

Technological Innovation in Rural Enterprises of Jiangsu, China

(2nd draft)

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Introduction

The importance of technological innovation has been extensively documented, and it has been regarded as the driving engine for modern economy. National and regional governments, along with businesses have all emphasized the significance of technological innovation. This study examines the issue of technological innovation in rural manufacturing enterprises¹ of Jiangsu, a leading province in China.

Rural industries in China have experienced rapid growth during the last two decades and have been widely acclaimed as the major vehicle to develop rural areas. By the end of 2000, there are more than 20 million rural enterprises in China, providing more than 128 million employments, or about 27% of China's total rural labor force, and contributing about one-third to China's gross industrial value added (China Statistics Bureau, 2000). From 1978 to 1999, industrial output value of rural enterprise has been growing at an average rate of 18.9%, compared to 7.4% for state-owned enterprises (SOEs). However, rural industries are facing increasing competition since the middle 1990s when the market in China started to become oversupplied. Reforms in SOEs and rapid growth in the private sector and foreign investment have made the situation more challenging for rural enterprises. Growth of rural industry has been slower than average since 1995. In 1999, output value for rural industries grew by 6.0%, compared with 8.8% for SOEs. The number of rural enterprises decreased from 25 million in 1994 to 21 million in 1997, and remained at the similar level afterwards. The employment in rural enterprises has also remained stagnant during the same period. As the result, urban-rural income gap in China has been enlarged in recent years. In 1985, income per capita for the urban and rural area was about 740 yuan and 397 yuan correspondingly. In 2000, the income per capita for urban and rural areas increased to 6,280 yuan and 2,253 yuan.

During the fifteen years between 1986 and 2000, urban income grew faster than rural income in nine years. Consequently, the urban and rural income ratio has increased from 1.86 in 1985 to 2.79 in 2000, though it did decrease from 1994 to 1997.

Given the fact that the majority of China's population is still living in rural areas, how to further develop rural economy has become a critical issue faced by the Chinese government. The new government led by Hu Jintao and Wen Jiabao has made the issue of rural development (or the so called "*San nong wen ti*") one of its top priorities. Scholars and officials have largely attributed the problem of rural enterprises to their collective ownership, where nobody is explicitly responsible for their performance. Therefore, the major approach that has been adopted is to privatize the rural collective industries (*Gai zhi*). By the end of 2000, more than 90 percent of rural collective enterprises in China have been restructured (privatized) (China TVE Yearbook Compilation Committee, 2001). I argue that such an approach is too simplistic, and the fortunes of rural enterprises are related not only to the arrangement of property rights, but also to many other factors including their capabilities of technological innovation and management. A rural enterprise without innovation is doomed to fail in the long run.

Against such a backdrop, this study investigates the issue of technological innovation in rural manufacturing enterprises in Jiangsu province, a leading area of economic development in China. Specifically, three related questions are examined through surveys in Jiangsu:

- 1) How innovative are rural enterprises?
- 2) How do rural enterprises organize their R&D activities or where are the sources of technological innovation for rural enterprises? What kind of sources are more important for them, external sources or internal sources?

3) How do rural enterprises build their technological networks?

The next section describes the survey and study area and the subsequent three sections deal with the three corresponding questions. Embedded in these three questions, we will also examine the spatial difference of technological innovation among rural enterprises to see if enterprises in different areas show different mode of technological innovation.

Then we present three case studies in different industries to demonstrate how innovative rural enterprises are and how they develop their products. The paper ends with some concluding remarks and a brief discussion.

About the Survey and Study Area

Data for this study were obtained through surveys of 450 rural enterprises in three counties (county-level cities) in Jiangsu province, 150 in each of them. As many studies have revealed, significant regional inequalities exist in Jiangsu (Wei and Fan, 2000), which can be divided into three subregions: Sunan (south Jiangsu), Suzhong (middle Jiangsu), and Subei (north Jiangsu) (Figure 1 and Table 1). In 2000, per capita gross domestic product (GDP) for Sunan, Suzhong and Subei was 23,000 yuan, 9,400 yuan and 5,100 yuan respectively. They differ from each other not only in general development levels, but also in sectoral structure. The secondary and tertiary sectors account for more than 90 percent of the GDP in Sunan, while their corresponding share in Suzhong and Subei was only about 80 percent and 70 percent (Table 1). In many senses, Sunan is similar to what Keeble et al.(1992) characterized as accessible rural areas, while Suzhong and Subei are similar to what they called remote areas.

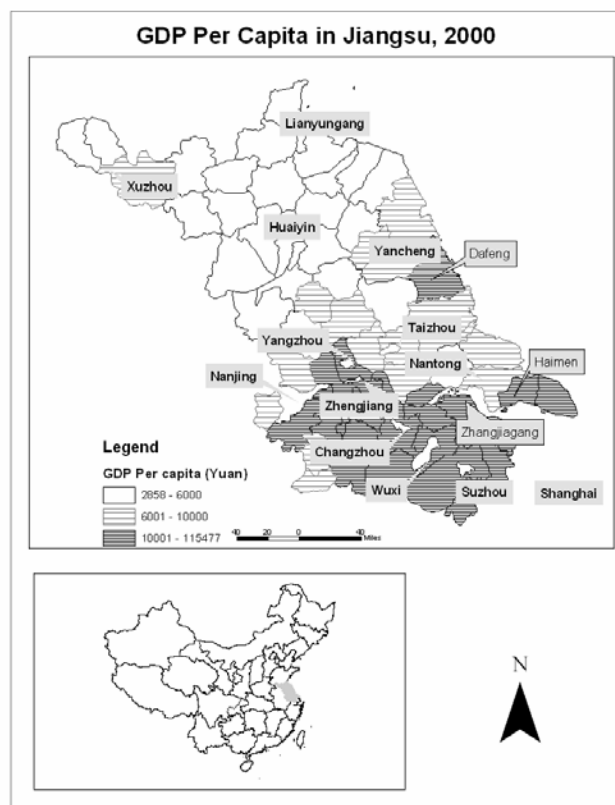


Table 1 Selected Counties in Jiangsu, China

	Sunan	Zhangjiagang	Suzhong	Haimen	Subei	Dafeng
Population(M)	10.4	0.9	18.3	1.0	28.9	0.7
GDP (B. Yuan)	245.4	27	171.6	12	147.2	7.6
GDP per capita (1,000 Yuan/person)	23.6	31.6	9.4	11.6	5.1	10.3
GDP per capita regional ranking		3		1		1
Primary GDP (%)	8.3	3.7	19.6	14.3	36.0	32.2
Secondary GDP (%)	55.3	59.1	45.4	48.2	44.6	37.7
Tertiary GDP (%)	36.4	37.2	35.0	37.5	19.4	30.2

Source: Jiangsu Province Statistics Bureau, 2001, *Jiangsu Statistical Yearbook*.

