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Township and Village Enterprises (TVEs) have played a significant role in the growth of the Chinese economy since the economic reforms of 1978. This paper analyses the productive efficiency of a cross section of TVEs in the manufacturing sector, and compares them with those for state-owned enterprises (SOEs) and major international competitors of TVEs. TVEs are found to be much more efficient than comparable SOEs. They are also competitive in the international markets. Their management which responds to market forces and their outward-orientation have contributed to their productive efficiency. The performance of TVEs suggests that efficient management, which successfully exploits the endowments and resources of the country rather than the nature of ownership of production entities, is crucial to the success of manufacturing firms.

I. Introduction

Township and Village Enterprises (TVEs) have played a significant role in the growth of the Chinese economy since the economic reforms of 1978. They accounted for 61 percent of total industrial output in the year 1999[1] and their annual average real growth rate over the ten-year period 1988-99 was as high as 19 percent[2]. Whilst the literature on the Chinese economy recognises their role in the growth process, TVEs have not received the attention they deserve. We know very little about the structure and performance of TVEs though they are a major force in China's growth and development. This paper analyses the productive efficiency of TVEs and the sources of their efficiency. Various indicators of productive efficiency for a cross section of TVEs in the manufacturing sector are estimated and compared with those for state-owned enterprises (SOEs), and for some of the major international competitors of TVEs.

Section II of the paper provides a brief review of the development and characteristics of TVEs. Section III estimates indicators of productive efficiency for TVEs. Section IV examines the sources of efficiency. Section V concludes.

[1] Estimated from China statistical yearbook, China township and village-owned enterprises statistical yearbook, 2000.
[2] Estimated from China township and village-owned enterprises statistical yearbook, various issues.

II. The Development and Characteristics of TVEs

TVEs are economic units which are either collectively-owned by local residents in the rural areas of China or mainly owned and controlled by the peasants[3]. The broad concept of TVEs includes, in addition to the collectively-owned enterprises, other rural non-state enterprises such as the enterprises owned and run by individual peasants (Appendix 1)[4]. The collectively-owned township and village enterprises, however, account for two thirds of the output of all TVEs. This paper is confined to these TVEs.

Many of the TVEs followed on from the 'commune- and brigade-run' enterprises established at the time of the Great Leap Forward at the end of 1958. Since the economic reforms in 1978, especially the agricultural reforms, TVEs have experienced impressive growth. Their gross output reached RMB 7674 billion (US$927 billion) in 1999, accounting for 61 percent of China's total industrial output. The annual growth rate of their output at 1990 prices over the ten-year period 1988-99 was as high as 19 percent. They employ a total of 127 million people, accounting for 18 percent of the total labour force of the country and 25 percent of the rural labour force. In the year 1999 their exports reached US$94 billion, accounting for 48 percent of the country's total exports. The annual real growth rate of their exports over the ten-year period 1988-99 was as high as 28 percent, exceeding the growth rate of China's total exports at around 13 percent over the same period. The composition of their exports has shifted over the years from primary and unskilled-labour intensive products towards relatively skilled-labour intensive products[5].

TVEs exhibit a number of distinctive characteristics: they are publicly-owned but market oriented; they are small in size, enjoy a high degree of autonomy of operations; they are much more outward-oriented than SOEs; they are subject to hard budget constraints (Table 1). The most significant characteristic of TVEs is that though they are publicly owned, they are subject to the discipline of the market, yet another attempt by the Chinese at walking on two legs. In general TVEs are the property of local residents, but rights of ownership on their behalf is exercised by the town and village governments. The profits of TVEs are an important source of local government revenues.

[3] Law on Township and Village Enterprises, P.R. China, 1996.

[4] China's industrial enterprises are subdivided into eight groups based on the nature of ownership: the State-Owned Enterprises (SOEs), collectively-owned enterprises, privately-owned enterprises, individually-owned enterprises, jointly-owned enterprises, share-holding enterprises, foreign-owned enterprises and other types of enterprises. The major component of TVEs is the collectively-owned enterprises (Appendix 1).

[5] Estimated from China statistical yearbook, China township and village-owned enterprises statistical yearbook and China foreign economic statistical yearbook, 1999.

Although they are publicly owned, TVEs are subject to a hard budget constraint. They have very limited access to the loans from the formal financial system such as the state-owned banks and the Rural Credit Cooperatives (Qian and Roland, 1996). They may go bankrupt when they lose money.

The management of TVEs is executed by the township and village leaders who act as entrepreneurs, or by hired managers. Day-to-day management functions have been increasingly devolved to professional managers. Managerial remuneration systems of TVEs have evolved over the years, changing from the fixed wage contract to profit sharing contract and fixed payment scheme, which is essentially a lease agreement.

In the early years, during the decade of the eighties, a fixed wage contract was the preferred method of remuneration for the professional managers. These salaried managers had very little autonomy over decision-making and the enterprises were virtually run by the leaders. As the TVEs grew in size and numbers, the leaders appear to have been hard put to cope with the external managerial functions as well as internal management. Profit sharing contracts introduced during the decade of the nineties was one attempt at developing a cadre of managers capable of executing internal management functions. Profit sharing contracts between the leaders and the professional managers not only freed the leaders from internal management tasks, but also ensured that profits of the enterprises were preserved. It was the hope that increased autonomy over decision-making and the lure of a share in the profits of the enterprise would promote efficient internal management on the part of professional managers. Yet another form of contractual agreement is the fixed payment scheme which is essentially a lease agreement between the manager and the leader. The manager pays a fixed amount of the total profits in the form of a rent to the local government and retains the residual. This scheme also allows managers a considerable degree of autonomy over decision-making.

The remuneration of workers as opposed to managers in most TVEs is tied to performance. Workers are mostly paid by piece rates. TVEs are able to acquire high quality engineers because their salaries and wage payments methods are tied to performance. TVEs also enjoy a high degree of freedom in their management of labour. They can recruit and lay off workers depending on demand conditions for their output. The average skill level of employees, however, is relatively low in the TVE sector. Most of the workers are from the countryside with little training and skills.

Many TVEs have positioned their business in areas with severe shortages of output or where SOEs have been weak. They have taken advantage of China's endowments of cheap labour and specialised in the production of labour or resource-intensive products such as textiles, clothing, food processing, and toys. With the gradual opening up of the economy, TVEs have also attracted substantial volumes of export-oriented FDI (Table 2).

III. Productive Efficiency of TVEs

A. Methods of Estimation

There are three principal approaches to the measurement of productive efficiency: ratio analysis such as labour productivity and capital productivity, econometric approach such as the stochastic frontier model, and programming approach such as the data envelopment analysis. One of the most popular efficiency measures is labour productivity, but it ignores all other inputs save labour. The other partial indicators such as capital productivity suffer from similar problem. Cost per unit of output is another measure of efficiency. The unit labour cost or the efficiency wage, which is composed of wage rate per unit of labour and its productivity, is widely used in empirical studies.

