The Developing Economies, XLII-3 (September 2004): 421–52

EFFICIENCY OF CHINESE TOWNSHIP AND VILLAGE ENTERPRISES IN THE 1990s BASED ON MICRO DATA FOR WUXI CITY, 1991–97

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First version received March 2003; final version accepted December 2003

We examine the (technical) efficiency of collective-owned township and village enterprises (COTVEs) in Wuxi City, China, after 1990 to study whether the acknowledged success of township and village enterprises continued in the late 1990s. Our results suggest that COTVEs did not decline in relative efficiency compared with other types of enterprises in the late 1990s, but that their productivity leveled off or declined. Furthermore, we find that COTVEs faced with a more serious shortage of working capital had a lower efficiency after the mid-1990s recession. These findings cast doubt on the view that the vaguely specified property rights of COTVEs are responsible for their declining performance problems during the period just before 1998 when massive privatization began. Privatization of COTVEs without other macroeconomic policy changes may now be insufficient to cope effectively with their declining productivity.

I. INTRODUCTION

The success of Chinese township and village enterprises (TVEs) was a stylized fact from the inception of economic reform until the first half of the 1990s. The share of production that TVEs accounted for in the manufacturing sector increased from 9 percent in 1979 to 30 percent in 1990, and the press has often reported on successful TVEs. The strong performance of Chinese TVEs owned by township and village governments, so-called collective-owned TVEs (COTVEs), poses a challenge to traditional property right theory. According to this theory, public ownership of property is inconsistent with technical efficiency.[1] Since the prop-

We thank Akira Kohsaka, Hiromi Yamamoto, Hiroshi Ohnishi, Yukihiko Kiyokawa, Deqiang Liu, Naoki Murakami, and the anonymous referees for their helpful comments; however, all errors and views expressed are ours. This work was funded by a Grant-in-Aid for Young Scientists (B) No. 15730137 from the Japanese Ministry of Education, Science, Sports, and Culture (MESSC), and Go Yano would like to thank the ministry for its financial support.

[1] Hereafter, the term "efficiency" in this paper means "technical efficiency." This technical efficiency is defined as $AF(\cdot)/BF(\cdot) = \exp(-u_i)$ (< 1) in equation (4) mentioned in Section III below, where $BF(\cdot)$ and $AF(\cdot)$ are respectively a best-practice production frontier and an actual production

erty rights of these enterprises are often not clearly specified, publicly owned enterprises are predicted to fail to motivate their managers and workers adequately (Alchian and Demsetz 1972).

This claim and subsequent reports led economists to measure the efficiency of TVEs, especially COTVEs, using micro level data. They reported favorably on the efficiency of COTVEs. For example, Murakami, Liu, and Otsuka (1994) found that COTVEs were more efficient than state-owned enterprises and urban collective-owned enterprises,[2] and that cooperative (*lianying*) type COTVEs, which were domestic joint ventures in rural area between state-owned or urban collective-owned enterprises, were as efficient as joint ventures and managed rationally in terms of profit maximization. Svejnar (1990), Dong and Putterman (1997), and Pitt and Putterman (1999) found no significant difference in efficiency between COTVEs and private enterprises or joint ventures. This discovery verified that vaguely specified property rights might not raise serious problems for COTVEs, contrary to standard economic theory regarding property rights. Jefferson (1999) compared total factor productivity in state-owned enterprises with that in COTVEs, which is equivalent to comparing their efficiencies in production, and found it to be higher in COTVEs.[3] Motivated by press reports and empirical studies of the success of COTVEs, other economists have tried to explain this success theoretically, focusing on property rights and the role of local governments in the activities of COTVEs (Weitzman and Xu 1994; Chang and Wang 1994; Li 1996; Che and Qian 1998a, b).

However, none of the above empirical studies used up-to-date micro data for the TVEs or the COTVEs. The data used all derived from samples before 1990, so that results revealed only the success of TVEs before that date.[4] Over a decade later, can the success of TVEs still be taken for granted? Or has the collective-owned enterprises' vaguely specified property rights become inconsistent with efficiency, as

function. In Section III, $\ln[BF(\cdot)]$ and $\ln[AF(\cdot)]$ are respectively the components other than ε_i on the right-hand side of equation (3), and these less u_i.

2 Even ordinary type COTVEs independent of state-owned enterprises or urban collective-owned enterprises had higher efficiency levels than state-owned enterprises and urban collective enterprises, based on their final and most credible estimates.

3 Using aggregated macro data, unlike the firm-level micro data used in this study, Jefferson, Rawski, and Zheng (1992) compared the total factor productivity growth rate in state-owned industries with that in collective-owned industries. The collective-owned industries included both rural COTVEs and urban collective-owned enterprises; even their data showed that the total factor productivity in collective-owned industries grew more rapidly than that in state-owned industries from 1978 to 1988. However, the claim that collective-owned industries increased their total factor productivity more rapidly than state-owned industrial enterprises cannot be regarded as firmly established because the output and price data for collective-owned industries were problematic (Jefferson, Rawski, and Zheng 1996).