The three counties chosen in this study include Zhangjiagang from Sunan, Haimen from Suzhong, and Dafeng from Subei, each representing the leading county in the respective subregions (Table 1) and their per capita GDP significantly higher than the average of the corresponding subregions. The rationale to choose the three top counties instead of average counties is because we expect most rural enterprises are not very innovative. Choosing the leading counties helps ensure to include enough innovative enterprises in the sample. While findings from this study may not be readily applied to other parts of the province or China, they would give us a rough idea about the overall picture of technological innovation in Jiangsu's rural enterprises.

An information survey center, which belongs to the policy research institute of Jiangsu provincial government, helped conduct the surveys. The information survey center has a contact person in each county/city, which made it rather convenient to gather data. One hundred and fifty rural enterprises were chosen from each county based on the following principles. First, all the enterprises were chosen from the rural areas including designated towns, townships and villages. Second, no SOEs should be chosen (though not so many SOEs exist in rural China). Third, no enterprises at the county seat were included since these places are more urban than rural in nature. It is also the intention of the authors to choose "big" rural enterprises as many as possible, which are more likely to be innovative. As such, the survey center was asked to collect data on enterprises with sales value in 2001 above 5 million yuan as many as possible, as the criteria is adopted by the State Statistics Bureau in collecting data as well. If a county has more than 150 such rural enterprises, all the 150 enterprises will be chosen from this group; in counties with fewer than 150 such rural enterprises, smaller enterprises are chosen accordingly. In

choosing such enterprises, a stratified method was used to ensure enterprises with different rates of profitability are chosen.

Table 2 Surveyed Enterprises in Jiangsu, China

	Total	Zhangjiagang	Haimen	Dafeng
Surveyed Enterprises	450	150	150	150
Median # of Employees	60	159	39	30
Median annual sales (M. yuan)	4.4	21.5	2.7	1.5

Sources: Personal surveys

Table 2 gives the summaries of the surveyed enterprises. It is clear that the enterprises are pretty small in general: the median workers employed are only about 60 and the median annual sales value was only about 4.4 million yuan or about half a million US dollars. In addition, there exist significantly spatial variations among the enterprises in Sunan, Suzhong and Subei. Enterprises in Zhangjiagang are significantly larger than those in Sunan or Subei: the median number of workers in Zhangjiagang is 159 while it is only 39 and 30 respectively for Haimen and Dafeng; the median annual sales value for enterprises in Zhangjiagang is 21.5 million yuan while it is only about 2.7 million yuan and 1.5 million yuan for Haimen and Dafeng respectively.

The survey included a number of questions about technological innovation, from input (R&D expenditure, R&D employees, technology importation, and internal R&D departments/labs, among others), output (product innovation, process innovation, patents, sales of new products), to organization (whether or not the enterprise has technological partnership with other enterprises, universities, and government R&D institutes, and the

roles of different factors in building these R&D networks). The next three sections will explore the three questions listed at the end of Introduction.

Technological Innovation in Rural Enterprises of Jiangsu

Geographical studies have revealed that there exist tremendous differences among regions regarding technological innovation. At the regional level, Feldman and Florida (1994) reported that new products in the United States highly concentrate in New Jersey, Massachusetts, California and New York. The study by Wynarczyk and Thwaites (1997) also revealed that enterprises in South East and South West within the UK are more innovative than those in the North.

Other studies have examined the urban-rural difference in technological innovation, and an urban-hierarchy hypothesis has been developed (Smith et al. 2002). The hypothesis expects enterprises in urban areas to be more innovative than those in rural areas because of a number of factors including higher quality labors, higher density of information and businesses, proximity to universities and research and development institutes, and better infrastructure in the urban setting. However, findings from empirical studies are not so conclusive. For example, the study by Kleinknecht and Poot (1992) in the Netherlands and the studies by Love and Roper (2001) and Roper (2001) in Ireland did not find significant impacts of urban environments on industrial innovation. Studies by Cosh and Hughes (1996) even showed that rural firms are more innovative than their urban counterparts in the UK.

At finer scales, other studies have examined the issues through further differentiating the regional settings. Keeble et al. (1992) classified the rural areas into two categories: accessible and remote areas and a similar scheme was also adopted by North

and Smallbone (2000). Smith et al. (2002) classified their study area into four categories: urban centers, other urban regions, rural regions close to centers and rural and peripheral regions. Keeble et al. (1992) and Smith et al (2002) found that enterprises in accessible rural areas are more innovative than their urban counter parts, though North and Smallbone (2000) found that there was not much difference of innovativeness between firms in remote and accessible rural areas. It is argued by North and Smallbone that enterprises in remote rural areas may become more innovative because of their disadvantaged locations: they are stimulated to be more innovative in order to overcome their local constraints.

This section examines technological innovation in surveyed rural enterprises of Jiangsu and the key finding is that there do exist significant regional differences among enterprises in rural Jiangsu regarding their technological innovation, and enterprises in accessible areas are more innovative than those in remote areas. Innovation here is primarily measured by input and output data, including:

1) *Patent*: Whether or not an enterprise holds any patent(s).

