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"Learning-by-Subcontracting" or "Self-Selection" as a TNCs' Local Subcontractor: Micro-Level Evidence from China

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Abstract

In this paper, I raise the question of whether SMEs can benefit from "learning-by-subcontracting" or they "self-selecting" to work as a subcontractor because they have the ability to do so and can derive more income from subcontracting than from other work. Using firm-level survey data, I analyze the causal links between subcontracting and productivity. I confirm that the "learning-by-subcontracting" effect exists in Kunshan, China. Subcontractors perform better in terms of technological progress than non-subcontractors. Furthermore, we find that subcontractors can not only benefit from productivity growth but also from improved latent technological progress.

1. Introduction

The role of Small and Medium-sized Enterprises (SMEs) in the progress of economic development and industrialization has long been a topic attracting wide attention in development literature. In the foreseeable future, SMEs will still be the economic backbone of most developing countries. The promotion of SME's efficiency and dynamism, especially technical capabilities, can yield great profits in virtually all economies. However, it is unrealistic for most SMEs to achieve technological progress since most of them are private enterprises. Restrained by their shortage of capital and their small scale, SMEs have natural disadvantages with regard to innovation and technology. Their lack of capital results in insufficient investment in research and development. Even with sufficient R&D funding, they are more vulnerable to R&D risks. Their small size makes increasing returns difficult, thus frustrating the accumulation of sufficient capital to enlarge production or conduct in-depth research and product development. Therefore, the independent innovation capabilities and technological progress of SMEs are restrained.

The acquisition of technologies from external sources is an important means of improving the technological capability of the SMEs. Empirical evidence shows that SMEs tend to rely more on external linkages with customers and suppliers for their innovations (Lee, 1995). Successful SME countries, such as Japan and Korea, have strong technical support systems which linked large enterprises (LEs) with SMEs and transferred technology from LEs to SMEs. In most developing countries, it is generally believed that FDI companies, especially those associated with new or technologically complex products, have more advanced technologies than local firms. FDI is an important source of technology transfer to local enterprises. Kokko (1994) states that there are four channels for the spillover effect from FDI: the demonstration of new technologies; the provision of technical assistance to local suppliers and customers; labor turnover from multinationals to domestic firms and the effect of competition. Such characteristics have led to the extensive liberalization of FDI regimes in many developing countries. On the other hand, although FDI plays a dominant role in cross-border technology transfer and technology diffusion in developing countries, it does not automatically mean that local SMEs will benefit from FDI companies. It depends on whether local SMEs are ready to do business with FDI companies, and whether local SMEs have the ability to leapfrog over the traditional barriers and constraints facing SMEs. Indeed, capital, technology and markets have long been insurmountable constraints and barriers confronting most SMEs (Berry & Mazumdar, 1991).

Subcontracting relationships with large enterprises, especially Transnational Corporations (TNCs) and their joint ventures and corporate affiliates, are considered an important source of technological progress for SMEs in most developing countries

(UNCTAD, 2001). According to Hondai (as quoted in Hayashi, 2002), the main benefits that SMEs can obtain from subcontracting transactions with large scale parent firms are: (1) the reduction of information and transaction costs through subcontracting ties, which includes the easy and cheap acquisition from large-scale parent firms of new technologies, product designs, production processes, management methods, marketing and input materials; (2) the reduction of risk and uncertainty and an increase in the expected rate of profit as a consequence of stable orders and better payment conditions; and (3) improvements in their credit worthiness.

Developing countries lack large enterprises. TNCs and FDI can act as a source of growth for local SMEs. TNCs and their local affiliates can provide more opportunities for backward linkages through subcontracting to local SMEs, thereby providing local SMEs with better scope for accessing infrastructural resources, such as technology, finance, marketing and human resources. Therefore, a subcontracting relationship with TNCs and FDI companies may be one of the few important short cuts that will enable a firm to leapfrog over the traditional barriers and constraints facing SMEs. The parent firm (TNCs) will provide "missing elements" to subcontractors (SMEs) who need to be fully competitive (Lall, 2000). Subcontracting benefits to SMEs include accepting technical assistance from TNCs to enhance skills, improve standards and capacity, provide access to technical support for product quality and upgrading, management support, financial support, and the provision of large/stable orders. In addition, networking with MNEs and large enterprises can often be a valuable source of modern technologies as well as access to foreign markets, marketing and distribution information (Knorringa and Schmitz, 2000). SMEs from developing countries should seize this opportunity to enter into subcontracting relations.

Subcontracting relationships with TNCs or their local affiliates have now attracted renewed attention. Several studies have examined the export-spillover effect of FDI on local firms, which often take place through the subcontracting arrangement (Berry & Levy, 1994, 1999; Lall, 2000). Unfortunately, most of the existing literature on technology transfers or spillovers from TNCs and FDI to developing countries does not make a distinction between local SMEs and local large enterprises. Some researchers have investigated the role of subcontracting arrangements between TNCs and SMEs through case studies (Islam, 1992; Sato, 2000; Supratikno, 2001; Tangkitvanich, 2004; Gwari, 2005; Punyasavatsut, 2007). However, only a few empirical studies employ firm-level survey data (Deardorff and Djankov, 2000; Hayashi, 2002; Thompson, 2002; Sudhir Kumar and Bala Subrahmanya, 2010). One shared conclusion from these studies is that TNCs or their local affiliates can play an important role in capacity building in local SMEs through subcontracting arrangements.

There is much we do not understand about subcontracting relationships with TNCs.

The following questions still need an answer.

(1) Whether the SMEs of developing countries can make use of their subcontracting relationships with TNCs to acquire technological upgrading and competitiveness? This must be confirmed by large-scale firm-level data, and by comparing subcontractors with non-subcontractors.

(2) Do SMEs who seek inter-firm linkages with TNCs through subcontracting do so as a result of ―self-selection" or of ―learning-by-subcontracting"? If the answer is self-selection, subcontracting will be an ordinary business activity, and this answer will challenge the strategy of governments of developing countries who hope to promote technological progress in local SMEs through subcontracts.

(3) Which kinds of SMEs should benefit from subcontracting relationships with TNCs? Does it depend on a firm's size, differences between industrial sectors, technologies and skills, brands, locations in clusters, or are there other factors involved?

(4) How could the SMEs of developing countries make use of their subcontracting relationships with TNCs to acquire technological upgrading and competitiveness?

There is still a question which has not been noticed by the previous literature. What should we use to measure the impact of TNCs who outsource work to subcontractors on local SMEs who work as a subcontractor, particularly in the area of technology transfers. What should we take to measure the performance of local SMEs? In the existing literature, total factor productivity (TFP) is viewed as a precise method in subcontracting research. As we know from the seminal contribution of Hall (1988), the usual Solow residual (TFP) is a bias estimate of actual unobserved productivity growth. On the other hand, the impact of TNCs is not only on local SMEs' productivity. TNCs can transfer ―hard" technologies to a subcontractor, such as patents, specifications and mechanical details. They can also transfer ―soft" technologies, such as information, expertise, organizational skills, management, marketing and technical know-how (Dunning, 1994; Pavitt and Patel, 1988; Thompson, 2002). Some of this impact can be felt on performance immediately and can be measured through productivity or by TFP, but others only show up as a rise in the level of technology and cannot be measured by TFP. Compared to productivity, the level of technology is more important for local SMEs, because it represents a capacity for sustainable development. Objectively measuring the level of technology and the extent of its increase is beset with difficulties. I suggest we use an enterprise's subjective judgment.

This paper examines these topics by focusing on two types of enterprise and two types of technological progress. The two types of enterprise are subcontractors and non-subcontractors. The types of technological progress are productivity (TFP) and

recessive technology progress as measured by a rise in the level of technology and an enterprise's subjective judgments.

The remainder of this paper is organized as follow. The next section reviews the literature. Section 3 explains the reasons for choosing Kunshan as a sample. Section 4 describes the questionnaire, data and empirical method. Section 5 presents the empirical results, and section 6 concludes the paper.

2. Review of the Literature

Many studies concern themselves with the subcontract, but not many are concerned with subcontracting relationships with TNCs, and fewer still are empirical studies based on the use of firm-level survey data. In the field of subcontract research, Japan is a major topic in the literature. Japan's multi-tier subcontracting system, based on specialization and SMEs, is considered a factor in the improvement of a firm's efficiency and the competitiveness of Japanese manufacturing (Nishiguchi, 1994; Hines,1994), especially in textiles, general machinery, electrical machinery, and the automobile industry (Kimura,2002). One special characteristic of the Japanese subcontracting system is the impact of SMEs on technological progress. Urata and Kawai (2002) pointed that subcontractors can acquire technologies from their parent firms, and parent firms often put pressure on subcontractors to improve their technological capabilities by having flexible relations. In-house R&D, participation in R&D seminars and technological assistance provided by parent firms are the main source of technology for SMEs through their subcontracts. This observation appears to be very attractive for the developing world. Lots of developing countries are fond of building subcontracting relationships between local SMEs and TNCs.

In the existing literature, we lack strong evidence to support the idea of developing countries doing this. Some evidence has been found in the research of the spillover effects from FDI. Kinoshita (1999), using firm-level survey data in 1992 in China, found that a "catch-up" (technology spillover) effect significantly raised a firm's TFP. Locally owned firms' productivity growth was positively affected by the presence of supplier linkages with foreign-owned firms. Sjöholm(1997) arrived at the same conclusion by using micro-data from the Indonesian manufacturing sector, but other empirical literature has not been unambiguous. Haddad and Harrison (1993) employ firm-level data from 2000 enterprises in the Moroccan manufacturing sector between 1985 and 1989. They suggest that FDI was associated with a one-time increase in domestic firms' efficiency. Aitken and Harrison (1999) use a panel of more than 4,000 Venezuelan plants between 1976 and 1989, find foreign equity participation is positively correlated with plant productivity, but observe that this relationship is only robust for small enterprises.

From some evidence from the research on backward vertical linkages established by TNCs. Turok (1993), Lall (1995) believed that the benefit of FDI in terms of technology transfers and spillovers can be enhanced by backward vertical linkages. In other words, technology transfers and spillovers are most likely to take place through backward linkages. Based on a firm-level panel data set from Lithuania, Javorcik (2004) examined whether there exists a correlation between the productivity growth of domestic firms and the presence of foreign affiliates in downstream sectors and found the presence of productivity

spillovers taking place through backward linkages. Belderbos *et al.* (2001) examined the factors determining backward vertical linkages through an analysis of the local content ratio of 272 Japanese electronics manufacturing affiliates in 24 countries, using the local content ratio as a dependent variable. They found that the quality of infrastructure and the size of the local components supply industry was a promoting factor. Kiyota *et al.* (2008) did the same work as Belderbos *et al.* but focused on local procurement and used a wider range of affiliate-level panel data from 1994 to 2000. They found that local supply-chain networks played an important role in the formation of backward linkages with foreign affiliates and that the length of the operation has positive effects on the local procurement of affiliates, especially in Southeast Asian countries and China.

