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12-1996

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**Measuring the Technological Leadership
of International Joint Ventures
in a Transforming Economy**

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*Forthcoming in the *Journal of Business Research*

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Measuring the Technological Leadership of International Joint Ventures in a Transforming Economy

Abstract

This paper introduces technical efficiency as an objective criterion for measuring the performance of international joint ventures in China. We compute the estimates of time-invariant and time-varying technical efficiency in four major manufacturing industries in Shanghai. We show that international joint ventures are in general more technically efficient than domestic firms in the industries of textile, machinery and equipment, and electronics and telecommunications equipment are widening in our sample period although the industrial reforms and active technology policies have improved the productivity of domestic firms. However, in the clothing industry, the technical efficiency of domestic firms, especially state-owned firms, is comparable to the efficiency leader, international joint ventures.

Introduction

An important element of economic reforms in the People's Republic of China (PRC) is the shift from "Self-reliance" to "Open-door". In order to attract foreign direct investment, the Chinese government has offered a number of investment incentives, like tax concessions, an abundant supply of cheap labor, and a huge domestic market. The success of this policy is demonstrated by large and increasing inflows of foreign direct investment. According to the official statistics, foreign direct investment increased from a cumulated sum of US\$15.50 billion for the period of 1979-1989 to US\$11.16 billion in 1992 alone. The growing importance of China to foreign investors has motivated researchers to study the business and management issues of international joint ventures (IJVs) in the country.

The objective of this study is to measure the performance of IJVs, in terms of technical efficiency, relative to domestic enterprises in the Chinese economy in transition. This study aims at investigating two questions, which are relevant to understanding the competitive environment of IJVs in the Chinese economy: (1) Are these IJVs more technically efficient than domestic enterprises ? (2) If yes, is the efficiency gap widening in the process of economic reforms ?

When seeking to measure the performance of IJVs, researchers encounter prior studies which offer numerous criteria on which there is no consensus. Geringer and Hebert (1991) classified these criteria into two groups, subjective and objective performance measures. Subjective criteria are usually questions designed to directly ask a parent company's perception of its satisfaction with an IJV's performance or fulfilment of its expectations (Killing, 1983; Schaan, 1983; Artisien and Buckley, 1983; Beamish, 1988). Objective criteria include a variety of financial indicators like profitability, growth and cost position (Tomlinson, 1990; Good, 1972; Renforth, 1974; Dang, 1977; Coughlin, 1981; Artisien and Buckley, 1983; Lecraw, 1983), survival of the IJVs (Franko, 1971; Stopford and Wells, 1972; Killing, 1983; Geringer, 1990), their duration (Harrigan, 1986; Kogut, 1988), instability of their ownership (Franko, 1971; Gomes-Casseres, 1987; Chowdhury, 1992), capital intensity (Good, 1972; Chowdhury, 1992), and renegotiation of the IJV contracts (Blodgett, 1987). Both sets of criteria embody potential limitations that are critical to the evaluation of IJV performance. For example, financial indicators usually provide an incomplete picture for the IJVs because (1) some crucial data are usually unavailable, or included in consolidated corporate data (Geringer and Hebert 1991), and (2) they are subject to intrafirm pricing rules or transfer pricing practice (Chowdhury, 1992). Subjective criteria may also lead to inconsistent results due to the dissimilarities of national

cultures which may lead to differences in the partners' perceptions of each other and result in disagreement in the IJV performance (Geringer and Hebert, 1991).

Different criteria are adopted in the performance evaluation of IJVs in China. Foreign sides of IJVs are assessed in terms of satisfaction of IJVs' operation and fulfilment of targets (Beamish, 1993; Henley and Nyaw, 1990; Stelzer et al. 1992). Other research suggests that managers and officials on the Chinese side focus on criteria like technology transfer, management skill transfer, foreign exchange revenues and job creation (Baird et al., 1990; Campbell, 1989; Hendryx, 1986; Pearson, 1991; U.S.-China Business Council, 1990). On the other hand, overseas partners like U.S. partners would like to use output measures like profitability, sales growth, market share, productivity and costs to evaluate IJV performance. Although joint venture partners appear to be converging on using profitability as the performance criterion (Osland, 1994), previous studies of the profitability of IJVs in China have produced mixed results (Beamish, 1993; Campbell, 1987, 1989; Davidson, 1987; Stelzer et al. 1992).

In assessing the technical performance of manufacturing firms, technical efficiency, which has rarely been considered by any IJV researcher as an objective criterion of measuring IJV performance, is the undisputed criterion commonly adopted by numerous researchers in studying manufacturing productivity, e.g., Caves and Barton (1990). Technical efficiency measures the productivity of a production process which is free from the effects of price changes, i.e., not affected by intrafirm pricing or transfer pricing. Technical efficiency also provides a more objective criterion to compare its performance with other production processes.

The objective of this paper is to introduce technical efficiency as an objective criterion of measuring the technical performance of IJVs in the manufacturing sector of Shanghai. In order to assess the competitiveness of these IJVs, we compare them with domestic firms in Shanghai's manufacturing industries in terms of their technical efficiency. Consequently, the measured technical efficiency is useful for manufacturers to evaluate their productivity performance.

