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RESEARCH ON TECHNOLOGICAL INNOVATION AS SEEN THROUGH THE CHINESE LOOKING GLASS

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The rapid development of the Chinese economy during the 1990's has intensified research on technological innovation. Recent policy emphasis on innovation as a path to sustainable economic growth will only accelerate work on this important topic. The work by individuals and groups at various research institutes and universities has mainly been published in leading Chinese scholarly journals. In this paper, we develop a framework and do a substantive review of the literature to characterize the state of knowledge about technological innovation in China, with special emphasis on: 1) conceptual contributions, 2) empirical results, and 3) connections between innovation and performance.

INTRODUCTION

Chinese scholars, like their peers elsewhere, have long agreed on the importance of innovation in determining financial success and survival of enterprises. At the macro level, innovation is held to be the prime driver of historical growth of industrial economies, and increasingly of current and future growth of industrializing economies. At the micro level, innovation has been shown to be one of two prime drivers of firm profitability in both manufacturing and services, the other prime driver being leading market share in growing markets (Capon, Farley and Hoenig, 1996) Along with

the speeding up of technological and economic development, the rate of innovation is speeding up year by year. For instance, in 1940, the average life-cycle of household products was about 22 years; while 90% of newly introduced products are now replaced in less than 4 years. While innovation is increasingly an indispensable strategic tool, the intensified global competitive environment has made the benefits of innovation erode more quickly. In 1935, the real benefits to the firm could be expected to last perhaps 15 years, while in 1998, the period is down to 2 or 3 years in many cases. All of the importance and dynamics of innovation have made it a challenging research area for academics around the world. The rapid development of China's economy during the 1990's has also intensified Chinese research on technological innovation. Recent policy emphasis on innovation as a path to sustainable economic growth will only accelerate work on this important issue. The purpose of our work is to provide an integrative summary of important research, both conceptual and empirical, on technological innovation which has appeared in leading Chinese scholarly journals in the last decade. In this paper, we try to present a substantive review of the literature, with special emphasis on: 1) important conceptual contributions, 2) conclusive empirical findings, and 3) connections between innovation and performance.

Background of Chinese Research about Innovation

Work of individuals and groups on innovation at various research institutes and universities has mainly been published in leading Chinese scholarly journals. An intensive literature search revealed about 160 articles dealing with innovation in a half dozen leading Chinese journals, and most of these publications have been fairly inaccessible to the international scholarly community. The heavy scientific emphasis of the journals is reflected in the fact that much of the research was supported by the Natural Science State Foundation (NSSF), and 29 of the 166 papers reviewed claimed sponsorship by the NSSF Chinese Technological Innovation Study. The top 7 Chinese scholarly journals as the source on technological innovation are: Scientific Management Research (49 articles), Science Research Management (48 articles), Science & Technology Policy and Management (31 articles), Science & Technology Progress and Policy (11 articles), Studies in Science of Science (10 articles), Science of Science and Science & Technology Management (9 articles) and Journal Industrial Engineering / Engineering Management (8 articles).

The great majority are conceptual studies based on theoretical analysis or logical reasoning, with only about 30 papers having empirical results derived from survey data. Among the empirical pieces, many individual papers shared raw data from surveys of large samples of Chinese firms (see Table 1).

Our focus is on Chinese studies on innovation, but they have some important connections with the Western literature on innovation. For example, the Chinese papers which our study focuses on, make multiple references to Joshph Shumpeter's The Theory of Economic Development and Business Cycle, C. Freeman's The Economics of Industrial Innovation, P. Stoneman's The Economics of Technological Change, R. Nelson's Understanding Technical Changes as an Evolutionary Process, N. Rosenberg's Perspectives on Technology, M. Kamien and N. Schwartz's Market Structure and Innovation and C.F.Carter and B. Williams's Industry and Technical Progress. However, in comparison with Western innovation literature, we also find that the Chinese studies are much more focused on improvement than on either conceptual developments or empirical validation of the impact of innovation (e.g. Capon, Farley and Hulbert and Lehmann, 1992).

Table 1. Representative Large-Sample Surveys of Innovation in Chinese Firms.

Author	Year	Research Question	Sample	Note
Shoupeng Deng, Ke Ma, Yuchuan Zhao and Fei Feng	1996	Factors related to innovation performance	1947 firms of an inland and an coastal province	Conducted by the Development Research Center of the State Council
Huasheng Zhang, Jianchen Guan and Baoyang Gao	1997	Factors hindering technological innovation	1258 firms (including 1034 technological firms)	NSSF sponsorship

Table 1. (Continued)

Author	Year	Research Question	Sample	Note
Jian Gao and Jiaji Fu	1996	Effects of technological innovation on corporate performance, and factors related to innovation performance	1051 manufacturing firms	NSSF sponsorship Conducted by Tsinghua U.
Yi Liu, Yuan Li and Tieding Yang	1997	Effects of technological innovation on corporate competitiveness	823 state-owned industrial firms	NSSF sponsorship Conducted by Xi'an Jiaotong U.
Statistics Bureau of Haerbin	1997	Innovation performance and related factors	331 industrial firms based in Haerbin	A part of a nation-wide survey on innovation organized by the State Academy of Science and the State Statistics Bureau
Chi Ma and Weiwen Jia	1992	Comparative study on innovation performance and related factors	145 industrial firms based in two medium-sized cities	Compared with innovation studies conducted in Nordic countries

The results in Table 1 probably reflect the fact that, major Chinese academic achievements are made by research teams of a few notable universities and institutions (see Table 2).

Table 2. 7 Major Research Teams Engaged in the Study of Innovation.

Institute	Number of Articles	Number of Researchers	Main Researchers
Zhejiang University	51	26	Qingrui Xu; Jiang Wei; Jin Chen; Bin Guo; Gang Zhang
Tsinghua University	35	18	Peigong Shi; Jiaji Fu; Jiaxiao Lei; Jian Gao; Xielin Liu
Development Research Center of the State Council	25	8	Ke Bao; Shoupeng Deng; Fei Feng

Table 2. (Continued)

Institute	Number of Articles	Number of Researchers	Main Researchers
Wuhan Automotive Industry University	13	7	Kefan Xie; Shuhua Hu; Junkang Wan
Xi'an Jiaotong University	9	8	Yuan Li; Yingluo Wang
Huazhong Science & Technology University	8	11	Xixian Cai; Shaobing Chen; Yanhua Lian
*CSTPDRC	7	7	Chi Ma; Weiwen Jia

* CSTPDRC refers to China Science & Technology Promotion and Development Research Center.

Innovation in China: The Basic Current Situation

As far as innovation performance is concerned, Chinese firms are active in developing new products and processes, and the levels of contribution of innovation to sales revenue, profits and exports are in line with the rest of the world. As reported in Statistics Bureau of Haerbin (1997), products derived from technological innovations account for 14.8% of corporate sales revenue, 30.9% of profits and 52.2% of exports; and the ratio of the number of new products to the total number of products is 0.20. According to Zhang, Guan and Gao (1997), 26.6% of sales revenue and 16.2% of profits are generated by new products, and the ratio of the number of new products to the total number of products is 0.39.