Some researchers have investigated the role of subcontracting arrangements between TNCs and SMEs. Most of them employ case studies. Their main approach is to select some typical industries or enterprises, and then describe and summarize the changes before and after their work as subcontractors. The standard is the company's subjective feeling about some significant indicators like the results of one specific technology or other. Iman and Nagata (2002) researched the case of Komatsu Indonesia and its two small local subcontractors, and found that the local subcontractor could upgrade its technological capability, although the main benefits were largely in a tacit or unspoken form and the evidence is weak and subjective. They employed training opportunities and new customers as evidence. Berry *et al.* (2002) provide some evidence of the importance of subcontracts to SMEs in Indonesia. They find that subcontracting with foreign firms has played an important role in helping SMEs become successful exporters in rattan, Jepara furniture, and in the garments industry in Indonesia. Ivarsson and Alvstam (2004, 2005) interviewed AB Volvo and its 389 local component suppliers in Brazil, China, India, and Mexico. This case study shows that even relatively simple assembly operations by a TNC lead to technological upgrading among domestic suppliers, and the main benefits that local suppliers gained from Volvo were improved product and process quality. In addition, Ivarsson and Alvstam suggest that even short-term and "market-based" relationships can generate benefits for suppliers, but we cannot find precise evidence of this from their article. Punyasavatsut (2007) studied the SMEs who work as domestic suppliers for foreign firms in the automotive industry in Thailand, and found that linkages between foreign assemblers and domestic suppliers played an important role in improving the competitiveness of SMEs. Foreign assemblers are the major source of technologies in SMEs, especially management technology in the areas of quality control and production. Sudhir Kumar and Bala Subrahmanya (2009) use a case covering two SMEs in Bangalore. They take new plant and machinery, outputs and the customer base as the ideal indicators of SME performance with regard to technical progress, and find that customer (TNCs) requirements were the major factor.

Compared with the interest and action shown by the governments of developing

countries, much evidence about the impact of subcontracts still needs to be gathered. Despite the adoption of case studies, we found that the evidence for knowledge transfers from TNCs to their local subcontractor and for technology development in SMEs is indirect, subjective and weak. It is only through empirical research that we can arrive at a precise answer, and we need firm-level data, but few researchers have attempted to go beyond qualitative case study evidence. Deardorff and Djankov (2000) draw on detailed enterprise surveys and interviews with the managers of 373 manufacturing firms in the Prague region, and discovered the significance of subcontracting arrangements as a source of knowledge transfer and increased efficiency for Czech firms from 1993 through 1996. In their view, subcontracting is a less formal channel of knowledge transfer, but Deardorff and Djankov's sample only covers large and medium-sized firms listed on the Prague Stock Exchange. The finding should be treated with caution in developing countries. Hayashi (2002) calculated TFP indices, based on micro-level data from 60 metal-working and machinery firms in Indonesia that supply their products to automobile, motorcycle, agriculture machinery and bicycle manufacturers. Hayashi's study implies that inter-firm cooperation through subcontracting ties increased the productivity of Indonesian SMEs. Thompson (2002) examined the proposition that FDI in areas where firms are in geographical industrial clusters should transfer technology more than is the case when FDI is geographically dispersed. Data are drawn from a quantitative survey of Hong Kong garment firms with manufacturing investments in Mainland China, and they use, as a criterion, a five-point interval to measure subjective perceptions as expressed using the perceptions of executives as a criterion. They find that clustered FDI is shown to be significantly better than dispersed FDI at transferring technology in certain respects. Sudhir Kumar and Bala Subrahmanya (2010) collected 33 firms' data from local SME suppliers who are manufacturing parts and components for the production or assembly line requirements of a TNC automobile manufacturer in Bangalore. They found that even such weak inter-firm linkages with a TNC through subcontracting are beneficial to Indian SMEs in terms of productivity improvements, particularly labor productivity and overall economic performance.

Why do some developing countries and/or enterprises in developing countries not benefit from subcontracts? The existing literature gives some evidence, but the evidence is insufficient. Brannon *et al.* (1994) found that local technological capacities are the main obstacle in their Northern Mexico case research. Kelegama and Foley (1999) examined the impediments to backward linkages in the garment industry in Sri Lanka, and found that the poor quality of the local (energy) infrastructure is the major obstacle to FDI. Also, capital intensity, and the scale of the economies in upstream fabric and accessory production are major obstacles for local firms. Altenburg (2000) believed that the main reason for the weakness of linkages and spillovers from TNCs to local SMEs is the lack of efficient SMEs who are able to seize new business opportunities related to foreign direct investment. Iman

and Nagata (2002) concluded that the relative ineffectiveness of backward linkages in Indonesia is attributable to the problem of institutional coordination.

There is still one question that has never been discussed in the literature of subcontracts: the direction of causality between subcontracting with TNCs and technological progress among local SMEs. Is there any evidence that SMEs become more efficient after becoming TNCs' local subcontractors (learning-by-subcontracting) or that the efficiency gains from subcontracting gains are related to more efficient plants "self-selecting" into the TNCs' subcontracting system because the returns for doing so are relatively high? Similar problems are now widely discussed among export-led development strategists. Which hypothesis is true? "Learning-by-trading" or "self-selection"? Clerides *et al.* (1998) first discussed this issue. Greenaway *et al.* (2005) summarize the relevant empirical studies, and find that the "self-selection" hypothesis received more support.

It is very important for developing countries to know which hypothesis is true? "Learning-by-subcontracting" or "self-selection"? We also need to answer this question. If subcontracting indeed generates efficiency gains, then subcontracting can be an engine of development for SMEs in developing countries. Maybe for this reason, the governments of developing countries believe that any policy is acceptable as long as it can promote backward vertical linkage between TNCs and SMEs, even regarding local content requirements for foreign investment. On the other hand, TNCs have their own interests, which may not be the same as those of their potential local suppliers, especially local SMEs. These make it more costly for TNCs' local affiliates to invest in building SMEs' capabilities and competitiveness. Only when they can benefit within a reasonable period, will they make such an investment. Most of the time, TNCs may find it too costly and time consuming to help local SMEs to climb to their standards, so they would rather wait for local businesses to raise their standards than help them. We observed contradictory conclusions in the existing literature, although none directly examined this hypothesis. Deardorff and Djankov (2000) seem to support the "self-selection" hypothesis. In their sample, subcontracting is associated with firms with higher initial variable costs. In other words, larger firms attract more subcontracting. Iman and Nagata's case (2002) also supports the "self-selection" hypothesis. In their story, Komatsu Indonesia tested a lot of suppliers. Only four of them were accepted due to their ability to learn and increase their skills. Sudhir Kumar and Bala Subrahmanya (2010) seem to support the "learning-by-subcontracting" hypothesis, band Japan's experience seems to support the "learning-by-subcontracting" hypothesis. Kimura (2002) finds that taking in work as subcontractor is negatively related to size, foreign sales and technological capability.

In fact, the extent to which SMEs in developing countries can benefit from subcontracting relationships with TNCs and FDI companies has been a focus of attention for

governments. However, much evidence still needs to be gathered. The literature reviewed above suggests that a variety of factors are important for subcontracts. So, in the remainder of this paper, we will employ more variables to explore the role of subcontracting.

3. Why We Choose Kunshan as a Research Sample

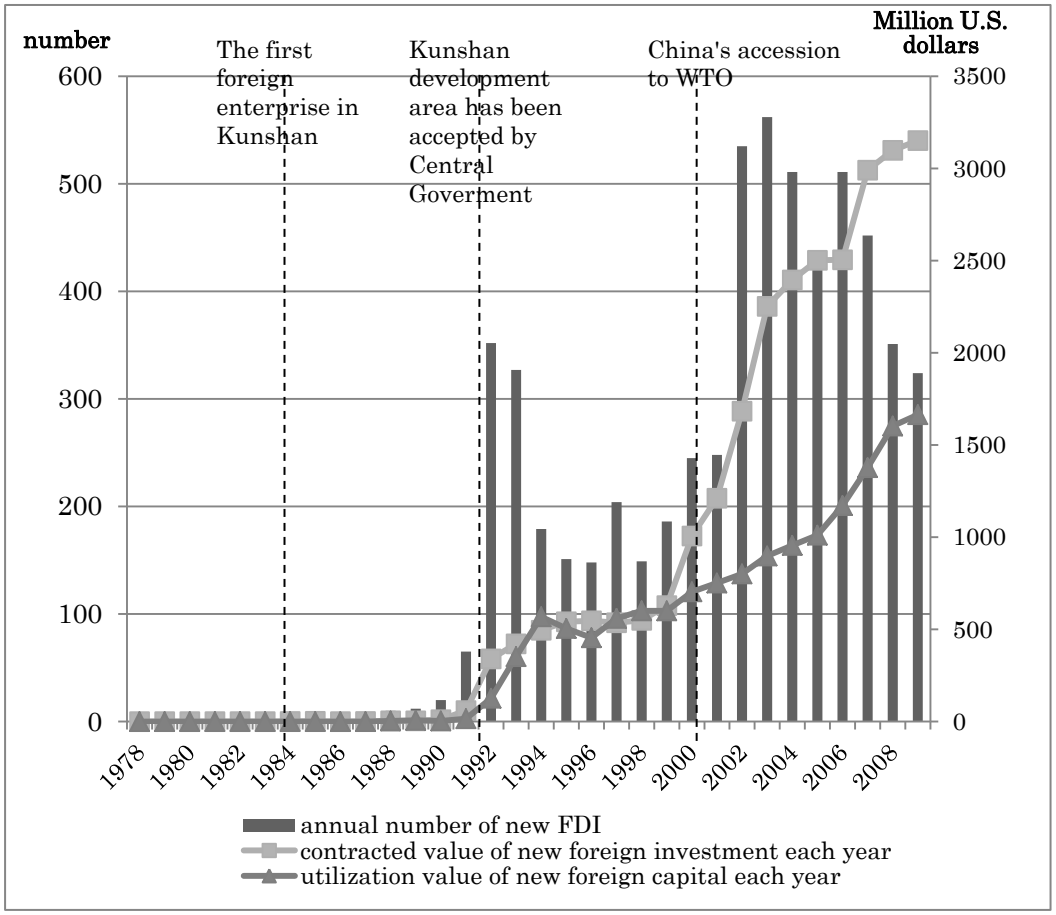
Kunshan is a county-level city within Suzhou City in Jiangsu Province, China, covering 927.68 square kilometers. The registered population of the whole city in 2008 was 69,435, and the transient population from other parts was 954,162.[1] There are three reasons for choosing Kunshan as the research object.

The first reason is that Kunshan is an example of economic development driven by foreign investment in China. Before 1978, Kunshan was just an agricultural county, whose GDP was only 240 million Yuan RMB (about 142 million U.S. dollars, calculated by the Middle Exchange Rate of RMB in 1978), and gross industrial output value was only 100 million Yuan RMB (about 59 million U.S. dollars), whose GDP per capita was just 466 Yuan (about 300 U.S. dollars) and per capita deposits were 22 Yuan RMB (about 13 U.S. dollars). Kunshan was the first city to establish a development zone (Kunshan Development Area) at its own expense in China in 1984. This started its journey to FDI-based economic development. In the history of FDI development in Kunshan (Figure 1), two time points are very important. One is 1992, when the Kunshan Development Area was accepted by the Chinese Central Government, so they could give the same preferential policies to foreign investors as other areas. Kunshan attractiveness to foreign investors was thus greatly enhanced. The actual utilization of foreign capital increased by 717% over 1991-92. Another time point is 2001, with China's accession to the WTO, when the distribution of foreign trade changed in Kunshan. Before 2001, the fields for foreign investment were labor-intensive industries in Kunshan, such as textiles, foods and machinery. However, from 2001, most foreign-funded enterprises invested in capital-intensive industries in Kunshan, such as the electronics information industry. As of 2007, the electronics industry and the mechanical industry became the largest foreign investment fields in Kunshan. Their registered capital, taking into account the proportion of total registered foreign capital, reached 32% and 20.6 % (Table 1).

