hagedoorn (1990), Brockhoff et al. (1991), and Narula and Hadgedoorn (1999), the proposed modes that high-tech SMEs prefer to choose are listed in order from equity-based modes to non-equity-based modes and from the highest degree of organizational involvement and interdependence to the least as follows: research corporation, joint venture, minority holding, joint research agreement, joint development agreement, customer-supplier R&D contract, second sourcing agreement and licensing agreement.

Among the listed cooperation modes, 'research corporation', 'joint research agreement', 'joint development agreement', 'customer-supplier R&D contract' are clear-cut examples of defined technological cooperation. 'Joint venture', 'minority holding', 'second sourcing agreement' and 'licensing agreement' are taken into account in this study as long as technology transfer or joint R&D is involved in the agreements.

From the resource-based view, Das and Teng (2000) argue that firms are interested not only in accessing or acquiring their partners' valuable resources through an alliance, but also in protecting their own valuable resources during the alliance-making process. It is suggested that the choice of cooperative modes is based on considerations of these two issues simultaneously: "being able to procure valuable resources from another party without losing control of one's own resources" (Das and Teng, 2000, p.44). Firm age and size signify their capabilities in coordinating internal and external resources and managing the cooperative relationships. Therefore, two hypotheses are proposed as follows:

Hypothesis 2a: The choice of a cooperative mode is associated with firm age.

Hypothesis 2b: The choice of a cooperative mode is associated with firm size.

4.3.4 Capabilities for Firms Cooperating and Impact of Cooperation on Innovation Performance

According to resource-based theory, inter-firm technological cooperation is a mechanism by which firms use external technology and information to develop innovation capabilities dynamically. To analyse how inter-firm technological cooperation influences firms' innovativeness, there are two issues to be addressed: the capabilities required for firms to engage in cooperation and the impact of cooperation on firms' innovation performance.

The perspective of resource-based theory assumes that a partnership will not be built unless both sides can provide complementary resources for each other. The likelihood of a firm cooperating depends on not only its own demand for complementary resources but also its attractiveness to its prospective partner. As stressed by Eisenhardt and Schoonhoven (1996), firms must have resources to get resources. Miotti and Sachwald (2003) also posit that unless the firm has something to offer in terms of its own technological capabilities, there may be little reason for potential partners to engage in collaboration with the firm and therefore high-profile innovators with the finest technological capabilities should be the most attractive partners.

Questions 3: Do resource capabilities influence the propensity of high-tech SMEs to cooperate?

Leonard-Barton (1992) claims knowledge embedded in technical systems results from years of accumulating, codifying and structuring the tacit knowledge in people's heads, suggesting that firm age is connected to firms' capabilities. Fritsch and Lukas (2001) declare that firms that engage in R&D cooperation tend to be relatively large, have a comparatively high share of R&D employees and are characterized by a relatively high aspiration level of their product innovation activities. In Gulati (1993), firm size is assumed to be indicative of a firm's economies of scale and resource sufficiency. Dickson and Weaver (1997) claim that limited resources of small firms make the likelihood of alliance use minimal. From the transaction cost perspective, Shrader (2001) posits that a firm's size reflects its ability to absorb costs associated with various foreign market entry modes. Smaller firms may rely more on collaboration due to their limited resources. Shrader and Simon (1997) find that even among a relatively homogeneous group of new ventures, firm size influences the resources available to them, the strategies they pursue, and the firms' performance. Hagedoorn and Schakenraad (1994, p.303) conclude that "firm size reflects the degree to which firms actively seek and find external opportunities in strategic linkages."

Studies (e.g. Cohen and Levinthal, 1989; Rothwell, 1991; Macpherson, 1997; Ritter and Gemunden, 2003) suggest that a firm's ability to forge effective external technical links depends to some extent on its level of in-house technological resources, and the employment of QSEs (qualified scientists and engineers) is one of the most important factors determining SMEs' propensity and ability to access external sources of technology. As stated by Bougrain and Haudeville (2002, p.746), "Internal expertise facilitates the identification of external information, their absorption and the improvement of SMEs' performances. If a decoding does not happen, the assimilation of external knowledge to the firm's 'technological capital' will not be effective." Hagedoorn (1990, 1993) claims innovative firms are largely decided by their R&D level although innovation has a variety of determinants. Furthermore, studies (e.g. Freeman, 1999) stress the importance of R&D intensity in recognizing and utilizing external resources.

Literature has been paying attention to the role of leadership in SMEs. Miller (1983) argues that owners and chief executives (often the same individual) in small firms act as the brain of the organization and is the key determinant of its strategic posture. Lumpkin and Dess (1996, p.138) believe that "the small business firm is simply an extension of the individual who is in charge". Eisenhardt and Schoonhoven's (1996) empirical study has concluded that the social position of top managers, including such factors as reputation, extensive connections and relationships with potential partnering firms, is the key source of leading firms to cooperate. Bougrain and Haudeville (2002) claim the managers' educational level influences the scope of the network. Therefore, it is reasonable to consider managers' education level and managerial experiences as supporting factors for top managers to build their social position.

Based on the preceding discussion, this study considers 'manager's educational level', 'manager's managerial experience', 'firm age', 'firm size', 'R&D employees', and 'R&D expenditure' as proxies of capabilities for firms engaging in cooperation. Therefore, a hypothesis is proposed as:

Hypothesis 3: A firm's resource capabilities are positively correlated with the propensity of the firm to cooperate.

Firms are motivated to enter into inter-firm cooperation for the considerations of competitive forces, cost minimization and complementary resources. It is necessary to analyse the outcome of firms' involvements in technological cooperation.

Question 4: Does inter-firm technological cooperation influence a firm's innovation performance?

According to resource-based theory, a firm accumulates its own resource capability over time and this accumulation process is path-dependent. Any technological innovation project requires more or less new or specific resources which focal firms may lack and are unable to develop these resources with cost efficiency in a competitive time frame. High-tech small firms are more unlikely to have the broad range of skills, assets and capabilities necessary for innovation. In these instances, inter-firm technological cooperation seems an efficient solution for gaining complementary resources. Teece (1992, p.22) argues that "to be successful, innovating

organizations must form linkages, upstream and downstream, lateral and horizontal."
So, two hypotheses are proposed as:

Hypothesis 4a: Firms that have been involved in cooperation have better innovation performance than those that have not.

Hypothesis 4b: Cooperation is positively correlated to a firm's innovation performance.

Literature suggests that firms' involvement in cooperation can provide experience in coordinating and managing partnerships, and therefore reduce the costs incurred in governance. Some studies (e.g. Gulati, 1995) have pointed out that cooperating with repeated partners can apparently reduce the cost in defending opportunistic behaviour due to increased trust between partners. Deeds and Hill (1996) and Shan et al. (1994) found a positive relationship between the number of a firm's strategic alliances and their new product development. This leads to the next hypothesis:

Hypothesis 4c: The number of cooperative projects is positively correlated to innovation performance.

4.3.5 Critical Success Factors in Inter-firm Technological Cooperation

Inter-firm technological cooperation is a more complicated phenomenon due to more than one firm being involved. Better understanding of influential factors helps to provide effective strategic management on cooperative activities.

Question 5: What are the critical success factors in inter-firm technological cooperation?

Based on the success factors suggested by literature, e.g. the stage model of product development collaboration in Leverick and Littler (1993) and the five stages of alliance evolution in Hoffmann and Schlosser (2001), 12 factors are chosen to be contributing factors to successful cooperation and are classified into three groups from the view of their contribution to successful cooperation.

The first group includes factors which are considered to be the natural merits for making a successful cooperation. These are 'flexible organizational and managerial style', 'resource complementarity', 'geographical proximity', 'compatible technology and business strategies with partners'.

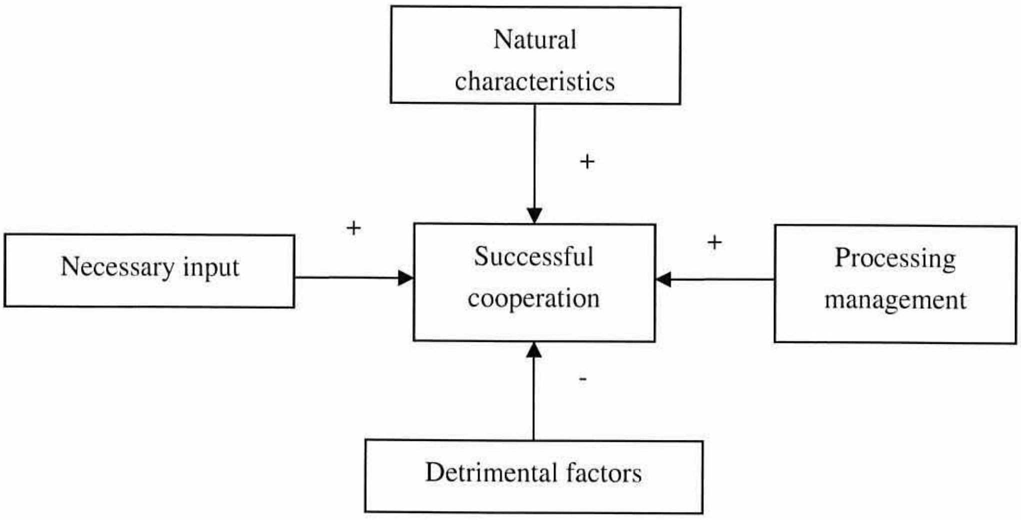
The second group includes 'well-documented agreement', 'safeguards in place for protecting core technology', 'top leader's commitment', and 'sufficient cooperative resources'. These factors are assumed to be necessary input at the first beginning of a cooperative activity.

Lynch (1990) points out that "The success of the venture will not depend on its legal agreements but on the success of the operations." The third group consists of factors which are related to cooperation process management. These are 'ongoing monitoring and coordinating', 'milestone appraisal', 'adjusting to external change', and 'trust, communication and reciprocity'. Leverick and Littler (1993) name them as procedural factors.

To verify the critical success factors from the opposite view, five factors which are assumed to be detrimental to successful cooperation are proposed. They are 'only focusing on short-term financial performance', 'unilateral dependency on partners', 'not contributing as promised', 'time-consuming decision making', and 'lack of compatibility in technology, management and organisation'. According to literature, all these five detrimental factors are negatively associated with successful cooperation.

The proposed 12 contributing factors and 5 detrimental factors are displayed in Figure 4-8. The plus sign '+' represents contributing effect on successful cooperation and minus sign '-' represents detrimental effect on successful cooperation.

Figure 4 - 8: Contributing factors and detrimental factors to successful cooperation



4.4 Summary

An overview of China's high-tech industries and national innovation system concerning high-tech SMEs in China develops an understanding of the research context of the current study. Consequently, a research framework is formulated, in which research questions and hypotheses are proposed to be tested and analysed in the following chapters.

According to the Tentative Classification Standards on Small and Medium-sized Enterprises (State Economic and Trade Commission of China et al., 2003), SMEs in industrial sectors in China are those which have the number of employees less than 2000, or annual sales revenue less than ¥300 million, or total assets less than ¥400 million. This study uses the number of employees as the criterion for sampling and for classifying sample firms. While high-tech industries greatly contribute to China's economic growth and exports, information and communication technology industries hold a large share of added value in all high-tech manufacturing and have the fastest growth rate. SMEs in information technology industry play a significant role in technological innovation. However, insufficient innovation input has been the bottleneck for high-tech firms' productivity and competitiveness. High-tech firms have mainly resorted to inter-organizational cooperation in pursuing technological innovation.

The national innovation system in China has been transformed to foster firms' role in technological innovation. Inter-organizational cooperative projects for commercialisation and industrialisation of science and technology achievements are facilitated by a wide range of favourable policies, financial support, and infrastructure investments. High-tech SMEs benefit from the Innovation Fund for Small Technology-based Firms (Innofund), the SMEs Promotion Law, and the SME Board in Shenzhen Stock Exchange, and the 'innovation milieu' formed particularly in high-tech development zones.

The term 'inter-firm technological cooperation' in this study refers to a firm's involvement in cooperative relationships by which partnering firms pursue technology transfer or joint innovative activities to develop new products and technologies. The cooperative relationships are specified by formal agreements. Those partnerships that solely entail manufacturing or marketing of existing products or processes are excluded from this study.

Based on a critical review of theoretical studies, empirical studies, and high-tech SMEs' technological innovation in China, the research framework is outlined which is constructed by five research questions and eight hypotheses. The current study aims to investigate and examine the relationships articulated in hypotheses, and thus to answer the proposed research questions.

Chapter Five: Research Design and Methodology

This chapter presents research design and methodology in great detail. The first section states the research strategy, consisting of the deductive approach, the cross-sectional survey method and the postal questionnaire instrument. Forms of survey error are systematically discussed to emphasize the importance of questionnaire design and administration of questionnaire process. The second section articulates the construction of the postal questionnaire developed for this study, including data to be collected, type of questions and measurement considerations. Steps for improving response rate are displayed. The third section describes the sample design from sampling frame to procedures of data collection. This section also introduces semi-structured interviews with 20 managers. The information from interviews, supplementing the postal questionnaire survey, provides further detailed insights into several key issues in SMEs' cooperative activities. The fourth section, based on data from the questionnaire, defines research variables and their measurements for data analysis in the following chapter. The last section provides a conclusion to the chapter.

5.1 Research Strategy

5.1.1 A Deductive Study and the Process of Deduction

Concerning the link between research and theory, approaches to research are categorized into deductive and inductive. According to Zikmund (1991), deductive approach is the logical process of deriving a conclusion from a known premise or something known to be true while inductive approach is the logical process of establishing a general proposition on the basis of observation of particular facts. Theory construction is often the result of a combination of deductive and inductive reasoning. Observations and studies in the area of inter-firm cooperation have led to conclusions at a certain extent. This study is to empirically verify these theoretical assumptions and empirical findings by using a scientific method. Therefore, a deductive approach is employed.

Bryman (2004) describes a deductive study as a research approach through which a researcher, on the basis of existing theory in a particular domain or related to that domain, deduces hypotheses and processes empirical observation. The purpose of empirical deduction is to examine and develop the theory. The concepts developed in hypotheses need to be operationalised into testable terms in order to define what data should be collected. The theory, as Merton (1967) argues, is principally used to guide empirical inquiry. The theory and hypotheses deduced from it come first and drive the process of gathering data. According to Robson (1993), the process of a deductive study can be outlined in the following steps:

(1) Deducing a hypothesis (or hypotheses) from the theory;

(2) Expressing the hypothesis in operational terms which propose a relationship between variables;

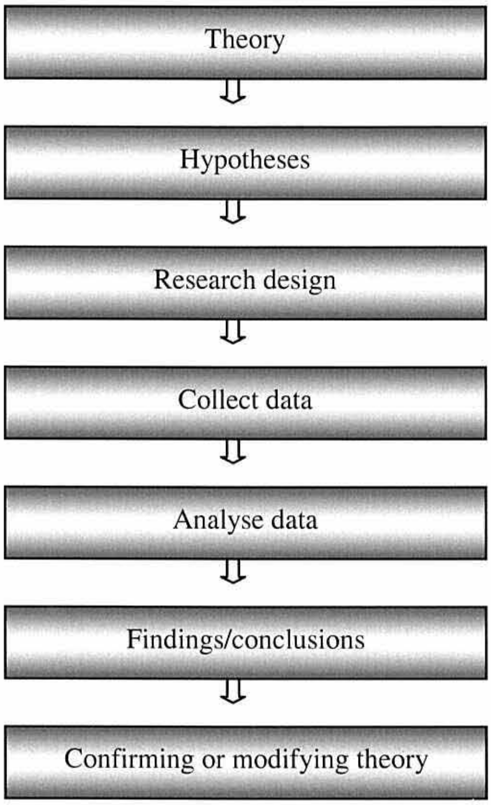
(3) Testing this operational hypothesis;

(4) Examining the specific outcome of the inquiry;

(5) Confirming the theory if the hypothesis is supported, or modifying the theory in the light of the findings if the hypothesis is not supported fully.

Saunders et al. (2003) summarize several important characteristics of the deductive approach. First, researchers follow scientific principles, moving from theory to data and explaining the causal relationships between variables. Second, researchers operationalise the concepts developed in hypotheses, enabling the facts to be measured quantitatively. Third, researchers collect quantitative or quantifiable data and employ controls to allow the testing of hypotheses. Fourth, research process is highly structured so as to facilitate replication, and researchers are independent of what is being researched to ensure the objectivity of the research. Fifth, a sufficiently sizable sample is needed in order to generalize the conclusions. Taken all into account, the process of a deductive study is depicted in Figure 5 – 1.

Figure 5 - 1: The process of a deductive study



Sources: Bryman (2004); Saunders et al. (2003)

Following the process of deductive approach, this chapter, carrying on research questions and hypotheses developed in the prior chapter, provides an entire research methodology for data collection.

5.1.2 Rationale for Conducting a Questionnaire Survey

Karami (2003) and Karami et al. (2006) state that research question and context should dictate the choice of appropriate research instrument. Literature reveals that studies on inter-firm cooperation either conduct a survey to collect data or employ available secondary data. The secondary sources employed in literature include the MERIT-CATI database (Hagedoorn, 1993; Hagedoorn and Schakenraad, 1994; Hagedoorn, 2002), the CORE database (Link and Bauer, 1989), the NCRA-RJV database (Vonortas, 1997), the STEP TO RJVs databank (Caloghirou and Vonortas, 2000), BioScan (Shan et al., 1994; Deeds and Hill, 1996), Recombinant Capital (Lerner and Merges, 1998; Audretsch, 2001) and some others. However, SMEs' cooperative activities are not well represented in most of these secondary sources. As Hagedoorn and Schakenraad (1994) state, the MERIT-CATI database has its limitation since some small firms' cooperative links are excluded. The scarceness of data makes the study of SMEs more difficult than of large firms. This explains why the survey method is popular in the studies on the subject of SMEs.

Public data sources in China, like statistical yearbooks, haven't covered the small firm sector. The SME board in Shenzhen Stock Exchange, designed to support SMEs, was newly launched in 2004 and only 50 firms are listed (Shenzhen Stock Exchange, 2006). Looking at widespread high-tech SMEs in China, most of them have been neither listed in security exchange market, nor systematically tracked or recorded by official or academic organizations. A specific database concerned with inter-organizational cooperation hasn't been built in China either. Furthermore, the nature of research constructs (motives for cooperation, cooperative mode preference, perceptions of successful rate, etc.) makes it impossible to access secondary data with sufficient validity.

To address the research questions proposed in this study, a comprehensive survey becomes necessary. Regarding the advantages of collecting primary data over using the secondary data, Azriel (2003) states that, "The use of secondary data sources often directs the development of research questions and hypotheses due to the limits of data availability, which potentially ignores important aspects of the phenomena. When collecting primary data, the researcher is able to focus on personal interests or key problems that are of interest to the field."

Based on literature, research questions and hypotheses developed in this study, the questionnaire survey and semi-structured interview are chosen to be the instruments of data collection. The research strategy is to use the questionnaire survey to gather data from a large sample at a general level, whilst conducting a semi-structured interview for a more detailed understanding of key issues of cooperation strategies.

The research method is a cross-sectional study. According to Bryman (2004), a cross-sectional research design entails the collection of data on more than one case and at a single point in time in order to collect a body of quantitative or quantifiable data in connection with two or more variables, which are then examined to detect patterns of association. Research questions and hypotheses dictate the variables to be studied. The number of cases is decided by sample size in this case. Data on the variables of interest are collected simultaneously in cross-sectional design which is different from experimental design where data from pre-test and post-test, and different from longitudinal research design where data from a time series. Table 5-1 illustrates that a cross-sectional design comprises the collection of data on a series of variables and a group of cases at a single point in time. Data in each cell in the matrix represent the information of a certain variable of a certain case at a certain time.

5.1.3 Unit of Analysis and Time Horizon

Previous studies on inter-firm cooperation ground their analysis units at different levels. For example, Cainarca et al. (1992) discuss the pattern of technological agreements between firms at the industry branch level; Eisenhardt and Schoonhoven (1996) portray patterns of joint development contracts at the industry level; Hagedoorn (1993) shows the differences of motives for strategic technological alliances at the industry level; Lee et al. (1988) and Lee (1995) present technology transfer and technological development at both of industry level and firm level; Chung et al. (2003) examine the dynamic patterns of technological cooperation activities along technological development stages at firm level; and Bougrain and Haudeville (2002) select technological cooperative projects as analysis unit to examine the impact of cooperative relationships on successful innovation. The findings from using different units of analysis might be not applied to each other. The unit of analysis in this study is a firm.

Table 5 - 1: The data rectangle in cross-sectional research

	Variable 1	Variable 2	……	Variable n
Case 1				
Case 2				
……				
Case n				

About the time horizon in previous studies, Man and Duysters (2005) find that research has a time horizon of a few years with three years being the most prevalent, which coincides with the suggestion of OECD (1997). This study adopts a three-year time horizon from 2002 to 2004 as the time frame of studied variables. Using a three-year time frame to measure SMEs' cooperative activities and their impact on firms' innovation is to better capture relationships between variables compared to a single year time frame. It is worthy noting that research variables derived from summing amounts or averaging values over three years still fall into cross-sectional study rather than longitudinal study.

5.1.4 Discussion of Postal Questionnaire Instrument

According to Zikmund (1991), a questionnaire survey has different types. A postal questionnaire is a type of self-administered questionnaire, which carries advantages and disadvantages. Researchers need to fully understand and to exploit the advantages and to avoid the negative effect of disadvantages.

As Zikmund (1991) and Saunders et al. (2003) state, a postal questionnaire entails the following advantages: (1) Lower cost and higher efficiency. Postal questionnaires can be sent out in a large quantity in one time. Compared to face-to-face interview, this form saves time and cost of travel for interview. The advantage is apparent in this study because the sample firms are geographically widely dispersed. (2) Avoiding administrative error from interviewers. Studies have found that characteristics of interviewers may affect the answers that respondents give. For example, the variability of interviewers' skills may produce the biasing error. Postal questionnaires are completed or administered by respondents themselves and questions are highly standardized and structured, which is independent of the influence of interviewers. (3) Increasing the accuracy of respondents' answers. The absence of an interviewer provides greater anonymity and induces respondents to reveal sensitive information, which helps to increase the accuracy for the answers of sensitive questions. For questions, such as number of R&D employees, R&D

expenditures and number of technological cooperative projects, respondents may not recall accurately. A postal questionnaire allows respondents to take time to think about or consult the documents or people concerned.