Total factor productivity (TFP) provides a much more comprehensive guide to efficiency than these indicators. It takes into account the contribution of factors, other than raw labour and capital, such as managerial skills and technical know-how. It is usually defined as a residual, after the contribution of labour and capital to output growth has been taken into account. A Solow-type TFP index based on the Cobb-Douglas production function with constant returns to scale is as follows (Good, et al., 1997),

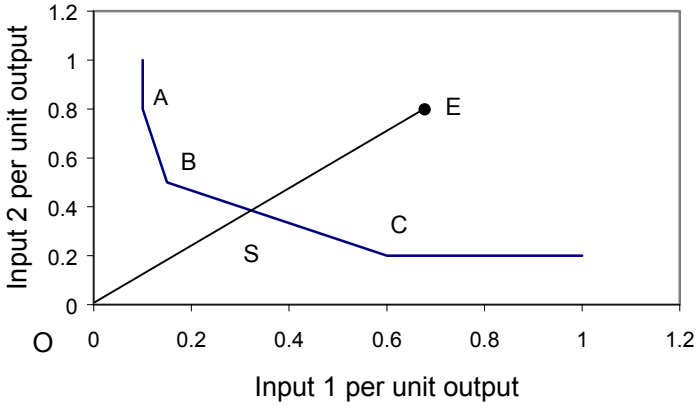
$$TFP = Y/(L^{\alpha}K^{1-\alpha})$$

where TFP = total factor productivity, Y= value-added, L = labour, K = capital. At cost-minimizing levels of inputs, α denotes the share of labour in total output and 1- α denotes the share of capital in total output. However, estimation of TFP is subject to several well-known problems.

The main advantage of the econometric approach is that measurement error can be minimized and hypotheses can be tested with statistical rigour. Its main drawback is that the production function is assumed to be known. In many empirical studies, the production function across sectors and over time periods is assumed to be homogeneous when this may not be the case.

In the programming approach, 'the efficiency measure of a Decision Making Unit (DMU) is defined by its position relative to the frontier of best performance established mathematically by the ratio of weighted sum of outputs to weighted sum of inputs'[6]. Graph 1 illustrates the general DEA approach developed by Farrell (Farrell, 1957). For example, assume 4 production units which use two inputs to produce one output. Plotting input 1 per unit output against input 2 per unit output, the efficiency frontier is given by the line joining ABC and extends parallel to the axes beyond A and C. Technical efficiency (TE) at point E is calculated as TE = OS/OE. Technical efficiency measures a firm's success in minimizing inputs to produce a given amount of output (input-oriented technical efficiency), or its success in producing the maximum of output with a given set of inputs (output-oriented technical efficiency)(Fare, et al, 1984; Coelli, 1996).

Graph 1



For a sample of n firms, if X and Y are the observations on inputs and outputs, assuming variable returns to scale, the firm's efficiency score, θ, is the solution to the linear program problem,

$$Min_{\theta,\lambda}\ \theta$$

$$\text{st.} \quad \theta x_i - X\lambda \geq 0$$

$$-y_i + Y\lambda \geq 0$$

$$\lambda_i \geq 0$$

$$\sum \lambda_i = 1 \qquad i = 1,...,n.$$

where θ is a scalar and λ is a nx1 vector of constants. The efficiency score ranges from 0 to 1. If $\theta_k = 1$, the kth decision making unit (DMU) is deemed to be technically efficient.

[6] Charnes, Cooper and Rhodes, 1978.

The strength of the programming approach lies not only in its lack of parameterization, but also in that no assumptions are made about the form of the production function. Instead, a best-practice function is built empirically from observed inputs and outputs. The main shortcoming of this technique is that there is no provision for statistical noise or measurement error in the model. Any deviation of an observation from the frontier must be attributed to inefficiency (Greene, 1997; Norman and Stoker, 1991).

B. Data and results

The data we use for efficiency estimation are taken from 'The third national industrial census of China' for a total number of 179 industry groups for the year 1995. The data for international comparison are collected from the 'International Yearbook of Industrial Statistics', UNIDO. We utilize ratio analysis and data envelopment analysis (DEA) to estimate the productive efficiency of TVEs.

In the data envelopment analysis, we use value-added in current prices as the measure of output, net fixed assets as the measure of capital[7], and total wage bill as the measure of labour inputs in order to capture, to a certain extent, the quality of labour input. Because growth of output has been the major objective of Chinese industries in recent years, we concentrate on output-oriented technical efficiency under variable returns to scale (VRS)[8].

Estimates of the various indicators of productive efficiency for TVEs at the industry level are reported along with comparable estimates for SOEs (Figure 1). All of the estimated indictors attest to the superior efficiency of TVEs. In 1995, the average technical efficiency score of TVEs was 85 percent higher than that for SOEs. Six industries are found to be technically efficient, including 1 SOE industry and 5 TVE industries. TVEs' total factor productivity (TFP) was 74 percent higher than that for SOEs[9]. The estimates of TFP are consistent with those reported in previous studies (Svejnar, 1990; Jefferson *et al*, 1992; Woo et al, 1993; Weitzman and Xu, 1994; Zheng, et al, 1998). All the other indicators including capital productivity, labour productivity and social efficiency index

[7] Because non-production capital such as housing and health care facilities can be regarded as part of the incentive scheme for the employees which can attract high quality personnel and promote work efficiency, we do not separate it from the total capital input.

[8] According to Zheng et al (1997) and Avkiran (2001), results under variable returns to scale is usually preferred when the estimation under constant returns to scale and variable returns to scale differ. Thus in this study we report mainly estimation results under variable returns to scale (VRS).

[9] Following Bernard (1999), assuming the production function across industries is homogeneous, we estimate the coefficients of a Cobb-Douglas type production function of value added on capital and labour for TVEs to obtain the share for labour (α). The estimated share of labour in TVE sector for the year 1995 is 0.39.

also attest to the relative superior efficiency of TVEs. The statistical tests for paired samples show that the mean of the two sectors are significantly different from each other for all the indicators[10]. Sectoral analysis of the performance of TVEs also indicates that, in general, TVEs are relatively efficient (Table 3)[11].

The unit labour costs of China's TVEs in principal export industries, such as textile, apparel, leather product and footwear industry, are also lower than that in comparable industries in Indonesia, Philippines, Thailand and India, her major competitors in world markets. This is either because her wage rates are relatively low or because her labour productivity is higher [12](Figure 2). International comparison of technical efficiency also indicates that, in comparable industries, China's TVEs are efficient relative to other major developing country suppliers in the world market[13] (Figure 3). In the case of textile industry, Brazil, Turkey, Indonesia and TVEs are on the frontier, which indicates they are efficient relative to other competitors such as India, Philippines, Thailand, Korea and Mexico. In the case of the leather product industry, TVEs lie on the frontier together with Thailand, Chile, Indonesia, Turkey and India. They are much more efficient than Philippines, Korea, Hong Kong and Taiwan. Electrical machinery is an item of exports on the comparative advantage ladder which China is trying to move up to. Here Brazil, Korea and Indonesia form the efficiency frontier. TVEs are less efficient than firms in these countries, but they are as efficient as Thailand and more efficient than firms in Mexico, Philippines, India and Malaysia. In sum, TVEs are not only much more efficient than comparable SOEs, they are also, in general, more efficient in comparison with their major international competitors in the principal export industries.

IV. Sources of efficiency

What are the sources of productive efficiency of TVEs? Their exposure to international markets through trade and FDI could be a principal factor in their observed superior productive efficiency (Grossman and Helpman, 1991; Egan and Mody, 1992; Balasubramnayam, *et al*, 1996; Clerides,

[10] The statistical test for paired samples tests the null hypothesis that the means of SOE and TVE samples are equal. The probabilities associated with t-test are all 0.00 for every indicator.

[11] Of the total 18 industry groups, TVEs exhibit much better performance except in the alcohol and tobacco industry which is rigidly controlled by the state. In the leather product industry TVEs have the largest efficiency advantage over the SOEs in terms of technical efficiency and labour productivity; while the largest gap lies in the machinery equipment manufacturing industry in terms of total factor productivity and capital productivity.