Contrary to what one might imagine, only small enterprises invest in Kunshan and every investment project is small. Since 1992, the average size of foreign investment continued to grow. In the period 1984-1991, the average size of contracted foreign investment was 720 thousand U.S. dollars and it increased to 4.77 million U.S. dollars in the period 2002-2007 (Table 2). Especially in 2007, the average registered capital of foreign-funded enterprises reached 6.6 million U.S. dollars. Many foreign enterprises have invested more than 10 million U.S. dollars in Kunshan since 1991. Some enterprises have

[1] All data in this paragraph are from the Kunshan Statistics Bureau.

Figure 1. The History of FDI in Kunshan



Source: Kunshan Statistics Bureau

Table 1. Distribution by Industry of Foreign-funded Enterprises (End of 2007)

Industry	Number	Total investment (million USD)	Total registered capital (million USD)	Proportion (%)
Agriculture	81	517.34	238.44	1.16
Food	162	1916.36	932.46	4.53
Ttextiles	698	2323.46	1094.41	5.32
Furniture	161	1130.15	541.95	2.63
Chemical industry	632	5196.09	2501.43	12.15
Machinery	1399	9425.55	4245.15	20.62
Electronics	1067	16318.71	6587.04	32.00
Tertiary industry	680	5139.22	2498.33	12.14
Total	5293	46039.70	20584.14	100.00

Source: Kunshan Statistics Bureau

Table 2. The Average Size of Contracted Foreign Investment in Kunshan

Year	Number	Contracted foreign investment（million USD）	The average size of contracted foreign investment（million USD）
1984～1991	112	80.96	0.72
1992～1996	1157	2344.46	2.02
1997～2001	1032	3932.83	3.81
2002～2007	3006	14338.87	4.77

Source: Kunshan Statistics Bureau

invested even more than 100 million U.S. dollars. As of 2007, Kunshan has 1,227 foreign investment projects which have invested more than 10 million U.S. dollars, and 46 projects which have invested more than 100 million U.S. dollars. Of the Forbes Global 500 enterprises, 25 companies invested in Kunshan, and they had established 55 factories as of 2007.[2]

Now, Kunshan has become a representative of economic success driven by foreign investment. With the help of FDI, the per capita GDP in Kunshan in 2008 reached 120,882 Yuan. It thus became the richest area in China. In 2008, industrial output reached 500 billion Yuan, making Kunshan the first county-level city in China to reach this figure, and the FDI enterprises' output reached 448.596 billion Yuan. Exports totaled 38,664 million USD in 2008, accounting for 16% of the exports in Jiangsu Province and 2.4% of nation-wide exports. The production of laptops, the main product of Kunshan, reached 60 million in 2008, accounting for almost half of global production. The production of digital cameras accounted for 15% of global production.[3]

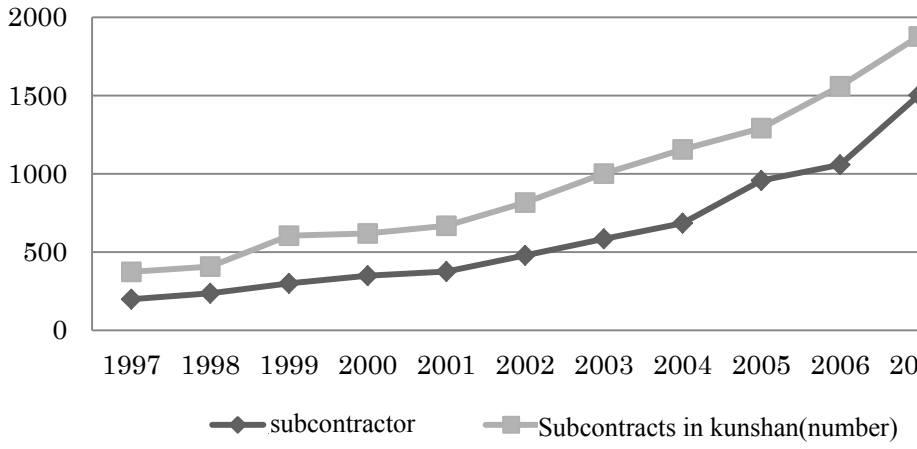
The second reason for choosing Kunshan as a research sample is that Kunshan is a typical sample of subcontracting with TNCs in China. Kunshan is a district in which there are nearly no state-owned enterprises. Most of the "local enterprises" are small private enterprises, which mainly produce intermediate materials, components, and other parts for foreign-funded enterprises. We call this type of enterprise "Subcontractor". We do not know when the subcontractors began to emerge, but since 1997, we have statistical data. Figure 2 and 3 shows the development of subcontracting in Kunshan, and all of the firms concerned are private enterprises. In 1997, only 199 private enterprises were subcontractors, and they carried out 374 projects for foreign-invested enterprises with a sales value of 1.1 billion Yuan for foreign-funded enterprises and a tax value of 0.161 billion Yuan. In 2007, the

[2] All data in this paragraph are from the Kunshan Statistics Bureau.
[3] All data in this paragraph are from the Kunshan Statistics Bureau.

number of subcontracts was 1503, the number of projects rose to 1878, the sales value was 31.62 billion Yuan, and the tax value 3.33 billion Yuan.

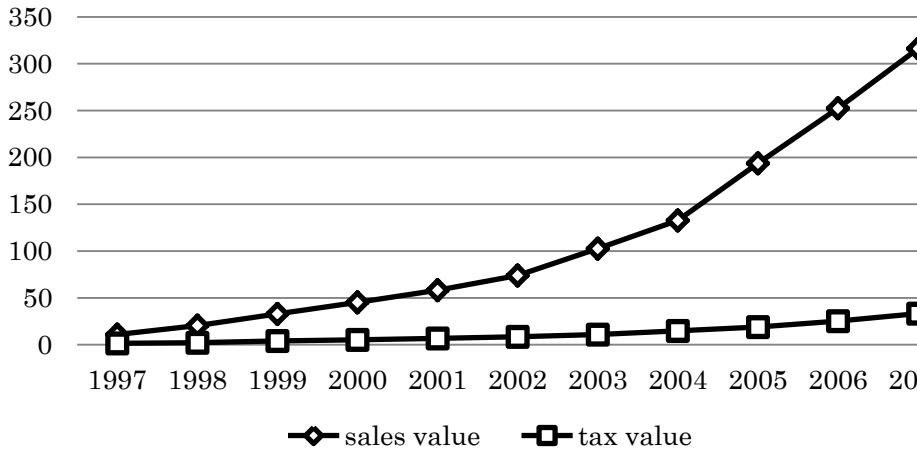
Subcontracting with TNCs in Kunshan is distributed among many industrial sectors, such as the IT industry, the auto parts industry, the printing and packaging industry, and so on. The dominant sectors are the electronics information industry, the precision machinery industry, the printing and packaging industry, the consumer goods industry and the fine

Figure 2. Subcontracts in Kunshan(number)



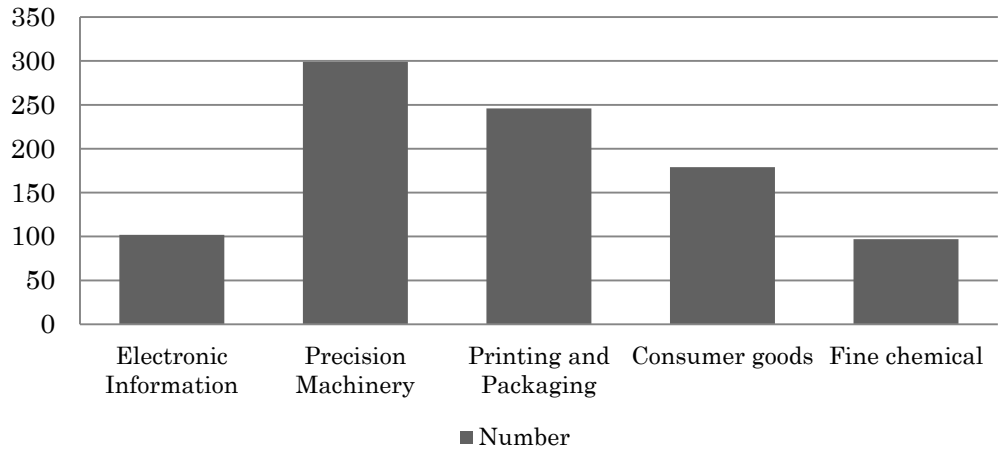
Source: Kunshan Statistics Bureau

Figure 3. Subcontracts in Kunshan(value 100 million yuan)



Source: Kunshan Statistics Bureau

Figure 4: Five Major Industrial Sectors Involved in Kunshan's Subcontracting



Source: Kunshan Statistics Bureau

chemicals industry (Figure 4). In terms of geographical distribution, affiliates in Kunshan appear to be clustered. The IT industry is clustered in Kunshan Economic & Technical Development Zone. The abrasives industry is clustered in Yushan town. The circuit board industry is in Qiandeng town, printing and packaging industry in Zhangpu town, the children's products industry in Lujia town, the auto parts industry in Huaqiao town, and so on.

Observing the history of subcontracting in Kunshan, there has been a large time lag between FDI entry into Kunshan and local enterprises working as subcontractors. When foreign companies settled in Kunshan, their local procurement ratio was generally small. However, with improvements in the chain of production, in order to reduce procurement costs, FDI companies increased their local procurement ratio in line with the promise of improved quality standards. During our research in Kunshan, we find evidence of this in such firms as Giant Bicycle, Makita (China) and Kunda Computers. When Giant Bicycle first settled in Kunshan in 1992, their main subcontractors came from Taiwan and these subcontractors invested in Kunshan, together with Giant Bicycle, but in 2007 the main subcontractors were local private enterprises. When Makita (China) first settled in Kunshan in 1993, their local procurement ratio was less than 5%. This ratio became more than 65% in 2007. When Kunda Computer first settled in Kunshan in 1993, more than 95% of their raw materials and components were imported, but in 2007, their local procurement ratio was more than 85%. These stories seem to confirm the "vintage effect" hypothesis put forward by Kiyota *et al.* (2008). They found that the experience of Japanese multinationals operating

Table 3. Technical Capacity of Private Enterprises in Kunshan (End of 2007)

standard	number	standard	number
Provincial Private Technology Enterprises	191	Top Chinese brands	4
National Hi-Tech Enterprises	12	Famous Chinese brands	4
National High-Tech Products	19	Provincial brands	18
Provincial High-Tech Enterprises	73	Famous provincial products	13
Provincial High-Tech Products	159	Patent applications	8686
Provincial-level Enterprise Technology Centers	7	Licensing volume	4688
Suzhou Municipal Enterprise Technological Centers	26	Registered trademark	2000

Source: Kunshan Statistics Bureau

in a local area, measured by their length of operation, has positive and sometimes non-linear effects on the local procurement activities of affiliates, especially in Southeast Asian countries and China.

People are not aware that Kunshan has taken advantage of the influx of overseas investment, by improving the technological level of local enterprises by virtue of subcontracting with TNCs and FDI companies, but through investigation in Kunshan we found that local private enterprises continuously improve their technology and product quality through subcontracting with foreign firms (Table 3). For example, Kunshan ZhenXiong Wire and Cable Company is the largest subcontractor in Kunshan. It is also the world's largest supplier of copper conductors to the IT industry. Ten years ago, it was only a small business. By subcontracting with TNCs and FDI companies, it became a big business. In 2003, Kunshan ZhenXiong became a supplier for Panasonic and Sony. Currently, 80% of the copper conductors needed by Kunshan Foxconn are supplied by Zhenxiong. In 2008, ZhenXiong's sales value was more than 3 billion Yuan. Another example, Kunshan ChangXin Metals and Electric Motor Company is a private enterprise that entered the field of subcontracting with TNCs and FDI companies early on. At first, it could only carry out roughing operations and supplied one kind of accessory. With the help of foreign-funded enterprises, Kunshan ChangXin's buyers, the technical capacity of Kunshan Chuangxin continuously improved. Now Kunshan ChangXin can produce more than 200 kinds of accessories, all of these finished products.