Fully exploring and recognizing the potential drawbacks of postal questionnaires helps design a good questionnaire. The disadvantages of postal questionnaire include: (1) Absence of supervision or administration on the process of answering the questions. Respondents may be not clear with some questions due to the ambiguity of the question or the limited knowledge of the respondent. This issue may lead to missing data. Missing data also emerge in the situation that respondents choose to skip over some questions which they are unwilling to provide answers. (2) Lack of in-depth information. Researchers are limited to the answers on the questionnaire and do not have chance to probe the questions concerned further. (3) Limit on number of questions and depth of questions. Studies have found that a lengthy questionnaire is the main reason of low response rate or more missing data. (4) No control over the respondents. Although questionnaires are sent out to the named persons or the person in the named positions, it is not uncommon that respondents are not the required ones. When respondents are in senior positions, such as CEOs in companies, the questionnaire may be highly possible to be delegated to others to complete. (5) Low response rate. Compared to interview, the low response rate is the most serious disadvantage. Although there is no certain tolerance of low response rate for questionnaire survey, low response rate risks the lack of representativeness and generalisability of quantitative research.

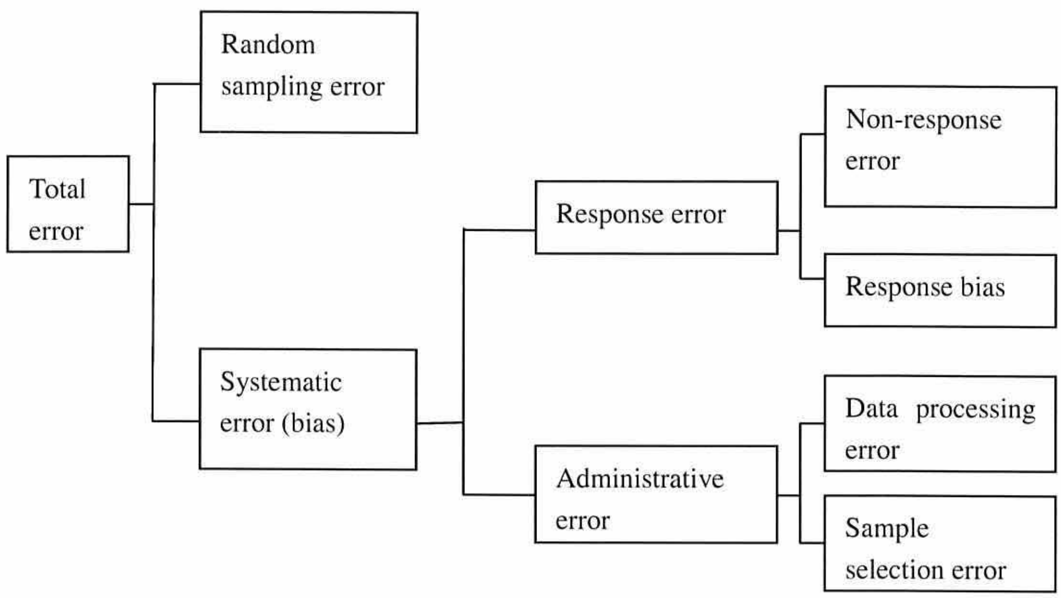
5.1.5 Errors in Questionnaire Survey Research

The quality of a research project largely depends on the accuracy of the survey. Being aware of and realizing various sources of error are the basic method for handling and reducing survey errors. In Zikmund (1991), two major sources of survey error, random sampling error and systematic error, are discussed. The various forms of survey error are outlined in Figure 5-2.

Random sampling error occurs when samples cannot represent the target population. Random sampling error is an unavoidable statistical problem. Appropriate questionnaire design, sample design and sampling procedures can reduce random sampling error.

Systematic error results from imperfect aspects of the research design and execution of the research. It is also called non-sampling error, implying that all sources of error not included in random sampling error fall into systematic error.

Figure 5 - 2: Tree diagram of total survey error



Source: adapted from Zikmund (1991, p.145).

Zikmund (1991) presents two groups of systematic error, response error and administrative error. There are two types of response error: non-response error and response bias. Few questionnaire surveys have a 100 percent response rate. A questionnaire survey with low response rate risks non-response error wherein respondents have significant differences with non-respondents. Therefore, Zikmund (1991) suggests that a researcher must be sure that those who did respond to the questionnaire were representative of those who did not. Response bias occurs when respondents' answers are falsified or misrepresented, either intentionally or inadvertently. A thoughtful questionnaire design helps reduce response bias.

Administrative error results from the improper administration of research process. Misunderstanding, neglect, or some other mistakes are causes. Administrative error can occur in the process when data are wrongly edited, coded, or entered into computer, which is called data processing error. Administrative error can also occur when sampling frame is not proper, which is called sample selection error.

5.2 Questionnaire Design

5.2.1 Questionnaire Construction

Generally speaking, questionnaire construction should be especially easy to follow and its questions should be particularly easy to answer because there is no interviewer in the administration of postal questionnaire. The questionnaire design under this study follows a three-fold principle: firstly, to translate the research questions into a set of specific questions that the respondents can answer; secondly, to motivate respondents' willingness to participate in the survey; thirdly, to minimize the potential response error.

5.2.1.1 Data to Be Collected

The questionnaire is structured step by step. The first step is to decide what information is needed to be collected. Based on research questions and hypotheses, the following information needs to be collected by questionnaire:

(1) The manager's characteristics, including age, gender, education level, managerial

experience, and foundership;

(2) Basic information on the firm, including firm age, firm size, number of R&D employees, R&D expenditures, new product development, patent application, sales, and profit;

(3) General issues regarding inter-firm technological cooperation, including number of cooperative projects, intention on engaging in cooperation, concerns preventing a firm from cooperation, successful rate of cooperative projects, and perception on importance of cooperation strategy;

(4) Strategic management issues of inter-firm technological cooperation, including motives, modes, partner's characteristics, critical success factors, detrimental factors, and limitations of learning ability.

All of these required data are specified by questions. There are total 20 questions in the questionnaire in this study. The first 19 questions are information collected for data analysis, while the 20th question asks the respondent whether a summary report under this study is requested. The researcher then promises that a research report will be provided for the respondents who request.

5.2.1.2 Type of Questions

The second step is to decide the type of questions. In Zikmund (1991), according to whether alternative answers are provided for respondents, questions are categorized into open-ended questions and close-ended questions. An open-ended question allows respondents to give answer in their own way. A close-ended question provides a number of alternative answers from which the respondent is instructed to choose. Besides the quantity questions which require respondents to provide the certain value or amount such as sales, number of employees and so on, all other questions in the questionnaire are close-ended. For example, question 14 in the questionnaire is:

What are the primary motives for deciding to engage in inter-firm technological cooperation? (Please tick the top three only)

□ Financial support

□ Specific experts

□ Manufacturing or marketing support

□ New market

□ Economies of scale or scope

□ Sharing risk and cost

□ Technology transfer

□ Learning from partners

□ Others (please specify)

Close-ended questions are considered to be advantageous in response rate from the following aspects: (1) Easy to process. Respondents only need to tick or circle an answer or the answers among the alternative answers provided. In the case that respondents may not be clear about what a question is getting at, availability of answers may help to clarify the meaning of the question for respondents. The characteristic of providing alternative answers can reduce the likelihood of missing data and improve respondents' confidence to complete the questionnaire. (2) Less energy and time required. Considering that respondents are not willing to write extensively, close-ended questions provide easier and quicker way for them to go through questionnaires.

However, close-ended questions exhibit disadvantages as well. Bryman (2004) points out that close-ended questions deter the spontaneity of respondents. There is possibility that respondents might come up with interesting replies that are not covered by the fixed answers. Another case is that forced-choice answers are not exhaustive, and to achieve exhaustiveness will result in a long list of possible answers. To overcome the potential drawbacks and to capture as more detailed information as possible, a catchall category of 'other' is suggested to be included in the provided choices. The questionnaire under this study uses this catchall category in question 11, 14, 16 and 19 (see Appendix C-1).

5.2.1.3 Measurement Considerations

The third step of questionnaire design is to decide the type of scales. According to Zikmund (1991), four types of scales can be used to collect data, which are nominal scale, ordinal scale, interval scale and ratio scale. The questionnaire under this study uses nominal scale, interval scale and ratio scale.

(1) Nominal scale: questions use nominal scale when the alternative answers are categories with regard to the subject's characteristics or attributes. The requirement for a nominal scale is that its categories are mutually exclusive and exhaustive of all possibilities. This means each category must be different and all possible categories must be included. To ensure all possible categories are considered, the category of 'other' is used and 'please specify' is followed the 'other' category to collect the information not listed in the provided answers. In the questionnaire, the respondent's gender, education level and foundership, the firm's intention on engaging in cooperation, the concerns preventing a firm from cooperation, the motives and modes of the firm engaging in cooperation, partner's characteristics, and the limitations in learning ability are measured by nominal scale. For example, question 11 in the questionnaire is:

What concerns might prevent the firm from inter-firm technological cooperation? (Please tick all boxes that apply)

□ Technology leakage

□ Loss of control/ownership

□ Distraction from main goal

□ Lack of experience

□ Lack of personal relationship

□ Legal issue

□ Diverse organizational culture or value

□ Others (please specify)

Nominal scale is the lowest level of measurement and therefore the precise of data is relatively low. Data analysis is restricted to counts of the number of responses in each category, calculation of the mode or percentage, and use of the Chi-square statistic.

(2) Interval scale: questions use interval scale when asking respondents to assess and rate objects or events. With interval scale, the distances between the rating numbers are equal, thus, differences between points on the scale can be interpreted and compared meaningfully. For instance, the difference between a rating of 3 and 4 is the same as the difference between a rating of 1 and 2. An interval scale has all the qualities of nominal and ordinal scales, plus the differences between the scale points is considered to be equal. Therefore, data obtained using an interval scale can handle more sophisticated calculations than nominal scale and ordinal scale. Mean, standard

deviation, Pearson's product-moment correlation coefficient can be calculated. For example, question 13 in the questionnaire is:

In general how important do you consider inter-firm technological cooperation to your business?

□ Very important

□ Important

□ Uncertain

□ Less important

□ Unimportant

(3) Ratio scale: questions use ratio scale to collect quantity data, such as number of employees and sales. A ratio scale provides the highest level of measurement. A distinguishing characteristic of a ratio scale is that it possesses a unique origin or zero point, which makes it possible to compute ratios of points on the scale. All statistics can be computed based on ratio scale. For example, question 3 in the questionnaire is:

How many employees did the firm have in the past three years?

2002__________ 2003__________ 2004__________

5.2.2 Steps to Improve the Response Rate

Considering the aforementioned disadvantages of postal questionnaire, the following steps are employed to improve the respondent rate.

(1) Attaching a covering letter to the postal questionnaire. The covering letter articulates the importance of the research project to respondents, the scientific process that the respondents' organizations are selected, and the significance that the respondents provide the truthful information. The sponsorships are named to boost the respondent's willingness to participate. The covering letter guarantees the confidentiality over the information of respondents' individuality and organizations respondents represent. The estimated time for completing the questionnaire is declared to facilitate respondents' confidence to contribute their time. To encourage respondents to contact the researcher for any queries, the detailed contact information of the researcher is provided. Covering letter uses official letterhead of Bangor Business School, University of Wales, UK and official envelop of Management School of Shandong University, China. Every copy of covering letter has the researcher's signature to show the formality and sincerity. The full format of covering letter in English version and Chinese version are displayed in Appendix B-1 and B-2 respectively.

(2) Providing the precise definition. Before starting with the questions, a precise definition of 'inter-firm technological cooperation' is provided to help the

respondents' understanding and therefore to obtain reliable information.

(3) Providing a stamped addressed envelope. A stamped addressed envelope is attached to the postal questionnaire for respondents' convenience to return the completed questionnaires.

(4) Designing a considerate format to motivate respondents to complete the questionnaire. The efforts include keeping the questionnaire in a reasonable length; using closed-end questions to a higher extent which save respondents' energy and time; designing a clear layout which is easy on eye; asking questions in the order from the basic ones to specific ones.

(5) Promising that a summary report will be offered to respondents under their permission for appreciating their cooperation and assistance in the survey.

(6) Pre-testing the questionnaire. The detailed discussion is in subsection 5.2.3.

(7) Following up the non-respondents. The detailed discussion is in subsection 5.3.2.

5.2.3 Pilot Study

According to Bell (1993, p.84), "however pressed for time you are, do your best to give the questionnaire a trial run". As Bell's advice, without a trial run, there is no way of knowing that the questionnaire will succeed. The pilot study was carried out in Jinan, the capital city of Shandong province in June 2005. Five high-tech SMEs outside high-tech industrial development zone are selected. These 5 firms, operating in information technology industry, are similar to the studied population. The researcher presented the questionnaire to managers on face, observed the managers filling out the questionnaires and asked their comments after completing the questionnaires. After the pilot test on this small number of firms, original questionnaire script was revised and reworded to ensure that respondents would have no difficulties in understanding and answering the questions. Preliminary analysis on the pilot test data demonstrates that the data collected enable the research questions to be answered.

5.2.4 Translation

The questionnaire was originally developed in English and was translated into Chinese. Chinese version uses terminologies that Chinese managers are familiar with. Going through pilot test in a small number of firms in Jinan, the Chinese version was revised according to the comments from the respondents and was used in the large-scale questionnaire survey. Consistent with the recommendations of Brislin (1980) and Usunier (1998), the Chinese text was back-translated into English text again. The final English version was adjusted to changes made in Chinese version. Two versions of questionnaire were checked by bilingual experts to ensure that the English text and the Chinese text convey the same information.

The full format of questionnaire in English version and Chinese version are displayed in Appendix C-1 and C-2 respectively.

5.3 Survey Process

5.3.1 Sampling Frame

The sample firms come from information and communications technology industries. As described in Chapter Four, firms in software development industry and firms in electronics, telecommunication equipments and computers manufacturing industries have a relative high proportion of SMEs and contribute greatly to export and overall economy in China. According to Kelly and Rice (2000), these industries are closely interrelated due to the increased integration of computer, telecommunications and software technologies and products, enabling control of inter-industry differences in patenting, alliance, and product innovation activities. These industries are also heavily reliant on technology and innovation, which makes them the best setting for testing the impact of technological cooperation on firms' innovation performance.

Small high-tech firms have recently been the subject of much attention among researchers and policy makers in China. A particularly strong interest has developed in dynamic companies operating in the field of newly emerging technologies with promising innovative potential, especially ICT companies. These are identified as key agents of industrial regeneration which can help close the productivity and innovation gaps between China's industry and the world leading competitors. According to China Enterprise Evaluation Association et al. (2005), communication equipment, computer, and other electronic equipment manufacturing holds the highest growth rate in SME sector. It is reported that more than 80% firms in high-tech industrial zones in China operate their main businesses in information and communications sectors. Therefore, the sample firms are selected from those operating in information and communications technology sectors. They are computer and peripheral equipment manufacturers, electronic and telecommunications equipment manufacturers and software developers.

Empirical studies in these sectors have been conducted by many researchers, e.g. Leverick and Littler (1993) and Park and Ungson (1997). Leverick and Littler (1993) state that against a background of higher R&D costs, an increasingly rapid pace of product innovation, the growing interrelatedness of technological development, and the increasing internationalisation of industries, collaborative agreements appear to be especially common in the information and communications technology (ICT) industry.

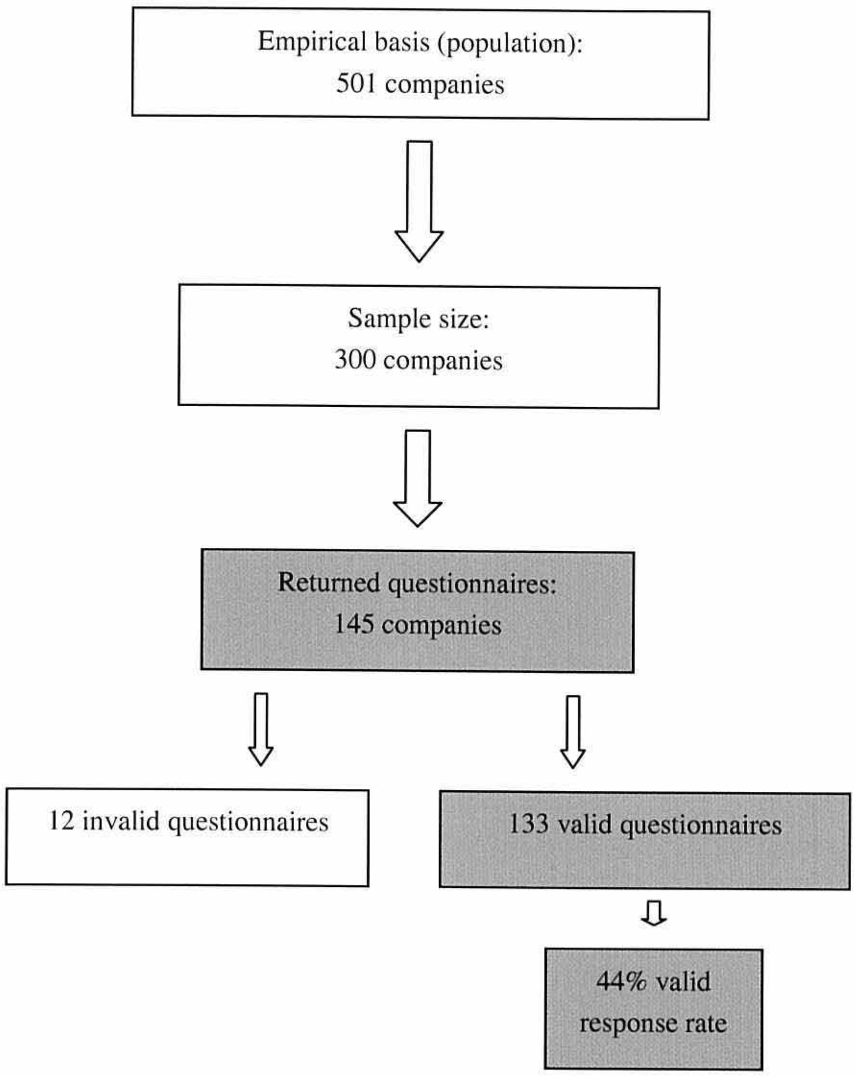
Sample firms are selected from Jinan National High-tech Industrial Development Zone, Qingdao National High-tech Industrial Development Zone, and Weihai National High-tech Industrial Development Zone. These three national industrial zones are all located in Shandong province. Their geographical proximity implies a less variance between three industrial zones. There are 690 high-tech firms within these three high-tech industrial zones by 2004. Based on the registers or directories of companies provided by administration centres of industrial zones, firstly, firms that are not operating in electronic equipment manufacturing, telecommunication equipment manufacturing, computer manufacturing or software development, are removed; secondly, firms, which have 2000 or more employees, are removed. The remaining 501 firms are population or sampling frame under the survey and they are coded with 3-digit number from 001 to 501. 300 firms are chosen by simple random sampling method. Sample firms' main business activities and number of employees are checked again to ensure that sample firms are qualified as the studied subject.

5.3.2 Data Collection

A total of 300 questionnaires were sent to named CEOs or senior managers in charge of technological innovation in the early July 2005. By the end of July, 97 completed questionnaires were returned. In early August, a follow-up letter enclosing a reworded covering letter, a copy of questionnaire and an addressed stamped envelope was sent to each of non-respondents. Other follow-up methods, including phone calls, emails and calling non-respondents in person were made as well. The follow-up efforts generated a further 48 completed questionnaires. By the end of September 2005, there were total 145 returned questionnaires. Among 145 returned questionnaires, companies those with substantial missing data in questionnaires were removed. Finally, 133 companies were identified as valid respondents and the valid response rate is 44.33%. These data are used in data analysis.

Literature contains different views on the level of acceptable response rate. For example, Owen and Jones (1990) and Saunders et al. (2003) consider a response rate of approximately 30% is reasonable for postal surveys while Mangione (1995) considers the response rate should be at least 50%. Prior studies using postal questionnaire methods show a modest response rate. For example, Littler et al. (1995) achieve a 36% response rate and Chung et al. (2003) have a 31% response rate. In Hoffmann and Schlosser (2001), the response rate is 16.4%. Compared to the reported response rate in prior studies in the research field concerned, 44% respondent rate under this study can be accepted as representative. The sampling process is outlined by a flow chart in Figure 5-3.

Figure 5 - 3: Flow chart of the questionnaire survey process



The validity and reliability of data are secured by several means. The questionnaire is carefully pre-tested in a small number of firms as described in subsection 5.2.3. Furthermore, CEOs or senior managers in charge of technological innovation are targeted as respondents, who are considered the most knowledgeable informants. With regard to systematic error, Bruce et al. (1995) mention that respondents with a major involvement in collaborative product development would have been more likely to complete and return a questionnaire. Kleinknecht and Reijnen (1992) find small firms responded somewhat less than larger ones in their questionnaire survey. These may reflect a degree of non-response bias. So, it is necessary to test whether there is significant difference for the response rate between firms that have been involved in collaboration and firms that never have and between larger firms and smaller firms. Following Armstrong and Overton (1977), a comparison between respondents before follow-up and after follow-up (with the latter respondents being assumed to be similar to non-respondents) is conducted in terms of number of employees and number of cooperative projects. The t tests show no significant differences between these two groups, and non-response bias is therefore not expected to have an effect on the results of the study.

5.3.3 Semi-Structured Interview

As suggested by Zikmund (1991) and Saunders et al. (2003), the purpose of conducting semi-structured interviews in this study is to probe some key issues to compensate for the limitations of the postal questionnaire and to provide more contextual information for discussion of quantitative analysis. Undertaking a basic analysis on the returned questionnaires, questions for the interview are produced, which are: (1) Why does the firm engage in inter-firm technological cooperation? (2) If not, what are the reasons for the firm not engaging in cooperation? (3) What are the considerations when the firm chooses the cooperative mode? (4) How does the firm select the partnering firm? (5) What are the major problems and difficulties for the manager in his/her cooperative innovation efforts?

Initially, 25 firms were chosen to conduct the semi-structured interviews with their CEOs or senior managers because they show their interest in answering the questionnaire and they are different from each other in products and firm size. While 5 chosen interviewees could not be approached, 20 chosen interviewees accepted the interview. Interviews with 20 managers last 40 minutes at least and 2 hours at most. To create a relaxing conversation environment, interview dialogues were recorded by taking notes instead of using an electronic recorder. The transcript of each interview was sent back to the interviewee to get his/her agreement with the content.

The postal questionnaire survey is the major research method for data collection in this study, and therefore it is not appropriate to undertake a full content analysis of interviews. However, information provided by interviewees is used to support the discussion of a few specific themes and greatly helps the understanding of firms' cooperation practices.

5.4 Data Analysis Plan

5.4.1 Data Coding

Coding is the process of identifying and classifying each of the provided answers in the questionnaire with a numerical score. The purpose of data coding is to transform the data in the questionnaire to computer readable data for data analysis. A data matrix is used to code data. Each row in the matrix represents a sample firm and total 133 sample firms are listed in 133 rows. Each column represents a variable in a given time. In this study, some variables are recorded as their values, counts or characteristics by 2004, for example, managers' age and firm age. Some variables are recorded in a three-year time frame from 2002 to 2004, for example, number of employees in 2002, 2003 and 2004. A total 41 variables with 51 variants under given time are recorded in 51 columns. Therefore, a 133×51 data matrix is formed by data coding. Table 5-2 is a codebook in which quantity questions have their own number automatically and for non-quantity questions all answers have a coded number. The codebook is for data analysis by using SPSS.