[12] Production of these industries in Thailand and Philippines are more capital-intensive than that in China's TVEs. The higher labour productivity of these two countries in these industries may be, to a certain extent, attributed to the higher capital-labour ratio in their production.

[13] Because the technical efficiencies of TVEs in these industries are higher than those of China as a whole, in order to keep data comparable, we use the data on China from UNIDO for the corresponding industries of TVEs.

1998). It could, however, be argued that it is only the relatively efficient firms which enter the world markets. The causation is from efficiency to exports and not the other way round (Henriques and Sadorsky, 1996; Yamada, 1998; Bernard and Jensen 1999; and Aw et al, 2000). Whilst there is no firm statistical evidence to support either of these contentions, the fact remains that exposure of TVEs to international competition has been to their advantage. In addition, the sizable volumes of FDI that TVEs have attracted may also serve as efficient conduits for the transmission of technology and managerial know-how.

Several other factors besides their outward-orientation could be conjectured to have played a role in the observed superior productive efficiency of TVEs. We discuss some of these factors prior to subjecting them to a rigorous statistical test.

Management is one of the major factors which contributes to productive efficiency. Efficient management serves to minimise costs of production, reduce transaction costs within firms, improves product quality and efficient utilisation of resources. However, when managers are not responsible for the consequences of their actions, with wages predetermined, there are opportunities for free-riding, the degree of X-inefficiency increases (Leibenstein, 1978). Performance related payments to managers, frequently observed in the TVEs, might be one method of reducing X-inefficiency. The incorporation of accountability through a hard-budget constraint, performance payment schemes for managers and piece rate payments for workers promote X-efficiency in the TVE sector.

Increased autonomy over managerial decision-making and a stake in the firm's profits may also contribute to efficient operations. Usually the larger the fraction of the total profits the enterprise is allowed to retain, the stronger will be the motivation to improve productive efficiency on the part of managers. A high degree of autonomy over decision-making is accorded to managers in most TVEs.

The nature of ownership of firms could also impact on productive efficiency of firms. The property rights model suggests that public ownership attenuates property rights, reduces incentives to minimize costs and encourages free-riding. Agency theory, however, suggests that when ownership is separated from management, the objectives of managers and owners may diverge. Individuals in the firm will not minimise costs for a given level of output. Such principal-agent relationship is regarded as an important source of X-inefficiency (Leibenstein, 1975; Button and Weyman-Jones, 1992). A number of empirical studies have investigated the comparative efficiency of different ownership

structures, but no strong evidence has been provided in favour of one system or the other (Byrnes et al, 1986; Ferrier, 1993).

TVEs in China, however, fit none of the commonly observed patterns of ownership and management. TVEs are nominally owned by the local residents, but controlled, managed and supported by the local governments and they respond to market forces. Their ownership is similar to SOEs to the extent that they are all publicly owned. Such public ownership may provide some institutional advantages over private firms in solving the agency problem (Bowles and Dong, 1996). Also, the assignment of property rights to the local government may be an efficient response to Chinese institutional constraints (Chang and Wang, 1994). Weitzman and Xu (1994) also argue that the demographic stability of China's rural communities and the Confucian tradition have promoted the emergence of a cooperative culture which renders well defined private property rights unnecessary for the promotion of entrepreneurial activity and productivity[14].

Although they are both publicly-owned, the management style of TVEs is considerably different from that of SOEs. TVEs are subject to the discipline of the market. The incorporation of accountability and exposure of publicly owned firms to market forces compels TVEs to minimise costs and maximise efficiency. Loss making enterprises are not bailed out by the state nor or they allowed to cream off all the profits they make. Whilst loss making firms go bankrupt, the successful ones share their profits with the local governments. The so-called agency problem is greatly reduced in the case of these contractual arrangements as managers' fortunes depend upon the efficiency with which they manage the enterprises. The unique combination of public ownership with market-orientated management of TVEs may have helped them overcome both the moral hazard and agency problems. The market environment in which the enterprises operate motivates entrepreneurship, allows managers to experiment and innovate, but it also holds them accountable for their actions. It is for these reasons that TVEs are not only much more efficient than the SOEs, they are also as productive as those firms which are owned privately (Pitt and Putterman, 1992; Dong and Putterman, 1997).

In sum, outward orientation, efficient management and the unique combination of public ownership with market-oriented management are factors which may have contributed to the productive

[14] Weitzman and Xu, 1994. For an excellent discussion on productivity and ownership structure, see Dong and Putterman, 1997, Zheng, Liu and Bigsten, 1998.

efficiency of TVEs. The influence of these and other factors on the observed productive efficiency of TVEs is analysed below in the context of a statistical model.

A. Model

We employ regression analysis to estimate the impact of the factors discussed earlier on the productive efficiency of TVEs. The equation to be estimated in logarithms is of the following form:

$$LPE_i = \alpha + \beta_1 LEX_i + \beta_2 LMS_i + \beta_3 LWS_i + \beta_4 LFS_i + \beta_5 LKI_i + \beta_6 DO_i + \mu \qquad (1)$$

where i = 1, …, N indexes industry, *PE* = productive efficiency, *EX* = outward orientation, *MS* = management intensity, *WS* = workforce skills, *FS* = firm size, *KI* = capital intensity, *DO* = sector dummy, 1 for TVEs and 0 for SOEs. Two alternative measures of productive efficiency, labour productivity (VAL) and technical efficiency (TE), are regressed upon the independent variables listed above respectively.

In the estimation of technical efficiency, the efficiency scores have an upper bound of 1.0 and a lower bound of 0.0, the ordinary least squares estimates would be inconsistent. Therefore, the regression model for technical efficiency is specified in form of the Tobit model as follows (Tobin, 1958; Greene, 1990; Zheng, 1997).

$$LPE = \begin{cases} \alpha + \beta LX_i + \mu & \text{if } \alpha + \beta LX_i + \mu < 0 \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$

where X_i is a vector of independent variables as listed in equation (1).

B. Data and Methodology

The main data set relates to a pooled sample of 358 industries including 177 TVE industries and 177 comparable SOE industries for the year 1995. It is derived from 'the Data of The Third National Industrial Census of P.R.China'. The second set of data relates to panel data for TVEs in 29 provinces of China over the time period 1987-1998. These are collected from the 'China township and village enterprises yearbook' and the 'China agricultural statistical yearbook'. This data set covers most of the TVEs during their period of rapid growth. It not only provides us with a base to investigate the dynamic effects of the determinants on efficiency, but also takes the regional

dimension into account. A more detailed description of the sources of data and the measurement of variables is given in Appendix 2.

The statistical test is in three steps. First, we estimate regression equations (1) and (2) with the pooled data set for SOEs and TVEs. The explanatory variables include ourward-orientation and management intensity. Labour skills, firm size, capital intensity and a sector dummy DO, which equals to 1 for TVEs and 0 for SOEs, are used as control variables. Because of possible endogeneity between openness and productive efficiency, we first apply Wu-Hausman specification test to test for endogeneity. Management intensity (MS), workforce skills (WS), capital intensity (KI), firm size (FS), market size (MARKS), comparative advantage[15] (CA), and policy dummy (DI) are used as predetermined variables. If endogeneity is detected between openness and productive efficiency, we utilise the 2-stage least square (2SLS) for labour productivity estimation and 2-stage Tobit model for technical efficiency estimation, otherwise we use the OLS and normal Tobit model.