By using a sample of 2147 enterprises in Shanghai from 1989-1992, we compare the technical efficiency (total factor productivity) of IJVs with that of domestic firms. Our empirical results can provide more information on understanding the relative competitiveness of IJVs in China. The first question being studied in this paper is whether IJVs are more technically efficient than domestic firms which have high productivity growth in the

post-reform period. The second question is whether the technological leadership of IJVs is challenged by other domestic firms in an increasingly competitive environment. IJVs can also use our results to evaluate their technical leadership over their competitors. If our results suggest that these IJVs can maintain their leadership, it indicates that their productivity policies are performing well in keeping their competitive advantage of technical efficiency. On the other hand, if our results indicate a narrowing of the technical efficiency gap between IJVs and their domestic counterparts, IJVs may consider improving their productivity management so as to maintain their leadership.

The rest of the paper is organized as follows: The second section reviews the development of different types of ownership in the Chinese economy since the implementation of economic reform. The third section discusses our data set and the research methodology. The fourth section presents empirical results. The last section provides discussion and conclusion.

Enterprises in the Chinese Economy in Transition

The rapidly booming non-state sector in China is dominated by a special type of organization called collective enterprises or township and village enterprises (TVE) in rural areas which have evolved from the cooperatives of the central planning era. In contrast with state enterprises which can easily obtain input materials, energy and loans from the central government (these inputs are under the control of the central government), these collective enterprises have to rely on market to obtain these input factors. In addition, products are sold in some form of market rather than being allocated by the state planning bureau. Finally, these collective enterprises are ultimately theoretically responsible for their own profits and losses. Therefore, their budget constraints are far from being soft (Lockett, 1988; The Economist, 1992). As a result, these collective enterprises are very much 'marketized' except that their ownership structure is far from the western concept of a private firm. These collective enterprises contribute substantially in improving the competitiveness of the economy; at the same time, they also increase the flexibility and adaptability of the whole economy because of their small size.

The rapid expansion and growth of these collective enterprises have forced the reluctant state enterprises to be more market-oriented. Facing so much competition from non-state enterprises, the Chinese government introduced a number of new measures to improve the productivity of state enterprises. The reform measures include the following changes: (1) A higher degree of autonomy is given to an enterprise's manager in input, output,

and pricing decisions; (2) manager's rewards are linked to the enterprise's performance; (3) bonus out of profits made are given to workers; and (4) more contract workers are employed to replace permanent workers so as to add more flexibility to the labor force in a firm (Groves et al., 1994). After introducing these new measures, the total factor productivity (TFP) growth rate in the state-owned enterprises was 3.4 percent during the period of 1980-1984 (Chen et al., 1988). In addition, the TFP of state-owned sector continued to grow at about 3 percent during the period of 1984-1988 (Jefferson et al., 1992) and 2.5 percent during the period of 1988-1992 (Jefferson and Rawski, 1994).

However, in comparison with collective enterprises, the improvement of state enterprises is still not good enough. The annual average TFP growth rates of the collective sector were about 5 percent in the period of 1980-1988 and 4.7 percent during the period of 1988-1992 (Jefferson and Rawski, 1994). These TFP growth rates were higher than the TFP growth rate of state enterprises (Jefferson et al., 1992). In a similar study on the collective sector in Jiangsu province for the period of 1981-1988, the TFP growth rate of collective enterprises was 6.2 percent, which was also higher than the national level (Prime, 1992). In addition, by using industrial Census Data, McGuckin and Nguyen (1993) show that the TFP growth rate of collective enterprises was six times higher than that of state enterprises for the period of 1981-1984. According to Weitzman (1993), these collective enterprises are actually the driving force behind the rapid economic growth of China. They are now the second largest sector of the national economy (after the state sector), constituting over 40 percent of total industrial output while accounting for only 20 percent of industrial output before the economic reform.

Although the private sector in China has been developing rapidly, the academic research in this area started not long ago (Chang and Macmillan, 1991; Tsang, 1994). Private enterprises in China are enjoying more flexibility compared with collective and state enterprises. These enterprises are behaving like private companies in market economies because of competition. However, private enterprises do not enjoy any privileges from either the central or local governments. Moreover, these enterprises also have difficulties obtaining funds from the state-owned banks (McKinnon, 1994).

Since the opening up of the Chinese economy in 1978, China has been one of the hottest choices for foreign direct investment. IJVs, which were the only allowed form of foreign investment until the early 1990s, include two different types, namely equity joint ventures and contractual joint ventures. Undoubtedly, China's objectives of forming IJVs are technology transfer, learning new techniques in production, management, and mar-

keting so as to improve productivity, and to create more jobs to absorb surplus labor from the loss making state-owned sector and from rural areas. For example, in order to develop its aerospace technology, the Chinese government uses the co-production ventures as a condition for continuing to purchase from its giant overseas corporate partners like Boeing and McDonnell-Douglas (Engholm, 1989). According to Beamish (1993), no country had more equity joint venture formation than China during the 1980s. Although IJVs in China have been developing rapidly, their proportion is relatively small compared with domestic enterprises because of numerous problems encountered like government restrictions, the long and complicated negotiation process (Eiteman, 1990; De Bruijn et al., 1993), and cultural differences and communication problems (Beamish, 1993). Despite the rapid development of IJVs, research in this area has been developing at a much slower pace. Most of the research concentrates on the business and management issues of these foreign-invested firms in China (Schroath et al., 1993; Shan, 1991). Little research has been done to measure their productivity and technical efficiency in comparison with domestic enterprises. This paper intends to fill this gap of knowledge by considering this issue.