4 Moreover, Dong and Putterman (1997), Pitt and Putterman (1999), and Jefferson (1999) used micro data selected from the same data set. Obviously, if only a few data sets had been used in previous research, there is concern whether the data is representative of all COTVEs.

traditional property right theory asserts? The press and several academic studies in China are increasingly reporting the declining performance of TVEs in the Chinese economy. Lu (1999) reports that the total deficit of TVEs has increased since 1997, and that 30 percent of TVEs have been compelled to reduce or cease production. COTVEs have frequently had their declining performance highlighted; private enterprises are now expected to play an important part in the Chinese economy. COTVEs can face serious problems as a result of their vaguely specified property rights. Li and Yan (1998) assert that efficiency in COTVEs having a deficit has remained low because of bailouts from local government, based on their case study in southern Jiangsu Province. This is a typical area in which the success of COTVEs has been supported by local governments; it includes Wuxi City from which the micro data used in this paper is taken. Several studies argue that the declining fund efficiency and high debt ratio of TVEs are related to their protection from market forces, for instance by subsidies or bailouts offered to COTVEs by the local governments that run them (Pan, He, and Zhuang 1997; Xu and Zhang 1997; C. Jiang 2000). The protection of COTVEs is a consequence of their vaguely specified property rights (G. Jiang 2000). Do these reports and studies really show a declining efficiency of TVEs? Has the vague specification of the property rights of COTVEs recently caused serious problems?

To study whether COTVEs succeeded after the first half of the 1990s, we measured the relative efficiency (on average) of COTVEs compared to other types of enterprises for each year from 1991 to 1997 using firm-level micro data including that from COTVEs (or various kinds of TVEs) in Wuxi City, Jiangsu Province.[5] If their vaguely defined property rights have caused COTVEs to fall in efficiency after the mid-1990s, then their relative efficiency compared with joint venture firms, private enterprises, or share-holding enterprises should have declined. These three types of enterprises have been chosen for comparison because their property rights are clear. Measurements involve both production function and production frontier approaches.

Since 1998 massive privatization of COTVEs has taken place in Wuxi City and Jiangsu Province. This is because the Chinese central and Jiangsu local governments came to believe that the vague property rights of COTVEs cause inefficiency, and that privatization would cure the problem by resolving the property rights. It is therefore important to measure the efficiency of COTVEs before 1998, prior to the privatization schemes, when property rights were poorly defined.

It is possible that the efficiency of COTVEs has not in fact declined recently but that their actual production function has nevertheless shifted downward. The actual

[5] Murakami, Liu, and Otsuka (1994), Svejnar (1990), and Pitt and Putterman (1999) also examine the allocative decisions of COTVEs, but our concern is with the efficiency, following Dong and Putterman (1997).

production function is defined as $AF(\cdot) = \exp(-u_i)BF(\cdot)$ (see footnote 1 for the notation). If the best-practice production frontier in the entire Wuxi economy shifts downward, the actual production function of COTVEs also shifts downward even if they maintain their relative efficiency compared to other types of enterprises. The actual production function of COTVEs involves their relative efficiency in the entire Wuxi economy and therefore involves macroeconomic factors which affect the best-practice production frontier throughout the Wuxi economy. The present study therefore examines not only the relative efficiency of COTVEs compared to other types of enterprises, but also those macroeconomic factors that determine the actual production function of COTVEs. When we use the terms "productivity change," "rising productivity," and "declining productivity" we refer to upward or downward, upward, or downward shifts respectively, in the actual production function. Through the production function approach, we measure changes in the productivity of COTVEs and other types of enterprises.

For the relative efficiency of COTVEs (compared to other types of enterprises), and for their productivity change, there are four possible outcomes: (1) both decline; (2) the relative efficiency declines but the productivity rises; (3) both rise; and (4) the relative efficiency rises but the productivity declines. In case (1), the vaguely specified property rights of COTVEs are likely to reduce the efficiency and the macroeconomic conditions may be worsening. In case (2), the vaguely specified property rights cause problems, but a favorable macroeconomic climate covers this up. In case (3), the vaguely specified property rights do not cause a serious problem, and the macroeconomic climate is also not problematic. In this case, claims of declining performance of (CO)TVEs may be an illusion. In case (4), although the vaguely specified property rights of COTVEs do not cause a reduction in efficiency, macroeconomic factors shift the best-practice production frontier downward, and then cause the declining productivity of various types of enterprises including COTVEs. The role of macroeconomic factors makes case (4) particularly interesting. For example, the late 1990s in China was a period of recession or economic retrenchment. Recession can reduce the net operating rate for machinery and equipment or labor, shifting the best-practice production frontier downward in two ways. The first is by decreasing demand, and the second is through insufficient working capital for the operation of machinery and equipment. The latter problem arises through shrinkage of lending operations. According to our recent field survey in Wuxi City and other regions in southern Jiangsu Province, insufficient working capital is a serious problem for COTVEs.[6]

[6] Based on a survey of ninety-five TVEs in Yi County, Hebei Province in 1991, Wu (1992) also reports that 83.2 percent of the managers interviewed identified the lack of funds as their greatest problem. Dong and Putterman (1997) show in a study of eighty-nine rural enterprises in China (COTVEs and private enterprises) that their credit was indeed constrained and that access to credit allowed the productivity of enterprises to rise.

Even if the two types of measurements confirm that the Wuxi economy after the mid-1990s is in category (4), this indicates only that the declining productivity of COTVEs was caused by some macroeconomic factor, such as recession since the mid-1990s. It does not, unfortunately, clarify through what path macroeconomic conditions influenced the declining productivity of COTVEs.