2) *New_Product*: Whether or not an enterprise has marketed any new products during the period of 2000-2002. Here, new products are used in its broad sense; they are new to the enterprises, though they are not necessarily new to the local, regional, national or international markets. Such a definition of new products captures the degree of commitment made by an enterprise to expand to new markets, an important aspect of innovation, despite of its potential weakness to include many lower-end and minor innovations.

3) *New_Process*: Whether or not the enterprise has adopted some new processing technologies or made significant improvements to existing processing technologies from 2000 to 2002.

4) *New_Sales (%)*: Share of new products over its gross sales value in 2001. The above variables measure outputs of innovative efforts, but do not consider the market success. Ultimately, the purpose of innovation is to keep pushing new products to the market, thus resulting in their enhanced competitive positions in the markets.

5) *Internal_R&D*: Whether or not enterprises had R&D spending in 2001

6) *R&D_Lab*: Whether or not the enterprises have internal R&D labs/departments.

7) *R&D_Staff*: Size of R&D staff (in persons).

8) *Equip_Import*: Whether or not enterprises have imported equipments.

It is clear that rural enterprises in Jiangsu are not so innovative measured by input, output or equipments. In terms of input, only 6 percent of them reported to have any internal R&D spending, the average size of R&D staff was about 11.7 persons or 9.1 percent of their total employees. In addition, about 19.5 percent of the surveyed enterprises reported to have imported equipments. It is interesting to note that 11.6 percent of reported to have internal R&D labs/departments, although only 6 percent of them reported to have any internal R&D spending in 2001. Perhaps it is because of the conceptual vagueness of R&D labs/departments. It is highly possible some enterprises include testing or technology management departments as R&D labs/departments, while those facilities involve no R&D activities at all. Finally, 14.6 percent of the enterprises reported to hold patents, while 28.6 percent and 24.2 percent of them reported to have adopted new product and process technologies respectively. The average share of new products among their annual sales was about 7.4% in 2001.

Table 3 Regional Difference of Technological Innovation in Rural Jiangsu, China

	Total	Zhangjiagang	Haimen	Dafeng
Patent	65 (14.6%)	44 (29.5%)	14 (9.3%)	7 (4.8%)
Internal_R&D	27 (6%)	13 (8.7%)	9 (6%)	5 (3.4%)
R&D_Lab	52 (11.6%)	34 (22.8%)	13 (8.7%)	5 (3.4%)
R&D_Staff	11.7(9.14%)	25.7(9.9%)	6.1(9.5%)	3.4(7.6%)
Equip_Import	87 (19.5%)	71 (47.3%)	12 (8.2%)	4 (2.7%)
New_Product	128 (28.6%)	76 (50.7%)	40 (26.7%)	12 (8.1%)
New_Process	108 (24.1%)	65 (43.3%)	34 (22.5%)	9 (6.1%)
New_Sales (%)	7.4	10.7	8.2	3.3

Note: data in the table are the number (and their corresponding percentages over the number of responded) of enterprises who reported to have such items.

Table 3 also demonstrates that there exists significant difference among rural enterprises in the three surveyed counties: enterprises in Zhangjiagang are most innovative, and those in Dafeng are least innovative, while those in Haimeng are in between. The regional gap is huge: 30 percent of those enterprises in Zhangjiagang reported to hold patents, about 40 percent and 50 percent of them have adopted new product and process technologies respectively, and the share of new products is about 10 percent of their annual sales. In comparison, only less than 5 percent of rural enterprises in Dafeng reported to have any patents, eight percent and six percent of them reported to have adopted new product and process technologies respectively, while the share of new products in their gross sales is only about 3 percent. Such patterns can also be observed in other variables: internal R&D, R&D staff, and imported equipments. Such a pattern

confirms the observations by Keeble et al. (1992) and Smith et al (2002) that enterprises in accessible rural areas are more innovative than those in remote areas.

Sources of Innovation in Rural Enterprises

It has been well recognized that innovation in industrial enterprises can come from different sources: internal R&D or purchasing from external sources (MacPherson, 1997). The role of internal R&D in the innovation of manufacturing enterprises has been well documented (Young et al. 1993; Galende et al. 2003). Recently, it has been argued that collaborative networks with external sources are also very important for successful technological development for enterprises (Carr 1995; Rothwell 1992). The roles of networking are particularly important for small and medium enterprises (SMEs), since often their internal R&D capabilities are limited and networking with external sources can enlarge their knowledge base (Lawton 1996; Malecki and Tootle 1996; MacPherson, 1997; Mackun and MacPherson, 1997). External sources include university research (Lawton, 1996), corporate R&D laboratories (Acs et al, 1994), private consultants (Rothwell 1992), and governmental agencies (Shapira et al. 1995), among others.

One question we want to explore in this study is how important are these external sources in relation to internal R&D efforts in rural enterprises? Internal R&D in this study is defined as technology development activities within enterprises, since research (either basic research or applied research) are not expected in rural enterprises due to their lack of quality labors. Existence of such activities can be exhibited through the presence of technical staff specifically assigned for technology (either product or process) development or improvement, not necessarily the existence of separate departments for product development. Such internal development activities may be combined with other

functions such as product quality testing and production monitoring as one person may perform several functions in a single enterprise. External sources particularly refer to purchasing of technologies from and collaboration with external sources including universities, governmental R&D institutes, other enterprises, and individuals.

Collaboration can be formal and long-term through setting up partnerships, joint projects, exchange of technical personnel and information, or informal and temporary through informal and periodical technology consultation and information exchange. A technology can be classified as internally developed as long as the development process is dominated by the enterprise itself, rather than by an external actor/agency. The dominance of enterprises may include proposal development and evaluation, project selection, resource allocation, and project monitoring and management. In other words, enterprise is in charge of the project and will own the intellectual properties through its own technological efforts rather than purchasing from external sources. We expect that external sources will be more important than internal R&D in rural enterprises, in the context of a developing country such as China. Rural enterprises traditionally are not very innovative and are at disadvantaged positions in recruiting quality R&D personnel because of the less desirable living and working environments in rural areas in general.