Data and Methodology

Data

The data set which is supplied by the Shanghai Economic Commission and the Shanghai Statistical Bureau covers 2147 enterprises in Shanghai and includes the input-output information of some large and independent accounting units of which gross industrial output values (measured at current prices) were more than one million *yuan* in 1989. This data set contains firm-level information like net industrial output values (value-added, measured at current prices), original values of fixed assets, net values of fixed assets and types of ownership. There are four types of enterprises in this data set: state-owned enterprises (SOEs), collective-owned enterprises (COEs), international joint ventures (IJVs), and other enterprises (OEs). IJVs only include equity joint ventures. On the other hand, other enterprises include state and collective jointly-owned enterprises and private enterprises.

Shanghai, a metropolitan city of fourteen million people, has a large number of experienced engineers, and well-educated labor forces and is the technological leader in many fields of manufacturing in China. The city has been one of the important commercial and

industrial cities before and after 1949. According to Shanghai's Statistical Yearbooks, the city's share in the national industrial output is very high, with an average of 15 percent from 1949 to 1979 and about 7 percent in the post-reform period although Shanghai accounts for only one percent of the national population. As reported by the Shanghai's Trade and Foreign Investment Yearbook (1985-1990), there has also been a large inflow of foreign direct investment into the city since the implementation of the "Open-door" policy. Numerous developed countries substantially increased their direct investment in Shanghai during the period of 1988-1990.

Among all Shanghai's manufacturing industries, two labor- or less skill-intensive industries (textile: including weaving and knitting cloth of different materials like yarn, chemical fibre, wool, and silk; clothing: garment manufacturing) and two capital- or skill-intensive industries (machinery and equipment; and electronics and telecommunication equipment) are included in our study. Our panel data set covers 654 firms (SOEs:269, COEs:216, IJVs:25, OEs:144) in the textile industry, 340 firms (SOEs:33, COEs:192, IJVs:13, OEs:102) in the clothing industry, 978 firms (SOEs:421, COEs:435, IJVs:13, OEs:109) in the machinery and equipment industry and 175 firms in the electronics and telecommunication industry (SOEs:50, COEs:97, IJVs:13, OEs:15). Since this data set contains much more SOEs or COEs than IJVs (only 64 IJVs in contrast with 773 SOEs and 940 COEs), this relatively small sample of IJVs may limit the inferences and conclusions drawn from our estimation results. However, this low proportion of IJVs is actually reflecting the fact that the international joint ventures sector is still relatively small compared with the state- and collective-owned sectors in the Chinese economy despite IJVs' higher productivity and technical capability. Other than the sample size of IJVs, the quality of data collected by Chinese officials may not be as good as those collected in developed countries. Chow (1986) discussed the quality of official Chinese Statistics and he further judged that "official statistical reporting in China is by and large honest" (Chow, 1993). This panel data set is collected from the four years 1989 to 1992 and we shall compare the technical efficiency of different types of firms by using this data set.

A Panel Data Model with Heterogeneity in Intercepts

Given our firm-level panel data, the technical efficiency of each firm in a year which is measured by its total factor productivity in that year can be estimated directly. For any firm in an industry, a simple Cobb-Douglas production technology which has been widely used in other productivity studies, e.g. Prime (1992) and Jefferson et al. (1992),

is considered:

$$Y_{ijt} = A_{ij} K'_{ijt}{}^{\alpha_{Kj}} L_{ijt}{}^{\alpha_{Lj}}, \quad A_{ij} = \frac{Y_{ijt}}{K'_{ijt}{}^{\alpha_{Kj}} L_{ijt}{}^{\alpha_{Lj}}}, \quad \alpha_{Kj}, \alpha_{Lj} > 0; \quad \forall i = 1, \dots, n_j, \quad t = 1, \dots, T, \quad (1)$$

where i and j are the indices for firm and industry respectively; Y_{ijt} are the i th firm in j th industry's net industrial product at constant prices at the end of year t which is calculated by deflating the value measured at current prices by its product price index using 1980 as the base year. K'_{ijt} is i th firm's price-efficiency-adjusted capital stock at the end of year t . Its measurement will be discussed later. L_{ijt} is i th firm's labor employed at the end of year t . α_{Kj} and α_{Lj} are the weights of capital and labor in industry j which measure the contribution of these inputs to output production. These two parameters are assumed to be the same among different firms within the same industry. n_j is the number of firms in industry j . A_{ij} is an index of the total factor productivity of the firm defined as the ratio of total measured output to total weight-adjusted inputs. Obviously, for a fixed level of capital stock and labor, the firm that has the largest total factor productivity is the most technically efficient one, i.e. it can produce the largest amount of output given a fixed level of inputs.

Schmidt and Sickles (1984) consider the estimation of stochastic production frontier with panel data, using the model

$$y_{it} = a + X'_{it}\alpha + e_{it} - \epsilon_i \quad (2)$$

where y = output, X = inputs, e = statistical noise with zero mean and finite variance, and $\epsilon_i > 0$ is a firm-specific effect representing technical inefficiency. This model can obviously be put in the form

$$y_{it} = a_i + X'_{it}\alpha + e_{it} \quad (3)$$

where $a_i = a - \epsilon_i$ is the measure of technical efficiency of firm i and it is also the target of our analysis here. The larger the a_i , the more technically efficient the firm i is.

In order to estimate the total factor productivity, a log-linear version of equation (1) is considered as the regression model following Schmidt and Sickles' (1984) analysis:

$$y_{ijt} = a_{ij} + \alpha_{Kj} k'_{ijt} + \alpha_{Lj} l_{ijt} + u_{ijt}, \quad i = 1, \dots, n_j, \quad t = 1, \dots, T, \quad (4)$$

where y_{ijt} , k'_{ijt} , l_{ijt} and $a_{ij} = a - \epsilon_{ij}$ are logarithms of Y_{ijt} , K'_{ijt} , L_{ijt} and A_{ij} . u_{ijt} is a random error with mean zero and finite variance σ^2 .