Secondly, we test for the effects of outward orientation, management and other factors on the productive efficiency of TVEs and SOEs separately, and investigate the major factors which determine the efficiency gap between the two groups. We test for the structural differences between the two productivity equations by applying the Wald test of restrictions imposed on parameters. The 'seemingly unrelated' equations are as follows:

$$LPE_t = \alpha_t + \gamma_1 LEX_t + \gamma_2 LMS_t + \gamma_3 LWS_t + \gamma_4 LFS_t + \gamma_5 LKI_t + \mu_t \qquad (3)$$

$$LPE_s = \alpha_s + \delta_1 LEX_s + \delta_2 LMS_s + \delta_3 LWS_s + \delta_4 LFS_s + \delta_5 LKI_s + \mu_s \qquad (4)$$

where t and s denote TVEs and SOEs, respectively.

We first compare the estimated coefficients for corresponding variables in the two equations, for example, γ_1 and δ_1; then we employ a Wald test to test the null hypothesis $\gamma_1 = \delta_1$. As there may be endogeneity between exports and productivity, a Hausman test is also applied. If there is endogeneity

[15] Comparative advantage is measured by revealed comparative advantage index developed by Balassa (1965) as follows, $RCA = (X_{ij} / X_{wj}) / (\sum_j X_{ij} / \sum_j X_{wj})$, where i is the country, j is the commodity and w is the world. Detailed information of the measurement of predetermined variables and sources of the data is given in Appendix 2.

between exports and productivity, we apply the 3SLS to the equation system; otherwise, we utilise the SURE method.

Finally, we estimate equation (1), with the panel data set, to test for the dynamic effects of outward-orientation and management on the productive efficiency of TVEs when regional specific characteristics are controlled for.

C. Cross-section Results

Table 4 reports the two-stage least squares (2SLS) estimation results for the pooled data set using labour productivity as the dependent variable[16]. The coefficients of outward-orientation (EX) and management intensity (MS) are positive and statistically significant suggesting a positive contribution of outward orientation and management to productive efficiency. Workforce skills, firm size and capital intensity variables also bear the expected significant positive coefficients. Results for the equation based on technical efficiency as the dependent variable are similar to that for labour productivity.

Table 5 presents the results for the three-stage least squares (3SLS) estimation of labour productivity of TVEs and SOEs[17]. Outward-orientation (EX) exerts a significant positive effect on the productivity of TVEs, while it is insignificant in the case of the SOE sector. The Wald statistic at 8.828 suggests that the estimated coefficient of outward-orientation variable in the TVE equation is significantly different from that in the SOE equation at the 1% significance level (Table 6) indicating the significant contribution of outward-orientation to the superior productive efficiency of TVEs.

Management intensity (MS) is positively correlated with productive efficiency in the TVE sector and the coefficient of management intensity (MS) variable is statistically significant. A one percent increase in bonuses per employee is to increase labour productivity of TVEs by 0.18 percent. But they are insignificant in the SOE equation. The Wald test indicates that the difference between the two coefficients is statistically significant. This fact suggests that, in the TVE sector, market-oriented

[16] The t-statistic of –3.70 for exports-residual in the labour productivity (VAL) equation and –3.55 in the technical efficiency (TE) equation suggest that there is significant endogeneity between exports and productive efficiency in the sample. Therefore we utilize the 2-Stage Least Square (2SLS) for labour productivity (VAL) equation and 2-Stage Tobit model for technical efficiency (TE) equation. The White heteroscedasticity statistics (cross term) suggest the existence of heteroscedasticity. Thus, we adopt White's heteroscedasticity-consistent estimates for the standard errors and t-ratios.

[17] When the 3SLS estimates are compared with those for the seemingly unrelated regression, Hausman specification test statistics (χ^2) which are as high as 918 strongly suggest the endogeneity between exports and productive efficiency.

management such as incentive schemes have played a significant role in the promotion of X-efficiency.

Workforce skills (WS) variable exerts a positive impact on productivity in both the TVE and the SOE sectors. But the magnitude of the coefficient of the workforce skills variable in the SOE equation at 0.599 is considerably higher than that in the TVE equation. The Wald statistic indicates that this difference is significant. It is likely production workers in the SOE sector are better trained than those in the TVE sector. The coefficients of capital intensity (KI) variable tell the same story. This suggests that capital intensity in the SOE sector plays an important role in determining its productivity mostly because of the recent vintages of technology embodied in capital goods in use in the sector.

The coefficients of the firm size (FS) variable in both equations are significantly positive, and the Wald statistic shows the difference between them is statistically insignificant. This suggests that, irrespective of the ownership structure the firm adopts, productivity and size are related. The test on the determinants of technical efficiency in the two sectors also lends evidence supporting the positive contribution of outward-orientation and management to the superior productive efficiency of TVEs (Table 7).

D. Panel Data Results

Results using the panel data set are presented in Table 8[18]. Again, outward-orientation (EX) exhibits a significant positive impact on the productive efficiency of TVEs. According to the estimation result, a one percent increase in openness increases productive efficiency by about 0.15 percent. Bonuses per employee (MS1) and retained profits per employee (MS2) are positively associated with productivity and are statistically significant. This suggests the increases in incentives and autonomy promote productive efficiency in the TVE sector. The coefficients of the coastal region dummy variable are positive but are not significant in either equation. This suggests that, when openness, management, capital intensity and technological progress have all been controlled for, the efficiency gap between TVEs in the coastal and the interior regions is not significant.

[18] In this case, we use bonuses per employee and retained profits per employee as measures of management intensity alternatively. Exports as a proxy of outward-orientation, a time trend capturing the technological change, and a coastal region dummy which equals to 1 for coastal regions and 0 for inland regions are also included as the explanatory variables. Because of potential endogeneity between exports and productivity, we use 2-stage-least-squares (2SLS) for estimation. The instruments we use are exports and productivity lagged by one year.

V. Conclusions

The conclusions of the paper can be briefly summarised. TVEs have made a major contribution to growth and exports of China. Most of the indicators of productive efficiency suggest that TVEs are much more efficient than comparable SOEs. They are also competitive in the international markets. The unique pattern of their ownership, their management which responds to market forces and their outward-orientation all appear to have contributed to their productive efficiency.

China's TVEs appear to have successfully combined public ownership of industry with management which responds to market based incentives. Their performance suggests that efficient management, which successfully exploits the endowments and resources of the country rather than the nature of ownership of production entities, is crucial to the success of manufacturing firms.

References

Arkiran, N., 2001. 'Investigating technical and scale efficiencies of Australian universities through data envelopment analysis', Socio-economic planning sciences, 35, 57-80.

Aw, B.Y., Chuang, S. and Roberts M.J., 2000. 'Productivity and turnover in the export market: micro-level evidence from the Republic of Korea and Taiwan (China)', *The world bank economic review*, v. 14, no.1, 65-90.

Bai, C., Li, D. And Wang, Y., 1997. 'Enterprise productivity and efficiency: What is up really down', *Journal of comparative economics*, 24, 265-280.

Balasubramanyam, V.N., Salisu, M., and Sapsford, D., 1996. 'Foreign direct investment and growth in EP and IS countries', *The Economic Journal*, v.106, No. 434 92-105.

Baldwin, J., and Caves, R., 1997. 'International competition and industrial performance allocative efficiency, productive efficiency and turbulence', *Harvard economics discussion paper*, no. 1809.

Bernard, A.B. and Bradford, J.J., 1999. 'Exceptional exporter performance: cause, effect, or both?', *Journal of international economics*, February 1999, v. 47, no.1, 1-25.

Birdsall, N., and Sabot, R.H. cited in Wei (1995).

Bowles, P. and Dong, X., 1996. 'A piece in the township and village enterprise puzzle', *working papre, department of economics*, University of Northern British Columbia and University of Winnipeg.