Knowledge of the path has important policy implications. For example, if insufficient working capital was responsible, reform of the corporate finance system in China would help tackle the declining productivity problem. To specify the path we must measure not only the average efficiency of COTVEs, but also the efficiency of each COTVE, and study what determines it. If the macroeconomic factor influences not only the best-practice production frontier but also the efficiency of each firm in the same way (or if the best-practice production frontier is not determined independently of each firm's efficiency), then there must be some macroeconomic path variables which are influenced by the macroeconomic condition, and which affect the efficiency of each firm as well as the best-practice production frontier. Vague specification of property rights is expected to be invariant within a group of COTVEs, whereas a macroeconomic path variable will vary within the group. Consequently, if macroeconomic conditions influence the best-practice production frontier and the actual production function of COTVEs via a path, then the path variable is correlated with the individual efficiency of each firm in the COTVEs sampled. For example, if insufficient working capital was responsible, firms faced with a greater shortage of working capital should have lower efficiency. To measure the efficiency of each COTVE, we use estimates of the production function and production frontier models.

The paper proceeds as follows. Section II classifies and discusses the types of enterprises in the Chinese economy. Section III describes our empirical model, and Section IV explains the data employed. Section V discusses the estimation procedure and results. Our conclusions are presented in Section VI.

II. ENTERPRISE TYPES

Enterprises included in our sample were classified into eight types: (1) collective-owned township and village enterprises (COTVEs); (2) state-owned enterprises (SOEs); (3) share-holding enterprises (SHEs); (4) private enterprises (PEs); (5) joint venture firms (JVs); (6) urban collective-owned enterprises (UCOEs); (7) urban cooperative enterprises (UCEs); and (8) urban other enterprises (UOEs). SHEs, PEs, and JVs include share-holding TVEs, private TVEs, and joint venture TVEs.

We measured the efficiency of COTVEs relative to PEs and JVs which should have better defined property rights and higher efficiency. Only a few PEs are included in our sample, and we look particularly at the efficiency of JVs as a benchmark when measuring the efficiency of COTVEs. Murakami, Liu, and Otsuka (1994) found that JVs were the most efficient of all types of Chinese enterprises.

SOEs and UCOEs are expected to be less efficient than COTVEs, as found by Murakami, Liu, and Otsuka (1994) and Jefferson (1999). If, however, the efficiency of COTVEs has declined in relative terms, differences between their efficiencies should be reduced.

SHEs were introduced experimentally from 1992 or 1993 (untill 1997) as a property rights reform measure (i.e., privatization) in collective-owned enterprises including COTVEs (and SOEs) which was expected to improve the definition of property rights and increase efficiency. If, therefore, the efficiency of SHEs was sufficiently high relative to that of COTVEs, the experimental reform policy would have been deemed successful in the period 1991–97. The SHEs introduced during this sample period generally had a considerable portion of state-owned shares, and they can be seen to have better defined property rights than COTVEs. They therefore comprise a second benchmark for the relative efficiency of COTVEs.

UCEs are liable to be inefficient because the central government or an SOE is likely to cooperate with a local government or with another type of enterprise in the management of UCEs; they may therefore share the inefficiency of SOEs.

III. MODEL

It is assumed that the production technology of firms can be represented by the Cobb-Douglas form with multiplicative disturbance and linear homogeneity. We adopted a linear homogeneous Cobb-Douglas production function with multiplicative disturbance as the maintained hypothesis; therefore when economy of scale exists, its effect will be considered as an increasing efficiency or a rising productivity. The assumptions concerning the disturbance and the homogeneity of production technology function lead to two models in a production function approach, and these are set out in subsections A and B.

A. *Production Function Approach*

Here, the disturbance is assumed to be the usual stochastic error term and to be symmetrically distributed. This is the production function approach. From the viewpoint of production frontier approach mentioned later, here we estimate the coefficients of the actual production function in the production frontier specification.

By using this approach to clarify the average efficiency for each type of enterprise relative to others, we estimate a log-linear productivity function derived from the Cobb-Douglas production function with linear homogeneity restriction:

$$\ln(Y/L)_i = \sum \alpha_j Z_j + \sum \beta_m W_m + \theta_K \ln\,(K/L)_i + \varepsilon_i \tag{1}$$

in each year from 1991 to 1997, where i (= 1, . . . , N) is the enterprise index. Here

Y_i, K_i, and L_i are respectively net output, capital, and labor. Z_j is an industry dummy variable of the j-th industry ($j = 1, \ldots, 11$),[7] and W_m is an enterprise-type dummy variable that is summed over enterprises (with dummy enterprise suffix $m = 1, \ldots, 8$). The coefficients α_j, β_m, and θ_K are unknown parameters that are to be estimated, and θ_K is the elasticity of output to capital. Since COTVEs are a benchmark in our estimation, the W_m terms do not include the dummy variable corresponding to COTVEs. Consequently, β_m represents the difference between the averages of efficiency of the m-th type of enterprises and COTVEs in each year, in other words, the average efficiency for the m-th type of enterprise relative to that of the COTVEs'. If the vaguely specified property rights of COTVEs have become inconsistent with efficiency in production, the estimated β_m's of JVs and SHEs are expected to be significantly positive and to increase annually in the late 1990s. Finally, ε_i is the independently distributed stochastic error term. It is also assumed to represent each firm's relative efficiency about the average for each type of enterprise, as explained below.