One candidate for K'_{ijt} is the deflated value of net fixed assets. The value of fixed asset is calculated from the sum of investment in previous year minus the accumulated depreciation without any adjustment for inflation. We follow McGuckin and Nguyen (1993) in

computing the capital price index by using a weighted average of the product price indices of five manufacturing industries which produce capital goods: machinery and equipment, automobile and transport equipment, electrical appliances, electronics and telecommunication equipment and instruments, and metres and measuring equipment industry (using 1980 as the base year). Given the high inflation rates in the eighties, deflating net fixed assets simply by using the capital price deflator may not be good enough. We follow the approach suggested by Jefferson et al. (1992) to adjust for the measurement errors of reported values of capital stock. Besides the adjustment for inflation, their approach can also capture the vintage effect of investment. Since more modern capital equipment may embody updated and more efficient technology, such newer equipment should have higher productivity than the older one. Suppose k' represents the logarithms of efficiency-price adjusted measure of the net value of fixed assets, following Jefferson et al. (1992), k' is expressed as

$$k'_{ijt} = k_{ijt} + \theta_j v_{ijt}$$

where k_{ijt} and v_{ijt} are logarithms of firm i 's values of original fixed assets deflated by capital price index and the ratio of the net fixed assets to original fixed assets at the end of year t . If the inflationary effect dominates (is dominated by) the vintage effect, we may expect a negative (positive) θ . For estimation purposes, the equation of k'_{ijt} is substituted into equation (4),

$$y_{ijt} = a_{ij} + \alpha_{Kj} k_{ijt} + \alpha_{Lj} l_{ijt} + \alpha_{vj} v_{ijt} + u_{ijt} \quad (5)$$

where $\alpha_{vj} = \alpha_{Kj} \theta_j$. The estimate of a_{ij} in (5) is the average technical efficiency of firm i in industry j during the period of 1989-1992.

As it was mentioned in the previous section, the productivity of both SOEs and COEs has been increasing after the implementation of industrial reforms. In such a dynamic environment, it is important to know how these firms are performing over time and what are the intertemporal shifts in their technical efficiency. In order to find out whether they are experiencing steady increases or decreases in technical efficiency, it is necessary to compute estimates of time-varying technical efficiency for each firm. Unfortunately, owing to insufficient annual observations for each firm, the desired firm-specific time-varying technical efficiency cannot be obtained. Instead, the ownership-specific time-varying efficiency coefficients are estimated. The regression model for the four types of ownerships (SOEs, COEs, IJVs and OEs) is as follows:

$$\begin{aligned} y_{ijt} = & a'_{ij} + b_{s1j} t_{sj} + b_{s2j} t_{sj}^2 + b_{c1j} t_{cj} + b_{c2j} t_{cj}^2 + b_{f1j} t_{fj} + b_{f2j} t_{fj}^2 \\ & + b_{o1j} t_{oj} + b_{o2j} t_{oj}^2 + \alpha_{Kj} k_{ijt} + \alpha_{Lj} l_{ijt} + \alpha_{vj} v_{ijt} + u_{ijt} \end{aligned} \quad (6)$$

$i = 1, \dots, n_j$; t_z and t_z^2 , $z = s, c, f, o$ are simply the linear and quadratic time trends of the corresponding enterprises (SOE (s), COE (c), IJV (f) and OE (o)), i.e., t_z and t_z^2 take zero values except for their own type of ownership. These time trend variables pick up the over-time variations of the total factor productivity. Compared with equation (5), the time-varying technical efficiency estimates of firm i in industry j is

$$a_{ijt}^* = a'_{ij} + b_{z1}t_z + b_{z2}t_z^2; \quad z = s, c, f, o$$

the time-varying technical efficiency, a_{ijt}^* , is estimated and classified according to their types of ownership.

Equations (5) and (6) generate two sets of estimates of total factor productivity: a_{ij} (time-invariant efficiency) and a_{ijt}^* (time-varying efficiency). Since we are going to compare efficiency of different firms, a measure of relative technical efficiency will be adopted here. We follow a selection rule suggested by Cornwall, Schmidt and Sickles (1990) and Schmidt and Sickles (1984): Among all firms in an industry, the firm that has the highest a_{ij} or a_{ijt}^* is the most technically efficient firm in industry j . The relative technical efficiency of other firms are expressed in terms of the technical efficiency of the most efficient firm:

$$a_j^{max} = \max_i a_{ij}, \quad ATE_{ij} = \frac{a_{ij}}{a_j^{max}} \times 100\%, \quad i = 1, \dots, n_j. \quad (7)$$

$$a_{jt}^{*max} = \max_i a_{ijt}^*, \quad TE_{ijt} = \frac{a_{ijt}^*}{a_{jt}^{*max}} \times 100\%, \quad i = 1, \dots, n_j; \quad t = 1, \dots, T. \quad (8)$$

ATE_{ij} measures firm i 's average relative technical efficiency (time-invariant) in terms of the most efficient firm in industry j for the period of 1989-1992. TE_{ijt} , firm i 's relative technical efficiency (time-variant) in year t , is defined analogously. By definition, the most efficient firm in an industry will have 100% relative technical efficiency. The rest are inefficient firms which have relative technical efficiency less than 100%. The lower these efficiency figures, the less efficient (relative to the most efficient enterprise) these other enterprises are.