5.4.2 Defining Research Variables and Their Measurements

To test hypotheses and address research questions, measurements of research variables need to be defined and computed based on raw data.

5.4.2.1 Measuring Primary Motives and Main Modes of Inter-firm Technological Cooperation

In question 14, respondents are asked to tick the primary motives for going to cooperate. The motives are coded with number from 1 to 9 for analysis. A dummy variable is used to measure the decision on whether a motive is considered a primary motive by firms (1 = Yes, 0 = No).

Regarding cooperation modes, in question 16, respondents are asked to tick the modes that firms have used or they intend to use. The modes are coded with number from 1 to 9. A dummy variable is used to measure the decision on whether a mode is considered by firms (1 = Yes, 0 = No).

Table 5 - 2: Codebook for data collected by questionnaires

Question	Data collected	Description of code value
1	Manager age	
	Manager gender	Nominal scale: 1 = Male 0 = Female
	Manager's educational qualification	Nominal scale: 1 = Graduate from high school or below 2 = Graduate from college or university 3 = Postgraduate with master degree or doctoral degree
	Manager's managerial experience	Number of years of senior management in career
	Founder	Nominal scale: 1 = Yes 0 = No
2	Firm age	Number of years since established
3	Number of employees	Number of employees in 2002
		Number of employees in 2003
		Number of employees in 2004
4	Number of R&D employees	Number of R&D employees in 2002
		Number of R&D employees in 2003
		Number of R&D employees in 2004
5	R&D expenditures	R&D expenditures in 2002
		R&D expenditures in 2003
		R&D expenditures in 2004
6	Number of new products	Cumulative number of new products over the year 2002 to 2004
	Number of new products in global markets	Cumulative number of new products in global markets over the year 2002 to 2004
7	Number of filed patents	Cumulative number of filed patents over the year 2002 to 2004
	Number of granted patents	Cumulative number of granted patents over the year 2002 to 2004
8	Sales	Sales in 2002
		Sales in 2003
		Sales in 2004
9	After-tax profit	After-tax profit in 2002
		After-tax profit in 2003
		After-tax profit in 2004

Table 5-2: Codebook for data collected by questionnaires (Cont.)

Question	Data collected	Description of code value
10	Number of cooperative projects	Number of cooperative projects over the year 2002 to 2004
	Intention in the near future	Nominal scale: 1 = Yes 0 = No
11	Concerns: Technology leakage Loss of control/ownership Distraction from main goal Lack of experience Lack of personal relationship Legal issue Diverse organizational culture or value Others (please specify)	Nominal scale: 1 = Yes 0 = No
12	Successful rate	5-point Likert scale: 5 = Almost all 4 = A large proportion 3 = Nearly half 2 = A small proportion 1 = None
13	Importance	5-point Likert scale: 5 = Very important 4 = Important 3 = Uncertain 2 = Less important 1 = Unimportant
14	Motives for cooperation: Financial support Specific experts Manufacturing or marketing support New market Economies of scale or scope Sharing risk and cost Technology transfer Learning from partners Others (please specify)	Nominal scale: 1 = Yes 0 = No
15	Partners: Domestic firm Foreign firm Within high-tech zones Outside high-tech zones Large firm Small and medium-sized firm Supplier Customer Competitor	Nominal scale: 1 = Yes 0 = No

Table 5-2: Codebook for data collected by questionnaires (Cont.)

Question	Data collected	Description of code value
16	Modes of cooperation: Research corporation Joint venture Minority holding Joint research agreement Joint development agreement Customer-supplier R&D contract Second sourcing agreement Licensing Others (please specify)	Nominal scale: 1 = Yes 0 = No
17	Success factors: Resource complementarity Flexible organizational and managerial style Geographical proximity Well-documented agreement Safeguards in place for protecting core technology Ongoing monitoring and coordinating Trust, communication and reciprocity Top leader's commitment Sufficient cooperative resource Milestone appraisal Adjusting to external change Compatible technology and business strategies with partners	5-point Likert scale: 5 = Very important 4 = Important 3 = Uncertain 2 = Less important 1 = Unimportant
18	Detrimental factors: Only focusing on short-term financial performance Unilateral dependency on the partner Not contributing as promised Time-consuming decision making Lack of compatibility in technology, management and organization	5-point Likert scale: 5 = Strongly agree 4 = Agree 3 = Uncertain 2 = Disagree 1 = Strongly Disagree
19	Limitations: Financial limitation in enhancing in-house R&D activity Shortage of qualified scientists and engineers Lack of high level of employee involvement in innovation activity Others (please specify)	Nominal scale: 1 = Yes 0 = No

5.4.2.2 Measuring Firms' Capabilities to Cooperate and Innovation Performance

(1) Manager's education level and managerial experience. In question 1, respondents are asked to indicate their education level and managerial experience. Manager's educational level refers to the highest qualification that managers achieved by the

year 2004. The three level categories are coded 1 for 'graduate from high school or below', 2 for 'graduate from college or university' and 3 for 'postgraduate with master degree or doctoral degree'. Manager's managerial experience is measured by the number of years that the manager has worked in senior management in his/her career by the year 2004.

(2) Firm age and firm size. In question 2 and 3, respondents are asked to indicate the firm's age and size respectively. Firm age is measured by the number of years that the firm has been established by the year 2004. Assets, sales and number of employees are the variables most often used as size indicators in literature. According to Dickson and Weaver (1997), small firms would be likely to provide more accurate information about employees than about sales or assets. Therefore, firm size in this study is measured by number of reported employees. The research variable 'firm size' is indicated by the average number of employees over the year 2002 to 2004.

(3) R&D employee intensity and R&D expenditure intensity. In literature, R&D intensity is mostly measured by the ratio of R&D expenditure to sales, and in some cases, it is measured by the ratio of the number of R&D employees to the number of total employees. This study examines both of these two ratio indicators. R&D employee intensity is the ratio of the average number of R&D employees to the average number of total employees over the year 2002 to 2004. R&D expenditure intensity is the ratio of the average R&D expenditures to the average annual sales over

the year 2002 to 2004. The number of R&D employees and R&D expenditures in each of three years are collected by question 4 and 5.

(4) Cooperation and the number of cooperative projects. Question 10 asks for the information about the number of cooperative projects the firm has had in the past three years, and if has not, what is its intention in the near future. Cooperation is taken as a dichotomous variable, coded 1 when a firm has been involved in at least one cooperative project and coded 0 otherwise. The number of cooperative projects is the cumulative number of cooperative projects a firm has had over the year 2002 to 2004.

(5) New product and globally new product. Adopting the definition of OECD (1997), 'new product' is defined as technologically new product and technologically improved product, and the minimum entry of 'new product' is new to the firm. This study names 'globally new product' as the product which is new to the world.

In question 6, the respondents are asked to provide the number of new products and the number of globally new products introduced to market over the year 2002 to 2004. To measure the productivity on innovation output, 'new product intensity' and 'globally new product intensity' are used as research variables to indicate the output of new product and globally new product per employee. New product intensity is the cumulative number of new products over the three years divided by the average number of employees under the same period. Globally new product intensity is the cumulative number of globally new products over the three years divided by the average number of employees under the same period.

(6) Filed patent and granted patent. According to United States Patent and Trademark Office, patent is a property right granted by the Government of the United States of America to an inventor "to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States" for a limited time in exchange for public disclosure of the invention when the patent is granted.

The UK Patent Office defines that "A patent for an invention is granted by government to the inventor, giving the inventor the right for a limited period to stop others from making, using or selling the invention without the permission of the inventor. When a patent is granted, the invention becomes the property of the inventor, which - like any other form of property or business asset - can be bought, sold, rented or hired."

In China, State Intellectual Property Office of the P. R. C. (SIPO) is the authority for filing and examining technology patent applications. Therefore, in this study, filed patent refers to the cumulative number of technology patent applications filed by SIPO over the year 2002 to 2004. Granted patent refers to the cumulative number of technology patent applications granted by SIPO over the year 2002 to 2004. The number of filed patents and the number of granted patents are collected by question 7.

To measure the productivity on innovation output, 'filed patent intensity' and 'granted patent intensity' are used as research variables to indicate the output of filed patents and granted patents per employee. Filed patent intensity is the cumulative number of filed patents over the three years divided by the average number of employees under the same period, and granted patent intensity is the cumulative number of granted patents over the three years divided by the average number of employees under the same period.

(7) Sales and profit. To measure the impact of product innovations on the performance of the firm, the proportion of sales due to technologically new or improved products and total annual sales are suggested by OECD (1997). Considering that many firms, especially small firms, may have difficulties in separating sales due to new products from total sales in their current accounting system, this study chooses total annual sales. Question 8 asks respondents to provide annual sales in each of three years. Profit in this study refers to the net profit of a company after taxation. Respondents are asked in question 9 to provide their net profit after tax in each of three years.

'Sales intensity' and 'profit intensity' are used as research variables to indicate the productivity on financial outcome. Sales intensity is the average sales over the three years divided by the average number of employees under the same time. Profit intensity is the average after-tax profit over the three years divided by the average number of employees under the same period.

(8) Success rate of cooperation. Success rate of cooperation is a measurement of a manager's perception on the proportion of successful cooperative projects. The information is collected by question 12.

5.4.2.3 Assessing Critical Success Factors of Cooperation

Question 17 provides 12 factors which are considered to be contributing to successful cooperation. Respondents are asked to assess the importance of each factor using 5-piont Likert scale (from 5 for very important to 1 for unimportant).

Question 18 provides 5 factors which are considered to be detrimental to successful cooperation. Respondents are asked to indicate their opinion on each factor using 5-point Likert scale (from 5 for strongly agree to 1 for strongly disagree).

All aforementioned variables, their definitions and measurements are listed in Table 5-3.

Table 5 - 3: Research variables and their definitions and measurements

Data collected	Research variable	Definition	Measure (indicator)
Motives for cooperation	Primary motives	Be considered by respondents the major motive for cooperation	Dummy variable: 1 = Yes 0 = No
Modes of cooperation	Main modes	Have been used or will be used by respondents	Dummy variable: 1 = Yes 0 = No
Manager's educational qualification	Manager's education level	The highest education qualification that managers have achieved by the year 2004	1 = Graduate from high school or below; 2 = Graduate from college or university; 3 = Postgraduate with master degree or doctoral degree
Manager's managerial experience	Manager's managerial experience	The number of years that a manager has worked in senior management in his/her career by 2004	The number of years that a manager has worked in senior management in his/her career by 2004
Firm age	Firm age	The number of years a firm has been established by the year 2004	The number of years a firm has been established by the year 2004
Number of employees	Firm size	The number of total employees	The average number of employees over the year 2002 to 2004
Number of R&D employees and number of employees	R&D employee intensity	The number of R&D employees set against the number of total employees	Ratio of the average number of R&D employees to the average number of total employees over the year 2002 to 2004
R&D expenditures and sales	R&D expenditure intensity	R&D expenditures set against sales	Ratio of the average R&D expenditures to the average sales over the year 2002 to 2004
Number of cooperative projects	Cooperation	Whether a firm has engaged in inter-firm technological cooperation or not over the 2002 to 2004	Dummy variable: 1 = Yes 0 = No
Number of cooperative projects	Number of cooperative projects	Number of cooperative projects	Cumulative number of cooperative projects over the year 2002 to 2004
Number of new products and number of employees	New product intensity	The number of new products per 100 employees	Ratio of the cumulative number of new products to the average number of employees over the year 2002 to 2004 × 100

Table 5-3: Research variables and their definitions and measurements (Cont.)

Data collected	Research variable	Definition	Measure (indicator)
Number of new products in global markets and number of employees	Globally new product intensity	The number of products new in global markets per 100 employees	Ratio of the cumulative number of products new in global markets to the average number of total employees over the year 2002 to 2004 × 100
Number of filed patents and number of employees	Filed patent intensity	The number of filed patents per 100 employees	Ratio of the cumulative number of filed patents to the average number of employees over the year 2002 to 2004 × 100
Number of granted patents and number of employees	Granted patent intensity	The number of granted patents per 100 employees	Ratio of the cumulative number of granted patents to the average number of employees over the year 2002 to 2004 × 100
Sales and number of employees	Sales intensity	Annual sales set against the number of total employees	Ratio of the average annual sales to the average number of employees over the year 2002 to 2004
After-tax profit and number of employees	Profit intensity	Annual profit set against the number of total employees	Ratio of the average annual profit to the average number of employees over the year 2002 to 2004
Successful rate	Success rate of cooperation	Managers' perception on the proportion of successful cooperative projects	1 = None 2 = Small proportion 3 = Half 4 = Large proportion 5 = Almost all

5.4.3 Data Transformation

Before running statistical analysis, distributions of studied variables are examined. The examination reveals that 'firm age', 'firm size', 'R&D expenditure intensity', 'filed patent intensity', 'granted patent intensity', 'new product intensity', 'globally new product intensity', and 'sales intensity' have highly skewed distributions. Following the suggestions in prior studies (e.g. Narin et al., 1984; Hagedoorn and Shakenraad, 1994; Fritsch and Lukas, 2001; Shrader, 2001), natural logarithm transformation is applied to these variables to reduce skewness of distributions. Log-transformed variables 'firm age (log)', 'firm size (log)', 'R&D expenditure intensity (log)', 'filed patent intensity (log)', 'granted patent intensity (log)', 'new product intensity (log)', 'globally new product intensity (log)', and 'sales intensity (log)' show improved distributions (see Appendix D). Therefore, these transformed variables are used in data analysis.

5.4.4 An Outline of Data Analysis

Descriptive analysis is conducted to produce a profile of respondents and surveyed firms, to identify the primary motives for and main modes of cooperation, to compute the perceptive successful rate of cooperation, and to rank the importance of critical success factors by calculating the mean score of each factors.

Pearson correlation analysis is employed in analysing the relationships between primary motives and firm characteristics, between main modes and firm characteristics, between cooperation and each of resource capability variables, between cooperation and each of performance indicators of innovation productivity, between the perceptive successful rate of cooperation and the factual performance indicators of innovation productivity, between the number of cooperative projects and the perceptive successful rate of cooperation, and between the number of cooperative projects and the factual performance indicators of innovation productivity.

Independent-samples t test is employed to conduct mean difference analysis in resource capability variables, performance indicators of innovation productivity, and critical success factors between experienced firms and inexperienced firms. Independent–samples t test is also used to analyse the mean difference in critical success factors between successful cooperating firms and unsuccessful cooperating firms.

Binary logistic regression models are used to examine the determinant variables on a firm's propensity to cooperate. Multiple regression models are used to examine the impact of cooperation on firms' innovation performance. Furthermore, moderated multiple regression models are used to analyse the combined effect of firm size and cooperation on innovation performance.

The statistical methods employed in this study and their main applied areas are outlined in Table 5-4.

Table 5 - 4: Statistical methods employed in this study

Statistical methods	Main applied areas
Descriptive analysis	A profile of respondents and surveyed firms; the primary motives for and main modes of cooperation; the importance of critical success factors.
Pearson correlation analysis	Associations between primary motives and firm characteristics, and between main modes and firm characteristics.
Independent-samples t test	Mean differences in assessment of critical success factors between experienced firms and inexperienced firms, and between successful cooperating firms and unsuccessful cooperating firms.
Binary logistic regression models	Determinant variables on a firm's propensity to cooperate.
Multiple regression models	Impact of cooperation on firms' innovation performance.
Moderated multiple regression models	Combined effect of firm size and cooperation on innovation performance.

5.5 Summary

Based on research questions and hypotheses proposed in the prior chapter, this chapter presents the research methodology step by step. The study adopts a deductive approach and employs a cross-sectional research method. Firm is the unit of analysis and time horizon is a three-year span. Postal questionnaire is the instrument for collecting data. The questionnaire design and data collection process exploits advantages of postal questionnaire instrument to the most extent and takes appropriate steps to secure the response rate and quality of data.

The questionnaire is constructed by two parts. Part one consists of the questions related to the demographic information of respondents, the basic information of the firm's business and the basic information of the firm's implementation of cooperation strategy. Part two is composed of questions concerning strategic management of inter-firm cooperation, including the motives for cooperation, the modes of cooperation, the category of partners, and the critical success factors of inter-firm cooperative relationships. The last question inquires respondents about their interests in receiving a summary research report to be an award of their cooperation. To clarify the investigated phenomenon, a definition of inter-firm technological cooperation is presented in the first place in questionnaire.

Sample firms come from information and communication technology industries, involving software developers, electronic and telecommunication equipment manufacturers, and computer and its peripherals manufacturers. 300 sample firms were randomly selected from three national industrial development zones in China. Among returned questionnaires, 133 questionnaires were valid and therefore a 44% response rate was achieved. Validity and reliability of data were secured by several means. T test verifies that non-response bias does not have significant effect on the results of study. Semi-structured interviews with 20 managers are the supplementary survey method, which provides in-depth information for addressing research questions.

To prepare for data analyses in the following chapter, raw data in questionnaire are coded and transferred into the computer, and consequently research variables are defined and computed. Those research variables that have highly skewed distribution are transformed into their natural logarithms to improve the effect of statistical analysis.

Finally, the employed statistical analysis methods are outlined. These are descriptive analysis, Pearson correlation analysis, independent-samples t test, binary logistic regression models and multiple regression models.

Chapter Six: Data Analysis

This chapter presents the entire process of data analyses and hypotheses testing. Section one provides a profile of respondents and surveyed firms. Section two investigates the primary motives for high-tech SMEs initiating cooperation and the main modes of their cooperative activities. The association of primary motives and main modes with firms' age and size is examined. Section three presents the statistical analysis of what resource capabilities make a difference in a firm's propensity to cooperate. Section four analyses how cooperation impacts firms' innovation performance. Section five analyses critical success factors in inter-firm technological cooperation. The final section draws conclusions from the data analyses and hypotheses testing.

6.1 A Profile of Respondents and Surveyed Firms

6.1.1 Descriptive Analysis of Manager Characteristics

Table 6-1 provides a personal profile of respondents. In surveyed firms, 63% of respondents are not more than 40 years old. Only 5% of respondents are above 50 years old. Most of managers are highly educated and less than 2% of managers are without higher education qualifications. Compared with their age, managers are quite experienced in management. 56% of managers have had more than 5 years senior management experience. Nearly 90% of respondents are male, indicating that male managers are dominant in information and communications technology industry, which is not uncommon in high-tech industry. 67% of managers report that they are the founder or one of co-founders of the surveyed firm, suggesting that these managers are highly involved in firms' businesses from starting up. The facts imply that leadership in high-tech SMEs is characterized as young, well-educated and experienced in management.

Table 6 - 1: A personal profile of respondents

Variable	Category	Frequency	Percentage
Manager's age (N = 125)	30 and below	12	9.60
	31 – 40	67	53.60
	41 – 50	40	32.00
	51 and above	6	4.80
Manager's gender (N = 126)	Male	113	89.68
	Female	13	10.32
Manager's education level (N = 126)	Graduate from high school or below	2	1.59
	Graduate from college or university	80	63.49
	Postgraduate with Master degree or Doctoral degree	44	34.92
Manager's managerial experience (year) (N = 125)	1 and less	6	4.80
	2 – 5	49	39.20
	6 – 9	21	16.80
	10 – 13	29	23.20
	14 and more	20	16.00
Manager's foundership (N = 126)	Founder	85	67.46
	Not a founder	41	32.54

Note: Sample size is 133 firms. Missing data lead to the total number of respondents less than 133.

6.1.2 Descriptive Analysis of Characteristics of Surveyed Firms

Table 6-2 presents a profile of surveyed firms. Sample firms are young in age. One third of firms are in business not more than 3 years which is the start-up stage. 80% of the firms are in business less than 10 years. Different from some studies, such as

Kleinknecht and Reijnen (1992) and Fritsch and Lukas (2001) in which very small firms with less than 10 employees are excluded from their sampling frame to increase response rate, this study takes all firms which fall into SMEs category into account. Survey data shows that firms with less than 10 employees are 9.77% of all surveyed firms. It might produce a biasing error if these micro firms were ignored in studying SMEs. Data also shows that 75% of firms have less than 250 employees while only 12% of firms have more than 500 employees, confirming that firms in high-tech industries are relatively smaller in size on average than firms in other industries.

Regarding firms' involvement in cooperative activity, 54 of 133 firms (41%) have had at least one technological cooperative project over the year 2002 to 2004 and these firms are named experienced firms in the study. Another 79 sample firms (59%) have had no inter-firm cooperative partnership over the year 2002 to 2004 and these firms are named inexperienced firms in the study. R&D employees and R&D expenditures are considered the most important determinants of technological innovation. Surveyed data shows that 16% of firms have R&D employee intensity less than 10% and 30% of firms have R&D expenditure intensity less than 5%, exposing that these firms fail to reach the standard of high-tech firms issued by Ministry of Science and Technology (2000a).

Table 6 - 2: A profile of surveyed firms (N = 133)

		Frequency	Percentage
Age of firms (Year)	1 – 3	44	33.08
	4 – 6	47	35.34
	7 – 9	15	12.28
	10 and more	27	20.30
Number of employees	1 – 9	13	9.77
	10 – 49	55	41.35
	50 – 99	18	13.53
	100 – 249	14	10.53
	250 - 499	17	12.78
	500 – 999	9	6.77
	1000 and 1999	7	5.26
Number of cooperative projects	0	79	59.40
	1	17	12.78
	2	10	7.52
	3	16	12.03
	4	1	0.75
	5	6	4.51
	6	2	1.50
	8	2	1.50
R&D employee intensity (%)	Less than 10	21	15.79
	10-20	30	22.56
	20-50	48	36.09
	50 and above	34	25.56
R&D expenditure intensity (%)	Less than 5	40	30.08
	5-10	25	18.80
	10-20	25	18.80
	20 and above	43	32.33

6.2 Statistical Analysis of Primary Motives and Main Modes

6.2.1 Primary Motives and Their Associations with Firm Age and Size

In the questionnaire, respondents were asked to indicate their top three motives for engaging in cooperation. The percentage of firms which considered a motive primary is presented in Table 6-3. Of 133 surveyed firms, 2 inexperienced firms with missing data regarding cooperative motives were removed from the analysis. Among 54 experienced firms, 67% firms chose 'new market' and 39% firms chose 'learning from partners' as primary motives. 33% firms chose 'economies of scale or scope' and 'technology transfer' respectively. Therefore, primary motives among experienced firms are 'new market', 'learning from partners', 'economies of scale or scope', and 'technology transfer'. Among 77 inexperienced firms, 'new market' was chosen as a primary motive by 61% firms. Different from experienced firms, 60% of inexperienced firms chose 'financial support' and 39% chose 'specific experts' as a primary motive respectively. Therefore, primary motives in inexperienced firms are 'new market', 'financial support' and 'specific experts'. The differences of primary motives between the two groups of firms can be explained by the facts that high-tech SMEs are resource-constrained in general, especially lacking finance, technical and management experts. SMEs, therefore, need to acquire these resources externally. However, financial influx and specialists input from partners seems not common for the inter-firm cooperative activities in information and communications industry compared to other industries, e.g. cooperative activities between pharmaceutical companies and biotechnology companies. Seeking financial support and specific expert support were not considered as important by experienced firms as by inexperienced firms. These implies two possibilities: one is experienced firms have recognized that cooperation is not only for complementary resources, but also for the channel of technology transfer and learning from partners; another one is that there are few opportunities actually to get financial and expert support through inter-firm cooperative activities. Survey data are not conclusive here.