The third reason for choosing Kunshan as a research sample is that the local government has played an important role in helping local private enterprises become subcontractors for foreign firms. From our observations, the local government seems to strongly support the "learning-by-subcontracting" hypothesis. They believe that subcontracting with foreign firms will benefit local enterprises, and these benefits include the upgrading of employee skills, quality improvement, upgrading designs, and obtaining technical knowledge and know-how from TNCs.[4] The Government has therefore taken many measures to establish backward vertical linkages between foreign firms and local enterprises, especially local private enterprises. They organize a cooperation forum between private enterprise and foreign investment enterprises every year, hold special events on subcontracting, use government websites to release supply and demand information about subcontracting. Moreover, every government department has a clear requirement to help foreign enterprises find local subcontractors. In addition, the government gives subsidies to enterprises for investment in equipment in order to stimulate private enterprises to develop the subcontracting side of their business.

[4] This conclusion comes from a discussion with local government officials that included the Major, the Deputy Mayor in charge of industry, and the Secretary of the Kunshan Bureau of Commerce.

4. The Questionnaire, Data and the Framework of Statistical Analysis

4.1. Survey Procedure and Questionnaire

In 2007, with the support of the Kunshan government, we conducted a large-scale questionnaire survey of local and foreign-funded enterprises. The questions focused mainly on the relationship between foreign-funded enterprises and local enterprises, including regarding business, management and technological contacts. We sent out questionnaires to 2000 manufacturing enterprises. 663 of them responded, 360 local manufacturing enterprises and 303 foreign-funded enterprises. The data obtained covers the main countries from which FDI originates, as well as the main export sectors and main industrial chains. The process of investigation is summarized as follows.

Based on discussions with local government staff, a questionnaire was devised. Initially, we wanted to use Kunshan's manufacturing enterprises as recorded with the Kunshan Industrial and Commercial Administration as a population, and use a random sampling method to select samples, but government staff told us of the risks of this approach: (1) There are often differences between the company's actual operating address and the address recorded with the Kunshan Industrial and Commercial Administration, so we would not know where to send the questionnaire; (2) Manufacturing enterprises are generally unwilling to accept any investigation. Our pilot test via mail also proved to be a failure. So we decided to cooperate with the government. 2000 questionnaires were sent by investigators, 1000 questionnaires for local manufacturing SMEs, and 1000 questionnaires for foreign manufacturers. All the investigators are government staff from various towns in Kunshan. To make the survey sample as consistent as possible with the requirements of random sampling, we asked the investigator to randomly choose manufacturing enterprises as a sample in their area of responsibility.

From the final results, we are close to the requirements for random sampling, but they are not equivalent to a random sampling. The weaknesses of this approach are: (1) We cannot obtain an enterprise's information on costs, profits, wages, debts, customer names, etc. This limits our choice in tools of analysis and in our scope of analysis. (2) There may be some beautification of the findings. Investigators may choose some "looks-good" enterprise in order to exaggerate their achievements and display a bright future for the region. While being investigated, an enterprise may exaggerate their achievements and difficulties in order to obtain encouragement and help from the government. (3) Micro-companies and family businesses were omitted. Micro-companies and family businesses make up the vast majority of the enterprises in Japan's subcontracting system. In Ota City in Japan, a symbol of Japan's SMEs' cluster areas, the number of family businesses with three or fewer employees

accounts for about 50% of the total, while the number of family businesses with nine or fewer employees accounts for about 82%. The majority handles subcontracted fabrication.[5] However, it is impossible to do a sample survey of micro-companies or family businesses, because they are never registered in any government department, they use private not business accounts, and some of them do not even have a formal business name. They are still part of the value chain, as a subcontractor at the lowest level. Omitting them, though, may cause sample bias.

There are differences between the Questionnaire for FDI companies and the Questionnaire for Local SMEs. The Questionnaire for FDI companies had 94 questions, the Questionnaire for Local SMEs 117. We will use the data which obtained from the Questionnaire for local SMEs in this paper.

The Questionnaire for Local SMEs has six aspects. (1) The basic situation of the enterprise, including the enterprise's name, address, source of investment, industrial sector, the main product, brand or non-brand, the company's ownership, etc. (2) Information related to the enterprise's size, including the company's registered capital, the number of employees, the number of management and technical staff, the fixed capital stock of the past two years, the sales value of the past two years, etc. (3) Information related to the enterprise's technology, including the proportion of imported equipment, the number and types of patents, the number of full-time researchers, R&D investment in 2006, the amount of technology imported in 2006, etc. (4) Relations with foreign-funded enterprises, including whether working as a subcontractor for foreign firms, how to obtain subcontracting opportunities, subcontracting for how many foreign firms, the ratio of sales value related to subcontracting, etc. (5) Information about technological progress, including whether they feel pressure over technological progress, where the pressure comes from, methods to enhance their technical level, how much technical level upgrading there has been over the past three years, whether they have new product plans for the next two years, what kinds of new products, etc. (6) Technological progress concerned with subcontracting, including whether they accepted technical support from foreign firms, the method of technical support from foreign firms, whether they upgraded the company's technical level after subcontracting with foreign firms, whether they will further invest in technology in order to expand the amount of subcontracting they do, etc.

4.2. Data

The data have the following selection characteristics. First, the types of survey data included nominal-level, ordinal-level and ratio-level data. Nominal-level data includes the enterprise's industrial sector, as defined by the Chinese Bureau of Statistics' standard, the

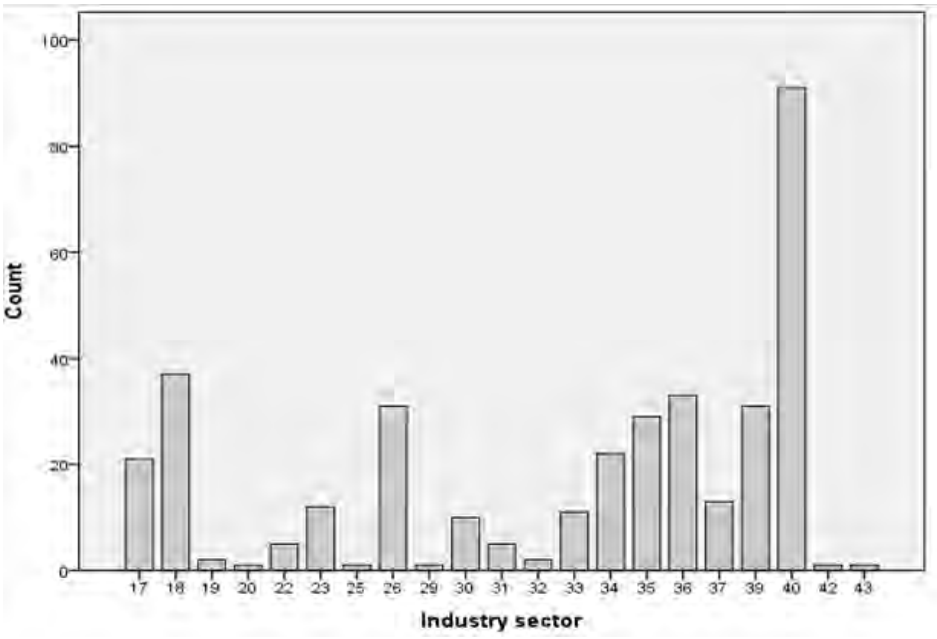
[5]Data source: Ota city industrial promotion organization, ―A guide to Ota city industries"

type of product (intermediate products or final products), the company's ownership, capital sources, whether local or foreign, market scope, position in the value chain, etc. Ordinal-level data includes the extent of technical progress determined by the enterprise's subjective judgments, the performance of the firm's operation, satisfaction with the business environment, the extent of the impact of the foreign company on technological progress, the degree of technical cooperation with local university and research institutions, the degree of technical cooperation with other companies, etc. Ratio-level data includes registered capital value, the number of employees, the number of management and technical staff, fixed capital stock of the past two years, the sales value of the past two years, etc.

Second, we use a five-point Likert scale for the ordinal-level data. Respondents were asked to state their degree of agreement or disagreement on a five point scale during the survey. A Likert scale is commonly used in questionnaires to evaluate any kind of subjective or objective criteria. Often five ordered response levels are used to distinguish between the degrees of agreement or disagreement. Although Dawes (2008) found that a 5- or 7- point scale may produce slightly higher mean scores relative to the highest possible attainable score, compared to those produced from a 10-point scale, and this difference was statistically significant, a five-point Likert scale is broadly accepted in questionnaire surveys because it is most likely to be accepted by respondents. This approach has been accepted in the research on clusters, technology transfers and subcontracts (Ball *et al.,* 1993; Sim & Ali, 1998; Nadvi, 1999; Schmitz, 1999; Thompson, 2002), in which statistical soundness has been demonstrated.

Third, our sample is large enough to accurately reflect the status of the manufacturing sector in Kunshan, and reflect the differences between subcontractors and non-subcontractors. At the end of 2006, Kunshan had 6,498 private manufacturers. We have 360 samples in the field of manufacturing and most of them are private enterprises. Our sample is distributed among 21 manufacturing sectors (Figure 5), close to the actual distribution of manufacturing in Kunshan.

Figure 5. Sample Distribution of Industrial Sectors



Source:Author's Survey

Notrs:

Definitions: Abscissa is the number of the manufacturing sector as defined by the Chinese Bureau of Statistics' standard. sector 17 for the Manufacture of Textiles; sector 18 for the Manufacture of Textile Wear, Footwear and Caps; sector 19 for the Manufacture of Leather, Furs, Down and Related Products; sector 20 for the Processing of Timber, and the Manufacture of Wood, Bamboo, Rattan, Palm and Straw Products; sector 22 for the Manufacture of Paper and Paper Products, sector 23 for Printing and the Reproduction of Recording Media; sector 25 for the Processing of Petroleum, Coking, and the Processing of Nuclear Fuel; sector 26 for the Manufacture of Raw Chemical Materials and Chemical Products; sector 29 for the Manufacture of Rubber; sector 30 for the Manufacture of Plastics, sector 31 for the Manufacture of Non-metallic Mineral Products; sector 32 for the Smelting and Pressing of Ferrous Metals; sector 33 for the Smelting and Pressing of Non-ferrous Metals; sector 34 for the Manufacture of Metal Products; sector 35 for the Manufacture of General Purpose Machinery; sector 36 for the Manufacture of Special Purpose Machinery; sector 37 for the Manufacture of Transport Equipment; sector 39 for the Manufacture of Electrical Machinery and Equipment; sector 40 for the Manufacture of Communication Equipment, Computers and Other Electronic Equipment; sector 42 for the Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work; sector 43 for the Manufacture of Artwork and Other Manufacturing.

Of the 360 samples, 251 enterprises are ongoing subcontractors, and 109 enterprises are non-subcontractors. Sector 40 has 91 enterprises and is the largest sample, and there are 71 enterprises who are ongoing subcontractors. This is also the largest number among all the samples. This is consistent with our observations in Kunshan. From our investigations, we

found that many local companies will actively look for potential foreign demand and import advanced manufacturing equipment in accordance with the quality requirements of foreign firms before they became subcontractors for foreign firms. The reason why these local enterprises dare to purchase the special equipment they need for their subcontracting beforehand is that they are not worried about demand. The electronics information industry is the most concentrated sector for foreign capital in Kunshan, and laptops are the main products of these foreign enterprises. Due to the FDI cluster in the electronics information industry, there exists a lot of potential demand in subcontracting with foreign firms. As long as local enterprises can produce low-cost intermediate products that meet the quality requirements of multinational companies, it is easy to find foreign demand.