Table 4 Sources of Product Innovation in Rural Enterprises of Jiangsu

	Total	Zhangjiagang	Haimen	Dafeng
Internal R&D	83 (76.9%)	50(76.9%)	29(85.3%)	4(44.4%)
Other Enterprises	12 (11.1%)	7(10.8%)	3(8.8%)	2(22.2%)
Universities	5(4.6%)	3(4.6%)	1(2.9%)	1(11.1%)
R&D Institutes	13(12.0%)	9(13.8%)	1(2.9%)	3(33.3%)
Import	3(2.8%)	2(3.1%)	1(2.9%)	0(0.0%)
Total	108(100%)	65 (100%)	34 (100%)	9(100%)

Notes: data in the table refer to frequency of enterprises (and the corresponding percentages over enterprises who claimed to have product innovation during 2000-2002) who reported to have the new product technologies from the corresponding sources.

Table 5 Sources of Process Innovation in Rural Enterprises in Jiangsu

	Total	Zhangjiagang	Haimen	Dafeng
Internal R&D	95 (74.2%)	55 (72.4%)	34(85.0%)	6(50.0%)
Other Enterprises	19 (14.8%)	9 (11.8%)	5(12.5%)	5(41.7%)
Universities	9 (7.0%)	7 (9.2%)	2(5.0%)	0(0.0%)
R&D Institutes	12 (9.4%)	9 (11.8%)	2(5.0%)	1(8.3%)
Import	4 (3.1%)	4 (5.3%)	0(0.0%)	0(0.0%)
Total	128 (100%)	76 (100%)	40(100%)	12(100%)

Notes: data in the table refer to frequency of enterprises (and the corresponding percentages over enterprises who claimed to have process technology innovation during 2000-2002) who reported to have new processing technologies from the corresponding sources.

Tables 4 and 5 report the results from surveys regarding the sources of their product and process innovation. Focusing on the overall pictures, it is surprising to observe that the major source of their technological innovation, in most of rural enterprises (about three-fourth) came from internal R&D rather than from external sources. External sources are only playing marginal roles. For instance, domestic enterprises, universities, R&D institutes, or import together only provide about one-fourth of the innovation. Such a finding is contrary to the conventional belief that rural enterprises rely primarily on external sources for innovation. Regarding their external sources of innovation, domestic enterprises and government R&D institutes are relatively more important than universities or import, though none of them is as important as internal R&D.

Table 6 Self-evaluation of the Importance of Different Sources of Technology

	Total	Zhangjiagang	Haimen	Dafeng
Internal R&D	353(79.9%)	136(91.2%)	139(95.9%)	78(52.7%)
Other Enterprises	292 (66.0%)	107(71.9%)	113(77.4%)	72(48.6%)
Universities	236(53.4%)	89(60.1%)	87(59.5%)	60(40.6%)
R&D Institutes	254 (57.2%)	98(65.8%)	92(63.1%)	64(33.0%)
Central Institutes	177(51.5%)	91(61.3%)	53(58.2%)	33(31.7%)
Local Institutes	186(53.7%)	89(59.7%)	61(67.7%)	36(33.6%)
Import	156 (35.3%)	79(53.0%)	58(40.3%)	19(12.7%)

Note: this table reported the number of enterprises that considers the corresponding source of technology “important” or “very important” regarding its general technology development. The percentages in the parentheses are of those who responded to the question.

However, self-evaluation of the importance of different sources of technology paints a different picture (Table 6). The question asked the interviewee to evaluate the relative importance of the different sources of technology for the enterprise in general, instead of only the product or process innovation during the two years before the survey. Here, internal R&D is still considered the most important, which is consistent with the findings before. However, importance of external sources is greatly elevated. For example, about two-third of the enterprises consider other domestic enterprises to be important/very important sources of technology, though only 11 percent of product innovation and 15 percent of process innovation came from other domestic enterprises. Similar patterns can be observed regarding the roles of universities, R&D institutes, and import. At least two explanations are possible. First, it is possible that external sources play more important roles in early periods of development for rural enterprises, while later on the importance of external sources decreases as internal R&D is established and becomes more important. Another explanation is that innovations from external sources are more significant economically than internally generated innovations.

In addition, significant difference exists among the three counties regarding their sources of innovation and their evaluation. Particularly, the difference between Dafeng on the one side and Zhangjiagang and Haimen on the other side is obvious. First of all, enterprises in Dafeng attaches far less importance to ALL the sources compared to those in Zhangjiagang and Haimen. Second, internal R&D is playing far less roles for enterprises in Dafeng than it is in Zhangjiagang and Haimen – about 50 percent of the product/process innovations come from internal R&D for enterprises in Dafeng, while the share is more than 70 percent for enterprises in Zhangjiagang and Haimen. Similarly, in their self-evaluation of the important of different sources of technology, only 52.7 percent of those enterprises in Dafeng consider internal R&D important/very important, while more than 90 percent of those enterprises in Zhangjiagang and Haimen consider so. Such a difference, on the one hand, indicates that innovation may not be considered so important in Dafeng in general. On the other hand, it indicates that internal R&D is less significant for enterprises in remote areas. This implies that it would be very challenging for enterprises in less developed areas such as Dafeng to catch up in the future due to their lack of internal R&D capabilities.

Regarding internal R&D, it is interesting to see the sources of R&D personnel. Traditionally, rural enterprises in China were cut off from the normal state plan for allocating college graduates and they primarily relied on retired technical workers from urban areas. In additional, they also relied on temporary technical support from “weekend engineers” or “holiday engineers”² from nearby central cities. Recently, government is no longer directly assigning jobs for college graduates, who increasingly look for job through the labor market. This survey reveals that rural enterprises use two major ways to obtain R&D employees. First, they have trained their own R&D technical personnel

through universities (Table 7). Many of them send their own rural workers (who are not able to go to colleges or universities) to universities or colleges to receive formal education and the cost for the training is covered by the rural enterprises in exchange of the students' guaranteed return to the enterprise after graduation. Second, many rural enterprises have been able to recruit R&D personnel from the labor markets directly. The survey also reveals that self-training is the major means for rural enterprises to have R&D personnel and about eighty-eight percent of the 378 enterprises with internal R&D personnel have self-trained R&D employees, while the corresponding shares for those who have market-recruited and government-allocated R&D personnel are just about 51 percent and 5.6 percent respectively. The median number of self-trained R&D employees is 3. In comparison, the median numbers of R&D employees through market recruitment or government allocation were only 1 and 0 respectively.