Innovation in China tends to be concentrated, with the minority of firms considered as innovative (see Table 3). A relatively large part of sales revenue of the innovative Chinese firms is generated by products at introductory and growth stage of the life cycle. By contrast, non-innovators depend more on products at growth and mature periods.

Table 3. Products and Revenues by Life Cycle (Zhao, 1996a).

	Total sample firms (1946)		**Firms having conducted technological innovation (874)**		**Firms having no technological innovation (1072)**	
Stage of product life cycle	Number of products (%)	Sales revenue (%)	Number of products (%)	Sales revenue (%)	Number of products (%)	Sales revenue (%)
Introductory	11.6	8.8	15.4	11.3	--	--
Growing	36.7	46.4	35.5	45.5	40.1	49.9
Mature	40.4	40.9	38.1	38.9	47.9	47.5
Declining	11.3	3.9	11.0	4.3	12.0	2.6

Ma and Jia (1992) compare contributions of innovation to sales revenue in various sizes of Chinese firms with those in firms of 3 Nordic countries. (Due to data availability problem, only the Nordic countries are included in their comparative study.) They found large Chinese firms derive a larger share of revenue from innovation than smaller firms, while the opposite is often the case in the West (Nordic countries):

Share of Revenue from Innovation	**Total sample (%)**	**Large-sized (%)**	**Medium-sized (%)**	**Small-sized (%)**
Yichang (China)	29	37	26	29
Nanyang (China)	26	40	24	16
Denmark	30	28	31	50
Finland	23	21	29	33
Norway	10	18	10	40

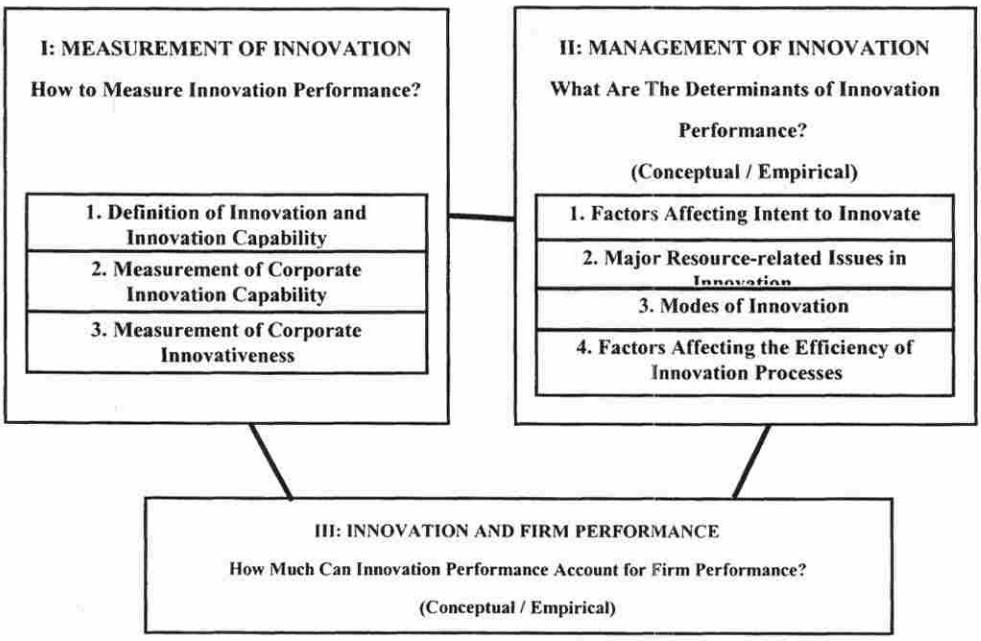
Innovations of Chinese firms, however, do not tend to be novel at international level, and the innovations are primarily "new to themselves" rather than "new to the world". As reported in Statistics Bureau of Haerbin (1997), 12.9% of innovations of Chinese firms are novel at firm level, 18.7% at provincial level, 61.3% at national level and 7.1% at international level. Gao and Fu (1996) also report that 66.6% of internal R&D results of Chinese firms are novel at firm level, 30.0% at national level, while only 3.4% at international level. As another indicator, the number of patents in possession of Chinese firms is very small, averaging 0.04 per firm in 1991 – 1993 (Gao and Fu, 1996). This pattern of performance in innovation

reflects the fact that, while Chinese firms are generally entrepreneurial, they have to substantially enhance their technological competence and strengthen their real R&D capabilities before they can become leading innovators in the world.

A FRAMEWORK FOR INTEGRATING FINDINGS OF CHINESE INNOVATION STUDIES

Because a wide variety of issues related to innovation are studied by Chinese researchers, we believe an integrative framework is needed that provides us with a comprehensive and coherent characterization of the state of knowledge about innovation in China. We use such an integrative framework to organize this paper (see Figure I).

Figure I. A Framework for Examining Chinese Research on Technological Innovation.



Looking at the long list of diverse topics of the papers reviewed, we find that three broad aspects of research questions can be generalized from it, including: how to measure innovation performance, what determines innovation performance, and how innovation performance accounts for firm performance. Taking these three aspects as central themes, we group individual studies into three building blocks as shown in Figure I.

In Block I, "Measurement of Innovation", we place studies which set out to establish valid and reliable measurement systems for two central indicators of innovation performance: corporate innovation capability and corporate innovativeness. Block I is further divided into three subgroups, which are addressed respectively as 1) Definition of Innovation and Innovation Capability, 2) Measurement of Corporate Innovation Capability and 3) Measurement of Corporate Innovativeness. In the first subgroup, we include representative definitions of innovation and innovation capability underlying most of the literature reviewed, from which we generalize about the Chinese conceptualization of innovation and innovation capability. The second subgroup of studies are concerned with calibrating innovation inputs and potential, while the third subgroup of studies look at innovative activities from the output side.

In Block II, "Management of Innovation", studies are primarily concerned with managerial issues related to good or poor innovation performance. A great deal of the conceptual material in the body of research as a whole is in this block. Most Chinese researchers hold the view that "lack of intent to innovate" and "lack of resources for innovation" are the two biggest obstacles to improvement of innovation performance of Chinese firms. Two large sets of studies center on finding answers to such matters as 1) what determines a firm's intent to innovate and how can the Chinese firm be made more active in supporting innovative initiatives, and 2) what is the current situation of resources for innovation in Chinese firms and what are the solutions to resource-related problems. We also find two other facets attracting substantial amounts of research interest. The first centers on lively debate over what is the "appropriate mode of innovation" for Chinese firms. A typical research question in this area is, for example, "How should a Chinese firm choose from alternative modes of innovation – "independent innovation" which is based on indigenous R&D, "secondary innovation" which is based on adoption of introduced technologies, or "cooperative innovation" which draws on external R&D resources." The second area of interest has to do with the efficiency of innovation processes. Considering the process of innovation as a sequence of interrelated actions ranging from new idea generation to new product launches, a num-

ber of Chinese researchers look into phases of the process separately, and identify factors perceived to affect the risk level and the input-output relationship of innovation projects. These four major directions of research on managerial issues related to innovation performance are addressed respectively as 1) Factors Affecting Intent to Innovate, 2) Resource-related Issues in Innovation, 3) Modes of Innovation and 4) Factors Affecting the Efficiency of Innovation Processes (see Figure I).