Table 6 - 3: The percentage of a motive being considered primary by firms

Code of motives	Motives for cooperation	All firms (N = 131) [a]	Experienced firms (N = 54)	Inexperienced firms (N = 77)
1	Financial support	47%	28%	60%
2	Specific experts	34%	28%	39%
3	Manufacturing or marketing support	19%	26%	14%
4	New market	63%	67%	61%
5	Economies of scale or scope	26%	33%	19%
6	Sharing risk and cost	14%	9%	17%
7	Technology transfer	23%	33%	16%
8	Learning from partners	32%	39%	27%
9	Others	1%	0%	1%

[a] Two inexperienced firms with missing data in motive are removed from the analysis.

The primary motives chosen by 54 experienced firms demonstrate the distinctive cooperative strategy of high-tech SMEs. On the one hand, SMEs cooperate in order to increase their economies of scale or scope of activity and get access to new markets. On the other hand, SMEs maintain close relationships with partner firms aiming at obtaining and learning technology, information, knowledge, and management expertise. The goal of cooperation is therefore aligned with a firm's growth strategy.

To analyse whether primary motives are associated with firm age, Pearson correlation analysis is conducted between firm age and firms' choice of primary motives among 54 experienced firms. Analysis results are presented in Table 6-4. It shows that only the motive 'technology transfer' significantly correlates with firm age ($r = 0.308$; $p < 0.05$). This indicates that firms become more motivated by 'technology transfer' as firm age increases. The motives 'new market', 'learning from partners', and 'economies of scale or scope' do not show a significant correlation with firm age. Hypothesis 1a "The motives for high-tech SMEs engaging in technological cooperation are correlated to firm age" is supported under the motive 'technology transfer'.

To analyse whether primary motives are associated with firm size, Pearson correlation analysis is conducted between firm size and firms' choice of primary motives among 54 experienced firms. Results are integrated in Table 6-4, showing that motives 'technology transfer' and 'learning from partners' significantly correlate with firm size ($r = 0.504$, $p < 0.001$; and $r = 0.275$, $p < 0.05$ respectively). This can be interpreted that the larger the firm size, the more firms' cooperative activities are motivated by 'technology transfer' and 'learning from partners'. The motive 'new market' and 'economies of scale or scope' do not show a significant correlation with firm size. Hypothesis 1b "The motives for high-tech SMEs engaging in technological cooperation are correlated to firm size" is supported under motives 'technology transfer' and 'learning from partners'.

Table 6 - 4: Correlation coefficients between the decision on primary motives and firm characteristics (N = 54)

Primary motives	Firm age (log)	Firm size (log)
New market	.157	.017
Learning from partners	.185	.275*
Economies of scale or scope	.094	- .034
Technology transfer	.308*	.504***

*** p < .001; * p < .05; all 2-tailed tests.

6.2.2 Main Modes and Their Associations with Firm Age and Size

In the questionnaire, respondents were asked to indicate the cooperative modes which they have engaged or intend to engage in. The percentage of a mode was chosen by firms is presented in Table 6-5. Of 133 surveyed firms, 4 inexperienced firms with missing data in cooperative mode were removed from the analysis.

Among 54 experienced firms, the modes chosen most often are 'joint development agreement' (70%), 'joint research agreement' (39%), 'joint venture' (35%), and 'customer-suppler R&D contract' (33%). Consistent with experienced firms, 75 inexperienced firms chose these four modes as main modes as well.

The main cooperative modes chosen by 54 experienced firms are instrumental to carrying out a firm's cooperative strategy and influenced by primary motives for cooperation. Joint R&D agreement and customer-supplier R&D contract can be seen as the means to get access to new markets, technology transfer and economies of scale or scope. Joint venture is suggested by the literature (e.g. Kogut, 1988) as a mechanism for inter-organizational learning.

Table 6 - 5: The percentage of a mode being chosen by firms

Code of modes	Modes of inter-firm cooperation	All firms (N = 129) [a]	Experienced firms (N = 54)	Inexperienced firms (N = 75)
1	Research corporation	24%	20%	27%
2	Joint venture	33%	35%	32%
3	Minority holding	12%	13%	12%
4	Joint research agreement	33%	39%	29%
5	Joint development agreement	51%	70%	37%
6	Customer – supplier R&D contract	35%	33%	36%
7	Second sourcing agreement	22%	32%	15%
8	Licensing	16%	19%	15%
9	Others	3%	2%	4%

[a] Four inexperienced firms with missing data in cooperative mode are removed from the analysis.

To analyse whether the choice of the cooperative mode is associated with firm age, Pearson correlation analysis is conducted between firm age and firms' choice of main cooperative modes. Results are presented in Table 6-6. They show that the mode 'joint venture' significantly correlates with firm age ($r = 0.336$; $p < 0.05$). It means that the propensity for firms to choose 'joint venture' as a cooperative mode increases as firm age increases. The mode 'customer-supplier R&D contract', 'joint development agreement' and 'joint research agreement' do not show a significant correlation with firm age. Hypothesis 2a "The choice of a cooperative mode is associated with firm age" is supported under the mode 'joint venture'.

To analyse whether the choice of a cooperative mode associates with firm size, Pearson correlation analysis is conducted between firm size and firms' choice of main cooperative modes. Results are integrated in Table 6-6, showing that the mode 'joint venture' significantly correlates with firm size ($r = 0.331$; $p < 0.05$). It means the larger the firm size, the more the firm tends to choose 'joint venture' as a cooperative mode. The mode 'customer-supplier R&D contract', 'joint development agreement' and 'joint research agreement' do not show a significant correlation with firm size. Hypothesis 2b "The choice of a cooperative mode is associated with firm size" is supported under the mode 'joint venture'.

Table 6 - 6: Correlation coefficients between the decision on main modes and firm characteristics (N = 54)

Main modes	Firm age (log)	Firm size (log)
Customer-supplier R&D contract	.067	-.174
Joint development agreement	.194	.240
Joint research agreement	.225	.198
Joint venture	.336*	.331*

* $p < .05$ (2-tailed).

6.3 Statistical Analysis of Firms' Capabilities for Cooperation

To test whether there are differences in resource capabilities between experienced firms and inexperienced firms, mean difference analysis is conducted with the variables 'manager's education level', 'manager's managerial experience', 'firm age', 'firm size', 'R&D employee intensity', and 'R&D expenditure intensity'. The independent-samples t test is used to examine mean differences between two group firms. The results, presented in Table 6-7, show that firm size in experienced firms is significantly larger than in inexperienced firms ($p = .001$). R&D employee intensity in experienced firms is significantly smaller than in inexperienced firms ($p = .037$). There is no significant difference in manager's education level, manager's managerial experience, firm age, and R&D expenditure intensity between two group firms. It appears that firm size is an essential element for firms engaging in cooperation and firms with lower R&D employee intensity are more likely to cooperate. Manager's education level, manager's managerial experience, firm age and R&D expenditure intensity do not have a significant impact on decisions regarding cooperation strategy.

Table 6 - 7: Differences in resource capabilities between experienced firms and inexperienced firms (N = 133)

Variable	Sample firms	Mean	S.D.	p-value
Manager's education level	Experienced Inexperienced	2.40 2.29	.49 .51	.236
Top leader's managerial experience	Experienced Inexperienced	7.59 8.22	5.10 5.38	.511
Firm age (log)	Experienced Inexperienced	1.73 1.51	.77 .70	.084
Firm size (log)	Experienced Inexperienced	4.68 3.74	1.47 1.57	.001
R&D employee intensity	Experienced Inexperienced	.28 .37	.21 .27	.037
R&D expenditure intensity (log)	Experienced Inexperienced	-2.60 -2.46	1.19 1.23	.548

To further explore the influential factors which impact a firm's propensity to cooperate, a logistic regression model is used. According to Oerlemans and Meeus (1999, p.19), "The goals of logistic regression analysis are (1) to develop a model that summarizes the relationship between a dichotomous dependent variable and a set of independent variables, (2) to determine which independent variables are useful for prediction, (3) to predict the value for the dependent variable from the values of the independent variables." Dickson and Weaver (1997, p.415) state "The beta coefficients provided by a logistic regression procedure give the change in the logarithmic odds of obtaining the outcome variable when there is a change of one unit in the predictor variable. If the beta for a variable is significant and positive, then the variable increases the odds of the outcome. If the beta is significant and negative, then the odds of the outcome are decreased." In the logistic regression model under this study, the dependent variable is "cooperation" which is coded 1 if the firm cooperates and 0 otherwise. Independent variables are manager's education level, manager's managerial experience, firm age, firm size, R&D employee intensity and R&D expenditure intensity. Kinnear and Gray (2004, p.390) suggest a correlation analysis before embarking upon regression procedure since "logistic regression is most likely to be successful if there are low or insignificant correlations among the independent variables." Table 6-8 provides descriptive statistics and Pearson correlation coefficients between cooperation and each of capability variables. Firm size is positively correlated to cooperation while R&D employee intensity is negatively correlated to cooperation. Between independent variables, 8 of 15 correlation coefficients are significant but no one is more than .70 which means the assumption of multicollinearity is not violated (Tabachnick and Fidell, 1996). Therefore, a logistic regression is undertaken.

Table 6-9 presents the results of the logistic regression analysis. Model 1 includes all variables but firm size. 'R&D employee intensity' does not show significant correlation with cooperation which is inconsistent with mean difference analysis shown in Table 6-7. The variable 'firm size' is added in model 2. Model 2 represents an improvement over model 1, as indicated by the increase in Nagelkerke R Square from 0.074 to 0.157 and the increase in coverage percentage from 56.9% to 66.7%.

Table 6 - 8: Descriptive statistics and correlation coefficients between cooperation and firms' resource capabilities (N = 133)

	Mean	S. D.	(1)	(2)	(3)	(4)	(5)	(6)
(1) Cooperation	.41	.49	1					
(2) Education level	2.33	.51	.106	1				
(3) Managerial experience	7.96	5.25	-.059	.116	1			
(4) Firm age (log)	1.60	.74	.150	.044	.262**	1		
(5) Firm size (log)	4.12	1.60	.288**	.109	.219*	.627**	1	
(6) R&D employee intensity	.3352	.2539	-.181*	.123	-.131	-.166	-.396**	1
(7) R&D expenditure intensity (log)	-2.4507	1.3940	-.094	.006	-.252*	-.250**	-.444**	.475**

** p < .01; * p < .05; all 2-tailed tests.

The small value of chi-square ($\chi^2 = 5.648$) and high p value ($p = 0.687$) from Hosmer and Lemeshow Test mean that the model fits the data well. Results of model 2 indicate that cooperation is positively related to firm size ($p < .05$). Other independent variables do not show significant impact on cooperation. Comparing with results of the mean difference analysis, logistic regression analysis ensures that firm size is a significant influential factor for a firm adopting cooperation strategy, but does not support that R&D employee intensity has significant influence on adopting a cooperation strategy.

Table 6 - 9: Logistic regression for cooperation [a]

Variable	Model 1	Model 2
Intercept	-1.708	-2.775*
Manager's education level	.618	.483
Manager's managerial experience	-.041	-.045
Firm age (log)	.265	-.280
R&D employee intensity	-1.010	-.202
R&D expenditure intensity (log)	-.117	-.409
Firm size (log)		.536*
- 2 log likelihood	134.610	127.693
Cox & Snell R Square	.055	.117
Nagelkerke R Square	.074	.157
χ^2	12.120	5.648
P-value	.146	.687
Coverage percentage	56.9	66.7

[a] N = 133. Values reported in the table are unstandardised regression coefficients.
* $p < .05$ (2-tailed).

6.4 Statistical Analysis of the Impact of Cooperation on Innovation Performance

6.4.1 Mean Difference Analysis of Innovation Performance between Experienced Firms and Inexperienced Firms

To examine whether there are differences in innovation performance between experienced firms and inexperienced firms, the independent-samples t test is employed. The results, presented in Table 6-10, show that there is no significant difference in each of innovation performance indicators between experienced firms and inexperienced firms except for 'new product intensity'. Inexperienced firms appear to perform better in 'new product intensity' than experienced firms ($p < .01$). Hypothesis 4a "Firms have been involved in cooperation have better innovation performance than those that have not" is not supported.

6.4.2 Multiple Regression Analysis for Cooperation

To explore how cooperation affects firms' innovation performance, a multiple regression analysis is conducted. It is assumed that a firm's innovation performance is a function of manager's education level, manager's managerial experience, firm age, firm size, R&D employee intensity, R&D expenditure intensity, and cooperation. Firstly, correlation analyses between each of innovation performance indicators and explanatory variables are performed and the results are presented in Tables 6-11. 'Cooperation' is negatively correlated to 'new product intensity'.

Table 6 - 10: Mean differences in innovation performances between experienced firms and inexperienced firms (N = 133)

Variable	Sample firms	Mean	S.D.	p-value
Filed patent intensity (log)	Experienced Inexperienced	1.4426 1.7431	1.14937 1.70507	.359
Granted patent intensity (log)	Experienced Inexperienced	1.4015 1.4328	1.10782 1.59466	.924
New product Intensity (log)	Experienced Inexperienced	1.4288 2.2128	1.31419 1.58132	.005
Globally new product intensity (log)	Experienced Inexperienced	.4009 .8733	1.38326 1.83855	.298
Sales intensity (log)	Experienced Inexperienced	2.9574 2.7080	.90295 .90240	.139
Profit intensity	Experienced Inexperienced	2.8153 2.1395	2.77629 3.67250	.335

'Manager's education level' is positively correlated to 'sales intensity'. 'Manager's managerial experience' is negatively correlated to 'new product intensity'. 'Firm age' and 'firm size' are negatively correlated to 'filed patent intensity', 'granted patent intensity', 'new product intensity', 'globally new product intensity' but positively correlated to 'sales intensity'. 'R&D employee intensity' and 'R&D expenditure intensity' are positively correlated to 'filed patent intensity', 'granted patent intensity', 'new product intensity' and 'globally new product intensity'. 'R&D expenditure intensity' is negatively correlated to 'sales intensity'. It appears that independent variables have some correlations with dependent variables except for 'profit intensity' and Table 6-8 shows that there is no multi-collinearity problem between independent variables. Consequently, multiple regression analyses on each of innovation performance indicators are performed and the results are integrated in Table 6-12.

Table 6 - 11: Correlation coefficients matrix between innovation performance and firms' resource capabilities (N = 133)

	Filed patent intensity (log)	Granted patent intensity (log)	New product intensity (log)	Globally new product intensity (log)	Sales intensity (log)	Profit intensity
Cooperation	-.103	-.011	-.257**	-.148	.136	.102
Manager's education level	-.054	.024	-.074	-.165	.266**	.079
Manager's managerial Experience	-.096	-.148	-.281**	-.191	.084	.204
Firm age (log)	-.457**	-.358**	-.444**	-.566**	.296**	.169
Firm size (log)	-.830**	-.788**	-.861**	-.936**	.432**	.166
R&D employee intensity	.389**	.489**	.426**	.469**	-.178	-.185
R&D expenditure intensity (log)	.493**	.430**	.467**	.560**	-.568**	-.166

** $p < .01$; * $p < .05$; all 2-tailed tests.

Table 6 - 12: Multiple regression models of innovation performance [a]

Variable	Filed patent intensity (log) (1)	Granted patent intensity (log) (2)	New product intensity (log) (3)	Globally new product intensity (log) (4)	Sales intensity (log) (5)	Profit intensity (6)
Intercept	4.229***	2.937***	4.892***	5.057***	.345	-.157
Cooperation	.291	.589*	-.163	-.165	.097	.001
Manager's education level	.187	.428	.123	.222	.330*	1.043
Manager's managerial experience	.023	.006	-.033*	-.037	-.017	.101
Firm age (log)	.063	.441	.252	.061	.147	.115
Firm size (log)	-.778***	-.891***	-.858***	-.906***	.051	-.065
R&D employee intensity	.281	.568	.530	-.624	.602	-1.582
R&D expenditure intensity (log)	.085	.032	-.043	.097	-.433***	-.064
F	18.381***	17.425***	41.637***	43.500***	8.595***	1.021
R^2	.689	.705	.776	.884	.393	.091
Adjusted R^2	.652	.665	.758	.864	.347	.002

[a] N = 133. Values reported in the table are unstandardised regression coefficients.
*** p < .001; ** p < .01; * p < .05; all 2-tailed tests.

In regression model 1 for filed patents, the model explains 68.9% of the variance in filed patents. The adjusted R Square value is 65.2%. ANOVA test shows the model reaches statistical significance (F = 18.381; p < .001). The number of filed patents is negatively related to firm size.

In regression model 2 for granted patents, the model explains 70.5% of the variance in granted patents. The adjusted R Square value is 66.5%. ANOVA test shows the model reaches statistical significance (F = 17.425; p < .001). The number of granted patents is negatively related to firm size and positively related to cooperation.

In regression model 3 for new products, the model explains 77.6% of the variance in new product. The adjusted R Square value is 75.8%. ANOVA test shows the model reaches statistical significance ($F = 41.637$; $p < .001$). The number of new products is negatively related to firm size and manager's managerial experience.

In regression model 4 for globally new products, the model explains 88.4% of the variance in globally new products. The adjusted R Square value is 86.4%. ANOVA test shows the model reaches statistical significance ($F = 43.500$; $p < .001$). The number of globally new products is negatively related to firm size.

In regression model 5 for sales, the model explains 39.3% of the variance in sales. The adjusted R Square value is 34.7%. ANOVA test shows the model reaches statistical significance ($F = 8.595$; $p < .001$). Sales is positively related to manager's education level and negatively related to R&D expenditure intensity.

In regression model 6 for profit, ANOVA test shows the model does not reach statistical significance ($F = 1.021$; $p > 0.05$). Explanatory variables do not fit the model very well, and therefore the model fails to explain profit.

The multiple regression analyses demonstrate that cooperation makes a significant contribution to the prediction of the number of granted patents but not to other innovation performance indicators.

6.4.3 Moderated Multiple Regression for Cooperation

As Shrader (2001) suggests, to better understand how cooperation affects innovation performance is to examine other factors that may moderate the relationship. Considering that firm size has a significant impact on the propensity of a firm to cooperate (see Table 6-9) and on innovation performance (see Table 6-11), it is reasonable to assume that firm size may be a moderator in multiple regression models. Therefore, an interaction term of firm size and cooperation is added to the regression analysis models and the results are integrated in Table 6-13. The interaction term shows significant correlation with performance variables in model 1 and model 2. These two models are highly significant predictors of dependent variables ($p < .001$ for each of two models) and present a significant improvement over the models without interaction term by a change in adjusted R^2 from .652 and .665 (see model1 and model 2 in Table 6-12) to .686 and .738 (see model 1 and model 2 in Table 6-13) respectively. According to Sharma et al. (1981), the significance of the interaction term in model 1 and model 2 in Table 6-13 indicates that firm size is a moderator variable in both instances. However, whether firm size is a quasi moderator or a pure moderator depends on the main effect of hypothesized moderator variable on the dependent variable. As can be seen in Table 6-12, firm size is significantly related to the dependent variable in model 1 and model 2. Therefore, firm size can be classified as a quasi moderator in moderated regression model 1 and model 2 in Table 6-13. This means firm size moderates the relationship between cooperation and filed patents and the relationship between cooperation and granted patents. Taking into account the interaction effect of firm size and cooperation, Hypothesis 4b "Cooperation is positively correlated to a firm's innovation performance" is supported under performance variables 'filed patent intensity' and 'granted patent intensity'.

Following Shrader's (2001) suggestion, an additional test is conducted to examine whether multi-collinearity problem exists between the variable 'firm size' and its interaction term with 'cooperation'. Correlation analysis results in a correlation coefficient of .486 ($p < .001$), indicating multi-collinearity between independent variables does not present problem in the statistical analyses.

Table 6 - 13: Moderated multiple regression models of innovation performance [a]

Variable	Filed Patent intensity (log) (1)	Granted patent intensity (log) (2)	New product intensity (log) (3)	Globally new product intensity (log) (4)	Sales intensity (log) (5)	Profit intensity (6)
Intercept	5.036***	4.007***	4.998***	5.199***	.408	1.175
Cooperation	-1.374*	-1.800**	-.458	-.479	-.070	-3.386
Manager's education Level	.126	.367	.126	.216	.331*	1.042
Manager's managerial experience	.021	-.002	-.034*	-.038*	-.017	.099
Firm age (log)	.021	.462*	.248	.057	.145	.054
Firm size (log)	-.965***	-1.160***	-.890***	-.940***	.033	-.179
R&D employee intensity	.378	.680	.544	-.595	.608	-.462
R&D expenditure Intensity (log)	.025	-.034	-.047	.090	-.435***	-1.275
Firm size × Cooperation	.381**	.553***	.070	.071	.040	.778
F	18.753***	21.443***	36.231***	37.568***	7.468***	1.185
R^2	.725	.774	.777	.885	.394	.119
Adjusted R^2	.686	.738	.756	.862	.341	.019

[a] N = 133. Values reported in the table are unstandardised regression coefficients.
*** p < .001; ** p < .01; * p < .05; all 2-tailed tests.

6.4.4 Association Analysis between Managers' Perception of Successful Cooperation and Factual Innovation Performance

As Table 6-10 shows, productivities on innovation output in experienced firms are not significantly better than those in inexperienced firms. It gives rise to a question why firms cooperate if cooperation doesn't appear to make a significant improvement in innovation. It is therefore, necessary to look at managers' perceptions of their cooperative practices (see Table 6-14). Within 54 experienced firms, 65% of firms express that at least half of their cooperative projects are successful while another 35% of firms express that less than half of their cooperative projects are successful. Correlation analysis between perceived successful rate and factual indicators of innovation performance in 54 experienced firms is conducted and presented in Table 6-15. The results do not show any significant correlation between perceived successful rate and each of factual indicators of innovation performance, implying that managers do not take the indicators of innovation productivity as criteria to assess the success of cooperation.