Table 7 Sources of R&D Employees in Rural Enterprises

	Total	Zhangjiagang	Haimen	Dafeng
Average R&D Employees	13.93	26.05	7.43	4.66
From:				
Government-allocation	0.14	0.30	0.02	0.11
Market-recruiting	5.87	13.81	2.85	0.95
Self-training	5.77	11.99	3.12	2.21

Self-training is particularly important for rural enterprises in Dafeng: the average number of self-trained R&D employees is 2.21 while it is just about 0.95 for market-recruited R&D personnel (Table 7). In Zhangjiagang and Haimen, the number of market recruited and self-trained R&D employees are similar to each, though market-recruitment

is much less important than self-training. The results indicate that less-developed rural areas are far less attractive for R&D personnel.

Technological Network Building in Rural Enterprises

The preceding section reveals that external sources including domestic enterprises, universities, R&D institutes, and import are playing important roles in technological innovation of rural enterprises, though their importance are not be as significant as internal R&D. The next important question is how rural enterprises build such networks.

Table 8 Importance of Different Information Sources for Technology Import

	Total	Zhangjiagang	Haimen	Dafeng
Government	125(72.3%)	99(71.2%)	26(81.3%)	0
Advertisement from news media	56(32.4%)	36(25.5%)	20(62.6%)	0
Customer	148(85.5%)	119(84.4%)	29(87.6%)	0
Import/Export Firm	133(77.3%)	111(76.7%)	22(71.0%)	0
Personal relations	91(52.6%)	67(47.6%)	24(75.0%)	0
Internet	124 (71.7%)	100(71.9%)	24(65.0%)	0

Notes: data in the table report the number of enterprises that consider the corresponding sources important or very important. Percentages in the parentheses are of the total respondents who answer the question. Comments apply to Tables 9 and 10 as well.

Table 9 Importance of Different Information Sources for Buying Technology from Domestic Universities

	Total	Zhangjiagang	Haimen	Dafeng
Government	132(72.9%)	102(72.8%)	26(81.3%)	4(80.0%)
Advertisement from news media	87(47.8%)	62(52.8%)	23(71.9%)	2(40.0%)
Customer	159(77.4%)	130(89.7%)	27(84.4%)	2(40.0%)
Personal relations	118(64.8%)	88(60.7%)	25(78.1%)	5(100%)
Internet	139 (76.4%)	112(77.3%)	24(75.0%)	3(60%)

**Table 10 Importance of Different Information Sources for Buying Technologies
from R&D Institutes**

	Total	Zhangjiagang	Haimen	Dafeng
Government	135(75.0%)	109(74.6%)	23(76.7%)	3(75.0%)
Advertisement from news media	82(45.3%)	58(39.4%)	22(73.3%)	2(50.0%)
Customer	158(77.3%)	129(87.7%)	26(76.7%)	3(75.0%)
Personal relations	115(63.6%)	89(62.5%)	22(73.3%)	4(100.0%)
Internet	131(72.3%)	105(71.5%)	23(76.7%)	3(75.0%)

Tables 8-10 present the survey results regarding the importance of government, advertisements from new media, customer, personal relationships, and the Internet in technology searching and purchasing from different sources including import, domestic enterprises, universities, and government R&D laboratories. Consistently, the most important source is customer, and the least important source is advertisement from news media. In addition, government agencies, personal contacts, and the Internet are also important, though to a less degree, compared with customer. It is particularly encouraging to note that more than two-thirds of the respondents consider the Internet as important way to find information about technologies. Given that rural areas are at disadvantaged positions regarding their local science and technology resources, using new information technology to search and find technology opportunities is going to be very helpful.

It is also interesting to note that personal relationships and government help play less important roles for enterprises in Zhangjiagang than those in Haimen or Dafeng in searching new technologies, either from domestic or international markets. For example, about 90 percent of rural enterprises in Zhangjiagang considered customers important or very important in obtaining technologies from universities, while only 40 percent of those

enterprises in Dafeng consider so (Table 9). Meanwhile, only about 60 percent of enterprises in Zhangjiagang consider personal relationships important or very important in obtaining technologies from universities, whereas 80 percent of enterprises in Haimen and all enterprises in Dafeng consider so. Such results demonstrate that rural enterprises in more developed areas are more skillful in using market channels to obtain technological information while those in remote areas are more reliant on government help and personal networks.

Finally, we explore the issue of technological partnerships between rural enterprises and various agencies (Table 11). It is obvious that most rural enterprises do not have stable R&D partnerships with domestic enterprises, universities, or government R&D institutes. In total, only 15 percent of the enterprises have any kind of R&D partnerships. Among the three major types of R&D partnerships, the one with government R&D institutes are the most important and 8.4 percent of the enterprises report to have such partnerships. Regarding the geographical difference, enterprises in Zhangjiagang are more likely to involve in all kinds of partnerships than those in Haimen or Dafeng.

Table 11 Technological Partnerships between Rural Enterprises and Other Agencies

	Total	Zhangjiagang	Haimen	Dafeng
R&D Partnership	67 (15.0%)	31 (20.7%)	22 (14.8%)	14(9.5%)
Ent_R&D Partnership	22 (4.9%)	7 (4.7%)	12 (7.9%)	3 (2.0%)
Un_R&D Partnership	24 (5.3%)	12 (8.0%)	8 (5.3%)	4 (2.7%)
Int_R&D Partnership	38 (8.4%)	21 (14.0%)	6 (4.0%)	11 (7.4%)

Notes: R&D partnership: R&D Partnership with enterprises, universities, or R&D institutes; Ent_R&D Partnership: R&D partnerships with domestic enterprises; UN_R&D Partnership: R&D partnerships with universities; Int_R&D partnership: R&D partnerships with government R&D institutes. Numbers in the table report those enterprises who reported to have such partnerships.