Byrnes, P., Grosskopf, S. and Hayes, K., 1986. 'Efficiency and ownership: further evidence', The review of economics and statistics, v.68, issue 2, 337-341.

Button, K. and Weyman-Jones, T., 1992. 'Ownership structure, institutional organization and measured X-efficiency', The American Economic Review, v.82, issue 2, 439-445.

Choudhri, E.U. and Hakura, S.S., 2000. 'International trade and productivity growth: exploring the sectoral effects for developing countries', *IMF working paper*, WP/00/17.

Chang, C. and Wang, Y., 1994. 'The natur of the township-village enterprises', *Journal of comparative economics*, v. 19, 3: 434-452. Dec, 1994.

Charnes, A., Cooper, W.W. and Rhodes, E., 1978. 'Measuring the efficiency of decision making units', *European Journal of operational research*, 2, 6: 429-444.

Chen, H. and Rozelle, S., 1999. 'Leaders, managers, and the organization of township and village enterprises in China', *Journal of development economics*, v. 60, p529-557.

Clark, T. And Du, Y., 1998. 'Corporate Governance in China: explosive growth and new patterns of ownership', *Long Range Planning,* V. 31, No. 2, 239-251.

Clerides, S.K., Laul, S. and Tybout, J.R., 1998. 'Is learning by exporting important? Micro dymanic evidence from columbia, Mexico and Morocco', *Quarterly journal of economics*, v. CXIII, 903-948.

Coelli, T., 1996. 'A guide to DEAP Version 2.1', *CEPA working paper*, 96/08.

Dong, X. And Putterman, L., 1997. 'Productivity and organization in China's Rural industries', *Journal of comparative economics*, 24, 181-201.

Dunning, J.H., 1970. *Studies in international investment*, George Allen & Unwin Ltd..

Egan, M.L. and Mody, A., 1992. 'Buyer-seller links in export development', *World development*, v. 20, no.3, 321-334.

Fare, R., Grosskopf, S. and Lovell, K., 1984. 'The measurement of efficiency of production', Kluwer. Nijhoff Publishing.

Fare, R., Grosskopf, S.,Norris, M. and Zhang, Z., 1994. 'Productivity growth, technical progress, and efficiency change in industrialized countries', *The American economic review*, v.84, issue 1, 66-83.

Farrell, M.J., 1957. 'The measurement of productive efficiency', *Journal of the royal statistical society*, v.120, series A, 253-291.

Feenstra, R.C., 2001. 'International trade and investment', *NBER Reporter*, winter 2000/2001, 1-9.

Ferrier, G., 1993. 'Ownership type, property rights, and relative efficiency', in Data envelopment analysis, theory, methodology, and application, edited by Charnes, A., Cooper, W., Lewin, A. and Seiford, L., Kluwer Academic Publishers.

Good, D.H., Nadiri, M.I. and Sickles, R.C., 1997. 'Index number and factor demand approaches to the estimation of productivity', in *Handbook of applied econometrics, Vol II. Microeconomics*, edited by Pesaran, M.H. and Schmidt, P., Blackwell Publishers.

Greene, W., 1997. 'Frontier production functions', in *Handbook of applied econometrics, Vol II. Microeconomics*, edited by Pesaran, M.H. and Schmidt, P., Blackwell Publishers.

Grossman, G.M. and Helpman, E., 1990. 'Trade, innovation and growth', *AEA papers and proceedings*, v.80, no. 2, 86-91.

Grossman, G.M. and Helpman, E., 1991. *Innovation and growth in the global economy*, MIT press.

Groves, T., Hong, Y., McMillan, J., and Naughton, B., 1994. 'Autonomy and incentives in Chinese state enterprises', *Quarterly Journal of Economics*, V. 109, Issue 1, 183-209.

Gujarati, D.N., 1995. *Basic econometrics*, McGraw-Hill , Inc.

Hentiques, I. And Sadorsky, P., 1996. 'Export-led growth or growth driven exports: theCanadian case', *Canadian journal of economics*, v. XXIX, 540-555.

Jefferson, G. and Rawski, T., 1994. 'Enterprise reform in Chinese industry', *The journal of economic perspectives*, V. 8, Issue 2, 47-70.
Jefferson, G., Rawski, T. and Zheng, Y., 1996. 'Chinese industrial productivity: trends, measurement issues, and recent developments', *Journal of comparative economics*, 23, 146-180.
Johnes, G. and Johnes, J., 1993. 'Measuing the research performance of UK economics departments: an application of data envelopment analysis', *Oxford Economic papers*, 45, 332-347.
Judge, G. et al, 1985. *The theory and practice of econometrics*, John Wiley & Sons, Inc.,Canada.
Li, W., 1997. 'The impact of economic reform on the performance of Chinese state enterprises, 1980-1989', *The journal of political economy*, V. 105, Issue 5, 1080-1106.
Leibenstein, H., 1978. 'On the basic proposition of X-efficiency theory', The American economic review, v.68, issue 2, 328-332.
Liu, H., Campbell, N., Zheng, L., and Wang, Y., 1996. 'An international perspective on China's township enterprises', in *Management issues in China: Volume I*, edited by Brown, D.H. and Porter, R., Routledge.
Liu, J., Tsou M., and Hammitt, J.K., 1999. 'Export activity and productivity: evidence from the Taiwan electronics industry', *Weltwirtschaftliches Archiv*, v. 135 (4), 675-691.
Liu, Y., Chew, S. And Li, W., 1998. 'Education, experience and productivity of labor in China's township and village enterprises', *China economic review*, V.9, No. 1, 47-58.
Marin, D., 1992. 'Is the export-led growth hypothesis valid for industrialised countries?', *Review of economics and statistics*, v. 74, 678-688.
Norman, M. and Stoker, B., 1991. *Data Envelopment analysis: the assessment of performance*, John wiley & sons Ltd., England.
Page, J.M., 1994. 'The East Asian miracle—four lessons for development policy', *NBER macroeconomics annual 9*.
Pitt, M. and Putterman, L, 1992. 'Employment and wages in township, village, and other rural enterprises', cited in Weitzman and Xu, 1994.
Qi, H., 2000. PhD thesis.
Qian Y. And Roland, G., 1996. 'The soft budget constraint in China', *Japan and the world economy*, 8, 207-223.
Ray, Y., 1999. 'The rise of township-vallage enterprise managers and the emergence of a new state-society relationship in rural China', memo of City University of Hong Kong.
Roberts, M.J. and Tybout, J.R., 1996. Industrial evolution in developing countries: micro patterns of trunover, productivity, and market structure, Oxford university press.
Sen, 1966. Cited in Fare et al, 1984.
Sexton, T.R., 1986. 'The methodology of data envelopment analysis', in *Measuring efficiency: an assessment of data envelopment analysis*, edited by Silkman, R. H., Jossey-Bass Inc., Publishers.
Svejnar, J.,1990. 'Productive efficiency and emloyment', in *China's rural industry: structure, development and reform*, edited by Byrd and Lin, Oxford university press.
Tong, C., 1999. 'Production efficiency and its spatial disparity across China's TVEs', *Journal of Asian Economics*, 10,415-430.
Wei, S., 1995. 'The open door policy and China's rapid growth: evidence from city-level data', in *Growth theories in light of the East Asian experience*, edited by Ito, T. and Krueger, A.O., The university of Chicago press.
Weitzman, M. and Xu, C., 1994. 'Chinese township-village enterprises as vaguely defined cooperatives', *Journal of comparative economics*, v. 18, 2: 121-145. Apr. 1994.
Willians, H., 2001. 'Property rights and legal reform in township and village enterprises in China', Asian-pacific law & Policy Journal, v.2, issue 1, 2001.
Woo, W., Hai, W., Jing, Y., and Fan, G., 1993. 'How successful has enterprise reform been?', cited in Weitzman and Xu.
Yamada, H., 1998. 'A note on the causality between exports and productivity: an empirical re-examination', *Economic letters*, v. 61, 111-114.
Yamawaki, H., 1991. 'Exports, and foreign distributional activities: evidence on Japanese firms in the United States', *The review of economics and statistics*, V. 73, Issue 2, 294-300.
Zheng, J., Liu, X. And Bigsten, A., 1998. 'Ownership structure and determinants of technical efficiency', *Journal of comparative economics*, 26, 465-484.