The estimation of equation (1) will clarify the average efficiency of each type of enterprise relative to others in a year. However, it is impossible to examine the productivity change, namely the shift of the actual productivity function for each type of enterprise in the time series by estimating the coefficients in equation (1). For this purpose we estimate coefficients of another log-linear Cobb-Douglas (actual) productivity function with linear homogeneity restriction:

$$\ln(Y/L)_{it} = \sum \alpha_j Z_j + \sum_m [\beta_{m1} W_m + \sum_{y=2\sim 7} \beta c_{my} (W_m \times PD_y)] + \theta_K \ln(Y/L)_{it} + \varepsilon_{it}, \quad (2)$$

using 1991–97 pooled micro data. Here, PD_y is a productivity change dummy variable at year y, which is 0 if the time is before year y and 1 if the data time is year y or after. This variable expresses the change from before to after year y in a firm's productivity. It follows that $W_m \times PD_y$ is a productivity change dummy variable for the m-th type of enterprise at year y [$y = (199)2, \ldots, (199)7$]. The coefficients β_{m1} and βc_{my} are unknown parameters to be estimated. In this case also, the W_m in the $\beta_{m1} W_m$ terms do not include the COTVE dummy variable. Consequently, β_{m1} denotes the starting point of the average efficiency of the m-th type of enterprise relative to the COTVEs in 1991, and βc_{my} denotes the change in the productivity for the m-th type of enterprise between year $y-1$ (not always the 1991 starting point) and year y. The term ε_{it} is the independently distributed stochastic error term just like ε_i in equation (1). Other symbols have the same meaning as in equation (1).

[7] Industry dummy variables are used to allow for differences between industries. The model allows net output to differ according to industry only by shifting the intercept of the production function, not by altering factor elasticities. Since different industries may have quite different characteristics, results should be interpreted with caution and further studies are needed based on adequate data samples from more industry-specific surveys.

B. *Production Frontier Approach*

To measure the average efficiency of COTVEs compared to other enterprises for each year from 1991 to 1997, and to confirm the robustness of the estimation results for equation (1), we suppose that the disturbance is the sum of white noise which is symmetrically distributed and an error term with a one-sided distribution which measures each firm's relative (in) efficiency. In other words, we estimate the best-practice production frontier. This approach is more consistent with the theoretical definition of production function, and was also adopted by Dong and Putterman (1997). The present paper adopts the panel-data production frontier model proposed by Battese and Coelli (1995)[8] among various production frontier models.[9]

For this estimation, we decompose the 1991–97 pooled micro data into cross section data for each year (to take into account the different elasticity of output to capital and disturbance structures between years during the sample period) and compare the estimation results and those for productivity function (1). We therefore reduce the panel-data model proposed by Battese and Coelli (1995) to a one-period cross section data model. To study the efficiency of COTVEs relative to the other enterprises for each year from 1991 to 1997, we estimate the following best practice productivity function derived from the Cobb-Douglas production frontier:

$$\ln(Y/L)_i = \sum \alpha_j Z_j + \theta_K \ln(K/L)_i + \varepsilon_i, \tag{3}$$

where the components other than ε_i on the right-hand side represent the best-practice production frontier and

$$\varepsilon_i = v_i - u_i. \tag{4}$$

Here v_i is assumed to be the symmetrically distributed white noise, specifically distributed normally with zero mean and constant variance, σ_v^2 [$v_i \sim N(0, \sigma_v^2)$]. The v_i is assumed also to be independent of the u_i. This error term u_i is a nonnegative random variable which is assumed to account for inefficiency in production and to be independently distributed as the normalized truncation at zero of the $N(P_i, \sigma_u^2)$ distribution. Following Battese and Coelli (1995), it is further assumed that the inefficiency distribution parameter, P_i, is a function of firm-specific variables which can explain the level of inefficiency, namely,

$$P_i = \delta_0 + \sum \delta_k V_{ki},$$

8 Kong, Marks, and Wan (1999) also adopt this model to study technological change and calculate the total factor productivity growth for enterprises (mainly SOEs) in four Chinese industries (building materials, chemicals, machinery, and textiles) from 1990 to 1994 using firm-level micro data. Kalirajan and Cao (1993) estimate the production frontier model of the Chinese iron and steel industry using the maximum likelihood (ML) method, as set out in Kumbhakar, Biswas, and Bailey (1989).

9 For example, see Aigner, Lovell, and Schmidt (1977), Meeusen and van den Broeck (1977), Jondrow et al. (1982), Kumbhakar, Biswas, and Bailey (1989) and Battese and Coelli (1992).

where V_k's are firm-specific variables that can influence the inefficiency, and δ's are unknown parameters to be estimated. For this estimation we adopt enterprise-type dummy variables, W_m's, as V_k's. This model of P_i allows us to estimate systematically the average inefficiency for each type of enterprise relative to the benchmark (in this case, the COTVEs) in a single stage.

The maximum likelihood (ML) method is used to estimate the coefficients in equations (3) and (4). For easy estimation, we need to re-parameterize $\sigma_s^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma_s^2$. The log-likelihood function of this model is presented in the appendix in Battese and Coelli (1993).

C. *Variation in Efficiency for Each COTVE*

So far we have investigated only the average (in)efficiency of COTVEs. Next, we examine how the relative efficiencies of individual COTVEs are distributed around the average. We also look at what determines these individual efficiencies.

In the production function approach, the residual, the estimate of ε_i, is considered to represent each COTVE's relative efficiency in the COTVE group. We examine how the residuals of the COTVEs are distributed.