Table 6 - 14: The perception of managers on firms' cooperative projects (N = 54)

Success rate of cooperative projects	Frequency of firms	Percentage
Almost all	6	11.1
A large proportion	20	37.0
Nearly half	9	16.7
A small proportion	6	11.1
None	13	24.1
	54	100.0

Table 6 - 15: Correlation coefficients between perceived successful rate and innovation performance [a] (N = 54)

	Successful rate
Filed patent intensity (log)	.004 (.984)
Granted patent intensity (log)	.022 (.915)
New product intensity (log)	-.111 (.490)
Global new product intensity (log)	-.095 (.644)
Sales intensity (log)	-.108 (.513)
Profit intensity	-.085 (.645)

[a] Number in parenthesis is significant p value.

6.4.5 Association Analysis of the Number of Cooperative Projects and Innovation Performance

To examine the role of the number of cooperative projects, correlation analysis is conducted between the number of cooperative projects and perceived successful rate, and between the number of cooperative projects and each of innovation performance indicators. The results are integrated in Table 6-16. The number of cooperative projects is significant correlated with the perceived successful rate ($r = .299$; $p < .05$). The number of cooperative projects also shows significant correlation with sales intensity and profit intensity ($r = .372$, $p < .01$; and $r = .330$, $p < .05$ respectively) but no significant correlation with other innovation performance indicators. Therefore, hypothesis 4c 'The number of cooperative projects is positively related to innovation performance' is only supported with regard to sales intensity and profit intensity.

6.5 Statistical Analysis of Critical Success Factors

Before employing statistical analysis of critical success factors, reliability analysis is conducted to check the reliability of the scales. Among constructed measures, Cronbach alpha coefficient for 12 contributing factors is 0.857, and Cronbach alpha coefficient for 5 detrimental factors is 0.726. According to Pallant (2001), Cronbach alpha coefficient of a scale should be above 0.70. Therefore, both contributing factors and detrimental factors have good internal consistency.

Table 6 - 16: Correlation coefficients between the number of cooperative projects and innovation performance (N = 54)

	Number of cooperative projects
Successful rate	.299*
Filed patent intensity (log)	-.230
Granted patent intensity (log)	-.205
New product intensity (log)	-.056
Globally new product intensity (log)	-.126
Sales intensity (log)	.372**
Profit intensity	.330*

** p < .01; * p < .05; all 2-tailed tests.

Descriptive statistics of 12 contributing factors are listed in Table 6-17. These factors are ranked by their mean scores. Table 6-17 shows that all factors but 'geographical proximity' are confirmed as critical success factors (Mean > 3). Managers assess 'trust, communication and reciprocity' with the highest mean score (Mean = 4.53) and the smallest variance (S.D. = .658; coefficient of variance = 14.53%), suggesting that the factor is viewed as the most important factor on average and respondents have high agreement on its importance. 'Geographical proximity' gets the lowest mean score (Mean = 2.76) and the highest variance (S.D. = 1.081; coefficient of variance = 39.17%), implying the factor is viewed as the least important factor on average and respondents have divergent opinions on its importance.

Table 6-18 presents mean scores of 5 detrimental factors, showing that all factors are confirmed as detrimental factors to successful cooperation (Mean > 3). 'Not contributing as promised' gets the highest mean score (Mean = 4.34) and the smallest variance (S.D. = .673; coefficient of variance = 15.51%), suggesting that the factor is viewed as the most harmful factor and respondents hold high agreement on its negative effect.

By dividing sample firms into the group of experienced firms and the group of inexperienced firms, factors in paired groups seem to have different mean scores. Differences of mean score of each factor between two group firms are calculated and displayed in Table 6-19 and Table 6-20. To examine the significance of difference of each factor between experienced firms and inexperienced firms, independent-samples t test is implemented and the results are integrated in Table 6-19 and Table 6- 20 respectively. The results of mean difference analysis reveal that 'resource complementarity' and 'unilateral dependency on partners" are given higher scores by experienced firms than by inexperienced firms, and the differences of mean score between two group firms are significant at $p < .001$ and $p < .01$ respectively. It implies that comparing to inexperienced firms, experienced firms put more emphasis on the contributing role of 'resource complementarity' and the negative influence of 'unilateral dependency on partners'.

Table 6 - 17: Descriptive statistics of 12 contributing factors (N = 133)

Rank	Factor	Mean	S.D	Coefficient of variance
1	Trust, communication and reciprocity	4.53	.658	14.53%
2	Resource complementarity	4.45	.668	15.01%
3	Safeguards in place for protecting core technology	4.32	.792	18.33%
4	Top leader's commitment	4.14	.736	17.78%
5	Sufficient cooperative resources	4.11	.735	17.88%
6	Well-documented agreement	4.01	.830	20.70%
7	Compatible technology and business strategies with partners	3.92	.804	20.51%
8	Adjusting to external change	3.80	.733	19.29%
9	Ongoing monitoring and coordinating	3.79	.922	24.33%
10	Milestone appraisal	3.77	.758	20.11%
11	Flexible organizational and managerial style	3.74	.920	24.60%
12	Geographical proximity	2.76	1.081	39.17%

Table 6 - 18: Descriptive statistics of 5 detrimental factors (N = 133)

Rank	Factor	Mean	S.D	Coefficient of variance
1	Not contributing as promised	4.34	.673	15.51%
2	Unilateral dependency on partners	4.18	.695	16.63%
3	Lack of compatibility in technology, management and organization	4.03	.768	19.06%
4	Only focusing on short-term financial performance	4.00	.749	18.73%
5	Time-consuming decision making	3.89	.850	21.85%

In Table 6-14, 35 firms express that at least half of their cooperative projects are successful and another 19 firms express that less than half of their cooperative projects are successful. This study considers the former as successful firms and the latter as unsuccessful firms according to managers' perceived successful rate. Between the group of successful firms and the group of unsuccessful firms, the difference of mean score for each factor is calculated. Independent-samples t test is applied to mean differences (also see Table 6-19 and Table 6-20). The factor 'trust, communication and reciprocity' shows a significant difference between successful firms and unsuccessful firms ($p < .05$), implying that successful firms put more emphasis on 'trust, communication and reciprocity' than unsuccessful firms.

Table 6 - 19: Difference in mean score: 12 contributing factors [a]

12 contributing factors	Difference in mean score between experienced and inexperienced firms	Difference in mean score between successful and unsuccessful firms
Resource Complementarity	+.40***	+.16
Flexible organizational and managerial style	+.22	+.20
Geographical Proximity	-.32	-.33
Well-documented Agreement	+.05	-.02
Safeguards in place for protecting core technology	-.01	+.41
Ongoing monitoring and coordinating	+.17	+.15
Trust, communication and reciprocity	+.14	+.54*
Top leader's Commitment	+.14	+.26
Sufficient cooperative resources	-.22	+.32
Milestone appraisal	+.02	+.23
Adjusting to external change	+.02	+.36
Compatible technology and business strategies with partners	+.01	-.11

[a] The sign (+) represents the mean score in experienced firms or successful firms is larger than the mean score in inexperienced firms or unsuccessful firms. Otherwise the sign is (-).

*** $p < .001$; * $p < .05$; all 2-tailed tests.

Table 6 - 20: Difference in mean score: 5 detrimental factors [a]

5 detrimental factors	Difference in mean score between experienced and inexperienced firms	Difference in mean score between successful and unsuccessful firms
Only focusing on short-term financial performance	+.07	+.14
Unilateral dependency on partners	+.35**	+.11
Not contributing as promised	+.21	-.18
Time-consuming decision making	+.16	+.30
Lack of compatibility in technology, management and organization	+.05	-.16

[a] The sign (+) represents the mean score in experienced firms or successful firms is larger than the mean score in inexperienced firms or unsuccessful firms. Otherwise the sign is (-).

** $p < .01$; 2-tailed test.

6.6 Summary

Basic information of respondents exhibits that leadership in high-tech SMEs is characterized by the youth of managers, well-educated background and rich management experience. Although SMEs' size standard in China is less than 2000 employees, a profile of surveyed firms reveals that 88% of surveyed firms have less than 500 employees. 59% of surveyed firms have been involved in inter-firm cooperative practice over the year 2002 to 2004, with the number of cooperative projects ranging from 1 at least to 8 at most.

High-tech SMEs are motivated to cooperate by getting access to new markets, increasing economies of scale or scope, benefiting from technology transfer, and learning from partner firms. Firms are more motivated by 'technology transfer' as firms' age increases. H1a is only supported under the motive 'technology transfer'. Firms are more motivated by 'technology transfer' and 'learning from partners' as firms' size increases. H1b is only supported under motives 'technology transfer' and 'learning from partners'. The cooperative modes that high-tech SMEs prefer include customer-supplier R&D contract, joint research agreement, joint development agreement, and joint venture. Joint venture becomes more preferred as firms' age and size increases. H2a and H2b are only supported under the mode 'joint venture'.

Firm size and R&D employee intensity show differences between experienced firms and inexperienced firms. Firm size is larger in experienced firms than in inexperienced firms, while R&D employee intensity is smaller in experienced firms than in inexperienced firms. Logistic regression analysis confirms that firm size has significant impact on whether firms adopt cooperative strategy. Hypothesis 3 is supported under the variable 'firm size'.

'New product intensity' in inexperienced firms is significantly higher than in experienced firms. For other innovation performance indicators, there is no significant difference between experienced firms and inexperience firms. It implies that experienced firms do not perform better in innovation than inexperienced firms.

H4a is not supported.

Regression analyses reveal that cooperation has significant impact on 'granted patent intensity', suggesting that cooperation enhances firms' productivity in granted patents. When combining the effect of firm size with cooperation, the interaction effect of firm size and cooperation shows significant impact on 'filed patent intensity' and 'granted patent intensity', suggesting that larger firms combined with using cooperation strategy perform better in productivity of patent creation. Taking the interaction effect of firm size and cooperation into account, H4b is supported under variables 'filed patent intensity' and 'granted patent intensity'.

No significant correlation is found between perceived successful rate and each of innovation performance indicators. The number of cooperative projects shows significant correlation with 'sales intensity' and 'profit intensity' but no significant correlation with other innovation performance indicators. H4c is only supported in terms of managers' perceptions and productivities on sales and profit.

Among 12 contributing factors, 'trust, communication and reciprocity' is viewed as the most important factor to successful cooperation. Among 5 detrimental factors, 'not contributing as promised' is viewed as the most harmful factor to successful cooperation. Experienced firms place more emphasis on the contributing factor 'resource complementarity' and the detrimental factor 'unilateral dependency on partners' than inexperienced firms, suggesting the importance of looking for the partners with complementary resources and being able to contribute to partnerships. Firms that are successful in their cooperative practices put more emphasis on 'trust, communication and reciprocity' than those that are unsuccessful.

Chapter Seven: Discussion

This chapter discusses data analyses and interprets implications of research results. Five research questions and associated hypotheses are discussed in five sections respectively. The last section summarizes discussions of research questions and hypotheses.

7.1 Discussion on Primary Motives and Their Associations with Firm Age and Size

Question 1: What are the primary motives for high-tech SMEs engaging in inter-firm technological cooperation? Are firm age and firm size correlated with these primary motives?

Hypothesis1a: The motives for high-tech SMEs engaging in technological cooperation are correlated to firm age.

Hypothesis1b: The motives for high-tech SMEs engaging in technological cooperation are correlated to firm size.

Generally speaking, high-tech SMEs' inter-firm cooperation activities are motivated by the search for new markets, learning from partners, achievement of economies of scale or scope, and benefits from the transfer of technology. The motive 'technology transfer' is positively associated with firm age, implying that the longer a firm has been in business, the more likely the firm will cooperate for 'technology transfer'. The motives 'technology transfer' and 'learning from partners' are positively associated with firm size, implying that the larger a firm's size is, the more likely the firm cooperates for 'technology transfer' and 'learning from partners'.

Motives which lead high-tech SMEs in information and communications industries to cooperate with partner companies appear to be a combination of cost-minimizing, strategic repositioning, and organizational learning. The data analysis shows that entering new markets is a dominant motive across all range of firm age and size. This outcome is consistent with Hagedoorn's (1993) empirical study in which the motive of acquiring market access has high percentages in most high-tech industries except for biotechnology and aviation/defence. However, the interpretations of market access should be different between large firms and SMEs. While Hagedoorn (1993) explains that firms often consider alliances as the strategic option for entering into foreign markets, high-tech SMEs under this study aim at borrowing partnering firms' marketing force, including marketing personnel, marketing channel, reputation, brand and information. SMEs, especially start-ups, have neither well-known brands nor production scale. Their survival and growth largely depends on bringing innovative technologies to market within competitive time frames. Cooperating with partner firms is considered by SMEs to be a practical marketing strategy which serves their long-term growth strategy.

The motive of 'economies of scale or scope' is in line with SMEs' growth strategies as well. Surveyed firms cooperating for 'economies of scale or scope' confirm Sachwald's (1998) claim that technical potential for economies of scale or economies of scope does not imply that a single firm should undertake the total amount of production necessary to exhaust these economies. Cooperation agreements can be an efficient solution. Mips (Gomes-Casseres, 1996 and 1997) set an example as a small computer firm in generating compensating competitiveness by allying with a broad range of firms.

It comes as no surprise that learning from partners and technology transfer are considered the primary motives by the surveyed firms. As the literature states technology life cycle has been shortening in the IT industry, and innovative new products are crucial to the survival of high-tech firms. SMEs allying with partner firms, especially large companies, not only benefit from the transferred technologies, but also learn from their partners. It is understandable that SMEs tend to pay more attention to learning technology and management skills from partners as their age and size increases. Examination of motives reveals that like large companies, high-tech SMEs are motivated to cooperate by long-term strategic considerations, which is different from Freeman's (1991) view that small new firms (new biotechnology firms) cooperate only when they need to finance R&D.

Hagedoorn (1993) distinguishes two broad groups of motives: one is motives associated with basic and applied research, and another is motives associated with market access and restructuring. According to this grouping, it appears that high-tech SMEs' cooperative activities are more market oriented rather than research oriented. Partly, this can be explained by noting that SMEs' survival and growth largely rely on their success in marketing. Partly, this result can be explained by these firms' weak R&D capabilities. Data from our questionnaire (see Table 6-2) reveals that surveyed firms have relatively low R&D inputs. 16% of sample firms have their R&D employee intensity (the ratio of the number of R&D employee to the number of total employee) less than 10%, and 30% of sample firms have their R&D expenditure intensity (the ratio of R&D expenditure to sales) less than 5%, exposing that these firms fail to reach the minimum standard of high-tech firms (Ministry of Science and Technology of China, 2000a). Additionally, from the questionnaire, 66% respondents report they have limitations in in-house R&D activity and 62% respondents report a lack of qualified scientists and engineers. The insufficient innovation inputs in surveyed firms explain why these firms are weak in technological innovation capability and why their cooperative activities have less association with research. The issue is a reflection of whole high-tech industries in China and demonstrates that China's high-tech firms have to strengthen internal R&D capabilities to be competitive in technology innovation.

7.2 Discussion on Main Modes and Their Associations with Firm Age and Size

Question 2: What are the main modes of cooperation preferred by high-tech SMEs? Are firm age and firm size correlated with these main modes?

Hypothesis 2a: The choice of a cooperative mode is associated with firm age.

Hypothesis 2b: The choice of a cooperative mode is associated with firm size.

The main modes chosen by high-tech SMEs are 'customer-supplier R&D contract', 'joint development agreement', 'joint research agreement', and 'joint venture'. The mode 'joint venture' is positively related to firm age and firm size. It indicates that the propensity of firms to cooperate by 'joint venture' increases as firms' age and size increases.

In this study, joint development agreements are considered the primary cooperation mode by surveyed firms. Customer-supplier R&D contracts and joint research agreements are considered main modes as well, bit secondary to joint development agreements. Non-equity based agreements seem to be preferred by SMEs. With regard to equity-based agreements, joint ventures are considered a main mode by surveyed firms in general but the propensity of firms to set up joint ventures increases as firms' age and size increases, confirming that the larger the firm size is, the more likely the firm takes on the complicated organizational structure to achieve combined strategic objectives.

Choices of cooperative modes can be explained from three perspectives: the general trend of inter-firm cooperation, the feature of studied industry, and the nature of SMEs. As noted by many studies, such as Hagedoorn (1990, 2002) and Li and Zhong (2003), equity-based cooperation agreements, e.g. joint ventures, have tended to decrease, while non-equity cooperation agreements, e.g. joint R&D agreements, tend to be increasingly popular in inter-firm cooperative enterprises. In Hagedoorn (2002), the share of joint ventures in all newly established R&D partnerships has decreased from above 80% in the early 1960s to below 10% in the late 1990s. Therefore, it is concluded by Hagedoorn (2002, p. 490) that "if joint ventures once dominated inter-firm R&D partnering, this activity is now almost completely dominated by contractual agreements as about 90% of the recently established partnerships are of a contractual nature."

The literature suggests that the degree of technological sophistication or the degree of technological change in industries also influences the preferred modes of inter-firm cooperation. For example, Harrigan (1985, 1988b) states that rapid technological change in high technology industries induces more flexible modes of inter-firm cooperation. Osborn and Baughn (1990), Yu and Tang (1992), and Osborn et al. (1998) emphasize that the technological instability in high technology industries leads firms to prefer contractual agreements. Information and communications technologies also have influence on firms' decision making in cooperative mode.

The resource-constrained nature of SMEs is another influential factor in choosing a cooperative mode. As noted by Brockhoff et al. (1991), small firms prefer project-based relationships which have a limited time frame and focus on applied research and product development. Customer-supplier R&D contracts and joint R&D agreements are characterized by project-based cooperation, and therefore are able to meet high-tech SMEs' motives for cooperation in the first place, and fit SME growth strategies. If large companies apply contractual partnerships to experiment with benefits of cooperation before entering into joint ventures (Contractor and Lorange, 1988; Hagedoorn and Schakenraad, 1990c), such an interpretation for SMEs should be derived from their resource-constrained nature. The increasing tendency to apply joint ventures as firm age and firm size increases confirms this argument.

As Hagedoorn (2002) stresses, project-based partnerships have limited time-horizons, and therefore firms may seek to build longer and more stable relationships after such successful contractual partnerships. It is not a surprising result that joint ventures become more popular when firms' age and size increases. Generally speaking, a firm's competence is enhanced with the increase of firm age and firm size, and therefore the firm will switch its growth strategy to the more mature strategy. Main cooperative modes fit primary motives dynamically. Smaller firms prefer the comparatively light engagement of partnerships, such as joint R&D agreements. As a firm's size increases, the firm becomes more interested in technology transfer and learning from partners. At the same time, the firm is more capable of setting up a joint venture, which confirms prior studies (e.g. Kogut, 1988; Hennart, 1988; Das and Teng, 2000) which state that equity joint ventures are the most instrumental in the transfer of tacit knowledge and learning between partner firms.

Interviews with managers confirm this. Among 20 interviewed CEOs or senior managers, two reported that their firms have set up joint ventures. Both of them partner with large international companies, one with an American company and another with a Japanese company. Two domestic firms were relatively older (13 years and 12 years respectively) and larger in employment (633 and 733 employees respectively). The goal for two firms setting up joint ventures was technology transfer from their world leading partners and joint innovation activity. By partnering with large international companies, these two firms appear to be more competitive within domestic markets compared to rival companies in their industries. It is worth mentioning that their partner companies simultaneously have succeeded in entering China's market through joint ventures.

7.3 Discussion on Firms' Capabilities for Cooperation

Question 3: Do resource capabilities influence the propensity of high-tech SMEs to cooperate?

Hypothesis 3: A firm's resource capabilities are positively correlated with the propensity of the firm to cooperate.

In this study, a firm's resource capabilities are established by manager's education level, manager's managerial experience, firm age, firm size, R&D employee intensity and R&D expenditure intensity. Firstly, the results of mean difference analysis with each of capability variables show that firm size and R&D employee intensity are significantly different between experienced firms and inexperienced firms (see Table 6-7). Firm size in experienced firms is significant larger than in inexperienced firms and R&D employee intensity in inexperienced firms is significant larger than in experienced firms. Secondly, the results of correlation analysis show that among studied capability variables firm size is positively related to cooperation and R&D employee intensity is negatively related to cooperation (see Table 6-8). Thirdly, the results of logistic regression analysis show that only firm size has significant impact on a firm's propensity to cooperate.

There are contradictory findings in the literature regarding the impact of firm size on a firm's propensity to cooperate. Kleinknecht and Reijnen (1992) posit that larger firms have a higher probability of cooperating with an R&D institution but firm size has no influence on cooperation between firms. Many studies, however, have found a significant impact of firm size in various industrial sectors, e.g. companies in IT, mechanical engineering and process industries in Europe, the United States and Japan studied by Hagedoorn and Schakenraad (1994), manufacturing firms with 6 to 499 employees in Norway studied by Dickson and Weaver (1997), and manufacturing enterprises with not less than 10 employees in Germany studied by Fritsch and Lukas (2001). Shrader (2001) concludes a positive correlation between firm size and cooperation for foreign market entry. Berg et al. (1982) find that firm size has a positive effect on joint venture participation. The current study confirms the findings of Berg et al. (1982), Hagedoorn and Schakenraad (1990c, 1994), Dickson and Weaver (1997), Shrader (2001), and Fritsch and Lukas (2001), and extends their findings to the field of technological cooperation by using a sample of high-tech SMEs in information and communications industries in China. This finding suggests that cooperating with partner firms requires a firm with a certain level of resource capabilities to contribute effectively to partnerships. Firm size determines, to a larger extent, a firm's resource capability. As noted by Hagedoorn and Schakenraad (1994, p.300), "size of firms partly reflects their degree of diversification which broadens their basis for potential cooperation with other firms…forging alliances takes substantial administrative, organizational and monitoring support, the support of a staff for these particular activities is usually only available to large firms". Therefore, the result that firm size has a strong positive effect on cooperation is reasonable.

Other capability variables do not show any significant impact on a firm's propensity to cooperate in logistic regression models. Although R&D employment intensity in experienced firms appears to be lower than in inexperienced firms, both R&D employee intensity and R&D expenditure intensity has no significant correlation with cooperation in the regression analysis. The literature reports contradictory findings on the influence of R&D intensity on R&D cooperation. Regarding R&D employee intensity, Kleinknecht and Reijnen (1992) conclude that R&D intensity (R&D man-years as a percentage of workers in a firm) has little impact on inter-firm R&D cooperation in information technology firms, whilst Fritsch and Lukas (2001) present the positive impact of the percentage of R&D employees on a firm's propensity to cooperate. Concerning R&D expenditure intensity, Fusfeld and Haklisch (1985) claim that R&D intensive firms cooperate more than average, whilst Shrader (2001) does not find a significant relationship between collaboration and R&D intensity (the ratio of R&D expenses to sales subtracting the industry average R&D intensity). Contradictory to Fritsch and Lukas (2001) and consistent with Kleinknecht and Reijnen (1992) and Shrader (2001), the results of this study suggest neither R&D employee intensity nor R&D expenditure intensity has significant impact on the propensity of high-tech SMEs to cooperate.