Table 12 Importance of Different Factors in Building R&D Partnerships

	Total	Zhangjiagang	Haimen	Dafeng
Government	46(68.7%)	18(58.0%)	17(77.2%)	11(78.6%)
Advertisement from news media	31(46.3%)	13(41.9%)	12(54.5%)	6(42.8%)
Customer	50(64.6%)	24(77.5%)	18(81.8%)	8(57.1%)
Personal relations	45(67.2%)	20(64.5%)	14(63.6%)	11(78.6%)
Internet	37(55.3%)	20(64.5%)	11(50%)	6(42.8%)

In building such R&D partnerships, government help, customers, and personal relationships play the major roles in general, while news media and the Internet are playing secondary roles (Tables 12). Again, there exists significant difference among the three counties. In Zhangjiagang, customer is playing the leading role, while the role of government agencies and personal relationships is significantly reduced compared with Dafeng and Haimen. Such results further confirm that enterprises in more developed areas are more experienced in using market channels rather than relying on personal relationships or government help. Finally, rural enterprises in Zhangjiagang consider the roles of the Internet more important than those in Haimen or Dafeng. Such results indicate that rural enterprises in developed areas are more skillful in using new information technologies.

Innovation in Rural Enterprises: A Few Cases

In this section, we will present a few cases to demonstrate how innovative rural enterprises are, and what problems they have in technology development and what strategies they adopted in response to such problems. The three selected enterprises are in different industries, one in auto parts, the second is an automobile manufacturer, and the third one is engaged in information technology. These three enterprises represent different levels of requirement for technological innovation. In each case we will include information about the township where the enterprise is located, the profile and brief history of the enterprise, and its innovation activities.

Case 1: A small rural enterprise in a remote township

Factory A's major products are vehicle lights and is a small rural enterprises with about 200 employees in 2002. Its annual sales were about 23 million yuan. The factory is located in a township about 30 km northeast of Zhangjiagang and right along the Yangtze River. The township has a population about 40,000 and traditionally was relatively poor compared with other townships in Zhanjiagang due to its short history (only about 100 years) and remote location. In 2002, its gross domestic product was about 0.6 billion yuan. In comparison, GDP for the other township we visited was about 1.3 billion yuan though its population was less than 30,000.

The light factory was founded in a neighboring township in 1992, when many automobile factories were founded in Zhangjiagang, which created a big demand for vehicle lights. In 1994, it was moved to the current site. The major reason for the move was that the City Government Supervising Bureau (*Jian cha ju*) was assigned by the city

government to help alleviate the poverty at the current township (*Fu pin*), and vehicle light industry was considered promising, since Zhangjiagang had many auto vehicle factories.

In 2002, the factory had 15 persons on its technical staff among its 200 employees. Among the technical staff, there are three engineers and five have B.A. above degrees. Such a technical staff has become the driving force of product development in this factory. Indeed, all the new products between 2000 and 2001 were developed by internally and new products were more than half of its sales in 2001. Surprisingly, no partnerships or cooperation with domestic universities, state R&D institutes or enterprises were reported. However, the factory did purchase processing technologies from foreign countries.

Technologies were very rudimentary at the early stage of development for the factory. Lights were made primarily through simple technologies such as Plexiglas heating, and their qualities were very poor. As the result, the central government Quality Monitoring Bureau prohibited the factory to manufacture vehicle lights any more in 1996. Consequently, the manager of the factory decided to invite outside experts from vehicle light testing institutes in Chang Chun in Jilin Province, Tianjin, Xiang Fan in Hubei Province to train workers in the factory. Meanwhile, the manager successfully hired a retired former manager of Hubei Automobile Light Factory, which was the only state-invested vehicle enterprise at the time. The retired manager is an expert on vehicle light manufacturing and design, and he also brought a few of his apprentices to the factory. Recently, the enterprise has been able to recruit 10 college graduates from the market to enhance its technology development capabilities.

Regarding the future, one co-founder told us:

“We are facing increasing competition in the market, particularly after China’s entry to the WTO. On the one hand, many large foreign auto parts manufacturers are coming to China and they are posing increasing challenges for domestic manufacturers. On the other hand, their pressure on us will not be so imminent, since most foreign companies are focusing on sedans while we are focusing on middle- and low-end vehicles. ...In order to survive and grow, we have to be innovative. There is no future if we always follow others. The style and color of vehicles change very quickly, many times a year... We at least need to manufacture one model, develop one, while think about still another... Our biggest problem is shortage of technology and high-quality labors. We have tried every year to recruit college students, but have failed most of the times. Only a few are willing to come here.”

Case 2: A large rural enterprise in a relatively technology demanding industry

Factory B is located in the same township as Factory A in the first case. It is a relatively big rural enterprise with 1,274 employees on its payroll in 2001, and its sales in 2001 were about 400 million yuan. Its main products are buses used both for urban and long-distance transportation. Its major business is to purchase vehicle chassis and engines and other major auto parts from external suppliers, then design its own vehicle body and assemble them together for the markets. Originally, the factory was part of the township Construction Team in 1973, which had some electric welding workers. In 1974, the group of people set up a shop and began to provide maintenance services for automobiles. In 1975, through hiring a senior engineer from an automobile factory in Suzhou, the group assembled the first mini-van (*Mian bao che*). In 1976, the automobile factory was established officially and separated from the Construction team, and assembled 16 mini-