Since these time-varying relative efficiency estimates are measured in terms of the most efficient one in an industry in each year, i.e., it is a definition of technical efficiency gap between an inefficient enterprise and the most efficient one in each year, this definition gives us an advantage of a more objective measurement of technical efficiency. In addition, these relative efficiency estimates actually measure the catching-up ability of enterprises because an increase/decrease in measured relative efficiency of an inefficient enterprise implies a narrowing/widening of its efficiency gap. Unfortunately, information on the

ages of manufacturing enterprises is not available. Therefore, it is impossible to analyze how the ages of enterprises affect the measured technical efficiency or efficiency gaps. Equations (5) and (6) are estimated by using the panel data estimation procedure of LIMDEP version 5.1.

Estimation Results

The estimation results of equation (5) and (6) are presented in Table 1a and 1b respectively. Despite our sample period being short (four years), both tables show that R^2 's are relatively high for all regression models and both labor and capital inputs are all statistically significant in accounting for output variations. Hence, our specification of production functions in the four industries under investigation is accurate.

[Put Table 1a, b here]

After introducing time trend variables to account for the intertemporal shifts of technical efficiency, estimates of α_{Kj} and α_{vj} are substantially affected. As reported in Table 1b, the vintage effect of investment goods, measured by the estimate of α_{vj} , is statistically significant in the electronics and telecommunication equipment industry. The estimate is positive and relatively large, suggesting that the quality of investment goods rises more rapidly than their costs. It is probably due to an aggressive upgrading of technology in this industry. This partly confirms that the active technology policies of the Chinese government are paying off. In the early 1980s, Shanghai and central government leaders decided to create small "Silicon Valleys" in China. The Minhang and Caohejing Economic and Technological Development Zone (ETDZ) in Shanghai is one such Chinese "Silicon Valley". Since the government offered preferential treatment like tax reductions and exemptions, as well as priority access to raw materials and credit, and because this area is equipped with better infrastructure, high-skilled labor and experienced engineers, the lion's share of U.S. direct foreign investment in Shanghai has been centred in the Minhang and Caohejing ETDZ (Simon, 1990). The presence of foreign technology, especially in the electronics industry, helps improve the production technology of domestic enterprises.

Besides the vintage effect, Table 1b also indicates whether technical efficiency of different types of firms in these four industries are time-varying or not. Except for the case of the clothing industry, the time trend variables of some types of ownership have statistically significant effects in explaining their output variations, suggesting that technical

efficiency of these firms is varying over time. This dynamic behavior of efficiency is very significant for the machinery and equipment industry (Table 1b).

After the estimation of (5) and (6), the most efficient firms are as follows: Except the clothing industry, the most efficient firms are IJVs in all the other three industries. A SOE is the most efficient firm in the clothing industry; it may be slightly surprising to many people as the SOEs are usually perceived to be inefficient. After the identification of the most efficient firms, we calculate both ATE_{ij} and TE_{ijt} . Table 2a and 2b report the means and standard deviations of time-invariant and time-varying relative efficiency estimates classified by their types of ownership.

[Put Table 2a, b here]

First, for these four industries, IJVs (except the TE_{89} of the clothing industry) have the highest average relative time-invariant and time-varying technical efficiency among all types of ownership within our sample period. Hence, this result indicates that IJVs in these four industries on average have higher relative technical efficiency for the period of 1989-1992. In addition, it also confirms that the China's IJV policy is working in improving her technology as the technical efficiency of their IJVs is relatively higher. Nevertheless, the standard deviations of the efficiency estimates of international joint ventures are also much larger than their counterparts, suggesting that some IJVs may have technical efficiency lower than their domestic counterparts.

Second, all firms in the clothing industry have average technical efficiency (both time-varying and time-invariant) higher than 80%, implying that the TFP of all inefficient firms (including IJVs) is quite close to the TFP of the most productive firm (a state-owned enterprise). In this case, it may not be difficult for those slightly less efficient firms (including IJVs) to catch up with the leader. On the other hand, in the other three industries, domestic firms have an average relative technical efficiency, except the TE_{89} of SOEs in the textile industry, below 80%, implying that the efficiency gaps between the most efficient firms (which are IJVs) and other domestic firms are quite large. These domestic firms may find it more difficult to catch up with the IJVs in these three industries.

Third, by contrast, the average relative technical efficiency of domestic firms is closer to that of IJVs in the clothing industry, e.g., the average relative technical efficiency of SOEs is even higher than that of IJVs in the year 1989. This may result from the fact that the industrial technology of the labor-intensive clothing industry is easier to learn.

In addition, it may also confirm the successes of industrial reforms undertaken in domestic firms in this industry. If further reforms are carried out, domestic firms may challenge the IJVs' leadership in technical efficiency. Nevertheless, in the machinery and equipment industry, there are substantial variations in average relative technical efficiency between domestic and foreign-invested firms. We suggest two reasons: (1) Machinery and equipment industry is a skill-intensive industry and requires higher skills and more advanced technology which are difficult for domestic enterprises to learn; therefore, it takes a longer time and much more effort for domestic firms to catch up with the IJVs. (2) The industrial reforms in this industry may not be very effective so that the productivity of domestic firms cannot be substantially improved.