The same thing happened in sectors 35, 36 and 39. Sector 39 has 31 samples, in which 24 enterprises are ongoing subcontractors. This sector, the sector for the "Manufacture of Electrical Machinery and Equipment", is the backward linkages sector of the IT and automotive industries. Near Kunshan, there exists an automotive industry cluster in Shanghai. Sector 35, the sector for the "Manufacture of General Purpose Machinery", has 29 samples, of which 23 enterprises are ongoing subcontractors. Sector 36, the sector for the "Manufacture of Special Purpose Machinery", has 33 samples, of which 21 enterprises are ongoing subcontractors. This is the most basic manufacturing sector and it is easy to find opportunities for subcontracting.

Table 4 reports the summary statistics. We found that the standard deviation of the sample is large, and the sample distribution is very scattered. Most enterprises are young; the average age is only 7.63. These samples are typical small and medium-sized enterprises, they have few employees, a low registered capital value, low fixed capital stock, low sales value and low value added. The number of management and technical staff is also small. These show that the SMEs of Kunshan cannot rely on their own ability to improve their technological level because of a shortage of human and financial resources. In these summary statistics, we find that there is little difference between subcontractors and non-subcontractors. Only the average size of a subcontractor is smaller than that of a non-subcontractor. The standard deviation of the subcontractor is also close to the standard deviation of the whole sample. These seem to challenge the hypothesis of "self-selection". There, SMEs should prove themselves more reliable partners than non-subcontractors, and they have the ability to get close to international standards concerning product quality and terms of delivery. Therefore, we need deeper research to find the difference between subcontractors and non-subcontractors.

Table 4. Descriptive Statistics, 2006

Variables	Total sample			Subcontractor		
	n	Mean	S.D.	n	Mean	S.D.
Age(year, end of June 2007)	353	7.63	5.76	248	7.14	5.33
Registered Capital Value(million Yuan)	351	7.05	23.36	250	7.36	26.97
Number of Employees	351	130.45	219.63	253	113.91	134.50
Number of management and technical staff	343	22.15	43.54	247	19.82	23.39
Fixed capital stock(million Yuan)	321	13.24	30.29	235	12.7	27.02
Sales value(million Yuan)	341	28.71	59.72	244	26.19	51.83
Value added(million Yuan)	228	9.37	23.40	172	8.57	20.54

Source: Author's survey

4.3 Measuring Technological Progress: Embodied Technological Progress and Latent Technological Progress

What can SMEs obtain from TNCs through subcontracting linkages? First, there is increased efficiency. Usually, we use productivity growth to express this increase in efficiency. The most commonly used indicator is total factor productivity. But, due to the limited amount of data in research on subcontracts, some researchers use capital productivity, labor productivity and value added to the value of the outputs as indicators (Kumar & Subrahmanya, 2010), some researchers use worker training and the market valuation of firms (net fixed assets plus inventory) as indicators (Deardorff & Djankov, 2000). However, the benefits that SMEs obtain from subcontracting linkages with TNCs extend beyond productivity growth. There still exists latent income. As numerous case studies indicate, TNCs and their local affiliates often provide technical assistance to their local suppliers in order to raise the quality of their products (Iman & Nagata, 2002; Ivarsson & Alvstam, 2004, 2005). They help local suppliers with the organization of the production process (Iman & Nagata, 2002), management technology training (Punyasavatsut, 2007), worker training (Deardorff & Djankov, 2000; Iman & Nagata, 2002), and access to new markets (Iman & Nagata, 2002). These benefits cannot be fully measured by productivity growth. I define these benefits as "Latent technological progress". In contrast, productivity growth can be defined as "Embodied technological progress", and TFP is always used to measure it.

As Deardorff and Djankov (2000) point out, subcontracting is a channel of knowledge transfer between foreign firms and local suppliers. There are two kinds of knowledge, "Explicit knowledge" and "Tacit knowledge". Explicit knowledge can be spread by formal, systematic language, but tacit knowledge cannot be conveyed in this way because

it is deeply rooted in action, commitment, and involvement in a specific context (Nonaka, 1994). TNCs not only transfer explicit knowledge, such as patents, standardization, and technical information to local suppliers, they also transfer tacit knowledge, such as know-how, marketing techniques, and purchasing skills to local suppliers. All of these cannot be fully measured by productivity growth either, so there may only be a small improvement if we use the "embodied technological progress" measure, but tacit knowledge is important for SMEs in developing countries because they lack this knowledge and cannot obtain it on their own. So, from the "latent technological progress" side, there may be a lot of improvement.

Quantitative measurements of knowledge transfers or "latent technological progress" is beset with difficulties. Some of this can be measured by productivity growth. In fact, entrepreneurs are in the best position to learn about the degree of change in their own abilities or knowledge. They know how much knowledge and technology is transferred from TNCs to them. They also know how much latent technological progress they have achieved, but they cannot use quantitative methods to show this, so some qualitative indicator may be acceptable for research purposes. A similar approach is often used in the study of technology transfers.

In this paper, we will use objective and subjective indicators together to define a local enterprise's capacity for change, the degree of influence by multinational corporations, and to measure embodied technological progress and latent technological progress. For an objective indicator, we use total factor productivity (TFP) and TFP growth. Although there are many ways to calculate TFP, the method we have chosen is due to the limitations in our data. We only have one year's data in enterprise's value added, so we use the following Cobb-Douglas form as the production function:

$$Y_i = AK_i^{\alpha} L_i^{\beta} \tag{1}$$

where small-medium enterprise *i* produces value added Y_i, using capital stock K_i and labor (the number of employees) L_i. Then, TFP will be:

$$\ln TFP_i = \ln Y_i - \alpha \ln K_i - \beta \ln L_i \tag{2}$$

The next question concerns our sample being distributed among 21 sectors, and the sample size of nine sectors being less than 10. So we use three ways to deal with this sample. First, every sector's TFP is calculated by using each sector's data, and we ignored sectors with a sample size of less than 10. So, we have data series $TFP1$.

Second, we merged the data between some sectors. From this first step, we found we lost a lot of samples due to our ignoring some sectors. In order to use as much of the sample

as possible, we combined the sectors which have the same production functions. All samples were divided into four industrial groups and each group is almost the same size. Industry Group A is Kunshan's traditional manufacturing industry,[6] Industry Group B is the metal and chemical industries,[7] [m1] Industry Group C consists of the machinery manufacturing industries,[8] Industry Group D is emerging manufacturing in Kunshan.[9] So, we have data series $TFP2$.

Third, TFP is calculated from the data of all samples, so we have data series $TFP3$.

In this test, we also measured the factor characteristics of the industrial group as regards labor, making a division between workers and management and technical staffs. We find that Industry Group A consists of labor-intensive industries, while the industries in Industry Group D are capital-intensive. The number of managers and technical staffs in Industry Group A has a major impact on enterprise output, even more than the role of the workers, but in the other three industry groups, management and technical staffs did not have a significant impact (Table 5). This means that Industry group A has entered a stage of technology-driven development by the technology-driven, and the other three industry groups are still in the stage of being factor-driven, especially Industry group D, where capital investment is the only factor in output growth.

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[6] Industry group A includes: sectors in the Manufacture of Textiles (sector 17); the sectors in the Manufacture of Textile Wear, Footwear and Caps (sector 18); the sector in the Manufacture of Leather, Furs, Down and Related Products (sector 19); the sector in the Processing of Timber, the Manufacture of Wood, Bamboo, Rattan, Palm and Straw Products (sector 20); the sector in the Manufacture of Paper and Paper Products (sector 22); the sector in Printing and the Reproduction of Recording Media (sector 23).

[7] Industry group B includes: the sector in the Processing of Petroleum, Coking, and the Processing of Nuclear Fuel (sector 25); the sector in the Manufacture of Raw Chemical Materials and Chemical Products (sector 26); the sector in the Manufacture of Rubber (sector 29); the sector in the Manufacture of Plastics (sector 30); the sector in the Manufacture of Non-metallic Mineral Products (sector 31); the sector in the Smelting and Pressing of Ferrous Metals (sector 32); the sector in the Smelting and Pressing of Non-ferrous Metals (sector 33); and the sector in the Manufacture of Metal Products (sector 34).

[8] Industry group C includes: the sector in the Manufacture of General Purpose Machinery (sector 35); the sector in the Manufacture of Special Purpose Machinery (sector 36); the sector in the Manufacture of Transport Equipment (sector 37); the sector in the Manufacture of Electrical Machinery and Equipment (sector); the sector in (sector); the sector in (sector 39); the sector in the Manufacture of Artwork and Other Manufacturing (sector 42); the sector in the Manufacture of Artwork and Other Manufacturing (sector 43).

[9] Industry group D is the sector in the Manufacture of Communication Equipment, Computers and Other Electronic Equipment (sector 40).

Table 5. Factor Characteristics of the Industrial Group

	All samples	Industry Group A	Industry Group B	Industry Group C	Industry Group D
LNK	0.447674* (7.196931)	0.169600*** (1.741301)	0.412423** (2.395465)	0.373877* (3.069414)	0.716711* （5.445810）
LNWORKs	0.151966*** (1.869834)	0.408722* (3.297114)	0.19418 (0.838422)	0.289914*** (1.67161)	-0.140454 (-0.660850）
LNHUMTEC	0.355466* (3.772423)	0.421761** （2.530497）	0.279356 （1.042634）	0.239588 (1.330906)	0.220488 （0.972776）
Adjusted R-squared	0.467541	0.663127	0.359336	0.403882	0.505037
F-statistic	65.68516	31.83953	10.16106	14.32454	19.70646
Observations	222	48	50	60	56

Source: Author's Survey and Calculation

Note: WORKs is defined as the number of workers in the enterprises, LNWORKs is the lLogarithm of WORKs; HUMTEC is defined as the number of management and technical staffs in enterprises, LNHUMTEC is the lLogarithm of HUMTEC. Figures in parentheses are t-values. *Indicates significance at 1% level. **Indicates significance at 5% level. ***Indicates significance at 10% level. As many enterprises do not report the number of their management and technical staff number, so the size of the sample size is significantly reduced.

We still need to calculate productivity growth, but we lack data. We only have one year's data in enterprise's value added, so we use Sales value as an alternative variable for value added. We assume:

$$\frac{Y_{i,t+1}}{Y_{i,t}} \cong \frac{S_{i,t+1}}{S_{i,t}} \tag{3}$$

Where $Y_{i,t}$ is defined as enterprise *i* producing value added Y_i in year t, and $S_{i,t}$ is defined as enterprise *I* sales value in year t. Due to:

$$\frac{\ln Y_{i,t+1} - \alpha \ln K_{i,t+1} - \beta \ln L_{i,t+1}}{\ln Y_i - \alpha \ln K_i - \beta \ln L_i} = \frac{\ln S_{i,t+1} - \alpha \ln K_{i,t+1} - \beta \ln L_{i,t+1}}{\ln S_i - \alpha \ln K_i - \beta \ln L_i} \tag{4}$$

So we have productivity growth $\Delta\mathrm{TFP}$. Treating the data we have for calculating TFP, we have $\Delta TFP1, \Delta TFP2$ and $\Delta TFP3$.

As a subjective indicator, the following question was addressed to respondents, including subcontractors and non-subcontractors:

How much technological advance have you made in the past three years? (1) very

significant; (2) significant; (3) some increase; (4) not much; (5) none.