Clustered in relatively small Block III are an important set of studies which emphasize connections between "Innovation and Firm Performnce". Chinese researchers agree that good innovation performance itself is not the ultimate goal; the final objective of becoming more innovative is to improve firm performance – to be more competitive and profitable through innovation as one direction of both strategic and daily managerial efforts. It is of theoretical and practical significance to pin down the relationship between innovation and firm performance, rather than just taking for granted that improved innovation performance will bring improved firm performance as a general matter. Conceptual and empirical work dealing with both innovation and performance are discussed in this section.

MEASUREMENT OF INNOVATION: "WHAT IS MANAGEABLE MUST BE MEASURABLE"

A substantial amount of work has been done in Chinese on the measurement of innovation. We divide this work into three parts: 1) definition of innovation and innovation capability, 2) measurement of corporate innovation capability, and 3) measurement of corporate innovativeness.

Definition of Technological Innovation and Innovation Capability

Before examining measurements of innovation, we look at several definitions of technological innovation and innovation capability in Chinese literature which resemble, and yet differ from those used in studies of elsewhere. This will help us to get a more comprehensive understanding of how the Chinese researchers interpret these two fundamental concepts.

In Guan *et al* (1993) technological innovation is referred to as "the commercialization and industrialization of science & technology achievements." Similarly, Gao (1996) hold that to implement technological innovation is to transform science and technology achievements into new features of products and processes. Wang (1994) stresses that innovation is

the process by which a firm generates new and improved products or production processes, but that the sources of innovation could differ greatly between firms in a developing country like China and those in developed economies. As he reasons, there is already a large pool of technologies available in a modern information society, the sources of new ideas or new technologies could either be internal or external, especially for firms in industrializing countries.

In Chinese empirical studies, technological innovation is generally defined as activities to develop new products and/or processes. The means to realize innovation are usually divided into three categories: 1) through internal R&D; 2) through technology acquisition; and 3) through secondary innovation – R&D on the basis of acquired technologies and equipment. In practice, innovation is often carried out in some kind of mixture of the above three approaches.

Fu (1996) argues that it is the "innovation spirit" – constantly setting one's mind on generating new things that are unique and superior – that distinguish innovators from non-innovators, rather than the means, sources or technological levels of innovation. We find Fu's point of view a fair generalization of the essential interpretation of the Chinese literature, i.e., to be innovative is to 'make every effort to bring to marketplaces new products/services which are unique and superior with respect to competitors'.

Measurement of Corporate Innovation Capability

The definition of innovation capability is naturally associated with the broad definition of innovation. For example, Gao (1996) defines corporate innovation capability as the capability to better satisfy or create market demands and thus to enhance corporate competitiveness through developing or introducing new products and new processes. In this view, innovation capability has seven components, including intent to innovate, resources for innovation, management of innovation, R&D capability, manufacturing capability, marketing capability and impact of innovation on performance.

Wei (1995) approaches corporate innovation capability from the perspective of technological innovation process. He divides the whole process of technological innovation into 6 stages: 1) identifying opportunities, 2) generating new ideas, 3) finding potential solutions, 4) deciding on the optimum solution as the direction of further R&D efforts, 5) implementation of R&D program, 6) manufacturing and marketing of R&D outcomes.

Corporate innovation capability is embodied in a) innovation decision-making capability, b) R&D capability, c) manufacturing capability and d) marketing capability. Capability of organizing serves as a fundamental condition for the exertion of the other four capabilities, and hence e) capability of organizing various innovative efforts should also be included as a component of corporate innovation capability. Guan *et al* (1993) and Gu and Zhang (1993) Yang, Zhao and He (1994) and Xia, Yuan ad Wu (1997) give similar definitions of innovation capability.

Measurement of Corporate Innovativeness

Corporate innovativeness is mainly measured in terms of the outputs of innovative activities. Frequently used measures in the Chinese literature include: 1) the proportion of sales revenue derived from products at introductory and growing stages; 2) the level of novelty (uniqueness and superiority) of technological innovations; 3) the number of patents in possession; 4) the ratio of the number of new products to the total of all products and 5) the average product life cycle for products of a given firm.

Table 4 lists measurements of corporate innovativeness (along with the signs used in weighting them to an aggregate index) that have been employed in empirical studies on technological innovation:

Table 4. Measurements of Corporate Innovativeness Used in Empirical Studies.

Yang, Zhao and He (1994)
1. The proportion of sales revenue derived from new products, weighted at 0.35 (+)
2. The probability of commercial success for new products, weighted at 0.30 (+)
3. The ratio of the number of new products to the total number of products, weighted at 0.20 (+)
4. The number of process innovations, weighted at 0.10 (+)
5. The duration for average product innovation, weighted at 0.05 (-)
Chen, Geng and Smith (1997)
1. The average product life cycle for products of a given firm (-)
2. The ratio of the number of technological innovations to the total number of prod ucts (+)
3. The share of sales revenue derived from technological innovations (+)

Table 4. (Continued)

Statistics Bureau of Haerbin (1997)
1. The proportion of sales revenue derived from products out of technological innovations (+)
2. The proportion of corporate profits derived from products out of technological innovations (+)
3. The proportion of export revenue derived from products out of technological innovations (+)
4. The level of novelty of technological innovations (+)
5. The income derived from technology transfer (+)
Zhang, Guan and Gao (1997)
1. The ratio of the number of new products to the total number of products (+)
2. The proportion of sales revenue derived from new products (+)
3. The proportion of profits derived from new products (+)
Zhao Yuchuan (1996b)
1. The proportion of sales revenue derived from products at introductory and growing periods of product life cycle (+)
2. The proportion of products at introductory and growing stages (+)
3. The number of technological innovations per 1000 employees (+)

The key in these measurements is the definition of "new product". According to the Statistical Bureau of China (SBC), a new product is defined as a completely new product which adopts technologies and designs that have never been used before, or a product whose performance has been greatly improved or whose costs have been greatly reduced by structural, material or process changes. Furthermore, the SBC categorizes a new product by the geographic level at which the product is novel. Thus, a new product could be 'new' at the firm, provincial, national or international level. According to Liu Xielin (1997), the majority of new products in China are at the provincial level, implying that most innovation consists of incremental changes to existing products or processes. The large size and relative autonomy of the provinces in promoting R&D projects in both local firms and local research institutes also contribute to the regional nature of most innovations in China. Most firms are also regionally focused rather than nationally focused since the local markets can be quite large.

Indeed, nine of China's 26 provinces have populations of over 50 million, putting them on a potential scale of the large Western European countries. While the characterization of 'new' products is somewhat different from that in developed countries, the innovative activity they represent is an important indicator of Chinese firms' efforts to generate new products and catch up with more advanced technology.

MANAGEMENT OF INNOVATION

The majority of the research discussed in this paper deals broadly with issues of management, including 1) factors affecting intent to innovate, 2) major resource-related issues in innovation, 3) modes of innovation and 4) factors affecting efficiency of innovation processes.

Conceptual Work on Management of Innovation

Management of innovation is a complex process that involves economic reasoning, social practices, psychological influences, and planned integration of initiation, organization and resources allocation (Wu, 1995). Chinese scholars have written papers on a wide variety of factors that are perceived to affect innovation performance -- some factors supportive, some barriers to innovation. These factors originate from a multitude of considerations, such as the state of knowledge in science and technology, the economic and political conditions of the society under investigation, patterns of innovators' attitudes and behaviors, etc. (Guan, 1996). In this section, we examine these factors and their implications for Chinese firms.