The continuous and aggressive industrial reforms and technology policies may imply a more competitive environment for foreign-invested firms in the Chinese markets. Given our estimates of TE_{ijt} , we can test whether there are changes in relative technical efficiency for different types of firms in the period of 1989-1992. Since JVs in general are more technically efficient than other domestic firms, we want to know whether these efficiency gaps have statistically significant changes within the sample period. We use ANOVA tests to compare their relative technical efficiency in different years. Results are reported in Table 3.

[Put Table 3 here]

Since the ANOVA test statistics of the clothing industry are all insignificant and there is no evidence of a time trend in the TFP growth of any type of firm in the clothing industry, Table 3 only reports the results of the other three industries. In Table 3, on the one hand, there is no statistically significant improvement in relative technical efficiency of IJVs in these three industries although the relative technical efficiency of IJVs are slightly increasing (Table 2a, b). On the other hand, the relative technical efficiency of SOEs and COEs are decreasing and the reductions in relative efficiency are statistically significant for the periods 1989-1990, 1990-1991, and 1991-1992 in textile and machinery and equipment industries and the period 1989-1990 in the electronics and telecommunication equipment industry. According to these results, we have the following conclusions about the efficiency gaps: First, the technical efficiency gaps between domestic and foreign-invested firms were widening for the 1989-1992 period in the industries of textile and machinery and equipment. Second, the efficiency gap in the industry of electronics was also widened in the 1989-1990 period but kept constant in the rest. Third, the efficiency gaps of the clothing industry, which are the smallest among all industries, remain unchanged for the

whole period. These results provide relevant information for both the government and manufacturers to further investigate why these patterns of efficiency gaps are observed. More research should be undertaken to account for these observed patterns of efficiency gaps.

Discussion and Conclusion

Since the implementation of economic reform in 1978, the People's Republic of China has been one of the hottest choices for foreign direct investment. Given the growing importance of China to foreign investors, the performance of IJVs in China has been evaluated by using different criteria in various studies. This study is the first attempt to evaluate the IJV's productivity relative to domestic enterprises in China. Using a panel data of more than two thousand firms in four manufacturing industries of Shanghai for the period 1989-1992, two questions are studied in this paper. First, we want to know whether IJVs are more technically efficient than domestic enterprises. Second, given the presence of such an efficiency gap, we should further investigate whether these IJVs can maintain their leadership while domestic enterprises are making progress in improving their technical efficiency induced by industrial reforms. This information is useful for us to assess the competitive advantages of foreign-invested firms in the People's Republic of China.

Two results are derived in this paper. First of all, we find that IJVs are, in general, leaders in technical efficiency relative to domestic firms. The relatively low technical efficiency of domestic enterprises may be caused by a relatively underdeveloped manufacturing management system, including inaccurate production planning (Wacker, 1987; Young et al. 1992; Handfield and Withers, 1993), poor inventory control (Yu and Gershon, 1988; Chikan and Whybark, 1990) and insufficient quality control (Wacker, 1987). Furthermore, we find that the gaps in technical efficiency between joint ventures and domestic firms are widening in some industries within our sample period even though the productivity of state- and collective-owned enterprises is improving under the effects of industrial reforms and active technology policies. Accordingly, IJVs in some industries are shown to be very successful in keeping their technological leadership even in an increasingly competitive environment.

Yet these results should be interpreted with caution. Given that the standard deviations of the efficiency estimates of IJVs are relatively larger (Table 2a, b), there are some IJVs which are inferior to domestic firms in terms of technical efficiency. This may

explain why some survey results suggest that IJVs have poor performance in China. For example, given that previous studies of the profitability of IJVs in China have produced mixed results (Beamish, 1993; Campbell, 1987, 1989; Davidson 1987; Stelzer et al. 1992), our findings may explain these empirical results by suggesting that high variations in measured technical efficiency of IJVs are one of the reasons. For instance, some studies which include more highly efficient IJVs produce very positive results while others which include more less efficient IJVs obtain negative results.

Although the state enterprises usually give people an impression that they are very inefficient, Table 2a, b suggests that the situation is not so bad, at least in Shanghai. The worst performing among them are in the electronics and telecommunication equipment industry in which they are ranked third place. In the other three industries, their measured efficiency is higher than collective and other enterprises. In the case of the clothing industry, their technical efficiency is comparable to the efficiency leader, international joint ventures. Nevertheless, this good performance of Shanghai's state enterprises may not be generalized to state enterprises in other places in China because manufacturing enterprises (including state-owned) in Shanghai are probably the most productive and technologically advanced among all manufacturing enterprises in China.

The measured technical efficiency of manufacturing enterprises provides important productivity information for overseas corporations which are investing or considering investing in Shanghai's manufacturing sector. IJVs operating in Shanghai can evaluate their performance in terms of relative technical efficiency by using our results. According to our results, an IJV manager in Shanghai's clothing industry may want to pay more attention to productivity management. In the clothing industry, the efficiency gap is not as wide as the gaps in other industries although IJVs are on average more technically efficient than domestic enterprises in the industry. On the other hand, the efficiency gap remains almost unchanged in the whole sample period. Therefore, better productivity management is necessary for IJVs in the clothing industry in order to keep their competitive advantage of technical efficiency if domestic competitors continue to increase their productivity in further economic reforms.