How much impact has local FDI companies had on the technological progress of your company? (1) large; (2) relatively large; (3) average; (4) small; (5) none.

4.4 Framework for the Analysis of Productivity Growth

In order to confirm the effects of subcontracting on enterprise's efficiency, we first need to identify the factors which affect the productivity of subcontractors. Based on the approach taken by Murakami *et al.* (1996) and Hayashi (2002), we use the following Cobb-Douglas form as the production function:

$$Y_i = AK_i^{\alpha} L_i^{\beta} \exp(\gamma \sum_h DUMF_{j,h}) \quad (5)$$

Where $DUMF_{j,h}$ $j = 1,2,\dots,m; h = 0,1,2,3,4)$ [m2] refers to m kinds of factors which affect the productivity of subcontractors. All of these factors have been set as dummy variables; each factor has h kinds of level. Using our questionnaire, we can distinguish a subcontractor from 25 aspects. We divided these into five categories: (1) The basic features of a subcontractor (Table 6); (2) The characteristics associated with hard technology (Table 7); (3) Technical Cooperation (Table 8); (4) The characteristics associated with Subcontracting (Table 9); (5) Characteristics associated with foreign involvement (Table 10).

Table 6 shows the basic characteristics of a subcontractor. Due to our sample being distributed among 21 sectors, different sectors may have different levels of productivity, differences between enterprises' productivity may be caused by differences between the

Table 6. Definition of Dummy Variables of Basic Features of Subcontractors

	$DUMF_{j,h}$	Null hypothesis	$DUMF_{j,1}$	$DUMF_{j,2}$	$DUMF_{j,3}$
1	Industry Classification	Industry Group A	Industry Group B	Industry Group C	Industry Group D
2	Enterprise's ownership	State-owned enterprise	Collective enterprise	Private	Others
3	Enterprise's source of capital	Outside the area but still in china	Local capital		
4	Operation's performance	Poor	Very good	Good	Normal
5	Position in the value chain	Low	Middle	High	
6	Satisfaction with the business environment	Dissatisfied	Satisfied	Normal	

7	Market scope	Domestic market	Overseas market	Both

industrial sectors. The position in the value chain also causes differences in productivity. High-end links seem equal to high productivity. The same applies to an operation's performance. State-owned enterprises are generally synonymous with low efficiency in China. Satisfaction with the business environment represents an omission variable, such as government help. The enterprise's source of capital is an important variable to test the "self-selection" hypothesis. We assume outside capital is invested locally in subcontracting because there exist subcontracting opportunities, and enterprises want to be close to demand. If outside capital has higher productivity than local capital, this may mean that enterprises engage in subcontracting from the outside because they have the ability to do so and can get high returns, instead of "learning-by-subcontracting".

Variables in Table 7 represent the technological capability of an enterprise. Usually, stronger technological capabilities will cause higher productivity. Table 8 represents an enterprise's efforts to acquire knowledge from outside. From these variables, we want to know what kinds of enterprises can benefit more from subcontracting, e.g. whether a firm with stronger technical capacity benefits more from subcontracting.

Table 9 gives some variables concerning subcontracting. From these variables, we want to know which kinds of subcontractor can benefit from subcontracting. According to Hayashi (2002), a higher subcontracting ratio (the share of sales through subcontracting transactions in the total turnover) will significantly affect the productivity of the subcontractor. We wish to verify whether this phenomenon is also observed in Kunshan. Table 10 represents the help of foreign enterprises. Here, we can know whether technical assistance from TNCs can benefit local suppliers, and which kinds of assistance can result in greater improvements in productivity.

Table 7. Definition of Dummy Variables about Characteristics Associated with Hard Technology

	$DUMF_{j,h}$	Null hypothesis	$DUMF_{j,1}$	$DUMF_{j,2}$	$DUMF_{j,3}$	$DUMF_{j,4}$
8	The proportion of imported equipment	40% or less	40-60%	60% or more		
9	Domestic procurement rate in raw materials and spare parts	30% or less	30-60%	60% or more		
10	Brand	No	Yes			
11	Sales of branded products as a ratio of total turnover	10% or less	10-30%	30-50%	50-70%	70% or more
12	R&D departments and/or staff	No	R&D departments	Only R&D staff		
13	The proportion of undergraduates and above	10% or less	10-30%	30-50%	50-70%	70% or more

14	Foreign management and technical staff	No	Yes			

Table 8. Definition of Dummy Variables about Technical Cooperation

	$DUMF_{j,h}$	Null hypothesis	$DUMF_{j,1}$	$DUMF_{j,2}$	$DUMF_{j,3}$	$DUMF_{j,4}$
15	Technical cooperation with local University and research institutions	No	Yes			
16	Technical cooperation with foreign research institutions	No	Yes			
17	Technical cooperation with a company located in a foreign Country	No	Yes			
18	Technical cooperation with other Companies	No	Very close	Close	Average	Relatively loose

Table 9. Definition of Dummy Variables about Characteristics Associated with Subcontracting

	$DUMF_{j,h}$	Null hypothesis	$DUMF_{j,1}$	$DUMF_{j,2}$	$DUMF_{j,3}$	$DUMF_{j,4}$
19	The number of foreign parent companies (a)	1	2-4	5-7	8 or more	
20	The number of foreign parent companies (b)*	0	1	2-4	5-7	8 or more
21	Subcontract product sales proportion of total turnover	20% or less	20-40%	40-60%	60-80%	80% or more
22	Further subcontracted to other firms	No	Yes			

**We will use the total sample which includes subcontractors and non-subcontractors to test this variable.*

Table 10. Definition of Dummy Variables about Characteristics Associated with Foreign Investment

	$DUMF_{j,h}$	Null hypothesis	$DUMF_{j,1}$	$DUMF_{j,2}$	$DUMF_{j,3}$	$DUMF_{j,4}$
23	Technical guidance by foreign investment enterprises	No	Yes			
24	Guidance in the purchase of equipment by foreign investment enterprises	No	Yes			
25	The degree of impact of a foreign eompany on technological progress	No	Large	Relatively large	Average	Small

5. Results of Statistical Analysis

5.1. "Learning-by-Subcontracting" or "Self-Selection"

There is no established method which can test "learning-by-subcontracting" and the "self-selection" hypothesis. We have learnt from Clerides *et al.* (1998) and Heckman *et al.* (1997). Clerides *et al.* verified the "learning-by-subcontracting" hypothesis. Their method is that "If exporting indeed generates efficiency gains, then firms that begin to export should thereafter exhibit a change in the stochastic process that governs their productivity growth. Hence their productivity trajectories must in some sense improve after they enter foreign markets", Clerides *et al.* (1998). Heckman *et al.* propose the matched sample technique.

In our view, we assume that enterprise A does not work as a subcontractor in time *t-1*. If enterprise A works as a subcontractor in time *t*, then the productivity of enterprise A is ω_t^1. If enterprise A does not work as a subcontractor in time *t*, then the productivity of the enterprise A is ω_t^0. The superscript for ω_t defines whether the firm is working as a subcontractor or not, 1 represents work as a subcontractor, 0 represents not working as a subcontractor. So, if we can find $(\omega_t^1 - \omega_t^0) > 0$, we are able to say that enterprise A can get obtained productivity improvements and technological progress from subcontracting, we can verify the hypothesis of "learning-by-subcontracting". But if we find $(\omega_t^1 - \omega_t^0) \leq 0$, we verify the hypothesis of "self-selection". The key issue is that ω_t^0 cannot be observed. How can we get the data we need?

We will use the "counterfactual" method. We assume that every subcontractor was a non- subcontractor before they worked as a subcontractor, so we can select some samples from non-subcontractors and let these samples have the same characteristics as the subcontractors. We define these samples as the control group to contrast them with the subcontractor group.

So, we need to test our survey sample and look for differences between the subcontractors and the non-subcontractors. First, we use the following regression equation as a test tool.

$$Z_{i,k} = \alpha + \beta SUB_i + \gamma S_i + \sum_q \delta_q industrygroup_{i,q} + \omega_i \quad (6)$$

Where $Z_{i,k}$ refers to *k* kinds of variables or characteristics of an enterprise *i*, these characteristics are value added per employee in the enterprise, fixed capital stock per employee in the enterprise, sales value per employee in the enterprise, the proportion of management and technical staff among the total employees. SUB_i is the dummy variable which represents a subcontractor or non-subcontractor, and the null hypothesis is the non-subcontractor. S_i refers to the size of the enterprise i and is expressed by a

logarithm for the number of employees. $industrygroup_{i,q}\ q = A, B, C, D$ is the control variable and the dummy variable. It represents enterprise i as belonging to an industry group as defined in the previous section. The null hypothesis is Industry Group *A*. The reason for using $industrygroup_{i,q}$ is to control an industry's effects. Table 11 gives the results.

From Table 11, we find that there is no difference between subcontractors and non-subcontractors. Whether the enterprise works as a subcontractor or not will not affect the value added per employee, the sales value per employee and the proportion of management and technical staff in the total number of employees. Only the fixed capital stock per employee is affected by subcontracting, but it is significant at 20%, and subcontractors have a higher fixed capital stock per employee. We suspect that this difference comes from an industry's effects. From Table 11, we find that an industrial sector will significantly affect fixed capital stock per employee. Industry Groups *B* and *C* have higher fixed capital stock per employee, especially Industry Group *B*, whose fixed capital stock per employee is 6 thousand Yuan more than the benchmark (Industry Group *A*). In

Table 11. Estimation Result for an Enterprise's Characteristics and Subcontracting

	Value added per employee	Fixed capital stock per employee	Sales value per employee	The proportion of management and technical staff in the total number of employees
Constant	13.45520**	1.582604*	2.604158*	-1.287851*
	(2.558035)	(4.400528)	(8.510996)	(-6.993983)
SUB_i	0.980702	0.217121^{+}	0.038552	-0.020574
	(0.433707)	(1.440563)	(0.297035)	(-0.270077)
S_i	-1.699891***	-0.032425	-0.042670	-0.182789*
	(-1.725207)	(-0.479504)	(-0.736861)	(-5.344309)
Industry Group B	-0.158081	0.606930*	0.815995*	0.369090*
	(-0.050283)	(2.842290)	(4.350893)	(3.329046)
Industry Group C	1.119086	0.325076***	0.538253*	0.426502*
	(0.410812)	(1.778632)	(3.420254)	(4.599712)
Industry Group D	3.475460	0.071693	-0.016941	0.386053*
	(1.205985)	(0.362658)	(-0.099695)	(3.827788)
Adjusted R^2	0.002110	0.029674	0.086659	0.151418
F-statistic	1.096438	2.944963	7.357064	13.09795
Observations	229	319	336	340

Source: Author's survey and calculation

Note: Figures in parentheses are t-values. *Indicates significance at 1% level. **Indicates significance at 5% level. ***Indicates significance at 10% level. + Indicates significance at 20% level.

addition, the size of an enterprise has a negative affect on value added per employee and the proportion of management and technical staff in the total number of employees. This may mean that SMEs of Kunshan have not entered the stage of increasing returns on scale, and that technology and technical staff are still rare among them. We also find the same conclusion in Table 5. What is interesting is that fixed capital stock plays an important role in output in Industry Group *D* (see Table 5), but Industry Group *D* is not significantly affected by its fixed capital stock per employee. This may mean that Industry Group *D* actually is a labor-intensive industry. We confirmed this through our survey in Kunshan.