Factors Affecting Intent to Innovate

The notion of "intent to innovate" (Wang and Xu, 1993) -- as well as other similar perspectives (Xiang, 1994, Li, 1993, and Shi, 1993) -- has been important in explaining differing innovation performance of Chinese firms. Xiang (1994) attempts to answer what incentives or pressures are driving some Chinese firms to innovate in products and processes, and what the reasons are for the lack of motivation to innovate in other firms. Li (1993) is concerned about that the reward systems of Chinese firms should be reformed so that both managerial and technical people will take more initiative in supporting and implementing innovative actions. Jiang and Shi (1993) examine what causes some firms to make aggressive in-

vestments in R&D, product development and process engineering, while others put excessive resources into non-innovative activities such as procuring capital goods, unrelated diversification etc. The essence of these questions is best captured by the term "intent to innovate" as introduced in Wang and Xu (1993). As they put it, the intent to innovate of a firm is reflected at three levels: 1) the priority of the policy of 'pursuing competitiveness through innovative products and processes' in its corporate strategy, 2) the extent to which senior management are engaged in innovative actions, and 3) the commitment of its technical people and personnel of other functions involved to innovation. The underlying presumption is straightforward: the more strategic emphasis a firm puts on innovation as a competitive tool, the more committed senior management is in seeking and meeting technological opportunities as well as market opportunities with new products and processes, and the more motivated employees are in carrying out innovation projects from initiation to conclusion, the better a firm will do in innovation and (presumably) the better the firm will perform.

Two reasons make "intent" of special interest to the Chinese researchers studying factors affecting innovation performance. First, they have found that strong intent to innovate is a precondition for good innovation performance (Guan and Guo, 1993). Therefore it is important to get in-depth understanding about forces that are influencing intent to innovate of Chinese firms. Second, weak intent to innovate is perceived by some Chinese researchers as the fundamental cause for unsatisfactory innovation performance of Chinese firms in general. Xiang (1994), Feng (1995), Wan and Wang (1997) all agree that, in a large number of cases, the major reason for not innovating is neither lack of resources nor lack of opportunities, but rather the lack of motivation to innovate, which is itself the result of various underlying factors. Naturally, Chinese researchers holding this belief have felt the immediate need to solve the puzzle of "intent to innovate".

Many factors perceived as salient to Chinese firms' intent to innovate have been studied. For example, Li Nujiang (1993) studies individual characteristics of innovative decision-makers and R&D personnel; Xiang (1994) relates organizational features to the formulation of aggressive technological innovation policy; while Wang and Xu (1993) conclude with suggestions for encouraging innovation at macro level. In discussing the factors suggested in these Chinese conceptual studies, we classify them into three subgroups: a) personal (relating to characteristics of a particular individual, such as personal values and abilities), b) internal organizational

(emphasizing factors within a firm, such as organizational climate and reward system) and c) external (considering environmental attributes, such as industry structure and government policy).

Personal Factors Affecting Intent to Innovate

Complex judgments on expectations of gains versus commitments needed for innovation are central to decision-makers' intent to innovate (Jia, 1996). For a given firm, the lower the opportunity costs of innovation, the more likely it will form innovative strategies; on the other hand, lower opportunity costs of non-innovative efforts make a firm less likely to form innovative strategies. Opportunity costs of innovations refers to the profitability and competitiveness derived from other non-innovative commitments. For instance, investment in unrelated diversification is negatively related to innovation performance, since the increase in efforts to diversify usually causes decrease of commitment to innovative activities within existing product lines (Fan Xiaopin, 1994).

Xiang (1994) points out that decision-makers' expectations of economic benefits (profitability, payoff period, and opportunity cost) derived from innovation in relation to alternative non-innovation activities and expectations on the controllability (level of risk and previous management experiences) of innovation with respect to alternative non-innovation activities are positively related to a firm's intent to innovate, and that expectations on the average duration of innovation projects are negatively related to intent to innovate. According to their "Theory of Expectation", Wan and Wang (1997) argued that there were two main factors determining the innovativeness of corporate strategies: 1) decision-makers' expectation on the benefits derived from technological innovation and 2) decision-makers' expectation on the probability of success of technological innovation. The sufficiency and fairness of the reward system for both decision-makers and implementers in the course of innovation is also positively related to their motivation to initiate and participate in innovative activities (Xiang, 1994).

Top managements that concentrate on the realization of long-term goals tend to be more supportive to technological innovations (Xiang, 1994). Having the desire and courage to step into new businesses before others is an important characteristic of innovative decision-makers, and being constantly active in seeking market and technological opportunities that have not been tapped by other firms is the soul of innovators (Fu Jiaji, 1996). When key executives of a particular firm are not so driven as to

pursue its competitiveness in the long run, they tend to favor strategic choice that can meet short-term goals over innovative moves (Xiang, 1994). The success of innovation projects will not necessarily maximize an individual's personal or potential rewards, especially when the lead time is long or the payoff period is beyond the executives' contract term. The researchers conclude that the governance system and compensation package for senior management in Chinese firms should be reformed so that those decision-makers have stronger motivation to be innovative.

Internal Organizational Factors Affecting Intent to Innovate

Uncertainty, due to the incompleteness of information about outcome, is inevitable in innovation (Jia, 1996), and thus innovative efforts are risky by nature. An organization's attitude towards previous failures would directly affect its decision-makers' willingness to take risks in strategic planning. There are two contrasting attitudes towards failed innovation -- one is that "failures in the process of innovation are just inevitable considering the attendant uncertainties"; the other is that "failed innovations are mainly due to decision-makers' faults or incompetence of innovation implementers." In organizations that cannot understand the uncertainties and the inevitability of failures in innovation, decision-makers afraid of getting blamed for failed innovations will tend to place unreasonably high 'risk costs' on innovative moves, constraining entrepreneurship. Firms' with strong intent to innovate are those that 1) clearly recognize the inevitability of risks in innovation, 2) let people with entrepreneurship lead innovations and fully understand their 'spirits of risk loving', and 3) have adequate capability to live through difficulties caused by failed innovations. Positive attitude towards risks in a firm that considers a reasonable number of innovation failures as largely unavoidable and that tends not to blame them on innovators will allow people to display creativity. Strong capability of a firm to live through innovation failure makes decision-makers less conservative about pursuing new products or processes (Xiang, 1994).

Varying organizational cultures, which differ in terms of emphasis on Order, Engagement, Result, and Opportunity, contribute to varying levels of attention to innovative activities, as does favorable organizational climate for entrepreneurial people to lead innovations and fully utilize their 'spirits of risk loving' (Jia, 1996). As a rule, the more entrepreneurial behavior is encouraged and valued inside a firm, the stronger the firm's motivation to innovate.

Seven major areas (Jiang and Shi, 1993) requiring investment (or re-investment) compete more or less directly against technological innovation for financial resources at the disposal of Chinese firms. First is need for technological renovation -- upgrading obsolete equipment and facilities or introducing state-of-the-art equipment and facilities (partly due to historically low level of technology, low rate of depreciation). Second is investment in infrastructure construction (e.g. office building). Third is high ratio of liabilities requiring heavy pay back to banks. Fourth are heavy social burdens. Fifth is investment in capacity expansion. Sixth is investment in vertical integration. Seventh is investment in entry into new businesses through internal development or acquisition.