Table 1 Industry Characteristics of TVEs and SOEs, 1995

	Exports / labour	Exports/output	Stock of foreign capital	Capital labour ratio	Output per firm	Number of employees	Net fixed assets per firm	Industries reported to be loss making (% of total)
SOE	5132	0.17[a]	0.79	27773	36	338	22	68
	(6310)	(0.12)	(1.69)	(17410)	(95)	(553)	(64)	
TVE	11591	0.26[a]	2.84	20052	7	84	2	2
	(17293)	(0.15)	(5.44)	(11408)	(6)	(49)	(2)	
t-statistic	0	0.07	0	0	0	0	0	

	Wage rate	Workers with university level education	Workers with secondary level education	Managerial staff	Engineers	Nonproduction workers	Nonproduction net fixed assets	Payment on piece rates
		(% of total)	(% of total)	(% of total)	(% of total)	(% of total)	(% of total)	(% of total)
SOE	5209	8	83	12	7	34	27	62
	(1680)	(4)	(5)	(6)	(4)	(8)	(9)	(40)
TVE	4199	2	82	11	7	23	17	86
	(1048)	(1)	(6)	(2)	(2)	(5)	(18)	(10)
t-statistic	0	0	0.01	0	0.13	1	0	0

Note:1. The figure presented here are unweighted average of all industries in TVE and SOE sectors respectively.

2. The standard deviations are shown in parenthesis.

3. The t-statistic tests the null hypothesis of the equality between SOE and TVE sector, data listed here are probabilities associated with Students's t-test.

a. Weighted average.

Source: Calculated from 'The Third National Industrial Census of P.R.China', 1995.

Table 2 Major Exporting Industries of TVEs, 1995

Industry	Export-output ratio	Export Value	FDI-total capital ratio
		million US$	
Toy manufacturing	0.70	579	0.54
Computer man.	0.65	193	0.54
Apparel man.	0.54	3146	0.36
Sport articles man.	0.54	100	0.39
Leather product man.	0.52	1320	0.41
Watch & Clock man	0.51	91	0.55
Other electric equipment	0.50	63	0.73
Feather product man.	0.47	243	0.28
Hat manufacturing	0.46	29	0.33
Electronic appliance man	0.44	93	0.67
Knitted product man.	0.41	833	0.33
Footwear man.	0.39	170	0.32
Plastic shoes man.	0.39	61	0.44
Office machines man.	0.36	13	0.40
Electronic parts man.	0.34	276	0.44
Textile	0.22	4484	0.17

Source: Calculated from 'The Third National Industrial Census of P.R.China', 1995.

Table 3 Performance of TVEs, sectoral analysis, 1995

SOE=1.00

Industry[1]	Technical efficiency	Total factor productivity	Value-added per fixed assets	Value-added per worker	Wage rate	Output /firm	Capital labour ratio
Machinery equipment	2	3.28	9.53	1.92	0.85	0.32	0.70
Leather	3.81	2.93	3.56	3.25	1.30	1.00	0.79
Transportation	2.39	2.70	6.22	1.62	0.64	0.15	0.63
Textile	2.47	1.93	2.25	2.16	0.97	0.43	0.93
Food	2.69	1.92	2.46	1.83	0.84	0.38	0.76
Plastic product	2.43	1.85	2.11	2.70	1.34	0.63	1.27
Mining	2.03	1.85	3.45	1.36	0.79	0.19	0.42
Electric machinery	2.25	1.80	2.12	2.09	0.89	0.53	1.04
Apparel	2.14	1.73	2.22	1.81	1.24	1.00	0.81
Chemical	2.42	1.73	2.31	1.43	0.71	0.19	0.62
Drug	1.64	1.69	2.10	1.70	0.71	0.48	0.89
Non-metal	2.41	1.63	2.23	1.86	1.02	0.36	0.94
Instruments and office machinery	2.16	1.59	1.81	1.90	0.80	0.50	0.82
Fibre & Rubber	2.33	1.57	1.87	1.74	0.83	0.25	0.99
Metal	1.95	1.54	1.92	1.87	0.94	0.09	0.94
Electronic and telecom	1.54	1.38	1.47	1.67	0.97	0.54	0.90
Miscel light industry	1.63	1.35	1.84	1.04	0.85	0.17	0.64
Alcohol & tobacco	1	0.61	1.03	0.35	0.66	0.05	0.50

Note: 1. The industries listed here are the major industry groups each consisting of several sub-industries.

Source: Calculated from 'The Third National Industrial Census of P.R.China', 1995.

Table 4 Estimation results of determinants of productive efficiency for pooled data

Independent Variable	Efficiency measures			
	Labour productivity		Technical efficiency	
	OLS	2SLS	TOBIT	2S-TOBIT
CONS	3.578***	3.829***	-2.066***	-1.876***
	(0.000)	(0.000)	(0.000)	(0.000)
DO	1.356***	1.560***	1.411***	1.563***
	(0.000)	(0.000)	(0.000)	(0.000)
LEX	0.029***	0.076***	0.013	0.047***
	(0.001)	(0.000)	(0.112)	(0.000)
LSM	0.157***	0.173***	0.128***	0.139***
	(0.000)	(0.000)	(0.000)	(0.000)
LWS	0.123***	0.178***	0.121***	0.160***
	(0.000)	(0.000)	(0.000)	(0.000)
LFS	0.074***	0.114***	0.035**	0.064***
	(0.000)	(0.000)	(0.019)	(0.000)
LKI	0.366***	0.290***	-0.170***	-0.225
	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	358	358	358	358
Adjusted R^2	0.546	0.505		
Log likelihood			-137.054	-129.54

Note: ***Significant at the 1 percent level; ** Significant at the 5 percent level; p-values are shown in parentheses.

Table 5 Estimates of labour productivity of TVE and SOE sectors

Independent Variable	3SLS		SURE	
	TVE	SOE	TVE	SOE
Intercept	6.337***	-1.381	6.221***	-1.393
	(0.000)	(0.122)	(0.000)	(0.118)
LEX	0.041***	-0.012	0.026***	-0.002
	(0.003)	(0.317)	(0.006)	(0.869)
LMS	0.180***	-0.007	0.180***	-0.002
	(0.000)	(0.851)	(0.000)	(0.963)
LWS	0.102***	0.599***	0.082***	0.602***
	(0.001)	(0.000)	(0.002)	(0.000)
LFS	0.046**	0.074***	0.033**	0.075***
	(0.012)	(0.000)	(0.042)	(0.000)
LKI	0.212***	0.609***	0.232***	0.603***
	(0.000)	(0.000)	(0.000)	(0.000)
N	179	179	179	179

Note: * Significant at the 10 percent level; ** Significant at the 5 percent level; *** Significant at the 1 percent level; p-values are shown in parentheses.