In the production frontier approach, the efficiency of each individual COTVE can be investigated more systematically. The $\exp(-u_i)$ term in production frontier models (3) and (4) can be interpreted as the efficiency of each firm i. Therefore, if $\exp(-u_i)$ can be estimated for each individual COTVE, it is the estimated efficiency of that COTVE. The individual $\exp(-u_i)$ can be estimated as the conditional mean of u_i, given ε_i (Battese and Coelli 1993). The conditional mean value of u_i is:

$$E[\exp(-u_i) \mid \varepsilon_i] = [\exp(-\mu_* + 1/2 \times \sigma_*^2)]\{\Phi[(\mu_*/\sigma_*) - \sigma_*] / \Phi(\mu_*/\sigma_*)\}, \quad (5)$$

where

$\mu_* = (1-\gamma)(\delta_0 + \sum \delta_k V_{ki}) - \gamma \times \varepsilon_i$,

$\sigma_*^2 = [\gamma(1-\gamma)\sigma_s^2]^{1/2}$,

and $\Phi(\cdot)$ is the usual normal distribution function. For the ε_i, δ's, γ, and σ_s^2, estimates are used.

Finally, we performed several regressions of the residuals of the production function estimation and the estimated $\exp(-u_i)$'s of production frontier estimation for some variables for the year 1996 and 1997. This is to study which factors were significant in determining the efficiency of each COTVE in the late 1990s. Since insufficient working capital is known to be significant for COTVEs, the independent variables include working capital/K (capital) and working capital/L (labor), in addition to various industry dummies. The working capital/K and working capital/L variables are assumed to express the extent of fund wealth of the COTVE. In particular, we advocate working capital/K as a better variable to influence each COTVE's net operating rate for machinery and equipment.

IV. DATA

In these estimations we have used micro data for enterprises in Wuxi City taken from the *Wuxi Statistical Yearbook* for 1992–98. In constructing the data used for making estimates, the following deflating methods have been used for output and inputs.

A. *Deflating Method for Output*

Output is measured by net output (added value) at 1991 fixed prices, i.e.,

$$Y_t = GV_t / DEFO_t - PME_t / DEFI_{jt},$$

where t is the time index, j is the industry index, GV is the gross value of output at current prices, PME represents intermediate inputs at current prices, $DEFO$ is the deflator for output, and $DEFI$ is the deflator for intermediate inputs. As indicated above, different deflators are used for the gross value of output and for intermediate inputs; this is called double-deflation. The aim is to avoid a biased measurement of real net output arising from differing inflation rates between the final product and intermediate inputs. The deflator for output is defined as

$$DEFO_t = (GV_t / GV90_t) / (GV_{1991} / GV90_{1991}),$$

where $GV90$ is the gross value of output at 1990 fixed prices.

B. *Deflating Method for Intermediate Inputs*

The intermediate inputs variable (M) is measured by intermediate inputs at 1991 fixed prices ($PME_t / DEFI_{jt}$).

The price deflator $DEFI$ for intermediate inputs is derived from the data on “the purchase price index of materials, coal, and engines” and the deflator for “the indices for the prices of services” published in the *Jiangsu Statistical Yearbook*. The $DEFI$ is derived as a weighted average price index. The weights are the average share of each component in the sum of the value of current intermediate inputs for each industry in the sample. The values of the intermediate inputs for each industry are obtained from the input-output table for China for 1992, 1995, and 1997, published in the *China Statistical Yearbook*. The shares of intermediate inputs for 1991 and 1992 are based on the input-output table for China for 1992; the shares of intermediate inputs for 1993, 1994, and 1995 are based on the input-output table for China for 1995; and the shares of intermediate inputs for 1996 and 1997 are based on the input-output table for China for 1997.

The price deflator was normalized by taking the 1991 index as 100 percent.

C. *Deflating Method for Fixed Assets*

Capital is measured by the real original value of fixed assets. We cannot learn the current original values of fixed assets from any data source for Wuxi City, only the nominal original (book) values. We therefore deflate the nominal original values of fixed assets to the real ones. Also, it would be better to measure capital by the real original value of "productive" fixed assets than whole fixed assets, which can include "non-productive" fixed assets such as housing for workers, schools, and hospitals. However, we do not adopt the productive fixed assets approach, since we cannot learn the data for productive fixed assets for each firm during the sample period (except for 1991 only) in the annual *Wuxi Statistical Yearbook*. Measuring capital by (whole) fixed assets is reasonable for our discussion of the property rights and efficiency of COTVEs, based on the assumption that the ratio of productive fixed assets to (whole) fixed assets in COTVEs was changing at a same rate as in other types of enterprises during the sample period (see footnote 10 for further details).

The price deflator for fixed assets is derived from "the price indices of investment in fixed assets" of Jiangsu Province in the *Jiangsu Statistical Yearbook*. This item is divided into three components: "construction and installation," "purchase of equipment, tools, and instruments," and "other." The deflator for fixed assets is derived as a weighted average price index. The weights are the average share of three of each component in the total investment in fixed assets. The weight of each component in the investment now differs not only for each industry, but also for each type of enterprise. For example, SOEs have a larger construction share in their fixed assets than other enterprises; this includes more nonproductive resources, such as housing, schools, health facilities, and other services for industrial workers and their families. Our procedure therefore includes separate calculations for SOEs, TVEs (including COTVEs), and other types of enterprise, although the *Jiangsu Statistical Yearbook* did not give data showing the allocation of investment by SOEs, TVEs, and other types of enterprise. This yearbook divides the investment in fixed

[10] We do not adopt the productive fixed assets approach partly because of the way we treat the property rights and efficiency of COTVEs. It is likely that the ratio of productive fixed assets to (whole) fixed assets is higher in COTVEs than in SOEs. We should therefore be cautious about estimates of absolute differences between the efficiencies of COTVEs and SOEs in each year; the true difference in efficiencies may be less than the measured one. There is little evidence that the ratio of productive fixed assets to (whole) fixed assets in COTVEs changed more rapidly than in other types of enterprises (including SOEs) in the 1990s, and the assumption about the ratio of productive fixed assets stated in the text does not seem unreasonable. So we do accept the observed trend in differences between the efficiencies of COTVEs and other types of enterprises. Our discussion of the property rights and efficiency of COTVEs relies more on the observed trend in differences between the efficiencies of COTVEs and other types of enterprises than on the estimated annual absolute differences between their efficiencies.