External Factors Affecting Intent to Innovate

During the planned economy period, Chinese enterprises were not held responsible for the economic risk of innovations, nor did they receive any particular revenues from successful innovations. Success or failure of innovation depended in part on financial allocations and other decisions of the planning authorities, on political priorities, and on scientific or technological capabilities. There existed almost no link between R&D (often performed by institutions external to the enterprises) and sales in such industries (Guan and Guo, 1992). It seemed to most researchers that the lack of intent to innovate on the firm's own was inherent in the planned economy. However, after two decades of reform, Chinese firms are increasingly exposed to more competitive market environment, and innovation is gaining higher priority in Chinese managers' pool of strategic tools.

Illegal imitation and counterfeiting, regional protectionism, and rent-seeking phenomena have done serious harm to Chinese enterprises' intent to innovate. Effective intellectual property protection that can reduce the risk of being imitated illegally will make firms more willing to be first-movers (Yin, 1996), and rampant infringement of innovators' proprietary rights has posed a significant threat to Chinese firms' enthusiasm in innovation (Liu, 1996). In general, rent-seeking behaviors refer to business practices intended to look after illegitimate profits by unlawfully taking advantage of power, privilege, flaws of government policies etc. The occurrence of rent-seeking phenomena can counteract the pressure from market competition, and thus negatively affect firms' intention to innovate, because various illegitimate ways of making profit will reduce the risk of non-innovative activities and increase the opportunity costs of innovation. The severity of rent-seeking phenomena which distort the rationale of fair

competition, is negatively related to firms' intent to innovate (Wang and Xu, 1993).

In one view, firms in more competitive environments feel stronger pressure to innovate, while lack of competitive pressure has negative impact on the feasibility of R&D and on the intensity of investment in R&D (Feng Fei, 1995). Firms with customer base that has increasing level of expectation and that is more diverse and variable feel more need to innovate. The impact of market concentration on a firm's intent to innovate is contingent on the development stage of technologies involved in specific innovation projects. If it is in a stage characterized by undetermined technological trajectory and gushing out of new products, a less concentrated market structure should have stronger positive impact on firms' intent to innovate. However, if it is in a stage perceived as having small development potential, marginal space for improvement and a mature technological system, innovation will have to depend on continued monopoly privileges as impetus (Liu and Wan, 1997). The more firms are concerned that their competitors will bring competing or superior products to the market, the more they intend to innovate in order to maintain competitive edge. A competitive market structure that perpetuate such kind of concern among firms is favorable for innovative activities as a whole; as a generalization, competition encourages innovation (Wang and Xu, 1993), although price competition may leave inadequate margins even for the most efficient firm in a particular industry to realize a positive return for innovation.

Major Resource-Related Issues In Innovation

A group of researchers have special interest in resources for innovation available to Chinese firms. They looked into issues such as financial commitment for innovation, qualification of technical personnel, institutionalization of internal R&D, technological level of equipment and facilities, etc. Their basic argument is that certain "threshold" requirements for resources which must be met before a firm can carry out substantive innovation on a regular basis:

- Institutionalized internal R&D (corporate lab) is the single most important tangible feature differentiating innovative firms from non-innovative firms (Wang Shu, 1996).

- It is widely believed that the proportional relationship of investments in R&D, in-house testing and full-scale production should be around 1

to 10 to 100. However, among Chinese firms this relationship is around 1 to 1 to 100 (Yang and Ge, 1993). They conclude that inadequate investment in in-house testing has negative impact on innovation performance.

- Neither high level of technological introductions nor large groups of R&D personnel alone distinguishes the firms that have high level of new product sales (Liu Xielin, 1997). Rather, firms gain leverage by investing simultaneously in technological introduction and in R&D personnel. The leverage gained by coupling technological introduction with R&D personnel is a result of combining externally acquired technologies with internal absorptive capability.

- The establishment of healthy venture capital market is instrumental in encouraging innovation nation-wide (Wang and Xu, 1993).

- Technological innovation is mainly accomplished through the creativity and initiative of human resources (Wang Huijiong, 1994). Therefore staffing of the enterprise must provide for several key functions necessary to achieve successful innovation.

- A technology market that facilitates the transfer of science and technology developments from research labs to the industrial sector is critical in upgrading the technological level of innovation in Chinese firms. Cooperation with public research institutes and universities is an important tool to strengthen corporate innovation capability.

Modes of Innovation

We also note lively debate on the 'most appropriate' mode of innovation for today's Chinese firms. Given the reality of innovation infrastructure, what strategic options are available for a Chinese firm which wishes to innovate? What are the contingencies of these strategic options? How should Chinese executives make innovation-related decisions that can match internal and external conditions? All above are typical questions which dominate research concerned with "modes of innovation". For example, Shi (1996a, b) and Wang (1995) deal with the strategic choice between independent innovation and secondary or imitative innovation; Wei and Xu (1995) stress the compatibility of strategy, capability and environmental factors in selecting the mode of innovation; Xu, Chen and Guo

(1997) advocate a more balanced innovation portfolio. The following are the major arguments made in the conceptual studies:

- As 'long waves' in economic growth and capital expansion mature, opportunities to apply new inventions also decline (Wu Xiaobo, 1997). As old capital goods embodying the technologies of a preceding buildup depreciates economically, opportunities to create new technologies improve. According to this theory, China appears well poised to undertake a substantial capital expansion, suggesting opportunities for significant innovation. There may be a reasonable analogy in the Japanese industrial buildup after WWII, where relatively new and efficient technologies in various manufacturing sectors allowed the Japanese to compete effectively in world markets. It may well be that China can skip over much of the capital-intensive industrial development phase that preceded the information age in the Western economies.

- In China today, many enterprises with strong technological and economic foundations are still short of resources for innovation (Shi Peigong, 1996). Therefore, imitative innovation, with relatively low risks in both R&D and marketing, is suitable for such Chinese firms. The major function of R&D in imitative innovation is backward engineering.

- Independent innovation is the most powerful tool for a firm competing for the position of industry pioneer and market leader (Shi Peigong, 1996). Most Chinese firms cannot yet afford to the technology and market risks accompanying independent innovation.

- Wei and Xu (1995) suggest levels of technology strategy: (1) technology introduction, (2) technology adoption, (3) imitative innovation and (4) independent innovation. There are three levels of technology capability: (1) capability of technology monitoring, (2) capability of technology adoption and (3) capability of innovation. Technology environment can be put into four classes: (1) stable, (2) reactive, (3) active and (4) proactive. A sound innovation strategy should be a match between the technology environment and the technology capability of a given firm.