The significant lower R&D employee intensity on average in experienced firms can be understood that R&D manpower is a precondition of technological innovation, especially for firms in high-tech industries. High-tech SMEs are limited in recruiting and retaining sufficient R&D employee resources and therefore are forced to compensate for this weakness by recourse to external resources. Of 52 experienced firms (two experienced firms with missing data), 56% of firms reported that the shortage of qualified scientists and engineers prevents their firms from absorbing new technology from cooperation, confirming the importance of R&D intensity in learning ability.

Manager characteristics are not significantly correlated with the propensity to cooperate. Although Eisenhardt and Schoonhoven (1996) point out the importance of the social position of top managers in forming alliances, the result of this study does not confirm that managers' education level and managerial experience are direct determinants of a firm's adopting a cooperation strategy. Firm size which often bestows competitive resource capabilities may be the only critical determinant.

In summary, a firm's resource capabilities, as evidenced by manager and firm characteristics, do not have any significant impact on a firm's propensity to cooperate except for firm size. Firm size has positive correlation with the propensity of high-tech SMEs to cooperate. However, experienced firms appear to have a lower R&D employee intensity compared to inexperienced firms, implying that high-tech SMEs resort to external resources to compensate for their internal shortage of R&D experts.

7.4 Discussion on the Impact of Cooperation on Innovation Performance

Question 4: Does inter-firm technological cooperation influence a firm's innovation performance?

7.4.1 Discussion on Hypothesis 4a

Hypothesis 4a: Firms that have been involved in cooperation have better innovation performance than those that have not.

Multiple indicators, computed by innovation output per employee, were applied to measure innovation performance. These are 'filed patent intensity (log)', 'granted patent intensity (log)', 'new product intensity (log)', 'globally new product intensity (log)', 'sales intensity (log)', and 'profit intensity'. The statistical analyses of the mean difference in six indicators between experienced firms and inexperienced firms were conducted. The results show that except for 'new product intensity (log)', there is no significant difference in innovation performance between experienced firms and inexperienced firms. Regarding 'new product intensity (log)', inexperienced firms appear to perform better than experienced firms. Put it together, experienced firms do not perform better in productivity of innovation output than inexperienced firms. Hypothesis 4a is not supported under this study.

To broaden understanding of the impact of cooperation on firms' innovation performance, the questionnaire survey collected managers' perceptions of cooperation performance. Managers' perceptions provide a more positive (or optimistic) assessment of firms' cooperative activities than factual assessment of innovation performance. 35 of 54 experienced firms (65%) report at least half of their cooperative projects are successful. Statistical analysis does not show any significant relationship between the perceived successful rate and each of innovation performance indicators (see Table 6-15). It means managers do not entirely assess cooperation performance in terms of factual innovation performance. This interpretation can be derived from several viewpoints. Firstly, most innovation takes long time. Even a three-year time horizon in this study may be too short for measuring the performance of cooperative innovation. A longer time horizon may present a different picture of cooperation performance. Secondly, identified primary motives help interpret the inconsistency between managers' perception and factual innovation performance. This study has found that 'learning from partners' is one of primary motives for cooperation. However, the outcome of 'learning from partners' is difficult to measure, at least in the short-term if it is possible in long-term. In this instance, managers' perception provides better insight into the outcome of learning than factual indicators. As Johnson and Sohi (2003) contend, benefits of learning may not be seen for extended periods of time, and how learning pays off in the firm's financial performance is not yet understood especially with regard to inter-firm partnering. Thirdly, from the transaction cost perspective, efforts to coordinate and manage the cooperative relationship may exceed what smaller firms can afford. If that is the case, SMEs that engage in cooperation may be not benefit from technological innovation. The fact that 35% of experienced firms perceive more than half of their cooperative projects as unsuccessful (see Table 6-14) may be partly due to this reason. However, as long as the benefits from cooperation in the long run outweigh costs incurred in governance, firms can fulfil their growth strategy through using the external resources, and therefore their innovation competence can be enhanced. As Shrader (2001) suggests, firms with ambitious market share objectives may be more likely to tolerate the costs associated with cooperation. That is why firms still initiate cooperation even if the innovation productivity cannot be improved significantly in a certain time.

With regard to 'new product intensity (log)', the result of an independent-samples t test shows that inexperienced firms produce more new products per employee than experienced firms. The mean value of 'new product intensity (log)' is 2.21 for inexperienced firms and 1.43 for experienced firms. The mean difference of an independent-samples t test is significant at $p < .01$ ($p = .005$). Prior studies (e.g. Acs and Audretsch, 1988 and 1990) have argued that smaller firms perform better in innovative output per employee than larger firms although large firms may create larger value on the total product innovation. Table 6-7 has shown that inexperienced firms are smaller in size on average than experienced firms. The mean value of 'firm size (log)' is 3.74 for the former and 4.68 for the latter, and the mean difference of independent-samples t test is significant at $p < .01$ ($p = .001$). Taking this fact into account, a significant difference in 'new product intensity (log)' between experienced firms and inexperienced firms is consistent with Acs and Audretsch (1988 and 1990).

7.4.2 Discussion on Hypothesis 4b

Hypothesis 4b: Cooperation is positively correlated to a firm's innovation performance.

Six multiple regression models were formulated to examine the relationships between cooperation (the independent variable) and each of innovation performance indicators (dependent variables). Multiple regression analyses showed that cooperation has no significant impact on firms' innovation performance except for 'granted patent intensity (log)'. The results support the findings of Berg et al. (1982), Shrader (2001) that cooperation has no significant positive impact on a firm's economic performance, and extend these findings by using productivity indicators instead of profitability or sales growth rate. The significant correlation between cooperation and granted patent intensity can be interpreted as meaning that cooperation enhances SMEs' productivity in granted technology patents.

Furthermore, this study confirms Shrader's (2001) methodology by taking firm size as a moderator and analysing the moderator's effect on the relationships between cooperation and innovation performance. The results of moderated multiple regression analysis reveal that firm size moderates the relationships between cooperation and patent creation (filed patent and granted patent), suggesting that cooperation has stronger positive impact on patent creation for larger firms than for smaller firms. Patent creation is the earliest stage of technology commercialisation process. It is not surprising that smaller firms are not as capable as larger firms of creating patents through cooperation. The moderated multiple regression models confirm Dickson et al.'s (2006) suggestion to take firm size as a moderator when examining the partnerships SMEs involved.

Research results indicate that hypothesis 4b is partly supported and cooperation provides advantages only under some conditions. Put differently, larger firms achieve better productivity in patent creation through cooperation than smaller firms. Apart from these positive relationships, there is no direct correlation between cooperation and other innovation productivity indicators. Although prior studies have reported the possible drawbacks of inter-firm cooperative activities, most of the studies on cooperation, as noted by Smith et al. (1995), tend to have a very positive tone. The results of this study show insignificant correlation between cooperation and some indicators of innovation productivity, suggesting that managers should take a more balanced and rational approach to decisions about cooperation rather than use it as a bandwagon.

7.4.3 Discussion on Hypothesis 4c

Hypothesis 4c: The number of cooperative projects is positively correlated to innovation performance.

Association analyses were conducted to examine the correlation of the number of cooperative projects with the perceived successful rate of their cooperative activities and the factual innovation performance. The results show that the number of cooperative projects is positively related to the perceived successful rate of firms' cooperative projects, and positively related to two of innovation performance indicators, which are 'sales intensity (log)' and 'profit intensity'.

Positive correlation between the number of cooperative projects and the perceived successful rate of cooperation implies that firms gain experiences and reduce costs incurred in cooperation governance as the occurrence of cooperative relationships increases. It confirms the previous studies, indicating that the more firms are experienced in engaging in cooperation, the more they can exploit the complementary resources and minimize the transaction cost associated with cooperating. 'Learning by doing' can be interpreted here as 'firms learn how to cooperate by cooperating'. It is worthy noting that Deeds and Hill (1996) warn that the relationship may become negative when the number of cooperative projects goes beyond a certain number.

The result that the number of cooperative projects is related to 'sales intensity (log)' and 'profit intensity' can be interpreted as that the more firms are involved in inter-firm cooperation, the more likely they can achieve better economic performance in terms of sales and profit. Although cooperation does not show direct correlation with sales intensity and profit intensity, the increase of number of cooperative projects seems to improve firms' performance of sales and profit. This result implies that firms' market oriented motives, therefore their growth goals can be achieved by cooperative relationships, given the partners are carefully selected and the relationships are energetically managed. This finding develops resource theory in recognizing that the creation of cooperative advantage through strategic cooperation is a key to success and therefore is an important competitive resource. It confirms the statement of Hakansson (1987) that relationships are one of the most valuable resources that a company possesses.

As Ritter and Gemunden (2003) state, technological-oriented relationships are not without costs. These costs relate to time, effort and resources a firm must invest to gain access to external partners' resources. The innovation performance is shaped by the offset between the benefits from synergic resource combination and the costs incurred in governing the cooperative relationships. Given the benefits from cooperation, high governing costs negate performance. On the one hand, the hybrid governance structure has comparative advantages compared to the alternatives of other organizational forms. The promise in capability accumulation without real investment is attractive to growth-firms in high technology sectors. On the other hand, the process of cooperating and gaining knowledge from partners is costly. Managing the inter-firm relationship and achieving the win-win goal is more challenging than managing a single firm. The costs incurred in negotiation and supervision of the relationships may overweigh the benefits. The effective management of cooperation is a practical imperative.

From the transaction cost perspective, Gulati (1995) demonstrates that repeated partnerships reduce transaction costs due to the emergence of trust between partners. This study provides insight into transaction cost theory from the view that firms gain experiences by cooperative practices and thus reduce transaction costs as well. Managers' perceptions and assessment of factual performance in sales and profit support this finding.

In summary, cooperation does enhance firms' innovation. Larger firms are more likely to benefit improved patent creation from cooperation than smaller firms. However, experienced firms appear to achieve better performance in sales and profit as they enter into more cooperative partnerships.

7.5 Discussion on Critical Success Factors

Question 5: What are the critical success factors in inter-firm technological cooperation?

By statistical analysis, of 12 contributing factors, 11 factors are confirmed as critical success factors for successful cooperation. These are:

- trust, communication and reciprocity
- resource complementarity
- safeguards in place for protecting core technology
- top leader's commitment
- sufficient cooperative resources
- well-documented agreement
- compatible technology and business strategies with partners
- adjusting to external change
- ongoing monitoring and coordinating
- milestone appraisal
- flexible organizational and managerial style

Only one factor, 'geographical proximity', is no longer viewed as a critical success factor as expected. 'Trust, communication and reciprocity' is viewed as the most important factor for successful cooperation by both experienced firms and inexperienced firms.

For detrimental factors regarding cooperation, all 5 factors are confirmed with high agreement by respondents. These are:

- not contributing as promised
- unilateral dependency on partners
- lack of compatibility in technology, management, and organization

- only focusing on short-term financial performance
- time-consuming decision making

'Not contributing as promised' is considered the most harmful factor to successful cooperation. Two factors stand out from the 17 assumed influential factors when conducting mean difference analysis between experienced firms and inexperienced firms. These are 'resource complementarity' and 'unilateral dependency on partners'. This implies experienced firms pay more attention to the contributing factor 'resource complementarity' and the detrimental factor 'unilateral dependency on partners' than inexperienced firms. Furthermore, when conducting a mean difference analysis between successful firms and unsuccessful firms, a significant difference shows in 'trust, communication and reciprocity'. Successful firms pay more to this factor than unsuccessful firms.

7.5.1 Resource Complementarity

The factor 'resource complementarity' holds significantly more importance in experienced sample firms than in inexperienced sample firms. Sharing the same conclusion with Azriel (2003), this result reconfirms that the resource-based perspective is a valid explanatory theory for SMEs' cooperative practices. The importance of 'resource complementarity' implies that companies should fully understand what resources they have had and what complementary resources they need to get from their partners. Therefore strategic analysis on resource complementarity has to be done before firms cooperate. It would not be overstated that SMEs need to place the utmost emphasis on the factor 'resource complementarity'. As an interviewed manager stated, "many things are important for working out a cooperation strategy, say personal relationship, but you would not go to cooperate with someone you know very well unless he could provide you with something which is the interest of your business." Thinking of complementary resources from the partner's view, say why the partner wants to engage in cooperation and what the partner wants to get, can be helpful as well.

An innovation process combines stages of research, development, production and commercialisation. Large multinational firms are capable of enduring huge and long-term research investment and caring less about short-term marketing return. However, cash flow is vital for SMEs' survival so that SMEs' innovative technology is more immediately market-focused. Previous empirical studies have found a conflict in innovation strategy between large and small firms. Alignment of technology strategies on both sides has proven to be a necessity. SMEs have to be convinced that the available complementary resources from prospective partners, such as technologies, experts, or other resources, could facilitate innovative product to be commercialised in targeted time. A promising return from the market can improve SMEs' cash flow in the future.

Technological innovation takes time. It is not realistic to expect the start-ups to have systematic innovation outcomes. Lack of cutting edge technology to attract partners may explain the reason why most of young firms do not engage in inter-firm technological cooperation. To develop specific technology advantage in house, it is imperative for SMEs to undertake continuous R&D investment and innovative effort.

7.5.2 Unilateral Dependency on Partners

'Unilateral Dependency on partners' as a detrimental factor explains the importance of a firm's core competence. SMEs are attractive to the prospective partners when they have their distinctive competitive edge that can be an art of the state technology, or a cost efficient product or process. Without any competitive advantage or gradually losing competitive advantage in a cooperative process will place small firms in the position of unilateral dependency on their partners. It can result in losing bargaining power, weakening control and, at worst, being taken over by their partners.

"Unilateral dependency on partners" may be caused by mismatch of partners in which two parties do not have equality in their power/dependency relations. Leverick and Littler (1993) warn that collaborations between strong and weak companies are rarely productive. Unilateral dependency on partners will leave the weaker firm in the position of tailoring products and procedures too much towards a single partner's need. The analysis of resource complementarity at the starting stage of cooperation and organizational learning in the cooperative process do help to avoid this problem.

In the survey, successful firms' managers highly agree with the point that original innovation is the essence of a high-tech firms' vitality. Literature has reported that high-tech SMEs have shorter life spans compared with firms in other sectors. The surveyed firms fit in this scenario. A firm's life cycle is consistent with its product's life cycle. Without original innovation, a firm's competitiveness will not last. This issue impacts not only on SMEs' strategic position in a partnership but also on the possibility of their survival.

7.5.3 Trust, Communication and Reciprocity

'Trust, communication and reciprocity' being considered the most important factor in successful cooperation reconfirms findings in the reviewed literature. As noted by Kale et al. (2000), subtle 'relational capital' such as trusting relationships, conflict resolution and effective communication may be more important than financial controls (e.g. mutual equity investment) for assuring alliance success. Mean difference analysis found that firms in successful group pay more attention to this factor compared with firms in the unsuccessful group. The result can partly explain the reason why firms in the unsuccessful group could not fulfil their cooperative objectives. According to the questionnaire survey and interviews with managers, core technology protection, key executives' recognition of the benefits of win-win cooperation, governmental policy and legal system, and regional industrial clusters all significantly affect inter-firm trust building.

(1) Core technology protection and trust building. High-tech firms heavily depend on their own distinctive knowledge or technology. When the specific technology a small firm holds is in 'weak appropriability regime' (Teece, 1986), it is difficult to protect it within the legal system. In many instances, unwanted drain of knowledge, which is named technology leakage, can negate trust and damage the relationship. 70% of surveyed firms (93/133) indicated that 'technology leakage' is a major concern of SMEs. Therefore, it is understandable that 'safeguards in place for protecting core technology' is considered one of the critical success factors for successful cooperation.

(2) Top leader's win-win mindset and trust building. The survey finds that a manager's win-win mindset increases the odds of successful cooperation. In some cases, one or both sides in a cooperative relationship want to have more control power over the cooperative activities and more benefit from the cooperative achievement. Surveyed firms indicate that 'unequal benefit distribution' is one of their greatest concerns. A two-hour face-to-face interview with a CEO reinforced this point. The interviewee is a CEO of a small but fast-growing telecommunications

equipment company. The company bought an original technology abroad and applied the technology in the telecommunications equipment industry with innovative applications. The products produced by this company enjoy cost-efficient advantage compared with its counterparts in global markets. As a professional manager, the interviewee did not hold an optimistic attitude towards inter-firm technological cooperation. Benefit distribution is a highly frequent hindrance to entering cooperative innovation or carrying on the established cooperative relationship, even if both parties are well matched and motivated. The interviewee stated that many firms only want to make use of the partner's specific technology advantage and care little about the partner's interest. He said that partners don't use win-win thinking to manage cooperative activities but exploit their fellow partners. By comparison, he viewed cooperative activities with international giant companies much easier and beneficial. He felt that these multinational companies maintain high profile towards partnerships and practically nurse their small partners. No matter whether they are in licensing-in, joint development agreement, or other cooperation modes, international giants offer technology transfer, training and support. Meetings and communications between key executives and between senior technical staff from both sides are scheduled and frequent. Communications and reciprocity facilitate trust. Consequently, these international giants have built up long-term partnerships with small partners in China. They make profit in China's domestic marketplace, and at the same time the domestic small partners get to improve their technological innovation capacities. The interviewee's telecommunications equipment company has been maintaining a good relationship with its multinational company partner and sharing a promising market with its partner company in China and other Asian countries. As Das and Teng (2000) have pointed, the firms' objectives in a partnership are rarely completely congruent and a certain degree of conflict is inevitable. Therefore inter-firm trust and mutual forbearance are important in order to control potential conflicts and maximize collective strengths.

For decades, interpersonal and inter-organizational crises of trust have negatively influenced inter-firm cooperation in China. Trust crises are not merely an individual phenomenon but also a social phenomenon. Firms have had fewer propensities to cooperate because of lack of trust-facilitating mechanisms in the whole market system. On the contrary, acquisition strategies have been more favoured by firms for improving competitive position. Hostile competition, instead of cooperative competition, gets even worse in the industries where companies compete with each other in the limited market. An interview with a CTO of an electronic equipment provider demonstrates that competition in the electronic information industry is so severe that firms do not think of cooperation and win-win partnership but make every effort to defeat rivals. To enlarge market share, prices have been decreased to a low point and all firms involved hardly make a profit. This vicious competition has distracted firms' investment from technological innovation, and has begun to undermine the development of the whole industry.

(3) The role of governmental and legal system in trust building. According to Schumpeter, innovations should lead to temporary monopolistic profits in order to harvest previous R&D investments. Therefore a strict legal intellectual property system with little uncertainty for the innovators is a prerequisite for technological process and high rates of innovation. China has passed a series of laws to update the intellectual property rights regime. However, as noted by Dahlman and Aubert (2001) and Yang (2003), serious problems of enforcement remain. Multi-pronged actions are required that include education and awareness campaigns, recruitment and training of appropriate human resources, streamlining of the judicial and administrative procedures, and strengthening of penalties. Counterfeiting practices that plague not only foreign investors, but also many domestic producers, should be energetically combated with vigilant monitoring and penalties. It has been recognized that Chinese authorities are well aware of most of these issues and stronger enforcement actions are being taken on trademarks and copyrights. However, enforcement on patent legislation is lagging behind.

Cooke (2004) analyses the role of Taiwan and Mainland China in IT business and concludes that major elements of the global IT supply chain – high-performance chip production, laptop/notebook assembly, original design manufacturing (ODM) and high-volume OEM manufacturing – were still mostly absent from Mainland China. Besides technological capabilities, lack of judicial recourse and administrative inefficiency is one of the reasons. It has been found that widely spread copying practices are becoming problematic in China, notably in the new technology-based firms. Under the circumstance of weak IPRs protection system, fear of technology leakage and low efficient justice system would hinder small firms from cooperating. As Perrone (1993) notes, the legal system and the relationship between business and government can affect firms' attempts to build cooperation.

(4) The role of regional industry clusters in trust building. In data analysis, 'geographical proximity' got the lowest score in its importance within 12 contributing factors. Physical proximity appears no longer to be particularly advantageous for successful cooperative innovation. This conclusion has been reached in many studies (e.g. Romijn and Albu, 2002). Dramatic advances in ICT and cost-reductions of long distance communications play a role.

However, in this questionnaire survey, about the preference of partners' location, 33% of respondents (44/133) chose their partners based in same industry development zone, and among experienced firms this rate is 41% (22/54). It helps to understand that the coefficient of variance on the factor "geographical proximity" is high whilst the mean score of this factor is low. SMEs prefer their partner firms located in same industry development zone which may imply that size-constrained firms seek to benefit from an 'innovative milieu' (Romijn and Albu, 2002) in industrial zones, and not solely for geographical proximity. The survey found that technology parks provide systematic services for start-ups, including building a platform for facilitating inter-firm technological cooperation among park-based firms. As an extensive branch of a governmental entity, technology parks carry out a broad program of governmental structural support comprising regulations and investment incentives. The aim is to boost the local economy.

Taking Jinan's Qilu Software Park as an example, Qilu Software Park is a part of Jinan high technology industry zone. The park's administration encourages and assists inter-organizational cooperation within the park. There are four inter-firm strategic alliances in Qilu Software Park, which are the Alliance of Export-oriented Software Companies, the Alliance of Electric Power Software Companies, the Alliance of Transportation Software Companies, and the DSP (Digital Signal Processing) Alliance. Each alliance was initiated and organized by local leading company in its industry, and companies volunteer to join the alliances. For example, the Alliance of Export-oriented Software Companies was led by Langchao which is the largest software exporting company in Jinan. The Alliance of Electric Power Software Companies was led by Jicheng which is the largest software provider in electric power industry in Jinan. To compete against India's software base 'Bangalore', Langchao-led Alliance of Export-orientated Software Companies integrates small software companies' competencies to strengthen their competitive position in software exporting market. Jicheng-led Alliance of Electric Power Software Companies builds a platform for electric power software enterprises to share resources and bind strength of local companies in aiming to improve technological innovation and competitive position in domestic markets and global markets.

Taking into account social factors in alliance formation and process management, Eisenhardt and Schoonhoven (1996) and Gulati (1995) have made attempts in their empirical studies. This study provides new insight into the influence of social factors on trust building of inter-firm relationship.

7.6 Summary

Market entry, economies of scale or scope, technology transfer, and learning from partners are primary motives for high-tech SMEs engaging in technological cooperation. These are combined considerations for market repositioning, cost-minimizing and organizational learning. Primary motives change dynamically with firm age and size. As a firm's age increases, the firm is more likely to cooperate for technology transfer. As a firm's size increases, the firm is more likely to cooperate for technology transfer and learning from partners.