Table 6 Wald Tests of Equality of estimated coefficients between TVE and SOE equations

Variables	Null Hypothesis	Wald Statistic	Reject Null (1%)
Intercept	$\alpha_t=\beta_s$	64.440***	Yes
LEX	$\gamma_1=\delta_1$	8.828***	Yes
LMS	$\gamma_2=\delta_2$	13.638***	Yes
LWS	$\gamma_3=\delta_3$	22.730***	Yes
LFS	$\gamma_4=\delta_4$	1.111	No
LKI	$\gamma_5=\delta_5$	34.659***	Yes

Notes: *** Significant at the 1 percent level. Dependent variable: log of labour productivity.

Table 7 Estimates of technical efficiency in TVE and SOE sectors

Independent Variables	2S-TOBIT		TOBIT	
	TVE	SOE	TVE	SOE
C	0.501	-2.257**	0.236	-2.258**
	(0.157)	(0.020)	(0.504)	(0.020)
LEX	0.028**	0.005	0.010	-0.001
	(0.040)	(0.693)	(0.304)	(0.940)
LSM	0.166***	0.117***	0.167***	0.115***
	(0.000)	(0.005)	(0.000)	(0.006)
LWS	0.113***	0.145	0.087***	0.143
	(0.000)	(0.182)	(0.001)	(0.188)
LFS	0.014	0.004	-0.001	0.003
	(0.447)	(0.869)	(0.937)	(0.886)
LKI	-0.309***	-0.166***	-0.283***	-0.163***
	(0.000)	(0.007)	(0.000)	(0.008)
N	179	179	179	179

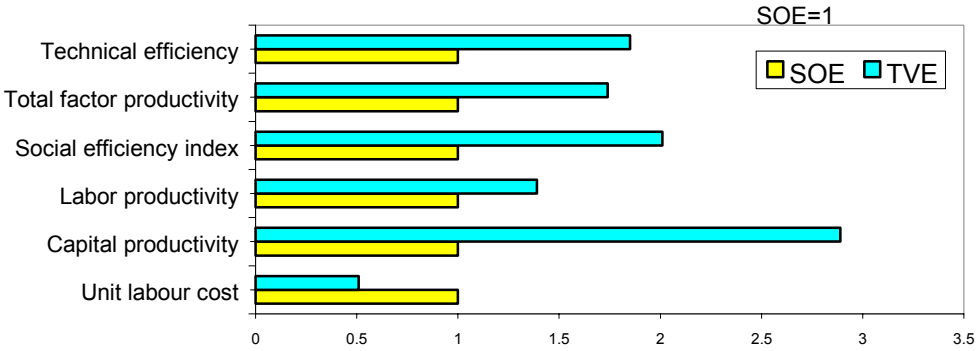
Note: * Significant at the 10 percent level; ** Significant at the 5 percent level; *** Significant at the 1 percent level; p-values are shown in parentheses.

Table 8 Determinants of productive efficiency: panel data results

Independent variables	(1)	(2)
C	0.547*	1.716***
	(0.077)	(0.000)
LEX	0.157**	0.136***
	(0.001)	(0.000)
LMS1	0.108***	
	(0.010)	
LMS2		0.340***
		(0.000)
LKL	0.134	0.320***
	(0.252)	(0.000)
T	0.099***	0.022**
	(0.000)	(0.013)
DC	0.103	0.042
	(0.394)	(0.203)
N	87	145
Adjusted R^2	0.898	0.973

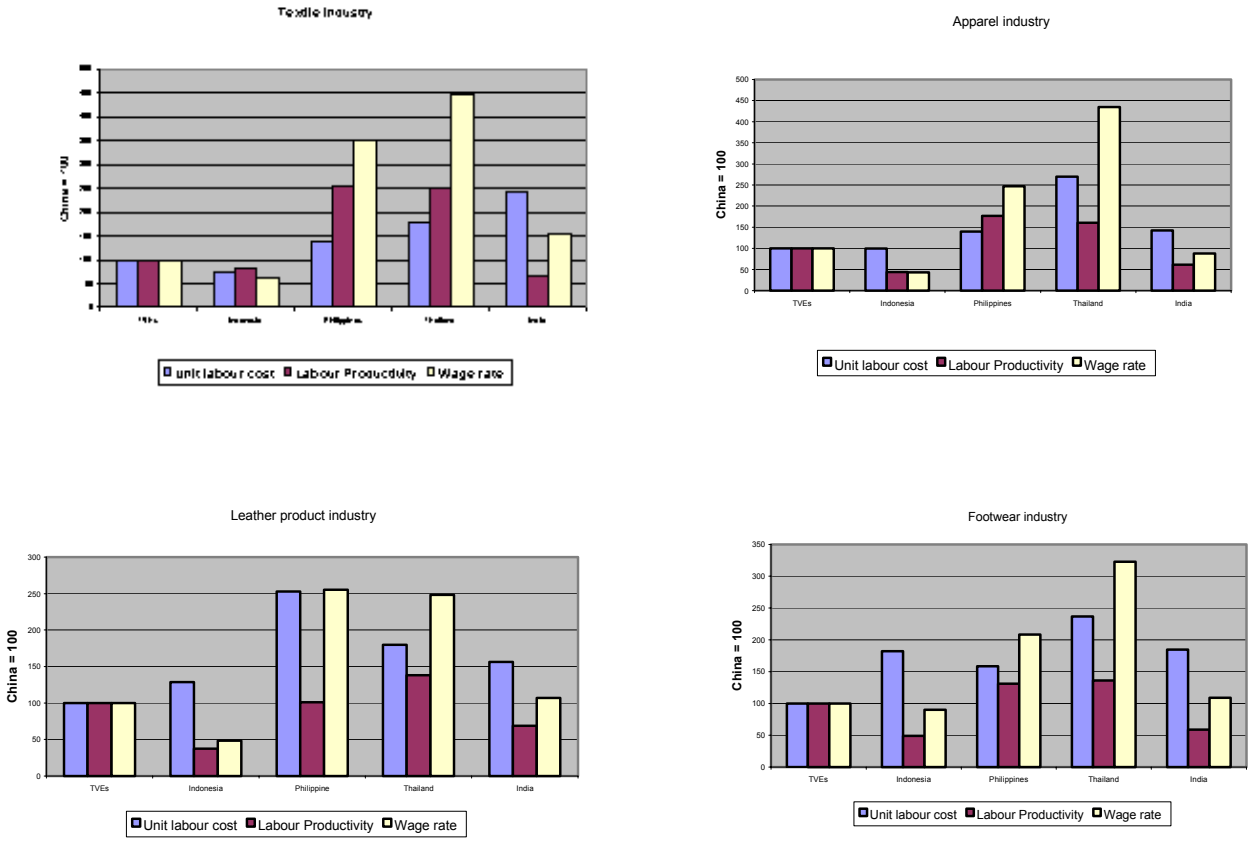
Note: Regression equation $LPE_{it}=\kappa+\theta LEX_{it}+\xi LMS_{it}+\eta DC_{it}+\upsilon T+\varepsilon_{it}$, where *PE* = labour productivity, *EX* = real exports per employee, *MS* = management intensity measured by real bonuses per employee (*MS1*), and real retained profits per employee (*MS2*) alternatively, *T* = the time trend, and *DC* = coastal region dummy variable which equals 1 for coastal regions and 0 for non-coastal regions. Instrumental variables are: *EX* and *PE* lagged by one year. Regression (1) and (2) cover the time period of 1995-1998 and 1987-1992 respectively.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level. p-values are in parentheses.

Figure 1. Comparative Performance of TVEs and SOEs, 1995



Note: 1.The figures here are the unweighted average of each indicator of TVE and SOE sectors respectively.
Source: Calculated from 'The Third National Industrial Census of P.R.China', 1995.