- Innovation efforts are often dispersed among individual projects of no substantial relevance to one another (Xu, Chen and Guo, 1997). In reality, the most successful technological innovations generally occur in groups or series of interrelated projects. Because 1) an enterprise usually has more than one project at a given point of time, 2) in a given period of time, resources available for R&D is limited and 3) various innovation projects have related requirements and outcomes, studies that treat innovation projects as separated and unrelated are insufficient by nature. Innovation projects should be viewed through a systematic, strategic and comprehensive perspective. The essence of a portfolio of technological innovation could be expressed as systematically coordinated innovation activities guided by corporate development strategy, subject to the influences of technological and institutional factors. A portfolio of technological innovations is distinguished from separated individual innovations. A portfolio of technological innovation is a multiple-aspect system, combining, incremental innovations and radical innovations, product innovations and process innovations, institutional (structural and cultural) innovations and technological innovations, and strategic innovations and technological innovations. Portfolio technological innovation can benefit from system advantages, including shared core technologies, shared R&D costs and lowered market and technological risks.

Factors Affecting The Efficiency of Innovation Processes

The fourth group of studies deal mainly with factors affecting the efficiency of the whole innovation process, ranging from new idea generation to new product launches:

- Xie and Wan (1997) argue that good innovation project management should make the fraction of projects eliminated decrease progressively as innovation efforts get closer to the market. The process of technological innovation can be divided into three stages: (1) internal R&D or technology acquisition, (2) applied engineering and manufacturing and (3) new product launches. To lower the losses caused by innovation failures, the faction of projects eliminated should be the highest at stage (1), which is the technological stage, and be the lowest at stage (3), which is the marketing stage. However, according a field survey conducted among a sample of Chinese firms by Xie and Wan (1997),

the fraction of projects eliminated at stage (1) is 14.3%, the fraction at stage (2) is 7.1%, while the fraction at stage (3) is 25.6%.

- Among failed innovations studies, over 60% are caused by market-related factors, while only 30% are related to technological factors (Xie and Wan, 1997). Again, Chinese firms should pay more attention to market-related risks in the course of innovation, cause the degree of customer orientation of innovation initiatives is the most important factor affecting the ratio of innovation success on marketplaces.

- Xie (1992), (1994), (1995), (1997) did a series of studies on innovation risks in Chinese firms, mainly dealing with the causes and measurements of innovation risks, and also made detailed suggestions on the means of lowering innovation risks.

- Liao (1997) stresses the importance of human resource management in the innovation process.

- For an enterprise to be responsive to technological innovations it should be structured to enhance the flow of technical and market information into research, development and design departments (Wang Huijiong, 1994). Specialized internal R&D departments with long-term strategic planning and development perspectives are the most important institutional resources for innovation in Chinese enterprises.

- The skills needed to support innovation capability involve all functional areas (Guan Jiancheng, 1996). These range from the establishment of appropriate accounting systems to necessary increases of productivity in production processes, and from the development of marketing functions to the initiation of market-oriented innovation processes. One major issue is the initiation of a market-oriented innovation processes. Neglect of marketing forces in innovation process has been identified repeatedly as a major source of failure. Marketing research especially needs to be strengthened to provide the information necessary for well-guided innovative activities. Also, the internal interface problems between R&D, production and marketing departments must be solved at both the project level and the corporate strategy level.

- Surviving innovation failures and quick learning from the them are important determinants of innovation performance, especially in the long run (Jia, 1996).

- An innovative senior management needs: (1) good perception of industrial trends of development from perspectives both of market and of technology, and (2) being abreast of latest market and technology information (Fu Jiaji, 1996).

- In a global information society, technology development will continue to occur both inside and outside a country's border (Wang Huijiong, 1994). Cooperative means to monitor, develop or acquire new technologies worldwide are becoming increasingly more important for large Chinese corporations.

Empirical Work on Management of Innovation

Descriptions of factors which cause differences in technological innovation has received the most attention in empirical study of Chinese innovation. The 9 empirical papers reporting work on this topic are all based on surveys, with the sample sizes ranging from 145 to 1947. Most respondents are members of top management who may not be specialists, and the studies generally focus on innovation performance and not on firm performance (Ulijn, 2000).

Performance-Related Empirical Work

The results are presented in the form of a "factor list" of condensed descriptions of causes for good or poor innovation performance, ordered by frequency of mention. These lists of factors are put in three of the four classes of the integrative framework presented in Figure I. (We fail to find empirical work on Modes of Innovation.)

12 frequently studied factors that are shown to have significant impact on innovation performance among Chinese firms	**12 frequently studied factors that are shown to have significant impact on innovation performance among Chinese firms**
1. Cooperation with external R&D forces (R)	1. Limited financial commitment (R)
2. Strong financial commitment (R)	2. Aversion of "high-risk" of innovation (I)
3. Senior management's engagement (I)	3. Lack of high qualification technical personnel (R)
4. Good internal coordination among R&D, manufacturing, marketing and other functions (P)	4. Lack of ability to collect information on new technological and market developments (P)
5. Having high qualification technical personnel, especially with technological pioneers (R)	5. Aversion of "high-initial-investment" of innovation (I)
6. Having substantial infrastructure for internal R&D (e.g., technology center, product development department, testing basis, etc.) (R)	6. Aversion of "prolonged-payoff-period" of innovation (I)
7. Good innovation project management (P)	7. Underdeveloped technological groundwork (e.g., out-of-date equipment and facilities, no special R&D department, etc.) (R)
8. Having the tradition of long-term strategic management (I)	8. Limitations imposed by policies, regulations and government interventions (I)
9. Being well informed with both new technological and market developments (P)	9. Low priority for technological innovation in corporate strategy (I)
10. Effective reward and promotion system for high performers in innovation (I)	10. Lacking cooperation with external R&D forces (R)
11. Being customer-oriented in innovation (P)	11. Lacking the tradition of internal R&D (e.g., marginal R&D expenditures, no follow-up innovation after technology acquisitions) (I)
12. Cooperation with customers and suppliers in the process of innovation (P)	12. Lack of marketing infrastructure for product launches (R)

Key: I – Intent to Innovate, R – Resource-related Issues, and P -- Efficiency of Process

The results indicate that the three categories of factors have received about equal attention. Besides, there are some interesting specific conclusions. For example, Gao and Fu (1996) suggest that the external cooperative factors could be further divided into two groups: 1) vertical cooperation, e.g. customers' and suppliers' cooperation, and 2) horizontal cooperation, e.g. cooperation with external research institutes, universities, peers, etc. It turns out that external vertical cooperation is more important than external horizontal cooperation. "Senior management support" is more important for innovation success in larger firms, while "leadership by technological pioneers" is more important for smaller firms. Technologically advanced product innovations depend more on "senior management support", "internal cooperation among R&D, manufacturing and marketing functions" and "external supportive factors", while less advanced innovations depend more on "leadership by technological pioneers" and "external cooperative factors".

Resource-Related Empirical Work

Financial commitment for innovative activities, given its importance in determining innovation performance, has been studied from various aspects. Sample averages of the ratio of total expenditures on innovation to sales revenue are not out of line with those reported elsewhere: Bao Ke (1996) reports the ratio of expenditures on innovation to sales revenue as 5.3% and the Statistics Bureau of Haerbin (1997) as 5.9%. However, sample averages of the ratio of expenditures on internal R&D to sales revenue are low -- 0.60%, 0.39% and 0.50% as reported by Statistics Bureau of Haerbin (1997), Zhao Yuchuan (1996), and Gao and Fu (1996) respectively.