Main modes of cooperation are customer-supplier R&D contracts, joint R&D agreements, and joint ventures. Like primary motives, main modes change dynamically with firm age and firm size as well. A firm is more likely to cooperate by setting up a joint venture with a partner firm when the firm's age and size increases. The modes of cooperation are aligned with the motives for cooperation.

Younger and smaller firms prefer non-equity based agreements for the access to new market and economies of scale or scope. Joint ventures are a better governance structure for technology transfer and learning.

Firm size is identified as the only influential factor on a firm's propensity to cooperate. It implies that a firm needs to possess a specific resource advantage for contributing to the partnership, confirming Dickson and Weaver (1997) that limited resources of small firms make the likelihood of alliance use minimal. The finding that R&D employee intensity in experienced firms is lower than in inexperienced firms implies that firms resort to external R&D employees through cooperative relationships to compensate for the weakness of in-house R&D force.

Firms that have been involved in cooperation do not significantly perform better in technological innovation than those that have not. Cooperation does not show direct correlation with innovation performance except for 'granted patent intensity'. Larger firms, coupled with cooperation strategy, significantly improve their capabilities in patent creation. In engaging in more cooperative practices, firms gain experiences and benefit from improved performance in sales and profitability.

Managers' perceptions of cooperation performance appear more optimistic than factual performance. Identified motives, such as 'learning from partners', cannot be fully captured by factual performance indicators, at least in the short term. This partly explains the inconsistency between perceptive assessment and factual measurements. Furthermore, a three-year time frame is limited in measuring the impact of cooperation on innovation performance. Therefore, managers' perceptions are a necessary supplement to the factual measurements of innovation performance.

'Trust, communication and reciprocity' is considered the most important contributing factor to successful cooperation. It implies that relational factors are at least as important, if not more important, as business and technology factors. The questionnaire survey and interviews show that trust building is reinforced not only by communication, reciprocity and top leader commitment, but also by social factors such as the governmental and legal system and regional industrial clusters.

Chapter Eight: Conclusions

This chapter presents the findings of the research, the implications for theory and practice, the limitations of the study, and also presents some suggestions for future research.

8.1 Major Findings

This study is the first comprehensive empirical study conducted in China's high-tech SMEs. The research questions cover: why do high-tech SMEs cooperate with other firms? How do they cooperate with each other? What resource capabilities make a difference on the propensity of firms to cooperate? Does inter-firm cooperation enhance firms' innovation? What are the critical success factors for inter-firm cooperation? The major findings in this study are:

1. Literature presents a variety of motives for inter-firm cooperation. These range from exploiting external resources to compensate for in-house resource shortages to jointly coping with environmental uncertainty and complexity, gaining tangible resources such as money and experts and learning technological know-how and managerial knowledge from partners. This study, focusing on firm-level factors, investigated motives for high-tech SMEs cooperating with other firms. The results indicate that the primary motives for cooperation are new markets, economies of scale or scope, technology transfer and learning from partners.

Correlation analysis between firm characteristics (firm age and firm size) and primary motives captures the variations of motives for cooperation over time. Older firms (in terms of the number of years that they have been established) are more likely to cooperate for 'technology transfer' than younger firms. Larger firms (in terms of the number of employees) are more likely to cooperate for 'technology transfer' and 'learning from partners' than smaller firms. The analysis shows that firms' motives for cooperation change with firm age and firm size dynamically. Firms become more interested in technology transfer and learning as their age and size increase.

The primary motives are combined considerations of cost-minimization, market and technology access, and organizational learning. The perspectives of transaction cost, competitive forces and a resource-based view of the firm jointly explain inter-firm cooperative practices. Any one of these perspectives on its own is not sufficient to fully explain the broad, often combined, motivations of high-tech SMEs' cooperative strategies. The study shows that a combination of these three theoretical perspectives helps understand this complex phenomenon.

2. Firms can choose different modes of cooperation, varying from highly interdependent modes, such as joint ventures, to less interdependent modes, such as unilateral licensing. This study examined the modes of cooperation preferred by

high-tech SMEs. It concluded that SMEs prefer non-equity based agreements, including customer-supplier R&D contracts, joint development agreements and joint research agreements. Joint ventures are a main mode as well, and firms that are older and/or larger are more likely to participate in joint ventures than those who are younger and/or smaller. Linking the primary motives with the main cooperative modes identified in this study, it is confirmed that joint venture is the most suitable device for technology transfer and learning.

3. Firm size is a significant factor in determining whether to use a cooperation strategy. Prior studies have found that firm size has a significant impact on the selection of a cooperation strategy in various industrial sectors. This study confirms this finding in the SME sector of the information and communications technology industries.

With regard to R&D intensity, experienced firms have a smaller percentage of R&D employees over the total number of employees than inexperienced firms. This indicates that high-tech SMEs resort to cooperation to compensate for an in-house shortage of technological personnel. Neither R&D employee intensity nor R&D expenditure intensity show a significant impact on high-tech SMEs' propensity to cooperate, suggesting R&D intensity is not a significant hindrance to SMEs' engagement in cooperation.

4. Indicators of innovation performance in experienced firms do not exhibit significant improvement when compared to inexperienced firms. However, the perceptions of managers from the questionnaire survey provided a more optimistic assessment. 65% of managers from experienced firms consider that at least half of their cooperative projects are successful. Given that the managers' perceptions are consistent, sensible and reasonable, it may imply that cooperative practices in more than half of the experienced firms align with their motives for initiating cooperative activities. Obviously, managers do not solely take innovation productivity as their criterion in assessing their cooperation performance. The objective measurements of innovation performance have apparent flaws in evaluating SMEs' achievements in cooperation, at least in the short term. Managers' perceptions of cooperation performance, therefore, seem to be a necessary supplement to the objective measurements.

5. Cooperation is positively correlated with 'granted patent intensity', revealing that inter-firm technological cooperation enhances a firm's capability in acquiring technology patents. Firm size plays a role that moderates the relationship between cooperation and innovation performance. Larger firms coupled with a cooperation strategy perform better in acquiring both filed and granted patents than smaller firms.

6. Although cooperation does not show a direct correlation with sales intensity and profit intensity, the number of cooperative projects is positively correlated with these

two indicators. This finding suggests that the more firms cooperate, the more they will benefit from market access, economies of scale or scope, technology transfer, and learning, and therefore the better their performances in terms of sales and profitability.

7. As Bruce et al. (1995) state, there are no universal 'recipes' for cooperation success due to the complexities of inter-firm cooperation and the diverse context in which the cooperation takes place. This study does not generate formulae for achieving successful cooperation. Rather, this study highlights a number of factors which are critical to successful cooperation. Of a number of factors critical to success, a few factors discriminate between experienced and inexperienced firms, and between successful firms and unsuccessful firms.

'Trust, communication and reciprocity' is found to be the most important factor in successful cooperation. 'Not contributing as promised' is found to be the most detrimental factor to successful cooperation. Between experienced firms and inexperienced firms, 'resource complementarity' and 'unilateral dependency on partners' are the discriminating factors. Experienced firms pay far more attention to the contributing role of 'resource complementarity' and the detrimental role of 'unilateral dependency on partners' than inexperienced firms. This highlights the attention paid to these factors by experienced firms due to their practical cooperative experiences. Between successful firms and unsuccessful firms, 'trust, communication and reciprocity' is the discriminating factor. Successful firms pay more attention to 'trust, communication and reciprocity' than unsuccessful firms, which may partly explain why some firms succeeded in their cooperative activities and others failed.

8. 'Trust' by no means arises without groundwork. Most of the identified contributing factors, including 'well-documented agreement', 'safeguards in place for protecting core technology', 'ongoing monitoring and coordinating', 'top leader's commitment', 'milestone appraisal', and 'compatible technology and business strategies with partners' are related to and enhance trust building. Interviews with managers further reveal that trust is more profound than reciprocity in the short term. It often requires compromise or sacrifice in a specific situation or in a certain period of time in order to achieve the final cooperative goal.

Furthermore, trust building involves business management, governmental administration and the legal system. Knowledge management for protecting core technology, regional industrial clusters and enforcement of intellectual property rights protection also significantly contribute to inter-firm trust building.

9. 'Geographical proximity' is no longer considered to be a significant contributing factor to successful cooperation. Communication technology and economic globalisation has made the spatial constraint less influential. However, the

community of regional industrial clusters provides a new interpretation for the significance of geographical proximity. It seems that firms located in the same industrial cluster, for example a high-tech park, can benefit from shared culture and 'innovative milieu'. Furthermore, SMEs take less risk by cooperating with firms that are tenants of the same high-tech park.

8.2 Contributions to Theory and Practice

8.2.1 Theoretical Contributions

1. The literature reveals a number of variables in examining the propensity of firms to cooperate, ranging from external environmental variables, such as market competition, technology development, and internationalisation (e.g. Dickson and Weaver, 1997), to internal resource variables, such as firm size and R&D intensity (e.g. Shrader, 2001) and top manager characteristics (e.g. Eisenhardt and Schoonhoven, 1996). This study proposes a set of resource capability variables, which consists of managers' educational level, managers' managerial experience, firm age, firm size, R&D employee intensity and R&D expenditure intensity. Firm size is confirmed to be a determinant factor on high-tech SMEs' propensity to cooperate. Expanding Eisenhardt and Schoonhoven (1996) where managers' social status is examined, this study examines the role of executive managers from the point of view of educational background and managerial experience.

2. This study develops a set of factual indicators and a perceptive assessment system

to measure innovation performance. Prior studies have evaluated cooperation performance using various measurements, such as profitability (Berg et al., 1982; Hagedoorn and Schakenraad, 1994; Shrader, 2001), sales growth (Shrader, 2001), and nominal scale (Bougrain and Haudeville, 2002). This study formulates a group of indicators to measure innovation outputs per employee. The rationale is based on the literature of Acs and Audretsch (1988 and 1990) that states that small firms are more productive in product innovation than large firms. The productivity indicators enrich the measurements of technological cooperation performance and broaden understanding of innovation performance.

Managers' perceptions of cooperation supplement the objective performance indicators. The senior manager in a small firm is considered 'the brain of the firm', and therefore it is reasonable to employ such managers' perceptions in evaluating cooperation performance. This study has found that firms are motivated to cooperate by multiple goals and some of these goals can not be readily measured by a few factual indicators, such as learning from partners. Factual performance measurements cannot cover all of the benefits of cooperative activities. As noted by Littler et al. (1995), the assessment of cooperation beyond the achievement of specific objectives is largely a matter of judgement and individual perspective. Objective measurements and perceptive judgements are complementary in improving our understanding of technological cooperation performance.

3. The positive association of the number of cooperative projects with perceived rates of success and with sales and profit intensity implies that transaction costs are not constant. The transaction costs decrease as firms engage in more cooperative activities. The benefits from cooperation emerge when firms conduct a broader scale of cooperative activity. The reason for this can be interpreted from the argument of Lundvall (1993) and Bougrain and Haudeville (2002) wherein cooperative relationships entail learning. Therefore transaction costs incurred with governing cooperative relationships vary from less experienced firms to more experienced firms. A static view of examining transaction costs incurred with inter-firm cooperation is insufficient for understanding why firms initiate multiple cooperative relationships.

If complementary resources are a main consideration when a firm formulates its cooperative strategy, the management of cooperative activities is the main consideration in implementing cooperative strategy. The management of cooperative activities is the basis of the transaction cost. Whether this cost is larger or smaller than the benefit of gaining complementary resources influences the assessment of managers of their cooperative performance.

4. A resourced-based view of the firm has been developed in this study as well. Identified primary motives indicate that firms are motivated to gain complementary resources via cooperation. 'Resource complementarity' is confirmed as an important

contributing factor to successful cooperation. As Das and Teng (2000, p.32) contend, "a resource-based view seems particularly appropriate for examining strategic alliances because firms essentially use alliances to gain access to other firms' valuable resources."

Furthermore, as Rumelt (1984, p.557) states, "a firm's competitive position is defined by a bundle of unique resources and relationships", the result of this study suggests cooperative relationships are firms' resources as well. The more a firm has been involved in inter-firm cooperative activities, the better the firm's performance in terms of the perceived rates of success, sales and profit. The empirical study confirms that making use of external resources and taking advantage of business networks is a strategic option for firms operating in competitive and fast changing technological industries.

5. Apart from developing the theoretical explanation of inter-firm cooperation from strategic behaviour, transaction cost, and resource perspectives, this study emphasizes the influence of social factors, such as governmental administration, legal system and regional industrial clusters, on alliance formation and process management.

8.2.2 Practical Implications

1. The identified primary motives for high-tech SMEs participating in cooperation indicate that cooperative activities of high-tech SMEs are market, technology and learning oriented. This is consistent with the nature of high-tech SMEs and aligned with SMEs' growth goals. The examination of motives reveals that high-tech SMEs cooperate strategically, not only for financial support or cost sharing. As firm age and size increases, high-tech SMEs tend to join in more strategic cooperative activities.

Customer-supplier R&D contracts and joint R&D agreements are project-based with short-term time horizons, which fit SMEs' market oriented cooperative strategy. If joint R&D agreements are typically large firms' experiments with the benefits of cooperation before participating in a joint venture as is stated by Hagedoorn and Schakenraad (1990c), then joint R&D agreements are SMEs' optimal option, given their resource constraints and market orientation. Joint ventures are a more complicated governance structure, which require organizational and managerial capabilities and commitment. The propensity of SMEs to set up joint ventures with partner firms increases as firm age and size increases, because joint ventures have been recognized as a better organizational form for learning (Hennart, 1988; Kogut, 1988). Therefore, managers should consider the congruence of their choice of cooperative modes with their motives in a dynamic view.

2. Consistent with most studies of SMEs, high-tech SMEs in this study consider growth as their primary strategy. Although it is not the only one, cooperation seems a popular strategic option for SMEs pursuing their growth goals. Consistent with many prior studies, this study, based on an empirical setting of China's high-tech SMEs, confirms that cooperation strategy is a strategic option with a low entry barrier. Neither managers' educational level and managerial experience nor firms' innovation input of R&D employees and expenditures is a significant hindrance to entering cooperative activities. Firm size is the only significant determinant. A higher propensity to cooperate in larger firms implies that firms that possess more in-house resources are more likely to engage in cooperation. It can be reasoned that if a small firm has its own specific resources, such as a technology patent with a promising market or is expert in a specific field, the firm will have advantages over its counterparts even if it has limitations in many other aspects because of its 'smallness'. The empirical studies of cooperative relationships in large/small pairings have revealed the potential advantages of small firms to be complementary to large partners' demands. A small firm must have an advantage in some aspect, which will be a basis for a possible partnership.

3. The criteria for a successful cooperative activity vary with theoretical perspectives. For example, criteria based on resourced-based theory are values added through integrating external complementary resources; criteria based on transaction cost theory are cost minimization through relatively a stable cooperative relationship

instead of arm-length market exchange. From a transaction cost perspective, inter-firm cooperation will not be initiated unless transaction costs are less than arm's length transaction costs, but inter-firm cooperation may be implemented by firms for complementary resources without expectation of transaction cost minimization. When firms give priority to capabilities accumulation rather than cost reduction, the motive for entering into a cooperative relationship is in anticipating the generation of value through synergistic and interdependent complementarities. In this instance, satisfactory economic performance, for example profit, is not the necessary outcome, at least not in the short term. From the standpoint of high-tech SMEs, information about market and technology is the strategic factor for sustainable growth. Therefore, learning and dynamic capabilities building might be the main goals of cooperation strategy in the context of shortening the technology life cycle. Strategic cooperation calls for managers to have a long term view to appreciate the existing partnerships rather than to assess the performance of cooperative practices solely by short-term performance.

4. This study provides evidence that cooperation is not a panacea. Experienced firms do not show significant improvement in their innovation productivity when compared to inexperienced firms. Referring to the managers' perceptions of cooperation performance, 35% of surveyed firms reported most of their cooperative activities are unsuccessful. The insignificant improvement in productivity performance and the unsuccessful cooperative practices perceived by managers

imply that many firms may not act rationally on the decision to cooperate or not to cooperate. Some managers may overestimate the potential synergy of complementary resources and downplay the necessary investments and the possible costs associated with cooperating. Dimaggio and Powell (1983) describe some firms' joint venture activities as a form of bandwagon behaviour. In these instances, the managers' decision to engage in cooperation is influenced by concerns for appearance and fashion trend-setting rather than economic or organizational rationality.

Insignificant improvement in innovation performance and unsuccessful cooperative practices perceived by managers also suggest cooperation is a two-edged sword by which the firms involved benefit from joint efforts of new product development or suffer from distraction from their main goals, leakage of core technology, conflict of organizational culture and values, or even loss of ownership.

Although the entry barrier for small firms entering into cooperation is low, a successful cooperative activity requires far more than running a single business. For example, protecting the core technology properly from unexpected leakage challenges a small firm's ability regarding knowledge management; learning from partners calls for investing sufficiently in both R&D employees and R&D expenditures to accumulate absorptive ability, and more importantly to internalise vital knowledge. The investigation of the current study into China's high-tech SMEs reveals that simple involvement in inter-firm cooperation does not guarantee improvement in innovation, and only successful cooperative activities make a difference. Managers cannot achieve collective strengths through cooperation unless they successfully manage the relationships.

5. SMEs enter into cooperation with partners because of complementary resources. Here, resources are a broad concept, which involves physical resources, technology, management, the market and legitimacy. Complementary resources become the main criterion for selecting the partner firms although many other factors need to be taken into account, such as compatible technology and business strategies. Providing complementary resources is the bond of a partnership, and when 'not contributing as promised' happens from one or both sides, the bond is broken and the trust is destroyed. Therefore, it would not be surprising if the partnership is destroyed.

6. Trust is always built on necessary conditions. The critical success factor 'safeguards in place for protecting core technology' implies that it is imperative for firms to implement knowledge management before entering into cooperation. According to Teece (1986), core technology can be in 'tight appropriability regime' or in 'weak appropriability regime'. Knowledge management can help firms categorize their technologies and give different levels of protection to the technologies which have different nature in an appropriability regime. Knowledge management also helps SMEs establish the balance between protecting proprietary

interests and achieving an open and trusting relationship.

7. Top management's win-win mindset facilitates trust building. Given the necessity of extensive communications at all organizational levels and functions that collaboration involves, the practicability of actually drawing boundaries around certain company assets is questionable. The challenge to a firm's management is to reach a balance between protecting the firm's proprietary interest and establishing trust and openness with its partners. Managers' win-win mindset is a key element to reconcile the underlying tension between the requisites of cooperation and the more natural tendency to compete.

8. Governments and legal systems play roles in trust building. In many countries, governments implement administrative, legal, and economical regulations to facilitate inter-organizational cooperation (see e.g. Oerlemans and Meeus, 1999; Dodgson, 2001; Bougrain and Haudeville, 2002). China's government system is transforming to adapt to a market-oriented economy. This new knowledge era and globalisation tendency presents further challenges to China's governmental administration. It has been argued that in some aspects, China's governmental administration interferes with the market too much, and in other aspects it has not undertaken its responsibilities very well. As the study of Dahlman and Aubert (2001) claims, special attention needs to be paid to the development of appropriate incentives for knowledge creation, valuation and protection.

A market economy requires environmental institutions to support it. Clear property rights, the enforcement of rights and rules defending contractual rights are imperative for an orderly market. As Dahlman and Aubert (2001) and OECD (2003) suggest, clearly defining property rights and enforcing them fairly and predictably is beneficial to both entrepreneurial Chinese people and foreign investors.

9. Firms in high-tech parks can benefit from the preferable policies towards tenant firms and also it is found that the trust-facilitating mechanism is developed much better inside the parks than outside. This may explain why high-tech SMEs favour regional industry clusters. The community of business culture and value operates a climate of trust. The administration in technology parks provides a variety of services, including being an intermediary in inter-firm cooperative engagement. This practice has been proposed and discussed by Nooteboom (1999) who suggests a trilateral governance to make cooperation more efficient and calls the mediatory role 'go-between'.

From the investigation of the current study into technology parks in China and relevant documentary reports, it can be seen that China's technology parks partly act as go-betweens. In pursuing the goal of facilitating local high-tech SMEs, technology park administrations, as an extension of the local governments assume the responsibility of assisting smaller firms with their development and maintaining a community of business culture and value within the parks. The survey in the current study found smaller firms situated in the parks commonly confirm that they have derived administrative support. Since most of technology parks are financed by local governments, at least in their early stages, governmental intervention in business is not avoidable. Governmental administration interference may have a negative effect. It is worthy of note that the ownership of high technology zones is in a state of transition regarding capitalization, and some of parks have become corporations with a substantial amount of shares held by governments. It is hoped that the corporate business model will lessen the downside of administration intervention and improve the services that development zones provide for SMEs.

Romijn and Albu's (2002) study is concerned with local industry cluster dynamism. According to the survey of the current study, there is no sign that companies based in technology parks lack dynamism due to being inward looking. It may be explained by the factor that park-based firms compete in markets across the country and globally rather than merely focus on local customers. However, considering the relatively short history of technology parks in China, both governments and companies need to be aware of keeping a sustainable dynamic. As Romijn and Albu (2002) suggest, effective area-based innovation policies for small high-tech firms should be those that strengthen local complementarities and thereby facilitate firms' strategies to capture specialized niches in leading international markets.

8.3 Limitations of the Study

1. The generalisability of the findings in this study is limited due to the sampling frame and the surveyed sector. Sample firms come from three national high-tech industrial development zones, which is a small percentage of the total 54 national high-tech zones in China. These three national zones are located in Shandong Province where the economy is about the average level of the country. Therefore, the representativeness of sample firms is limited due to the scope of geographical location and the development level of the regional economy. Sample firms come from information and communications technology industries. Prior studies have proved that the degree of innovativeness is correlated with technological opportunities in industries. The effect of cooperation on innovation performance may vary with industries. Additional research is needed to examine whether the results found here hold in other high-tech sectors. We should be aware that cooperation and its impact on innovation performance might present a different picture in other industries. Maturity of the technology, concentration of the market, and other industry-specific factors all matter. Additionally, the standard for classifying SMEs' size status varies with countries and classification objectives. This study adopts the classification standard issued by China's authority agencies. Attention also needs to be paid to this point.

2. Although the information and communications industry has a high level of homogeneity in technology, controlling for the effects of industrial sectors may

improve the examination of cooperative activities in general and in each of industrial sectors, involving software developers, computer and peripheral equipment manufacturing, and electronic and telecommunication equipment manufacturing. Through lack of information categorized by industrial sectors, this study is limited in taking into account the external industrial variables.

According to Lohrke et al. (2006), research has found that managers consider numerous external (e.g. industry growth rate) and internal (e.g. a firm's previous alliance experience) factors when considering alliance formation (e.g. Dollinger and Golden, 1992; Gulati, 1998). This study does not take industrial growth rate factor and previous alliance experience into account for firms' cooperation strategy decisions.