For overseas corporations which are considering investing in Shanghai, our results are helpful in evaluating the competitive environment in different industries. From our findings, IJVs in textiles, electronics and telecommunication, and machinery are doing well in maintaining their high technical efficiency compared with domestic enterprises. Hence, these industries are good choices for investment by overseas corporations given that their

technology is comparable with the existing IJVs in Shanghai. On the other hand, in forming joint ventures with domestic enterprises, our findings can help identify the types of domestic enterprises which perform well in terms of relative technical efficiency. According to past experience, state-owned enterprises are usually offered by the Chinese government to overseas corporations as potential candidates for IJV partners because of their better access to the government-controlled resources like materials, energy and bank credit. In terms of technical efficiency of the four manufacturing industries in Shanghai, the state-owned enterprises in the textile and machinery industries are the better candidates for joint venture partners because of their high technical efficiency relative to other domestic enterprises.

Finally, our estimated technical efficiency gaps are useful for the Chinese government to evaluate their joint venture policy by monitoring the dynamic technical performance of domestic enterprises. Since joint ventures are usually the technological leaders in various industries, the domestic enterprises can learn from their leaders and improve their technical efficiency by competing with them in the marketplace. Thus, the dynamic changes in the measured technical efficiency gaps of domestic firms relative to joint ventures (efficiency leaders) indicate whether the technical performance of domestic enterprises is improving or not. As a result, the government can evaluate the benefits of technology diffusion effect of their joint venture policy by monitoring the technical performance of domestic enterprises. For example, when the Chinese government invites some international joint ventures which have advanced technology to start operation in a targeted industry. The government may set some goal for efficiency. The government might give five years of joint venture operation before the efficiency gap between domestic enterprises and international joint ventures to close. By closely monitoring the technical performance of domestic enterprises, the government can get a clearer picture of the performance of their joint venture policy in the whole industry.

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Table 1a Regression results of the fixed effects model (equation(5))

Regressors ^a	Electronics & Telecommunication			
	Textile Industry	Clothing Industry	Machinery & Equip. Industry	Equip. Industry
l_{it}	0.7455 ^{**b} (0.0717)	0.5638 ^{**} (0.0828)	0.5563 ^{**} (0.0579)	0.4768 ^{**} (0.1449)
k_{it}	0.0576 [*] (0.0288)	0.1185 ^{**} (0.0309)	0.3063 ^{**} (0.0292)	0.2187 ^{**} (0.0837)
v_{it}	0.1932 ^{**} (0.0635)	0.0424 (0.0712)	-0.1800 (0.0468)	0.3250 [*] (0.1622)
adj. R^2	0.8768	0.8056	0.8964	0.8277
No. of firms	654	340	978	175
Total obs.	2616	1360	3912	700

^aThe estimates of fixed effects (individual efficiency) are not presented here because there are hundred of estimates for each industry. The values in parentheses are the standard errors of the corresponding estimates.

^b*, and ** imply $p \leq 0.05$ and $p \leq 0.01$ respectively.

Table 1b Regression results of the fixed effects model (equation(6))

Regressors ^a	Electronics & Telecommunication			
	Textile Industry	Clothing Industry	Machinery & Equip. Industry	Equip. Industry
t_s	-0.1109 ^b (0.0652)	-0.0503 (0.1862)	-0.2477** (0.0445)	-0.3913* (0.1904)
t_s^2	0.0108 (0.0128)	0.0147 (0.0366)	0.0598 (0.0087)	0.0839* (0.0373)
t_c	-0.3981** (0.0731)	-0.1002 (0.0783)	-0.4137** (0.0438)	-0.4284** (0.1390)
t_c^2	0.0671* (0.0143)	0.0201 (0.0152)	0.1009** (0.0086)	0.0897** (0.0272)
t_f	-0.1473 (0.2136)	0.0470 (0.2963)	0.7294** (0.2519)	0.3123 (0.3751)
t_f^2	0.0552 (0.0420)	0.0174 (0.0583)	-0.0704 (0.0496)	-0.0208 (0.0731)
t_o	-0.1960* (0.0899)	-0.1666 (0.1061)	-0.3788** (0.0873)	0.0633 (0.3460)
t_o^2	0.0299 (0.0176)	0.0258 (0.0208)	0.0857** (0.0171)	0.0009 (0.0680)
l_{it}	0.6679** (0.0723)	0.5212** (0.0863)	0.6504** (0.0554)	0.4635** (0.1503)
k_{it}	0.1400** (0.0321)	0.1273** (0.0368)	0.1321** (0.0316)	0.1645 (0.0963)
v_{it}	0.0173 (0.0703)	0.0377 (0.0745)	0.0182 (0.0482)	0.6545** (0.2106)
adj. R^2	0.8813	0.8068	0.9093	0.8331
No. of firms	654	340	978	175
Total obs.	2616	1360	3912	700

^aThe estimates of fixed effects (individual efficiency) are not presented here because there are hundred of estimates for each industry. The values in parentheses are the standard errors of the corresponding estimates.

^b *,** and *** imply $p \leq 0.05$ and $p \leq 0.01$ respectively.