In China, for historical reasons, the majority of R&D resources have been allocated in independent state institutions and universities, instead of within the business sector. Although the government is doing a lot of work to rebalance the allocation of research resources between the business sector and not-for-profit institutions, how to get support from or to set up cooperative relationships with external R&D organizations is still a critical issue in terms of innovation resources accessibility for Chinese firms in years ahead. According Ma and Jia (1992), 88% of large Chinese firms have ties with external R&D forces, while only about half of medium and small firms have such ties.

Innovation expenditures are distributed primarily among R&D (independent R&D and cooperative R&D with external organizations, engineer-

ing, test manufacturing and staff training, and technology acquisition (importing new equipment and technology). Bao Ke (1996), Ma and Jia (1992) and Statistics Bureau of Haerbin (1997) all report the distribution of innovation expenditures, as shown in Table 5. For the noticeable differences in results as reported by these studies, we believe there are three possible sources: 1) sample variation, 2) measurement variation and 3) shift of distribution pattern over time.

Table 5. The Distribution of Innovation Expenditures.

	Statistics Bureau of Haerbin (1997)	**Bao Ke (1996)**	**Ma and Jia (1992)**
On R&D	10.3%	8%	67%
On importing new equipment	46.2%	68%	19%
On importing new technologies	6.7%	7%	6%
On engineering, test manufacturing and staff training	35.7%	12%	4%
On sales for trial of new products	1.0%	5%	4%

About 90% of funds for technological innovation are drawn from internal sources or bank loans – the two are about equal. As with firms in many industrializing economies, Chinese firms lack equipment and facilities, and only one in twenty report facilities at an international level. (Statistics Bureau of Haerbin, 1997).

Out-of-date equipment and facilities restrict Chinese firms' technological innovation. Feng Fei (1996b) reports the following patterns of technology age for firms in Fujian and Gansu:

	Technology level of the 60s (%)	**Technology level of the 70s (%)**	**Technology level of the 80s (%)**	**Technology level of the 90s (%)**
Firms based in Fujian having innovations	10	23	46	21
Firms based in Fujian having no innovations	10	27	46	17

Continued

	Technology level of the 60s (%)	**Technology level of the 70s (%)**	**Technology level of the 80s (%)**	**Technology level of the 90s (%)**
Firms based in Gansu having innovations	21	28	37	14
Firms based in Gansu having no innovations	21	33	36	9

The number and qualification of employees in Chinese firms is also relatively low: 12.8% of staff have college and above education, technical personnel are less than 10 percent of the staff and R&D personnel less than 2.5%. Statistics Bureau of Haerbin (1997). Gao and Fu (1996) report the average number of R&D-related personnel is 40 in every 1000 employees. Unsurprisingly, institutionalized internal R&D function, a common indicator of basic independent R&D capability, is not well established in most Chinese firms either (Gao and Fu, 1996; Zhao Yuchuan, 1996):

> Enterprises with special R&D department and independent R&D capability – 38.7%
>
> Enterprises without special R&D department but with some internal R&D capability – 48.4%
>
> Enterprises having no internal R&D capability – 12.9%
>
> Enterprises having special R&D departments and carrying out internal R&D activities continuously – 15.9%
>
> Enterprises continuously carrying out internal R&D activities but without special R&D departments – 24.7%
>
> Enterprises carrying out internal R&D activities but not continuously – 28.9%
>
> Enterprises having no internal R&D activities – 30.5%

INNOVATION AND FIRM PERFORMANCE

Chinese firms generally report improved performance after carrying out technological innovations in most cases. For example, Gao and Fu (1996) report substantial increases in productivity and profitability after innovation. A few researchers (e.g., Li Guo (1997), He and Peng (1995), Wang

and Xu (1993), and Liu, Li and Yang (1997)) argue that the relationship may be contingent.

Chinese Conceptual Work on How Technological Innovation Affects Firm Performance

In general, the researchers view innovation as the principal route through which Chinese firms can generate products with more value added, and agree that only by innovation is it possible for Chinese firms to catch up with international technology leaders in terms of product quality and process efficiency (Fu Jiaji, 1992 and Shi Peigong, 1996).

Li and Guo (1997) argues that the effects of innovation on firm performance are conditioned by the nature of markets to which new products are introduced. For example, historically in China, consumers' tastes, purchasing power, and behavior patterns made the Chinese market far from rewarding for innovative activities. Second, the ability of a firm to amortize the costs of innovations depends heavily on the width of the potential customer base. Fragmented markets due to local protectionism, for example, had negative effects on the financial performance of Chinese innovators. Third, low levels of industry and market concentration may make it more difficult for innovators to appropriate the returns from new product or process development efforts. Finally, illegitimate imitation and other unfair competitive behavior in the market could reduce the potential benefits from innovation.

He and Peng (1995) also point out three levels of competitiveness among different types of innovators. The most competitive are firms that focus on new product development and at the same time spend equivalent efforts on market expansion; the less competitive firms stress product development and quality but do less well in market expansion; the least competitive are innovators that primarily concentrate on improving productivity and lowering costs. Wang and Xu (1993) hold that new product performance is linked to the key dimension of innovation strategy: this is orientation to target markets, which includes the regional markets, national markets, and international markets. An international orientation, through development of products which meet international requirements, gives better results than a domestic focus on product innovation. Industrial products that are developed for world applications and are targeted at export markets will bring more benefits to the innovator in that environment.

In many industries, companies seek competitive advantage primarily through product innovation. However, Lian Yanhua (1994) argues that

simply producing new product is not enough to gain competitiveness for an average innovator. Unless a firm can clearly establish and maintain for a reasonably long period of time the superiority of its products in its customers' minds, an innovation strategy based on developing new products is likely to be ineffective. Lack of product performance. differentiation in a market characterized by many new product introductions may help explain why a relatively small number of real successes makes it hard to find significant relationship between product innovation success and corporate competitiveness.

Chinese Empirical Work on How Technological Innovation Affects Firm Performance

With more than half of Chinese firms' sales resulting from products introduced in the past decade, successful new products are essential to the growth of many firms. That Chinese technological innovation has positive effects on corporate performance was supported by both Gao and Fu (1996) and Zhao Yuchuan (1996) in terms of 1) whether firms report that performance was enhanced after successful innovation and 2) whether innovators in general performed better than non-innovators.

As a general matter, Chinese empirical research linking innovation to performance produces similar conclusions as empirical work in several hundred Western studies (Capon, Farley and Hoenig, 1996):

- The best performing firms have been those which continuously offer new products (particularly those developed by internal research and development) to new markets (particularly by international expansions of markets).

- Methodologically, there is a shortage of empirical work on the organizational factors affecting firm performance in general and innovation in particular.

A specific study of innovation by a sample of large US manufacturers (Capon, Farley, Lehmann and Hulbert, 1992) similarly concludes that:

- Innovative firms have a higher-than-average returns on capital.

- Innovative firms have a combination of distinguishing characteristics which include environmental, strategic and organizational features.

Gao and Fu (1996) report that improved utilization of factors of production (productivity) after innovation led to strengthened corporate competitiveness (product quality, diversity and market share) and to reports of improved economic benefits (profitability) by more than 90% of enterprises studied. Using correlation analysis, they also concluded that every 1% increase in the intensity of investment in technology acquisition (as one major means of technological innovation in China) will bring about 0.88% increase in the sales of new products.