TABLE I

SAMPLE SIZE, AVERAGE NET OUTPUT, CAPITAL AND NUMBER OF EMPLOYEES BY TYPE OF ENTERPRISE, 1991–97

Type of Enterprise	1991				1992			
	Sample Size	Net Output (Added Value) (10,000 Yuan)	Capital (K) (10,000 Yuan)	No. of Employees (L) (Persons)	Sample Size	Net Output (Added Value) (10,000 Yuan)	Capital (K) (10,000 Yuan)	No. of Employees (L) (Persons)
COTVE	52	938.231	1,745.904	882.827	65	2,024.400	1,954.887	851.631
SOE	126	2,078.691	4,701.198	1,799.286	127	3,315.470	5,404.151	1,780.071
SHE	0				0			
PE	0				0			
JV	2	1,344.000	1,910.500	1,622.500	9	2,234.087	2,281.483	1,022.111
UCOE	37	1,041.189	2,835.730	966.946	21	1,469.317	2,421.109	885.048
UCE	23	1,941.435	2,982.000	1,534.565	26	2,722.360	3,181.870	1,502.308
UOE	0				0			
Total	240				248			

Type of Enterprise	1993				1994			
	Sample Size	Net Output (Added Value) (10,000 Yuan)	Capital (K) (10,000 Yuan)	No. of Employees (L) (Persons)	Sample Size	Net Output (Added Value) (10,000 Yuan)	Capital (K) (10,000 Yuan)	No. of Employees (L) (Persons)
COTVE	78	4,683.086	2,779.166	866.513	79	6,681.971	4,087.705	844.354
SOE	113	4,356.088	5,942.259	1,664.858	115	4,588.412	7,918.510	1,511.165
SHE	10	7,904.642	8,780.201	2,353.300	14	9,934.007	7,948.980	1,872.214
PE	0				0			
JV	22	3,724.334	4,146.586	1,014.864	33	5,239.712	5,229.782	1,018.515
UCOE	31	3,021.751	3,565.037	858.774	30	3,603.781	4,398.699	816.800
UCE	15	6,153.082	3,604.267	1,472.667	17	3,785.150	4,170.521	1,191.941
UOE	1	3,420.953	3,065.560	1,841.000	1	3,357.835	4,296.128	1,645.000
Total	270				289			

Type of Enterprise	1995 Sample Size	1995 Net Output (Added Value) (10,000 Yuan)	1995 Capital (K) (10,000 Yuan)	1995 No. of Employees (L) (Persons)	1996 Sample Size	1996 Net Output (Added Value) (10,000 Yuan)	1996 Capital (K) (10,000 Yuan)	1996 No. of Employees (L) (Persons)
COTVE	83	9,249.811	6,303.812	1,017.386	127	11,339.276	6,780.900	891.370
SOE	115	5,511.958	11,269.547	1,413.130	118	7,145.831	12,826.313	1,424.186
SHE	15	11,729.898	9,874.039	1,906.200	12	9,549.541	12,362.954	1,888.167
PE	0				2	12,663.880	12,333.177	1,330.500
JV	33	7,741.935	15,473.401	1,020.515	41	8,122.098	15,650.122	885.098
UCOE	31	4,358.914	5,643.632	798.871	35	5,327.389	6,579.355	848.000
UCE	20	4,089.411	4,878.901	897.550	18	4,240.951	6,179.385	938.389
UOE	0				0			
Total	297				353			

Type of Enterprise	1997 Sample Size	1997 Net Output (Added Value) (10,000 Yuan)	1997 Capital (K) (10,000 Yuan)	1997 No. of Employees (L) (Persons)
COTVE	104	12,902.585	10,969.669	841.154
SOE	107	8,922.389	17,216.309	1,580.140
SHE	15	9,155.111	16,879.753	1,612.467
PE	2	15,057.548	9,589.953	684.000
JV	45	9,331.370	20,295.509	865.111
UCOE	30	6,214.729	7,390.298	700.567
UCE	18	3,919.722	8,134.630	902.389
UOE	0			
Total	321			

assets into four types: investment in capital construction, in innovation, in urban collective units, and in rural areas. Here, since investments in capital construction and innovation appear to be mainly for use by SOEs, we have assigned the shares of the three relevant components to the sum of investments in capital construction and innovation for SOEs. The share of investment in rural areas is assigned to TVEs, and the share of investment in urban collectives is assigned to the other types of enterprise.