As subcontractors and non-subcontractors are similar in our samples, we can use non-subcontractors as a control group. We use ANOVA (analysis of variance) to compare the differences between subcontractors and non-subcontractors in terms of their technological capabilities and technological progress. We use *TFP* as an indicator of the technological capabilities of enterprises, and use TFP growth (ΔTFP) as an indicator of the technological progress of enterprises. Our null hypothesis is that there did not exist a difference between subcontractors and non-subcontractors in terms of their technological capabilities and technological progress. Table 12 shows the results.

Table 12. Estimation Results of ANOVA

		Levene test		*t* test			Conclusion
		F	Sig.	T	Df	Sig.(two tail)	
TFP1	Whether engaged in subcontracting or not	1.553	.214	-.181	221	.857	Accepted
	Whether ongoing subcontracting is ongoing or not	1.117	.292	.704	221	.482	Accepted
TFP2	Whether engaged in subcontracting or not	1.449	.230	-.249	222	.804	Accepted
	Whether subcontracting is ongoing or not	3.276	.072	.523	136.8	.602	Accepted
ΔTFP2	Whether engaged in subcontracting or not	.044	.834	-2.325	280	.021	Rejected
	Whether subcontracting is ongoing or not	.018	.893	-1.675	280	.095	Rejected
TFP3	Whether engaged in subcontracting or not	1.863	.174	-.302	222	.763	Accepted
	Whether subcontracting is ongoing or not	4.142	.043	.222	132.3	.825	Accepted
ΔTFP3	Whether engaged in subcontracting or not	8.439	.004	1.042	84.28	.300	Accepted
	Whether subcontracting is ongoing or not	1.382	.241	-.574	279	.566	Accepted

Source: Author's survey and calculation

Table 13. Difference in Latent Technological Progress between Subcontractors and Non-Subcontractors

Variable	Observations	Pearson χ^2	df	Sig. (two tailed)	Conclusion
Whether engaged in subcontracting or not	343	9.298	3	.026	Reject
Whether ongoing ongoing subcontracting is or not	352	7.938	3	.047	Reject

Source: Author's survey and calculation

From Table 12, we find that there is no difference between subcontractors and non-subcontractors in terms of their technological capabilities, no matter what method we use to calculate *TFP*. Three methods all accept the null hypothesis. Combined with the analysis above on the characteristics of an enterprise, we can confirm that there is no difference between subcontractors and non-subcontractors. On the other hand, there exist differences between subcontractors and non-subcontractors in terms of their technological progress. There is a difference in TFP growth between subcontractors and non-subcontractors in terms of whether these subcontractors are ongoing subcontractors or just engaged in subcontracting.

So, from a comparison of productivity, we can prove the hypothesis of "learning-by-subcontracting" and reject the hypothesis of "self-selection". Of course, for further confirmation, we should test the differences between subcontractors and non-subcontractors in terms of their "latent technological progress". In our null hypothesis there is no difference between subcontractors and non-subcontractors. From Table 13, we test two indicators: engaged in subcontracting or not and whether the subcontracting is ongoing or not. We find all of them rejected the null hypothesis. This implies that there exists a difference between subcontractors and non-subcontractors in latent technological progress. So we accept the hypothesis of "learning-by-subcontracting" and reject the hypothesis of "self-selection".

5.2 Which Kinds of Subcontractor Can Get More from Subcontracting?

From equation 5, we have the following regression equation:

$$\ln Y_i = \ln A + \alpha \ln K_i + \beta \ln L_i + \gamma \sum_h DUMF_{j,h} \quad (7)$$

Using this regression equation, we tested 25 factors which affect the productivity of a subcontractor (see Tables 6, 7, 8, 9, and 10). We find that 12 factors had no significant effect on the output of enterprises. These factors are: industry classification, ownership, source of capital, an operation7s performance, market area, the domestic procurement rate in raw

materials and spare parts, foreign management and technical staff, technical cooperation with the local university and research institutions, technical cooperation with foreign research institutions, technical cooperation with a company located abroad, technical cooperation with other companies and sales of the product in the subcontract as a proportion of total turnover.

Among these non-significant factors, some factors, including industry classification, ownership, source of capital, operation performance and market area, met our expectations. Thus, these factors do not affect the size of the enterprise, but some factors, including foreign management and technical staff, technical cooperation with the local university and research institutions, with foreign research institutions, with the company located abroad and with other companies, the results did not meet our expectations, because we guessed that the closer the link with external technology sources the greater the output would be. In particular, we were surprised that sales of the product in the subcontract as a proportion of total turnover is a non-significant factor. This may mean that subcontracting with foreigners is not an important factor in the growth of an enterprise.

Table 14 summarizes the factors which have a significant effect on the output of enterprises. We find enterprises with a higher position in the value chain will do better and have a higher output. Generally, enterprises with more hard technology perform better, but, in terms of the proportion of imported equipment, a medium amount will lead to the best performance. Enterprises which have an R&D department will have the best performance, and enterprises which only have R&D staff will have a better performance than those who

Table 14. Estimation Result for Production Functions

$DUMF_{j,h}$	Intermediate goods or final products	Position in the value chain	Satisfaction withof the business environment	The proportion of imported equipment	Brand	Proportion of sales branded products	R&D departments and/or staff	The proportion of undergraduates and above	Technical guidance by foreign investment enterprises	Guidance in the purchase of equipment by foreign investment enterprises	The impact of foreign investment enterprises ((enterprises' subjective judgments)	The degreeHow great ofthe impact a foreign company has onof technological progress
$DUMF_{j,1}$	0.46* (2.92)	0.45** (2.34)	1.22* (2.62)	0.44*** (1.83)	0.45* (2.84)	-0.58*** (-1.67)	0.23 (1.04)	0.084 (0.47)	0.40*** (1.81)	0.24^{+} (1.28)	0.39** (2.22)	-0.50^{+} (-1.37)
$DUMF_{j,2}$		0.62* (3.67)	1.33* (2.79)	-0.21 (-0.77)		-0.405 (-1.03)	0.42*** (1.94)	0.65 (0.008)			0.05 (0.16)	-0.54*** (-1.76)
$DUMF_{j,3}$						-0.25 (-0.564)		-1.86*** (-1.86)				-0.68** (-2.13)
$DUMF_{j,4}$						-0.07 (-0.22)		-0.20 (-0.31)				-0.72** (-2.08)
Adjusted R-squared	0.477	0.506	0.487	0.471	0.483	0.493	0.506	0.482	0.440	0.427	0.471	0.450
F-statistic	69.92	42.02	50.57	46.20	70.15	18.52	51.15	34.12	47.03	43.91	48.22	29.92
Observations	227	211	218	204	223	109	197	215	177	174	213	213

Source: Author's survey and calculation

Note: Figures in parentheses are t-values. *Indicates significance at 1% level. **Indicates significance at 5% level. ***Indicates significance at 10% level. + Indicates significance at 20% level.

have no R&D department and staff. Brands can also help to promote output, but a higher proportion of sales of branded products has a negative effect on an enterprise's performance. This also implies that it is difficult for SMEs to sell their own brands. Foreign firms can help local SMEs to improve, and the enterprises who get foreign firms' help will perform better than those do not get such help. Technical guidance and guidance in the purchase of equipment by foreign firms are all positive and have a statistically significant effect on SMEs' output.

5.3 Which Kinds of Subcontractor Can Get More from Subcontracting in Terms of Latent Technological Progress?

In our survey, 15.7% of the subcontractors said their technology had a very significant upgrade, 37.8% of the subcontractors said it had had a significant upgrade, 43.4% said it had had some improvement, 3.2% said it had not much improved and no one said they had not upgraded. This finding shows that there exists significant latent technological progress. We also find that 11.5% of the subcontractors said that foreign firms had had a large impact on the technological progress of their enterprises, 28.1% subcontractor said foreign firms had had a relatively large impact, 34.9% subcontractor said foreign firms had had an average impact, 9.5% of subcontractors said foreign firms had had a small impact and 6% of subcontractors said foreign firms had had no impact. These results show that foreign firms have played an important role in the technological progress of local subcontractors.

In order to find which kinds of subcontractor can get more in terms of latent technological progress from subcontracting, we use a non-parametric statistical method to find the difference between subcontractors which have a higher performance or lower performance in terms of latent technological progress. The reason for using this method is the unequal size of samples for most variables.

We use the respondents' answers to the following question as indicators of their performance in latent technological progress.

How much technological advance have you made in the past three years? (1) very significant; (2) significant; (3) some increase; (4) not much; (5) none.

The Pearson χ^2 test will be used first. We use the Pearson χ^2 test to find the relationship between the characteristics of the subcontractor and their performance in terms of latent technological progress. 27 characteristics of subcontractors and/or variables will be involved (Table 15). Most of them are the same as the variables which we used in our

analysis of the productivity of the subcontractors (see Tables 6, 7, 8, 9, and 10). We divided them into five categories: (1) Basic features of the subcontractor; (2) Characteristics associated with subcontracting; (3) Characteristics associated with hard technology; (4)

Table 15. Factors Influencing Latent Technological Progress

	Variable	observations	Pearson χ^2	Df	Sig.(two tailed)	Conclusion
Basic features of the subcontractor	Industry Classification	251	25.876	9	.000	Rreject
	Enterprise's ownership	251	13.957	12	.303	Accept
	Enterprise's capital source	249	9.992	9	.617	Accept
	Intermediate goods or final products	251	20.618	8	.008	Rreject
	Operations performance	247	30.190	9	.000	Rreject
	Position in the value chain	243	47.684	6	.000	Rreject
	Satisfaction with the business environment	243	53.531	9	.000	Rreject
	Market scope	248	32.218	6	.000	Rreject
Characteristics associated with the subcontract	Starting date of subcontract	248	1.296	3	.730	Accept
	The number of foreign parent companies	241	29.670	9	.000	Rreject
	Sales of the subcontracteding product as aproduct sales ratio of total turnover	244	8.792	12	.721	Accept
	Further subcontracted to other firms	251	3.708	3	.295	Accept
Characteristics associated with hard technology	The proportion of imported equipment	237	37.240	12	.000	Rreject
	Domestic procurement rate for raw materials and spare parts	243	38.801	21	.038	Accept
	Brand	243	16.577	3	.001	Rreject
	Sales of bBranded products as asales ratio ofin total turnover	131	10.838	12	.543	Accept
	R&D departments and/or staff	220	57.626	9	.000	Rreject
	The proportion of undergraduate and above	241	39.472	12	.000	Rreject
	Foreign management and technical staff	212	6.113	3	.106	Accept
Characteristics associated with foreign involvement	Technical guidance by foreign investment enterprises	241	2.742	3	.433	Accept
	Guidance in the purchase of equipment by foreign investment enterprises	237	12.316	3	.006	Rreject
	The impact of foreign investment enterprises (enterprises' subjective judgments)	247	18.753	6	.005	Rreject
	The degree ofhow great the impact of a foreign company on technological progress	251	36.008	12	.000	Rreject
Technical Cooperation	Technical cooperation with local university and research institutions	228	70.846	12	.000	Rreject
	Technical cooperation with foreign research institutions	189	9.917	3	.019	Rreject

	Technical cooperation with other companies	234	38.221	3	.000	Rreject
	Technical Cooperation with athe company located abroad	195	13.768	12	.003	Rreject

Source: Author's Survey and calculation

Characteristics associated with foreign involvement; (5) Technical cooperation. Our null hypothesis is no relationship between the variables.

In Table 15, our judgment is statistically significant at the 5% level. This is a more stringent standard and ensures the reliability of our conclusions. From Table 15, we have the following results.