vans and trucks. In 1983, the factory manufactured more than 1,000 vehicles and in 1988, and its main products are special-purpose vehicles including those used for environmental protection (*Huan bao che*), science and technology diffusion (*Keji pucha che* or *Kepu che*), Electricity maintenance (*Dianli che*), and ambulance. These special-purpose vehicles are included in the state auto industry plan and were about half of the factory's sales. In 1993, the factory attracted some investments from Singapore and Thailand. It was restructured into a joint-invested venture and foreign investors held 51% of the shares. However, the joint venture was not successful because of some disagreements regarding the expansion rate. In 1995, Zhangjiagang city government reorganized the automobile industries and consolidated many small local factories into an automobile industry group (Mudan Automobile Group) and the enterprise was not admitted because of its involvement with foreign investments. In 1998, foreign investors decided to withdraw their investments and the enterprise was changed back to a township one. At that time, the enterprise started developing airport dispatcher vehicles. However, it failed because of the vehicles' poor qualities. Major technical problems include those related to engine, the hydraulic system, and electronic circuit control panel. In 1999, the enterprise was restructured into a shareholding corporation, and started to focus on manufacturing buses. Recently it has become one of visible players in China's bus market, particularly in the lower-end segment.

Technologies for manufacturing auto vehicles are relatively sophisticated for rural enterprises, even though they still purchase major components from outside suppliers. Having a team of quality technical personnel is critical for their success. In 2002, the enterprise has 128 people on its technical staff including 28 engineers and 35 assistant engineers. Among the technical staff, 21 of them have B.A. above degrees. Among

technical staff, most of them are hired through labor markets and 6 of them are trained by the factory itself. The Factory has its own patents and has developed new products annually. In 2001, new products were about 20 percent of its annual sales. Again, the new products were developed internally, although the factory did consider external sources important. For example, the factory has formed partnerships with many other domestic automobile manufacturing enterprises in Shanghai, Beijing, Tianjin, Guangzhou, and Nanjing. However, no partnerships were formed with domestic universities or government R&D institutes.

The interview with the director of the Administrative Office gives us a better sense how the enterprise develops its products:

“We purchase chassis from outside suppliers, design and manufacture our own vehicle bodies, and then assemble them. At the very beginning, we designed our products through imitations. Our technical staff traveled to many large cities such as Shanghai, rode their buses, and watched their designs. Then they came back and design our own models. We also collected pictures of foreign vehicles and imitated their designs. We have tried hard to hire high-quality technical workers. In 1994 we hired 14 graduate junior college graduates from Hubei Provinces, and in 2002 we hired 31 college graduates with B.S. from Jiangsu University (at Zhenjiang, Jiangsu), Xi’an Science and Technology University, and Gansu Industrial University. We also “stole” 15 senior technical workers with more than eight years of working experience from other auto vehicle enterprises in Shanghai and other cities.”

“We have set up a Technology Development Department. Offices of the Marketing Department around the country collect information and provide their suggestions for new buses or design, and feed such information to the Technology

Development Department. Meanwhile, our technical staff from the Technology Department also makes lots of travels to different cities. Particularly they will talk with our major customers to find out their opinions on our products and what new products they want. Our model 6100 bus for urban public transportation was developed through discussion with two bus rental companies in Shanghai...Now we are investing 300,000 yuan a year on product development and we are using CAD in our product development and design...Our challenges include the restrictions of government policies, the poor qualities of auto parts from domestic suppliers....and the shortage of human resources...”

Case 3: A rural enterprise in a high-tech industry

Factor C is located in township Y, which is about 20 km east of Zhangjiagang city proper. Population for the township is about 30,000 and annual gross domestic product was about 1.3 billion yuan in 2001. The township is one of most developed rural areas in Zhangjiagang.

Factory C is a relatively large rural enterprise. It has 1,500 employees and its annual sales were about 400 million yuan. The enterprise has been engaged in information technologies since the early 1980s and its major products include PC-case and power suppliers, satellite Set Top Box (STB) decoder, direct broadcast satellite (DBS) tuner, RF Modulator which allows older TV's not equipped with audio and video jacks to be connected with camcorders, DVD players and video game systems. Other products include bank interest calculator, telephone fee calculator, banker cipher-specimen reader, and tax statistics processor, among others. Some of these products enjoy very high market shares in China. For example, it has become the biggest PC-case manufacturer in China, and its annual sales are about 500,000 sets. A few major computer manufacturers

in China are using the PC-cases produced by this enterprise. The enterprise also manufactures more than 20,000 satellite receivers every month and all of them are exported to foreign countries, particularly in the Middle East.

The enterprise has a long history of being innovative. In the early 1980s, it developed the first semi-conductor memory in China, and the memory was used by the surface control system when China launched its first geostationary telecommunication satellite in 1984 (Project “331”). The project first was assigned to a state enterprise in Shanghai but failed. When Factory C was assigned the task, it successfully developed the memory within one month. Consequently it was awarded by the State Defense Industry Science and Technology Commission and received many materials such as steel products with plan price, which was much lower than the corresponding market price when China was still adopting the double-track system of price (plan and market). The enterprise has undertaken more than ten national and provincial government projects for the “Torch Plan”. From 1999, it started developing satellite Set Top Box (STB) decoder, working with a R&D institute under the Ministry of Information Industry, and by 2002, the enterprise had become the leading producer for the product and its market share in China was about 50%. Now it is in the process of developing new products related to intelligent home, among others.

The success of Factory C comes from its strong internal R&D capabilities. Among its 1,500 employees, 400 are engaged among the technical staff, or more than 20% of its employees. Its R&D spending in 2002 was about 15 million yuan, a very impressive amount for a rural enterprise. In addition to developing its own products, the enterprises also have partnerships with many universities and government R&D institutes to jointly develop new products. To ensure that the new technologies will be marketable,

the enterprise gets involved in the cooperative projects from the very beginning including proposal development and evaluation, design and manufacture prototype, and testing.

The example was the development of the satellite Set Top Box (STB) decoder.