As stated above, capital is derived from the deflated original value of fixed assets, taking the 1991 index as the price base. The figures are as follows:

$$DOF_t = (1 - s)DOF_{t-1} + [(OF_t - OF_{t-1}) + sOF_{t-1}] / DEFA_{jmt},\ t = 1992\text{–}97,$$

where s denotes the rate of physical depreciation of fixed assets in each year (assumed to be 3 percent), m is the index denoting enterprise type, OF is the nominal original value of fixed assets, DOF is the deflated original value of fixed assets, and $DEFA$ is the deflator for the original value of fixed assets.

Finally, labor is taken as the total number of year-end employees.

The descriptive statistics for real net output (added value), real capital, and the number of employees explained in this section are presented separately in Table I, according to each year and each type of enterprise.

V. ESTIMATION PROCEDURE AND RESULTS

The coefficients specifying production functions (1) and (2) may be estimated in four ways: by the ordinary least square (OLS) method, the weighted least square (WLS) method, the instrumental variables (IV) method, and the weighted instrumental variables (weighted IV) method. The measurement error of capital can lead to the problem of inconsistency of the OLS and WLS estimates, so we have used instrumental variables. In IV estimation and weighted IV estimation, all variables are taken as the instrumental variables except for the logarithm of capital/labor [$\ln(K/L)$], which is included in our econometric models, labor (L), deflated intermediate inputs ($PME_t / DEFI_{jt}$), and their squares [$(PME_t / DEFI_{jt})^2$].

The data used is either cross section data or pooled cross section data, and since heteroscedasticity of the error term ε_i may arise, we use the WLS and weighted IV methods of estimation. When the Breusch-Pagan test is performed on OLS and IV estimates, heteroscedasticity occurs in most cases.

These estimation procedures employ two cross section data for each year, or two pooled data, to ensure robustness of the estimates and prevent data selection bias. The first of these is full cross section data for each year or pooled data comprising the full cross section data, whose number is unbalanced for each year. The second is balanced cross section data for each year or pooled data comprising the balanced cross section data. The balanced data consists of data from the same firm for each year; 177 such firms are used.[11]

We now examine the estimates of the average efficiency of COTVEs relative to other types of enterprises, based on production function (1). Since COTVEs provide the benchmark for estimation for each year, COTVE dummy variables and estimated coefficients do not appear in Table II. Table II shows the following:

First, COTVEs did not decline in average efficiency relative to other enterprises in the late 1990s. They have in fact become, on average, more efficient even than JVs as well as SOEs, UCOEs, and UCEs, from about 1994 (or 1996).[12] Compared to SHEs also, COTVEs were clearly a more efficient type of enterprise in 1997.[13] Roughly speaking, in the early 1990s the differences in average efficiency between these types of enterprises were small; thereafter the differences increased and COTVEs gained in average efficiency relative to the others.

Second, the estimates are robust. We find no major differences between results for the four estimation methods specified above, except for the higher *t* statistic found for WLS and weighted IV than for OLS and IV. Of course the estimates for WLS and weighted IV are more reliable than those for OLS or pure IV.

These estimates do not support the hypothesis that the vaguely specified property rights of COTVEs have been a negative influence on high efficiency.

The estimates reported in Table III allow us to make inference about the productivity change for COTVEs and other types of enterprises. The estimated coefficient of productivity change dummy for each type of enterprise in each year denotes the productivity change for that type of enterprise between the previous year and the present year. In Table III, the estimates for OLS differ somewhat from those for WLS, IV, and weighted IV, for example in the coefficients of $\ln(K/L)$ and the industry dummy variables. Of course, the estimates for WLS, IV, and weighted IV are more reliable than those for OLS. Therefore, in the following discussion of the estimation results derived from production function equation (2) shown in Table III, we rely on the estimates for WLS, IV, and weighted IV. Table III shows the following:

The productivity changes for COTVEs were positive and significant in the early

[11] In fact, estimation using balanced data gives almost the same results as unbalanced data. To save space the following text presents only the results using unbalanced data.

[12] In 1997, PEs were the most efficient of all types of enterprises, although there are few PE samples and very few conclusions can be drawn from the results.

[13] They state that SHEs were introduced experimentally from 1992 or 1993 (until 1997) as a measure for property rights reform; in other words, privatization in collective-owned enterprises including COTVEs (and SOEs). However, SHEs had a lower efficiency than COTVEs in the 1990s up to 1997, although the estimated efficiency gap between them is not statistically significant in some years. On this basis the experimental introduction of SHEs might not be enough to increase the efficiency of formerly collective-owned enterprises (and SOEs) before 1998 when massive privatization began. Jefferson et al. (2000) also mention the poor productivity changes in SHEs.