Variables related to the basic features of a subcontractor. We find that the type of ownership of an enterprise is independent of their performance in latent technological progress. This may be due to the distribution of the samples, because 91.3% of the subcontractors in our samples are private. A subcontractor's source of capital is also independent of their performance in latent technological progress, but this may be due to the fact that 77.9% of the firms in our sample are local, either because local capital has invested in them or because they result from restructuring in the township. Therefore we cannot confirm the relationship between ownership and/or the source of capital of an enterprise and its performance in terms of latent technological progress. We need more samples to confirm these results. A firm's sector has a significant correlation with latent technological progress. This implies that enterprises in some industrial sectors may have more opportunity to get knowledge and/or technology spillover from their foreign parent company. The foreign parent company in some sectors, such as IT and equipment manufacturing, may be more willing to give technical assistance to their local suppliers. The position in the value chain and market scope also had a significant correlation with latent technological progress. This implies that a higher position in the value chain and a broader market can help get more knowledge and technology.

Variables related to the subcontract. We find some interesting phenomena. Only the number of subcontracts had a significant positive correlation with latent technological progress. Sales of the subcontracted product as a proportion of total turnover did not have such an effect. This implies that the number of foreign parent companies is more important for SMEs than an SME's degree of involvement in subcontracting. On the other hand, further subcontracting to other firms also did not have a significant correlation with latent technological progress. This is not because of their lower position in the value chain because 21.5% of the subcontractors claimed that their products were located at the high-end of the value chain, 40.1% of subcontractors claimed that they were in the middle and 38.4% of subcontractors claimed that they were at the lower end. This may be because these SMEs' further subcontractors are also SMEs and/or family businesses, so the subcontractor cannot get or feel any transfer of knowledge.

Variables related to hard technology. We find the proportion of imported equipment, a brand, R&D departments and/or staffs, and the proportion of undergraduates and above had a significant positive correlation with latent technological progress, but foreign raw

materials and the sales of branded products as a proportion of total turnover were not a source of latent technological progress. As for foreign management and technical staff, perhaps because of their scarcity among SMEs in Kunshan as only 5.1% of subcontractors have foreign staff, this was not significant.

Variables related to foreign assistance. We find all of the variables had a significant positive correlation with latent technological progress, except for foreign technical guidance. However, this may be due to the uniform distribution of the ~~–t~~echnical guidance by foreigners" variable. In our survey, 55.3% of the subcontractors received assistance and 44.7% of the subcontractors did not. On the other hand, with variables related to technical cooperation, all the variables are significant, and this implies that the acquisition of technologies from external sources is important for SMEs.

In short, using the Pearson χ^2 test, we find that 18 factors had a significant correlation with latent technological progress. Each category has a significant factor. The category ~~–b~~asic features of the subcontractor" has 6 significant factors, the category ~~–s~~ubcontract" has two significant factors, the category ~~–h~~ard technology" has 4 significant factors, and the category ~~–t~~echnical cooperation" (has 4 significant factors)[m3]. In order to know which factor had the most significant impact, we will use an ordered probit model to test these factors. Due to each category having significant factors, we have the following ordered probit model:

$$TECHPRO = \beta' X + \varepsilon$$

where $TECHPRO$ refers to latent technological progress. In our questionnaire, there were 5 choices when we asked respondents how much technological advance they had made in the past three years. No one chose the fifth answer, which was no technological advance, so we coded the dependent variables as 1,2,3,4. X is the vector of explanatory variables, ε is the error term. Table 16 presents the variables for an ordered probit model. Although we have 18 significant factors, we only use 11 in the ordered probit model. We ignored the factors of intermediate goods or final products, industry classification and market scope, because we cannot rank the answers. We also ignored the two factors of the impact of foreign investment enterprises (enterprises' subjective judgments) and the size of the impact of a foreign company on technological progress, because they conflict with other factors. We ignored the factors of technical cooperation with foreign research institutions and technical cooperation with companies located abroad, because few enterprises have such linkages in our survey.

Table 16. Variables of the Ordered Probit Model

Variables		Code as					
		0	1	2	3	4	5
Basic features of the subcontractor	Operations performance		very poor	poor	normal	good	very good
	Position in the value chain		low	middle	High		
	Satisfaction with the business environment		very dissatisfied	dissatisfied	general	satisfied	very satisfied
Characteristics associated with the subcontract	The number of foreign parent companies		1	2-4	5-7	8 or more	
Characteristics associated with hard technology	The proportion of imported equipment		20% or less	20-40%	40-60%	60-80%	80% or more
	Brand	no	yes				
	R&D departments and/or staff		no	only R&D staff	R&D departments		
	The proportion of undergraduate and above		10% or less	10-30%	30-50%	50-70%	70% or more
Characteristics associated with foreign involvement	Guidance in the purchase of equipment by foreign investment enterprises	no	yes				
Technical Cooperation	Technical cooperation with local university and research institutions		no	very close	close	average	relatively loose
	Technical cooperation with other companies		no	very close	close	average	relatively loose

Table 17 presents the estimation results for the ordered probit model. First of all, we employed all the factors in the ordered probit model and find some factors were not significant. So we ignored the least significant factor and calculated the model again until all factors were significant. From the ordered probit model, we find that an operation's performance, the position in the value chain, satisfaction with the business environment, the proportion of imported equipment, a brand, guidance in the purchase of equipment by foreign investment enterprises, technical cooperation with local university and research institutions and technical cooperation with other companies had significant positive effects on latent technological progress. Factors with the greatest influence were an operation's performance, a brand, satisfaction with the business environment and guidance in the purchase of equipment by foreign investment enterprises. These significant factors play an important role in latent technological progress.

Table 17. Estimation Results for the Ordered Probit Model

Variables	Model 1	Model 2
Operations performance	0.387884** (2.308160)	0.388040* (2.680636)
Position in the value chain	0.210621^{+} (1.433548)	0.273946** (2.121325)
Satisfaction with the business environment	0.200962^{+} (1.304419)	0.335052** (2.405362)
The number of foreign parent companies	0.104298 (1.117625)	
The proportion of imported equipment	0.231264** (2.369148)	0.238628* (3.021424)
Brand	0.280613^{+} (1.332238)	0.354865*** (1.879137)
R&D departments and/or staff	0.054640 (0.970428)	
The proportion of undergraduate and above	0.103459 (0.952568)	
Guidance in the purchase of equipment by foreign investment enterprises	0.312333^{+} (1.554946)	0.315383*** (1.788534)
Technical cooperation with local university and research institutions	0.181552** (2.213667)	0.225091* (2.984447)
Technical cooperation with other companies	0.163868*** (1.737438)	0.153149*** (1.858089)
Limit Points		
LIMIT_2	2.517624* (3.242987)	2.688035* (4.031788)
LIMIT_3	4.574182* (5.711910)	4.726490* (6.734705)
LIMIT_4	6.251714* (7.284735)	6.372518* (8.403115)
Log likelihood	-146.9756	-172.1452
Observations	164	191

Source: Author's survey and calculation

Note: Figures in parentheses are z-values. *indicates significance at 1% level. **indicates significance at 5% level. ***indicates significance at 10% level. + indicates significance at 20% level.

5.4 What Difference is there between the Factors Affecting Embodied Technological Progress and those Affecting Latent Technological Progress?

We compared the factors affecting embodied technological progress and latent technological progress (Table 18). We find that there exists a difference.

Some factors, including an enterprise's ownership, an enterprise's source of capital, the sales of the product in the subcontract as a ratio of total turnover, and foreign

management and technical staff did not have a significant effect either on embodied technological progress or on latent technological progress. Of course, we find some common reasons behind the promotion of technological progress. First of all, the technological capabilities of enterprises significantly affect technological progress. The more ability they have, the more technological progress they will make. These technological capabilities include their position in the value chain, the proportion of imported equipment, a brand, R&D departments and/or staff and the proportion of undergraduates and above. Second, technological assistance from TNCs can significantly affect the technological progress of a subcontractor. In our study, the number of foreign parent companies and guidance in the purchase of equipment by foreign investment enterprises are significant factors both in embodied technological progress and latent technological progress. Third is the business environment. We find that the level of satisfaction with the business environment significantly affects the degree of technological progress.

Table 18. Difference between the Factors Affecting Progress

Variable	Embodied technological progress	Latent technological progress
Industry Classification	Accept	Reject
Operation's performance	Accept	Reject
Market scope	Accept	Reject
Technical cooperation with local university and research institutions	Accept	Reject
Technical cooperation with foreign research institutions	Accept	Reject
Technical cooperation with the company located in foreign countries	Accept	Reject
Technical cooperation with other companies	Accept	Reject
Further subcontracted to other firms	Reject	Accept
Technical guidance by foreign investment enterprises	Reject	Accept
Branded products sales as a ratio of total turnover	Reject	Accept

Source: Author's survey and calculation

Notes: WithIn the side of embodied technological progress, our null hypothesis is that these variables didwere not have aing significantly effect on embodied technological progress. WithIn the side of latent technological progress, our null hypothesis is that these variables didwere not have aing significant correlation with latent technological progress.

We find that some factors have a different effect on embodied technological progress and on latent technological progress. In all, latent technological progress is affected by more factors. We find that enterprises will be affected by their performance in their evaluation of technological progress. Enterprises with a better performance in operations and marketing will give a better evaluation of their technological progress. The more linkages with external sources of technology they have, the better their evaluation of their technological progress.

There are some factors which affect embodied technological progress, but they were not significantly correlated with latent technological progress. In our study, these factors include further subcontracting to other firms, technical guidance by foreign investment enterprises and branded products sales as a ratio of total turnover. We have already discussed technical guidance by foreign investment enterprises. For the other two factors, the implication is that there exist biases in an enterprise's evaluation of their technological progress.

6. Conclusions

Can SMEs benefit from subcontracting with TNCs? We cannot get strong evidence from the existing literature. So we raised the question of whether SMEs can benefit from "learning-by-subcontracting" or from their "self-selection" of work as a subcontractor only because they have the ability to do so and can gain more income from doing so than from engaging in other business activities. Due to no established method, we assumed that if "learning-by-subcontracting" is true, then enterprises who begin to work as subcontractors should show more technological progress, including productivity growth and latent technological progress, than if they did not do so. By using firm level data, and choosing non-subcontractors as a control group, with them having the same characteristics as subcontractors, we have confirmed that the "learning-by-subcontracting" effect exists in Kunshan. Of course, this result should be treated with caution, and its robustness should be tested in more developing countries and by using a larger firm-level data-set if we want to extend this result to all developing countries.

We believe that work as a subcontractor and the acquisition of technologies from a foreign parent company are important means of improving the technological capability of SMEs. TNCs not only transfer explicit knowledge, such as patents, standardization, and technical information to local suppliers, they also transfer tacit knowledge, such as know-how, marketing techniques, and purchasing skills. Some of these can be measured by productivity growth, but most cannot. These have not been measured although they are an important part of the technological progress. We call these factors "Latent technological progress" in contrast to "Embodied technological progress" which can be measured by productivity growth. Using quantitative survey data, we analyzed the factors influencing "Latent technological progress". We find that an operation's performance, the position in the value chain, satisfaction with the business environment, the proportion of imported equipment, a brand, guidance in the purchase of equipment by foreign investment enterprises, technical cooperation with local university and research institutions and technical cooperation with other companies play an important role in the "Latent technological progress" of a subcontractor.

These results have further policy implications for developing countries. Subcontractor-led development strategies can improve the technical efficiency of SMEs in developing countries. SMEs should seize the opportunity and focus on the needs of TNCs. In order to get more technological progress besides productivity growth, SMEs should make efforts to improve their ability, because the stronger their capability, the more they can get from subcontracting. Government must create an environment conducive to improving vertical backward linkages with TNCs and protect subcontractors from inappropriate treatment by foreign parent firms.

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