Sometimes, they also purchased technologies directly from external sources. Meanwhile, they have set up technology consultancy committee, consisting of Academicians from the Chinese Academy of Science to provide technological guidance. Finally, the enterprise has set up R&D labs in Nanjing and Beijing to tap into the pool of high quality labors in the urban environments, which has become provide strong technological support for the enterprise. The biggest challenge, as the President of the group told us, is “we do not have our own technology standards and we have to follow other’s standards and specification to produce the products. We hope in the future will be able to develop our own standards and others will follow us. Meanwhile we are in shortage of talent people because our poor locations. There is no way for us to compete against enterprises in cities such as Suzhou or Shanghai. For sure those really top talents will not come to us!”

Conclusions and Discussion

This empirical study reveals that rural enterprises in Jiangsu are not very innovative. In comparison to large and medium enterprises in China, rural enterprises are less innovative. For example, about 11.6 percent of rural enterprises in Jiangsu reported to have R&D labs, while about a third of large and medium enterprises reported so (Sun, 2002a); the share of new products in total sales was about 7.4 percent for rural enterprises in Jiangsu, while it was about 13.2 percent for large and medium enterprises (Sun, 2002a). It should bear in mind that enterprises in study are selected from leading counties from corresponding subregions of Jiangsu, itself a leading province in China. As such, rural

enterprises in China would be less innovative in general than those included in this study. Such results demonstrate that rural enterprises are technologically disadvantaged in competition against large and medium enterprises and the prospect for their long term growth is not optimistic.

In addition, this study finds that there exist tremendous regional differences regarding technological innovation in rural enterprises. Rural enterprises in Sunan, the more accessible areas, are more innovative than those in Suzhong and Subei, the remote/periphery areas. The implication of this finding is that it is going to be an extremely challenging task to reduce regional disparities of economic growth in the future, since enterprises in the more advanced areas are more innovative. Consequently, enterprises in more developed areas will be more competitive in market competitions than those in less developed areas. In their efforts to reduce inter-regional inequality, governments should consider promoting technological innovation in less developed areas as an important policy option.

Furthermore, this study demonstrates that rural enterprises are more reliant on internal sources than on external sources for technological innovation. On the positive side, this may indicate that rural enterprises have realized the importance of internal R&D in their technological efforts and have built up some internal R&D capabilities. Without appropriate internal R&D capabilities, rural enterprises will not be able to innovate effectively; they will not be able to screen, search, adopt, transfer and improve new technological opportunities from outside; they will never gain technological independence either. On the negative side, this may also indicate that technological innovation in rural enterprises is severely restrained by their disadvantaged local environments. Their reliance on internal capabilities is not because they want to, but

because they have to, since there are not so many opportunities in their local environments or they are unfamiliarity with the environments in far away urban areas. As such they are unable to access such external resources to help their innovation.

The weak linkages between rural enterprises on the one hand and universities and government R&D laboratories on the other hand clearly indicate that China's national innovation system is still fragmented after nearly two decades of reform (Sun, 2002b). China's national innovation system in the pre-reform era were characterized by the separation of civilian technologies from military technologies, which received most of the funding from the state budget, and the division of labor or separation among industries, government laboratories, and universities. Such a innovation system was low in efficiency, despite its spotty success in developing some military technologies such as satellite and missiles. Since the middle 1980s, the government has tried different approaches to restructure the national innovation system including reorienting R&D towards industrial needs, creating technology markets, merging government laboratories with state-owned enterprises, promoting spin-offs from universities and R&D institutes, and establishing high-technology zones. The overall aims of the reforms are to restructure the national innovation system towards an enterprise-centered and market-oriented system. However, the reforms are only partially successful. Particularly, the linkages among universities, governmental laboratories, and industries are still very weak. In our study, universities and R&D laboratories have not been able to provide quality services to rural enterprises that are lacking R&D resources. As one manager told us "those R&D institute and university researchers do not know what products people like. Their research leads to prototype (*Yang Pin*), but not marketable products (*Chan Pin*).” As such,

universities and government labs need to be further reformed so that their technological efforts are more closely linked with the demands of rural enterprises.

Finally, this study reveals that customers are playing pivotal roles in building technological networks for rural enterprises, while formal channels such as news media are far less important. It is also clear that government agencies are playing significant roles in such a process of network building, particularly in remote less developed areas. Strengthening instead of weakening such governmental services should be the policy choice in the new round of governmental restructuring. Such a policy will help enterprises in rural areas, especially in less developed areas, to be more innovative and consequently more competitive in the market.

This study is exploratory in nature and many questions remain to be explored in the future. Particularly important is to understand why most rural enterprises are not innovative and issues related to organization of technological innovation in rural enterprises. For example, why are certain enterprises more innovative than others? Does technological innovation matter for market performance in rural enterprises? Why do most rural enterprises in this study rely more on internal R&D instead of external sources for their technological innovation, given their limited internal resources? Why are interactions with external sources including universities and government R&D laboratories so weak? What are the barriers in building technological networks? Particularly important is how to attract and retain high-quality talents to work for rural enterprises as demonstrated in the three cases. Examination of these issues will enhance our understanding of technological innovation in rural enterprises and may shed light in terms of how to reduce the urban-rural inequality and the inter-regional inequalities in China.

¹During the 1980s and 1990s, rural enterprises in China were called township and village enterprises (TVEs), defined as those enterprises that are collectively owned by local citizens, controlled by the local (township or villages) governments. There existed a father-son relationship between the TVEs and the local government. Recently, the concept of TVEs has experienced significant changes. In the 1996 Township and Village Enterprises Act of China, TVEs refer to those enterprises with rural collective economic organizations or peasants as the primary investors, located in townships (including villages), and with the obligation to support agricultural development.” Such a definition clearly broadens the tradition concept of TVEs by incorporating those private businesses in rural areas. A further broader definition includes all those enterprises in rural areas, without reference to ownerships. This study concentrates on non-state manufacturing enterprises, since they are the major forms of TVEs in Jiangsu, the study area.

² “Weekend engineer” and “Holiday engineer” refer to those engineers who hold full-time positions in the urban areas, while traveling to rural enterprises during weekend or holidays to provide technical supports in exchange of extra income.

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