Table 2a Descriptive statistics of time-invariant (ATE) and time-varying efficiency (TE) level of firms in textile, clothing industries in Shanghai from 1989 to 1992

Textile industry				
Items	State	Types of ownership		
		Collective	Joint	Other
firm number	269	216	25	144
ownership mean (st.dev.) ^a of ATE	79.98 (4.218)%	74.64 (4.856)	84.77 (7.049)	75.27 (4.815)
ownership mean (st.dev.) of TE89	80.76 (4.408)	76.09 (5.258)	83.52 (7.409)	76.07 (5.106)
ownership mean (st.dev.) of TE90	79.89 (4.401)	74.12 (5.249)	83.55 (7.396)	74.95 (5.098)
ownership mean (st.dev.) of TE91	78.42 (4.348)	72.67 (5.187)	83.75 (7.309)	73.63 (5.037)
ownership mean (st.dev.) of TE92	76.41 (4.255)	71.75 (5.075)	84.10 (7.151)	72.16 (4.928)
Clothing industry				
Items	State	Types of ownership		
		Collective	Joint	Other
firm number	33	192	13	102
ownership mean (st.dev.) of ATE	83.22 (5.191)	80.00 (4.965)	84.52 (7.145)	80.68 (3.913)
ownership mean (st.dev.) of TE89	84.01 (5.154)	81.06 (5.001)	83.69 (7.116)	82.44 (3.967)
ownership mean (st.dev.) of TE90	84.00 (5.157)	80.76 (5.007)	84.58 (7.119)	81.71 (3.969)
ownership mean (st.dev.) of TE91	84.03 (5.147)	80.60 (4.997)	85.56 (7.105)	81.23 (3.961)
ownership mean (st.dev.) of TE92	84.10 (5.123)	80.58 (4.975)	86.61 (7.073)	80.98 (3.943)

^aThe values in parentheses are the standard deviations of the corresponding estimates.

Table 2b Descriptive statistics of time-invariant (ATE) and time-varying efficiency (TE) level of firms in machinery and equipment, electronics and telecommunication equipment industries in Shanghai from 1989 to 1992

Machinery and equipment industry				
Items	Types of ownership			
	State	Collective	Joint	Other
firm number	421	435	13	109
ownership mean (st.dev.) ^a of ATE	76.74 (5.578)	73.09 (5.415)	88.65 (10.68)	73.22 (5.248)
ownership mean (st.dev.) of TE89	84.47 (4.851)	79.68 (4.453)	89.15 (9.721)	80.79 (4.533)
ownership mean (st.dev.) of TE90	79.88 (4.623)	74.93 (4.244)	89.66 (9.264)	75.89 (4.320)
ownership mean (st.dev.) of TE91	77.69 (4.470)	73.25 (4.103)	90.00 (8.958)	73.82 (4.177)
ownership mean (st.dev.) of TE92	77.58 (4.379)	74.27 (4.020)	90.20 (8.776)	74.22 (4.092)
Electronics and telecommunication equipment industry				
Items	State	Collective	Joint	Other
firm number	50	97	13	15
ownership mean (st.dev.) of ATE	72.01 (5.652)	70.96 (5.000)	78.46 (9.347)	73.09 (6.464)
ownership mean (st.dev.) of TE89	75.86 (5.464)	74.08 (4.674)	78.68 (8.913)	75.00 (6.744)
ownership mean (st.dev.) of TE90	73.43 (5.363)	71.54 (4.588)	79.07 (8.748)	74.10 (6.620)
ownership mean (st.dev.) of TE91	72.52 (5.282)	70.60 (4.519)	79.39 (8.616)	73.47 (6.519)
ownership mean (st.dev.) of TE92	73.07 (5.219)	71.19 (4.464)	79.63 (8.512)	73.09 (6.441)

^aThe values in parentheses are the standard deviations of the corresponding estimates.

Table 3 ANOVA tests and % changes of technical efficiency of different ownership

1. Textile industry				
Types of ownerships				
ANOVA	State	Collective	Joint	Other
Technical efficiency gap with the most efficient enterprise				
All years ^a	51.49** ^b	28.76**	0.033	16.16**
89 to 90 ^c	5.251* (-1.08)	15.15** (-2.59)	0.0001 (0.03)	3.490 (-1.48)
90 to 91	15.24** (-1.84)	8.416** (-1.97)	0.009 (0.23)	4.886* (-1.76)
91 to 92	29.37** (-2.56)	3.469 (-1.27)	0.029 (0.42)	6.269* (-2.00)
2. Machinery and equipment industry				
Types of ownerships				
ANOVA	State	Collective	Joint	Other
Technical efficiency gap with the most efficient enterprise				
All years	208.2**	199.8**	0.033	60.95**
89 to 90	197.5** (-5.43)	259.6** (-5.96)	0.019 (0.57)	66.75** (-6.07)
90 to 91	48.99** (-2.75)	35.40** (-2.25)	0.009 (0.38)	12.99** (-2.73)
91 to 92	0.132 (-0.14)	13.84** (1.40)	0.003 (0.23)	0.513 (0.54)
3. Electronics and telecommunication equipment industry				
Types of ownerships				
ANOVA	State	Collective	Joint	Other
Technical efficiency gap with the most efficient enterprise				
All years	3.824*	11.01**	0.029	0.240
89 to 90	5.042* (-3.20)	14.65** (-3.44)	0.013 (0.50)	0.135 (-1.20)
90 to 91	0.724 (-1.23)	2.059 (-1.31)	0.009 (0.40)	0.069 (-0.85)
91 to 92	0.267 (0.75)	0.832 (0.83)	0.005 (0.31)	0.026 (-0.52)

* $p \leq 0.05$.

** $p \leq 0.01$.

^a Joint test of means of all four years that are equal. The reported values are the F statistics of the ANOVA test.

^b*,** and *** imply $p \leq 0.05$ and $p \leq 0.01$ respectively.

^c ANOVA test of two years. The reported values are the F statistics of the ANOVA and values in parentheses are the percentage increase/decrease (-) in efficiency using previous year as the base, e.g., 89 to 90: 1989 is the base year; 90 to 91: 1990 is the base year.