Using aggregate annual statistics, Tian, Cai and Ge (1995) observe that low levels of R&D investments (less than 1% of sales revenue) are associated with low returns; they also point out that intermediate levels of investment (1% to 3% of sales revenue) are associated with slightly higher ROI than higher levels of investment.

Zhao Yuchuan (1996) reports that large firms are more likely to report positive effects in terms of reduced operating, raw material and energy costs, increased productivity, and improved quality as a result of innovation. Over 80% of R&D successes are reported by personnel of large and medium enterprises. However, in terms of contribution of R&D expenditures to profitability, SOEs' R&D input contributes 2/3 less profitability than R&D input of Village-based collectives – especially small ones (Liu and Wan 1997). Perhaps smaller firms are more flexible, specialized and competition-oriented.

Liu, Li and Yang (1997) question the existence of a positive relationship between innovation and corporate competitiveness in Chinese State-Owned Enterprises. They point to a significant difference in means of Technological Edge of innovators but no significant difference between innovators and non-innovators in terms of Corporate Competitiveness, both measured on 5-point scales:

	Technological Innovators Among SOE's	**Technological Non-Innovators Among SOE's**	**Significance level of difference**
Mean of Technological Edge	2.53	2.18	P<0.001
Mean of Corporate Competitiveness	2.45	2.37	**Not Significant**

They also agree that R&D investment is the most crucial factor for establishing a technological edge, and that firms which are really heavy R&D investors are most able to integrate technological accomplishments with future market demands, and, in turn, strengthen future market status to reduce threat from competitors. They suggest the possibility of contingencies, with Chinese state enterprises generally failing to strengthen corporate competitive edge through technological innovation because: a) their innovation has mainly been technologically oriented rather than market oriented, and b) marketing efforts have been insufficient, making it difficult to realize the potential benefits that could be derived from innovation.

CONCLUSION AND DISCUSSION

Systematic study of technological innovation as a distinct research topic began in Western academia in 1930s. Much work in developed economies in the past decades have formed established theoretical traditions and certain kinds of mindset in studying innovation. However, in developing economies, the appropriateness of established theories and methodologies from developed economies is subject to reexamination, as they risk missing certain critical issues not easily perceptible in developing economies. Instead of attempting to give a direct answer to the question of appropriateness, we have done a literature review from Chinese researchers' perspectives. In doing so, we hope to make more broadly available the results of the work of Chinese researchers. We also hope to find answers to the following: first, what major issues have been raised by Chinese researchers; second, from what perspectives they have approached those issues; and third, what are the unique findings of the Chinese innovation studies. We have collected and reviewed over 100 Chinese journal articles, and organized within an integrative framework as introduced at the first section of the paper. This requires accessibility to the findings of Chinese researchers, whose publications are mostly limited to Chinese journals. We believe such a thorough literature review is an important first step to understanding Chinese firms' innovation activities in a broader range of contexts. We also identify the major journals publishing Chinese innovation papers, the nature of large-sample surveys, and influential institutions carrying out intensive innovation studies.

We find four major characteristics of Chinese papers on innovation. First, most papers are problem oriented, focusing on issues perceived to be hindering innovation in China. They often try to answer three questions --

"what is the nature of the problem?", "what causes the problem?", and "what are the solutions to the problem.?" Second, Chinese researchers tend to look at problems from the perspective of decision-makers or policy-makers, and Chinese innovation studies in most cases do not follow specific traditions or use certain theories as its foundation. This is reflected in the fact that, although some Chinese researchers are aware of a mixture of western and Chinese books and journals, most papers have a relatively short list of references. Third, conceptual pieces by far outnumber empirical pieces. Finally, design of large-sample surveys and treatment of survey data is largely at a descriptive level. More sophisticated statistical design and analysis might lead to more refined discoveries in the empirical work.

Substantively, innovation performance of Chinese firms is generally quantitatively near average by international standards of outputs, but is less so qualitatively. Chinese firms put "new" products into markets at a reasonable speed, but most of these products are new relative only to the firm or to local competitors. In most Chinese innovation studies, "new products" are referred to those reported as recently launched. Chinese firms have apparently managed to improve their products or processes incrementally on a regular basis, but these improvements are not really new to the world or to national marketplaces, especially in terms of technological novelty.

Chinese researchers have recognized the importance of improving innovation performance in an increasingly competitive environment, and generally reach the conclusion that innovation performance of Chinese firms is not satisfactory as compared with the rate of economic growth in the past two decades. It is generally acknowledged that with the further opening of Chinese markets and the increasingly competitive environment, Chinese firms have begun to (or are being forced to) more fully realize the value of technological innovation as a competitive tool. Taking innovation performance as the focus, we divide Chinese innovation studies into three groups, including 1) measurements developed to evaluate organizational innovation performance and ways to improve them so more reliable and valid scales can be developed in measuring corporate innovativeness; 2) factors causing unsatisfactory innovation performance and that will determine innovativeness of tomorrow's Chinese firms; and 3) studies of the relationship between the structure and quality of innovations and firm performance.

Chinese researchers have approached the subject on determinants of innovation performance from four perspectives, which can be generalized as "intent to innovate", "major innovation resource-related issues", "modes

of innovation" and "efficiency of innovation process". Researchers are interested in finding out factors that may affect Chinese decision-makers' attitudes towards innovation as a means to improve corporate performance, because decision-makers' attitudes often determine the policy of resource allocation and the level of commitment. From this perspective, the most important factors are 1) personal expectation on return of innovation investment relative to alternative strategic commitments, 2) openness of organizational culture and climate to innovative activities, and 3) external policy and competitive environment. It is generally agreed that the single most important factor distinguishing innovative Chinese firms from the non-innovative is intent to innovate. Chinese researchers have suggested various ways to make Chinese firms put more strategic emphasis on innovation.

The second main theme is that certain threshold requirements on financial resources, technological foundations, personnel and other infrastructure of the economy have to be met before fundamental innovations are possible by Chinese firms. However, scarcity of resources is a major constraint on Chinese firms' innovation performance. As a result, many researchers have focused on how Chinese firms can break the bottleneck of resources in a relatively short period of time, although they understand it needs long-term commitment for China to catch up with technological advances of developed countries. The most frequently suggested solutions include, for example, promoting collaboration between industries and independent research institutes or universities, and establishing healthy regional or national venture capital markets. In the studies dealing with "modes of innovation", the central point is that the appropriateness of different innovation strategies is conditioned upon individual firm's characteristics. Typology and fitness of innovation strategy are the major topics of papers in this area.

Compared with studies on "intent to innovate", "major innovation-resource related issues" and "modes of innovation", papers on "efficiency of innovation processes" are more tactical. For a firm with certain innovation initiative, given innovation resources and a chosen mode of innovation, the performance of innovation is determined by the efficiency of the process of innovation. Chinese researchers approach the issue of efficiency of innovation processes from many perspectives, including organizational climate, project management skills, control of innovation risks, etc. In general, they find weaknesses in all of these areas.

Some Chinese researchers have also studied how technological innovation affects performance. Although effects are generally positive, espe-

cially those on productivity, there is still much work to be done to quantify the interrelationship between corporate innovativeness and firm performance.

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