3. This study only focuses on cooperative relationships that are based on formal cooperative agreements. Informal relationships are not investigated. Audrestch (2001, p.18) states "Just as informal R&D is more important for small firms than for large corporations, informal research partnerships may also be of greater significance for small enterprises. These informal research partnerships clearly involve scientists from different firms and institutions working together, scientist mobility, as well as informal linkages among firms." According to Freeman (1991), it is generally recognized that in the technology accumulation process within firms and other organizations, tacit knowledge is often more important than codified formal

specifications, such as blue-prints, etc. Because tacit knowledge is so difficult to communicate, the movement of people, in addition to documents and drawings, is usually essential for effective technology transfer. Therefore, various informal networks are usually behind formal networks.

Interviewees from inexperienced firms also indicate that although they have not engaged in any formal cooperative activities, their firms have a wide range of informal relationships with other firms, such as know-how exchange.

4. To examine cooperation performance, a longer time frame under study is beneficial than a shorter time frame. Rothaermel and Deeds (2006) test hypotheses in the 25-year period between 1973 and 1997 in the biotechnology industry. Although a longer time period under study is more important in the biotech industry due to the nature of new drug development, a 3-year time horizon in this study is relatively short to examine the outcome of technological cooperation for product innovation. Additionally, it is assumed that cooperation strategy varies with the size of cooperative projects. This study does not take the size of projects into consideration.

8.4 Suggestions for Further Research

1. Based on the examination of the effects of manager characteristics on the propensity of firms to cooperate, a further step towards individual-level factors can be taken in seeking more explanation. According to Dickson and Weaver (1997),

managers with different entrepreneurial orientations and individualism/collectivism orientations respond to environmental uncertainty differently, and managers' perceptions of environmental uncertainty have significant effects on the propensity for alliance use. It suggests that an investigation of manager characteristics beyond their education level and managerial experience should be helpful to understand the role of leadership in cooperation strategy.

The resource construct in this study is built up by tangible resources, including manager characteristics, firm characteristics, R&D employee intensity and R&D expenditure intensity. It is assumed that intangible resources, such as technological and managerial resources, employee skills and knowledge of business environment (Hofer and Schendel, 1978; Grant, 1991) may have some relationships with firms' cooperation strategies. The literature has proposed many other classifications of resources; for example, Das and Teng (2000) classify resources into property-based resources and knowledge-based resources according to the characteristics of imperfect mobility, imperfect imitability, and imperfect substitutability. Further research could be conducted to investigate how different characteristics of resources that firms possess affect partner selection, the choice of cooperative mode and the performance of cooperation.

2. It is not uncommon that SMEs, obtaining technology from partner firms through technology transfer, re-develop and apply the technology to a specific field or niche

market. It could be important to examine whether a small firm should dedicate itself to radical innovation and whether incremental innovation strategy suits SMEs best. Further research into this issue would be helpful for SMEs to make effective technological cooperation strategy.

3. This study is conducted from the standpoint of SMEs. Further research to examine cooperative activities in paired firms would be helpful to understand the performance of cooperation as in the work of Park and Ungson (1997) and Judge and Dooley (2006). Park and Ungson (1997) investigate dissolution of joint ventures by analysing the differences of both sides, e.g. firm size differential, firm age differential and other significant factors. Judge and Dooley (2006) conduct their empirical research on matched-partners. A further study could follow this direction to improve our understanding of cooperation performance in all partnering firms involved.

4. This study has concluded that learning is a primary motive for firms entering into cooperation. It is necessary to design a set of measurements to evaluate the level of fulfilment in learning.

With regard to measurements of cooperation performance, Smith et al. (1995, p.16) propose that "Improving understanding of the causes and consequences of cooperation will probably require researchers to move away from simple bi-variate analyses of cooperation to more sophisticated multivariate longitudinal research methods." A longitudinal study can track the individual firms regarding how they switch their cooperation modes from one to another and what are the reasons behind the mode switch as firm age and size changes. As Littler et al. (1995, p.30) state, cooperation is "an evolutionary process with its form, scope, and the reasons for its initiation and continuation changing considerably over time." The analysis of innovation performance can be conducted by comparing the innovation performance supposedly affected by cooperation strategy to the innovation performance before adopting the cooperation strategy. A longitudinal empirical research would enable researchers to have greater understanding of the impact of cooperation strategy on innovation performance.

5. In the questionnaire design in this study, respondents are required to report the modes of cooperation in which they have been or intend to be involved. A further step could be taken to collect data by survey to discriminate how different modes of cooperation have different impacts on innovation performance. The literature has found that higher interdependency of partnerships has a positive impact on innovation whereas less interdependent partnerships, such as licensing, have a neutral impact. As suggested by Man (2003, p.18), "different types of alliances like licensing, joint ventures, public funded partnerships etc. need to be distinguished in order to meaningfully clarify the innovation effect of alliances." Further research is needed in this direction.

6. Managers' satisfaction and objective measurements are employed in this study to assess cooperation performance. As suggested by Smith et al. (1995, p.16), "many of the benefits of cooperation, at least to an organization, can be defined in non-economic terms; benefits might include faster cycle time of product to market, improved quality, higher-quality decision making, improved competitiveness, and so on. These dimensions can be seen as the intervening variables that help to explain why cooperation might enhance performance and satisfaction." Therefore, a further attempt to develop a broader and more proximal set of outcome variables would be beneficial in further research.

8.5 Summary

The idea that large firms, typically those operating in global markets, are the main players in inter-firm cooperation is inadequate. The results of this study suggest that inter-firm technological cooperation appears to be a much more widespread phenomenon than is generally suggested in the literature. SMEs are active players and take advantages of cooperative relationships to pursue growth strategies.

This study investigates the motives, the modes, and the performance of high-tech SMEs' cooperative activities. The broad research scope contributes to developing an integrated theory of inter-firm cooperation and helps to understand how a general theory of inter-firm cooperation might be constructed. As noted by Gray and Wood

(1991, p.3), “no single theoretical perspective provides an adequate foundation for a general theory of collaboration”. This study has made the attempt to expand the emerging general theory of inter-firm cooperation on the basis of relevant theoretical perspectives.

In high technology industries, it is not a firm’s choice as to whether it should undertake technological innovation since survival, competitiveness and growth depend on its ability to innovate. However, it is a firm’s choice to decide its innovation strategy, for example, go-it-alone or cooperation. Comparing to the development of competitive force theory, transaction cost theory and resource-based theory, empirical research of inter-firm cooperation in a framework based on these three theories is relatively infrequent and leaves many aspects unclear. This empirical study, using the theoretical lenses of competitive forces, transaction cost and resource-based theory, closely investigates high-tech SMEs’ cooperative activities. The results of the systematic analysis improve our understanding of the phenomenon of inter-firm technological cooperation and produces useful insights for management.

The key findings are:

(1) Successful cooperative practices do improve firms’ economic performance which meet primary motives for engaging in cooperation in the first place. More experienced firms achieve better performance in terms of sales and profitability.

(2) Cooperation does not have a significant impact on innovation in smaller firms. However, cooperation combined with larger firm size significantly enhances technological innovation in terms of patent creation.

(3) Experienced firms do not show a significant improvement in innovation performance compared to inexperienced firms. However, managers' perceptions of success in cooperative projects indicate a moderate accomplishment.

(4) High-tech SMEs are primarily motivated to cooperate for new market access, economies of scale or scope, technology transfer and learning from partners.

(5) High-tech SMEs cooperate mainly by means of joint development agreements, joint research agreements and joint ventures.

(6) Primary motives for and main modes of inter-firm technological cooperation change dynamically with firm age and size. The larger a firm's size is, the more likely it is that the firm is motivated by technology transfer and learning, and the more likely it is that the firm will set up joint ventures with partnering firms.

(7) Firm size is the only influential factor on the propensity of firms to cooperate.

(8) Resource complementarity, trust based communication and reciprocity, and contributing as promised are considered the fundamental success factors by all

surveyed firms. Firms that are successful in their cooperative practices put more emphasis on 'trust, communication and reciprocity' than firms that are not successful.

Managerial implications of this study include:

(1) Compared to their larger counterparts, high-tech SMEs have distinctive motives for cooperation which are determined by their resource-constrained nature and their particular growth strategy. Managers should consider these factors in formulating an effective cooperation strategy.

(2) The requirement of firm size implies that specific resource advantages are a prerequisite for firms entering into cooperation. Firms' access to needed resources externally is determined by the resources firms have in house. R&D intensity as an important innovative input should be emphasized at outset in order to enhance firms' innovative capabilities.

(3) Simple involvement in inter-firm cooperation does not guarantee improvement in innovation, and only successful cooperative activities make a difference.

(4) Relational factors, such as communications, reciprocity and trust, are at least as important as, if not more important than, business factors. Effective cooperative activities call for managers' attention to both cooperative relationships and compatible technology strategies.

(5) The objective measurements are not sufficient to assess the performance of cooperation, at least in the short term. Managers' perceptions supplement the measurements on the performance of cooperation.

The generalisability of the findings to other countries and other industries should be cautious due to the context which sample firms come from and the moderate size of sample. Limitations also exist in not being able to control for the external industrial variables, not taking informal relationships into account, and not being able to fully capture the innovation outcomes due to the shorter time frame.

The following future research directions are indicated: (1) how resource characteristics shape firms' cooperation strategy, (2) what innovation strategy suits SMEs best, (3) investigating cooperative activities among paired firms, (4) conducting a longitudinal study to investigate the dynamics of motives for and modes of cooperation and innovation performance before and after adopting cooperation strategy, (5) examining the relationships between the modes of cooperation and the innovation effects of cooperation, and (6) developing a broader and more proximal set of outcome variables to assess cooperation performance.

Appendices

Appendix A: Abbreviations

ICT: information and communications technology

Innofund: Innovation Fund for Small Technology-based Firms

IPRs: Intellectual property rights

KBV: knowledge-based view

M&As: mergers & acquisitions

RB: resource-based

RBV: resources-based view

RMB: Ren mi bi – Chinese curency

SIPO: State Intellectual Property Office (China)

SMEs: small and medium-sized enterprises

SRPs: strategic research partnerships

TC: transaction cost

TPP: technological product and process

Appendix B-1: Covering Letter for the Postal Questionnaire (English)

June 2005

Dear Sir or Madam

Re: A Survey on Inter-firm Technological Cooperation

I have the pleasure of informing you that we are conducting a research project on "Inter-firm technological cooperation" sponsored by the Bangor Business School, University of Wales, UK and the Management School, Shandong University, China. This survey aims to investigate how small and medium-sized high-tech firms practice inter-firm cooperative activities to enhance their technological innovation.

Your firm has been randomly selected to take part in this research. I would like to emphasize that your participation and invaluable comments are very important for us. In order to get meaningful and accurate results from this survey, it is very important that the questionnaire is completed either by yourself or a senior manager who has been fully and directly responsible for cooperative innovation activities.

The results of this survey will be presented in aggregate form, and in such a way that no single firm can be recognised. All information gathered in this survey will be held in the strictest confidence, and will never be disclosed to a third party. More specifically, the gathered data will be used solely for academic and scientific purposes.

We would be grateful if you could allocate 15 minutes of your time to complete the enclosed survey questionnaire and return it to the researcher. For your convenience, a prepaid and self-addressed envelope is enclosed with this letter.

I would like to take this opportunity to thank you for your invaluable comments and for participating in this research.

Yours sincerely

Dan Chen
PhD researcher in School for Business and Regional Development, University of Wales, Bangor, UK
Associate professor of Management School, Shandong University, China
Tel:
Mobile:
Fax:
Email:

Appendix B-2: Covering Letter for the Postal Questionnaire (Chinese)

企业间技术合作问卷调查

尊敬的女士/先生，

很荣幸向您介绍我们正在进行的"企业间技术合作"社会调查。该项目由英国威尔士班戈大学商业与地区发展学院和中国山东大学管理学院资助，目的在于了解中国高科技中小企业对企业间技术合作战略的态度和实践。本调查关注的技术创新合作包括所有为促进产品技术创新而开展的企业之间的合作活动。

本调查采取随机取样的方法确定样本，贵公司被随机抽选为样本企业。您的参与和建议对我们的研究意义重大。为了本项调查能取得真实准确的数据，由您本人或全面直接负责合作创新活动的高级管理人员填写该问卷至关重要。

该问卷调查所收集的数据只用于学术研究，不用于任何商业目的。我们将以最严格的形式保守信息秘密，公司的独立资料将永远不会被暴露给任何第三方。

我们已经为您准备了一份已付邮资并写有地址的回复信封，如果您能够花费 15 分钟的时间完成该问卷，并费心尽快将完成的问卷寄回本研究者，我们将不胜感激。

请允许我再次利用这个机会对您参与本项调查及给予的支持表示诚挚的谢意。

陈丹

2005 年 6 月

英国威尔士班戈大学商业与地区发展学院在读博士
山东大学管理学院副教授
电话：
传真：
移动电话：
电子邮箱：

Appendix C-1: Postal Questionnaire (English)

A Questionnaire Survey on Inter-firm Technological Cooperation

Inter-firm technological cooperation refers to those inter-firm cooperative relationships by which technology transfer or joint technological innovation activities are pursued under agreements between two or more firms. The cooperative relationships solely aim at manufacturing or marketing are excluded.

Section One: Basic Information

1. Personal details: Age__________

Gender: □ Male □ Female

Educational qualification:
□ Graduate from high school or below
□ Graduate from college or university
□ Postgraduate with Master degree or Doctoral degree

How many years have you worked in senior management in your career? __________

Are you the founder or one of the founders of this firm? □ Yes □ No

2. In which year was the firm established? __________

3. How many employees did the firm have over the past three years?
2002__________ 2003__________ 2004__________

4. How many R&D employees did the firm have over the past three years?
2002__________ 2003__________ 2004__________

5. How much was the firm's R&D expenditure over the past three years?
(Unit: ¥10000)
2002__________ 2003__________ 2004__________

6. How many new products had been commercialised over the past three years? __________

Of them, how many were innovative in global markets? __________

7. How many patents had been filed over the past three years? __________

How many patents had been granted over the past three years? __________

8. What were the firm's annual sales over the past three years? (Unit: ¥10000)
2002__________ 2003__________ 2004__________

9. What was the firm's annual after-tax profit over the past three years?
(Unit: ¥10000)
2002__________ 2003__________ 2004__________

10. How many inter-firm technological cooperation activities had the firm engaged over the past three years? __________

If the answer is '0', is the firm intending on engaging in such kind of activity in the near future?
□ Yes □ No

11. What concerns might prevent the firm from inter-firm technological cooperation? (Please tick all boxes that apply)

□ Technology leakage
□ Loss of control/ownership
□ Distraction from main goal
□ Lack of experience
□ Lack of personal relationship
□ Legal issue
□ Diverse organizational culture or value
□ Others (please specify)

12. With respect to the inter-firm technological cooperation activities practiced over the past three years, what is the proportion of successful cooperation activities in your opinion?

□ Almost all
□ A large proportion
□ Nearly half
□ A small proportion
□ None

13. In general how important do you consider inter-firm technological cooperation to your business?

□ Very important
□ Important
□ Uncertain
□ Less important
□ Unimportant

Section Two: Strategic Management of Inter-firm Technological Cooperation

14. What are the primary motives for deciding to engage in inter-firm technological cooperation? (Please tick the top three only)

□ Financial support
□ Specific experts
□ Manufacturing or marketing support
□ New market
□ Economies of scale or scope
□ Sharing risk and cost
□ Technology transfer
□ Learning from partners
□ Others (please specify)

15. What are the partners' (or potential partners') primary characteristics? (Please tick all boxes that apply)

□ Domestic firm
□ Foreign firm
□Within hi-tech development district
□ Outside hi-tech development district
□ Large firm
□ Small and medium-sized firm
□ Supplier
□ Customer
□ Competitor

16. In what forms of inter-firm technological cooperation had the firm engaged or intends to engage? (Please tick all boxes that apply)

□ Research corporation
□ Joint venture
□ Minority holding
□ Joint research agreement
□ Joint development agreement
□ Customer-supplier R&D contract
□ Second sourcing agreement
□ Licensing
□ Others (please specify)

17. Please assess each of the following factors' impact, in your opinion, on making cooperation successful.

	Very important	Important	Uncertain	Less important	Not important
Resource complementarity					
Flexible organizational And managerial style					
Geographical proximity					
Well-documented agreement					
Safeguards in place for protecting core technology					
Ongoing monitoring and coordinating					
Trust, communication and reciprocity					
Top leader's commitment					
Sufficient cooperative resources					
Milestone appraisal					
Adjusting to external change					
Compatible technology and business strategies with partners					

18. The factors below are considered to be detrimental to cooperation. What is your opinion?

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Only focusing on short-term financial performance					
Unilateral dependency on partners					
Not contributing as promised					
Time-consuming Decision making					
Lack of compatibility in technology, management and organization					

19. What are your firm's limitations in absorbing new technology from cooperation?

□ Financial limitation in enhancing in-house R&D activity
□ Shortage of qualified scientists and engineers
□ Lack of high level of employee involvement in innovation activity
□ Others (please specify)

20. Please attach your business card to the completed questionnaire and send them back to the researcher if you'd like to get a summary report under this research programme.

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE.

Appendix C-2: Postal Questionnaire (Chinese)

对企业间技术合作活动的问卷调查

企业间技术合作指两个或两个以上的企业以技术转移和合作创新为宗旨而建立的合作关系。单纯为加工制造或营销而建立的企业间合作关系不在本调查范围内。

第一部分：企业基本信息

1. 个人信息

   年龄：__________岁

   性别：　□男性　　□女性

   受教育程度：

   □高中毕业及以下　　□大学专科及本科毕业　　□研究生毕业及以上

   在您的职业生涯中，您有多少年的高级管理工作经历？__________年

   您是该企业的发起人或发起人之一吗？　□是　　□不是

2. 该企业成立于哪一年？__________

3. 过去三年中(指 2002-2004，以下相同)，该企业的职工人数分别为多少？

   2002 年__________　　2003 年__________　　2004 年__________

4. 过去三年中，该企业专门从事研究与开发的职工人数分别为多少？

   2002 年__________　　2003 年__________　　2004 年__________

5. 过去三年中，该企业用于研究与开发的支出分别是多少？（单位：万元）

   2002 年__________　　2003 年__________　　2004 年__________

6. 过去三年中，该企业有多少新产投入市场？__________

   其中，有多少是国际市场上的创新？ __________

7. 过去三年中，该企业有多少项专利申请予以受理？__________

   其中，有多少专利申请获得注册登记？__________

8. 过去三年中，该企业的年销售额分别是多少？（单位：万元）

2002 年__________ 2003 年__________ 2004 年__________

9. 过去三年中，该企业的年税后利润分别是多少？（单位：万元）

2002 年__________ 2003 年__________ 2004 年__________

10. 过去三年中，该企业共参与多少项企业间的技术合作活动？________

如果目前尚未开展企业间技术合作，该企业是否有近期开展合作的意向？

□是 □否

11. 您对企业间建立技术合作伙伴关系会有哪些顾虑？（请您最多选择三项）

□核心技术泄露
□丧失控制权或所有权
□分散企业的主要目标
□缺少经验
□缺少个人关系
□法律纠纷
□不同的组织文化和价值观
□其它(请详细说明)

12. 针对该企业过去三年技术合作的实践，您认为合作成功的比例是多少？

□几乎所有的合作都是成功的
□成功的合作占很大比例
□接近一半的合作取得成功
□成功的合作占很小比例
□几乎无一成功

13. 根据您的总体评价，企业间技术合作对该企业重要性如何？

□非常重要
□重要
□尚不明确
□不太重要
□根本不重要

第二部分：对企业间技术合作的战略管理

14. 以下哪些方面是该企业决定开展技术合作的主要动机？(请您最多选择三项)

□获取资金支持
□获取急需的专业人员
□获取制造或销售方面的援助
□开拓新的市场
□实现规模经济
□分担风险和成本
□通过技术转移获取知识和技术
□通过建立合作关系向合作伙伴学习
□其它(请详细说明)

15. 该企业技术合作伙伴(或潜在合作伙伴）的特征？（请您选择所有适用项目）

□内陆企业(位于大陆的内资企业、港澳台投资企业及外国投资企业)
□港澳台企业及外国企业
□高新技术开发区内的企业
□高新技术开发区外的企业
□大型企业(职工人数为 2000 及以上的企业)
□中小型企业(职工人数在 2000 以下的企业)
□供应商
□客户
□同业竞争者

16. 该企业已经采用或打算采用下列哪些技术合作形式？（请您选择所有适用项目）

□合资组建科研公司
□组建合资企业
□少量持股
□签署联合研究协议
□签署联合开发协议
□供应商与客户之间的联合研究与开发合同
□分包协议
□特许权
□其它(请详细说明)

17. 请您评价以下要素对企业间技术合作能否取得成功的影响程度？

	非常重要	重要	不明确	不太重要	根本不重要
优势互补	□	□	□	□	□
灵活的组织和管理风格	□	□	□	□	□
地理上毗邻	□	□	□	□	□
协议条款斟密完善	□	□	□	□	□
对核心技术的适当保护	□	□	□	□	□
从始至终的监控和协调	□	□	□	□	□
诚信、交流和互惠	□	□	□	□	□
企业领导者的承诺和支持	□	□	□	□	□
充足的人员和资金预算	□	□	□	□	□
阶段性成就评价机制	□	□	□	□	□
根据外部环境的变化调整合作	□	□	□	□	□
与合作伙伴的技术和经营战略相匹配	□	□	□	□	□

18. 下列要素被认为不利于合作的成功，请问您是怎样看待的？

	完全同意	同意	不明确	不同意	完全不同意
仅关注近期的财务业绩	☐	☐	☐	☐	☐
对合作伙伴的单方面依赖	☐	☐	☐	☐	☐
不按承诺履行责任	☐	☐	☐	☐	☐
耗时的决策程序	☐	☐	☐	☐	☐
在技术、管理和组织方面缺少兼容性	☐	☐	☐	☐	☐

19. 在学习和吸收新技术方面，该企业受下列哪些因素的局限？（请您选择所有适用项目）

☐资金短缺限制了企业内部的研发活动能力
☐缺少高水平的科学与工程技术人员
☐员工参与创新活动的程度不高
☐其它(请详细说明)

20. 如果您希望得到一份该调查项目的分析报告，请附上您的工作名片随该问卷一并寄回。我们会在该研究项目完成后尽快发送给您一份研究汇总报告。

感谢您的支持与合作！

Appendix D: Data transformation

Variable	Skewness of non-transformed data	Skewness of log-transformed data
Firm age	2.748	.441
Firm size	2.635	.326
R&D expenditure intensity	5.517	.406
Filed patent intensity	5.114	-.345
Granted patent intensity	3.110	-.793
New product intensity	7.968	-.505
Globally new product intensity	3.145	-.063
Sales intensity	2.327	-.266

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