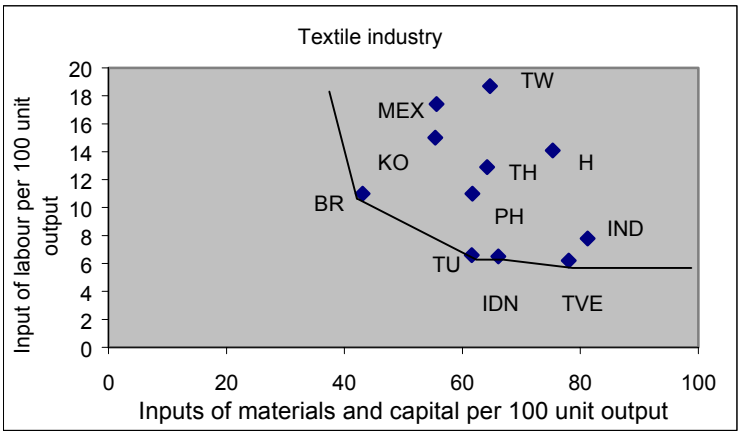
Figure 2 International comparison of unit wage costs

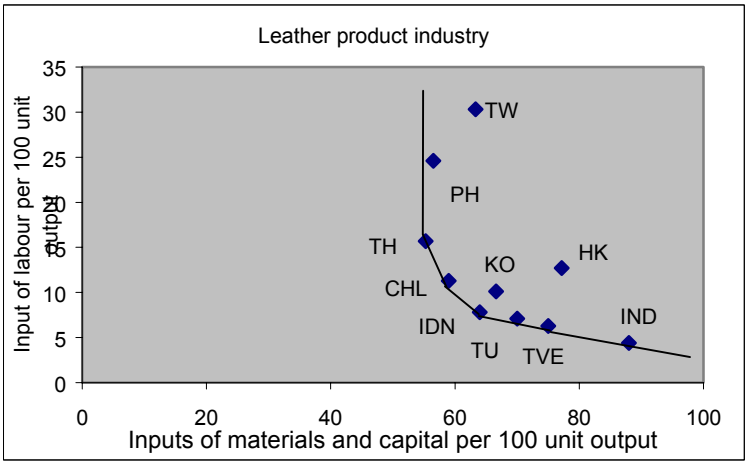


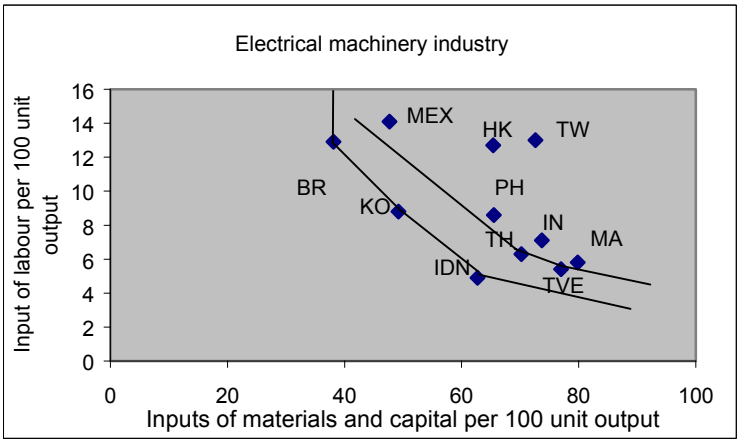
Note: 1. The data of TVEs and Indonesia are for the year 1998, Philippines 1997, Thailand 1994 and India 1999.
2. Labour productivity of TVEs in industry I = (UNIDO value-added per employee of China in industry I)* (The ratio of value-added per employee of TVEs in industry I to that of the whole country of China in the same industry); Wage rate of TVEs in industry I = (TVEs wage rate in industry I in 1995)* (growth rate of manufacturing wage rate in China over 1998-1995)

Source: UNIDO Country Industrial Statistics; China statistical yearbook, 1999; The data of the third national industrial census of the P.R.China, 1995.

Figure 3 International comparison of technical efficiency, 1995







Note: BR=Brazil, TVE=China' TVEs, HK=Hong Kong SAR, TW=Taiwan province, IND=India, IDN=Indonesia, MAL=Malaysia, MEX=Mexico, PH=Philippines, KO=Korea, TH=Thailand, CHL=Chile, TUR=Turkey

Source: UNIDO, International Yearbook of Industrial Statistics, 1999; The data of the third national industrial census of the P.R.China, 1995.

Appendix 1 Ownership structure of Chinese enterprises, 1995

Sector	Gross industrial output	
	Value 100million yuan	Percentage of total %
Total	80519	100
State-owned enterprises	25890	0.32
Collective-owned enterprises	28541	0.35
Private-owned enterprises	2334	0.03
Individual-owned enterprises	9632	0.12
Joint-owned enterprises	652	0.01
Share-holding enterprises	2727	0.03
Foreign invested enterprises	10660	0.13
Others	78	0.00
Of which		
Township and village-owned enterprises	36257	0.45
Of which		
Township-owned enterprises	11682	0.15
Village-owned enterprises	11906	0.15
Rural joint/cooperative enterprises	1631	0.02
Rural private-owned enterprises	2295	0.03
Rural individual-owned enterprises	8742	0.11

Source: The third national industrial census of China, 1995

Appendix 2. Data Sources and Variable Measurement

This study employs two data sets. One is a cross-industrial data set combined data derived from 'The Third National Industrial Census of P.R.China' 1995, various issues of 'International Yearbook of Industrial Statistics', UNIDO and 'International Trade Statistical Yearbook', UN. The other is a panel of data for TVEs across 29 provinces over the time period 1987-1998 collected from the 'China township and village enterprises yearbook' and the 'China agricultural statistical yearbook'. Tibet, Congqing and Hainan are omitted because of incomplete data. The measurement of variables use in the study in given below.

PE = productive efficiency. In this study we regress two measures of efficiency respectively: the labour productivity (VAL) measured by value-added per employee and technical efficiency (TE) which obtained by data envelopment analysis (DEA).

EX = outward-orientation, measured by export value of the industry;

MS = management intensity, measured by bonuses per employee. In the case of the panel data set, it is measured by bonuses per employee and retained profits per employee alternatively. Bonuses of TVEs in the cross-industry data set equals to *profits payable* times the ratio of bonuses to profits payable estimated from the 'Statistical yearbook of township and village enterprises', 1995.

WS = workforce skills, measured by payment by piece rate per production worker;

FS = firm size, measured by average output per firm in industry *i* to total output of industry *i*;

KI = capital intensity, measured by capital-labour ratio;

DO = sector dummy, 1 for TVEs and 0 for SOEs;

MARKS = market size, measured by total output of the industry;

CA = comparative advantage, measured by estimated revealed comparative advantage index developed by Balassa (1965); the data are collected from United Nation's 'International Trade Statistical Yearbook' at three digit level.

PI = policy dummy, which equals to 1 for the industries which are favoured by government export-promoting policy and 0 for others.

Appendix 3 Rank correlation matrix of efficiency scores

	TE	*TFP*	*VAD/K*	*VAD/L*	*Social efficiency index*	*1/Unit wage cost*
TE	1					
TFP	0.824	1.000				
VAD/K	0.572	0.406	1			
VAD/L	0.565	0.544	0.084	1.000		
Social efficiency index	0.795	0.806	0.264	0.584	1.000	
1/Unit wage cost	0.698	0.747	0.138	0.817	0.831	1