TABLE

THE ESTIMATES OF PRODUCTION

	1991			
	OLS	WLS	IV	Weighted IV
Industry dummy variables:				
Mining and quarrying	–0.405	–0.300**	–0.337	–0.326**
	(–0.378)	(–3.367)	(–0.313)	(–3.119)
Foodstuff	–3.911**	–3.876	–3.853**	–3.989
	(–6.087)	(–0.668)	(–5.938)	(–0.704)
Textiles, sewing, leather, and fur products	–0.384	–0.439**	–0.359	–0.449**
	(–1.915)	(–6.440)	(–1.759)	(–6.442)
Other manufacturing	–0.445	–0.433*	–0.407	–0.452**
	(–1.251)	(–2.575)	(–1.129)	(–2.607)
Production and supply of electric power, steam, and hot water	–0.129	0.053	0.612	–0.018
	(–0.190)	(0.212)	(0.009)	(–0.067)
Coking, gas, and petroleum refining	–3.123**	–2.575	–3.077**	–2.628
	(–5.457)	(–0.720)	(–5.336)	(–0.754)
Chemical industry	–0.192	–0.235	–0.143	–0.251
	(–0.699)	(–1.527)	(–0.503)	(–1.642)
Building materials and non-metal mineral products	–0.481	–0.464**	–0.447	–0.485**
	(–1.847)	(–3.792)	(–1.686)	(–3.722)
Metal products	–0.162	–0.133	–0.113	–0.165
	(–0.496)	(–0.750)	(–0.338)	(–0.893)
Machinery & equipment	–0.217	–0.237**	–0.177	–0.262**
	(–0.987)	(–2.823)	(–0.777)	(–2.952)
Other	–0.280	–0.197	–0.239	–0.233
	(–0.596)	(–1.110)	(–0.504)	(–1.133)
Enterprise-type dummy variables:				
SOE	–0.156	–0.057	–0.155	–0.041
	(–0.866)	(–0.757)	(–0.863)	(–0.540)
SHE				
PE				
JV	0.100	0.203	0.091	0.209
	(0.130)	(1.247)	(0.119)	(1.632)
UCOE	–0.290	–0.153	–0.284	–0.153
	(–1.249)	(–1.636)	(–1.224)	(–1.592)
UCE	–0.016	0.055	–0.021	0.061
	(–0.059)	(0.449)	(–0.078)	(0.512)
UOE				
$\ln(K/L)$	0.531**	0.450**	0.479**	0.470**
	(3.537)	(6.568)	(2.818)	(5.845)
Adjusted R^2	0.346	0.329	0.342	0.322
No. of observations	240	240	240	240

II

FUNCTION (1), 1991–97

1992				1993			
OLS	WLS	IV	Weighted IV	OLS	WLS	IV	Weighted IV
–0.617	–0.275**	–0.528	–0.266*	–0.379	–0.379**	–0.371	–0.340**
(–0.766)	(–2.761)	(–0.651)	(–2.287)	(–0.705)	(–4.256)	(–0.688)	(–3.299)
0.399	0.650*	0.465	0.648**	1.218**	1.020*	1.229**	1.064*
(0.820)	(2.513)	(0.945)	(2.679)	(4.439)	(2.210)	(4.414)	(2.263)
0.238	0.339**	0.266	0.338**	0.852**	0.868**	0.857**	0.889**
(1.698)	(5.258)	(1.853)	(4.900)	(8.662)	(9.835)	(8.517)	(9.500)
0.154	0.325**	0.198	0.322**	0.788**	0.793**	0.795**	0.822**
(0.536)	(3.547)	(0.680)	(3.738)	(4.149)	(5.149)	(4.136)	(5.107)
–0.244	0.331	–0.099	0.351	0.338	0.325	0.354	0.395
(–0.471)	(1.534)	(–0.183)	(1.482)	(1.099)	(1.523)	(1.122)	(1.586)
–3.484**	–3.696	–3.438**	–3.600	0.051	0.066	0.058	0.093
(–8.253)	(–1.067)	(–8.084)	(–1.009)	(0.176)	(0.233)	(0.199)	(0.323)
0.388	0.572**	0.442*	0.571**	0.750**	0.738**	0.757**	0.767**
(1.952)	(5.254)	(2.130)	(4.849)	(5.757)	(5.788)	(5.647)	(5.647)
0.111	0.270*	0.158	0.270*	1.187**	1.160**	1.194**	1.191**
(0.550)	(2.355)	(0.755)	(2.244)	(8.535)	(7.779)	(8.412)	(7.751)
0.428	0.628**	0.483	0.638**	1.080**	1.029**	1.088**	1.065**
(1.691)	(4.231)	(1.856)	(3.939)	(6.714)	(4.946)	(6.610)	(4.972)
0.419**	0.562**	0.462**	0.558**	1.143**	1.136**	1.150**	1.163**
(2.648)	(6.964)	(2.796)	(6.519)	(10.605)	(10.944)	(10.315)	(10.388)
0.243	0.361*	0.285	0.357*	0.758**	0.753**	0.766**	0.784**
(0.746)	(2.194)	(0.866)	(2.202)	(3.980)	(4.728)	(3.960)	(4.736)
–0.356**	–0.309**	–0.351**	–0.305**	–0.637**	–0.618**	–0.637**	–0.619**
(–2.858)	(–4.995)	(–2.813)	(–4.995)	(–7.893)	(–8.179)	(–7.895)	(–8.187)
				–0.428*	–0.379*	–0.427*	–0.374*
				(–2.356)	(–2.378)	(–2.352)	(–2.344)
0.055	0.020	0.064	0.038	–0.215	–0.275	–0.213	–0.265
(0.196)	(0.138)	(0.226)	(0.284)	(–1.634)	(–1.733)	(–1.615)	(–1.655)
–0.528**	–0.489**	–0.525**	–0.468**	–0.490**	–0.468**	–0.490**	–0.470**
(–2.667)	(–5.598)	(–2.650)	(–5.777)	(–4.314)	(–4.764)	(–4.316)	(–4.697)
–0.333	–0.337**	–0.338	–0.322**	–0.400**	–0.430	–0.402**	–0.432
(–1.805)	(–3.308)	(–1.827)	(–3.122)	(–2.613)	(–1.775)	(–2.622)	(–1.776)
				–0.778	–0.770**	–0.781	–0.784**
				(–1.449)	(–8.946)	(–1.455)	(–8.793)
0.535**	0.461**	0.482**	0.426**	0.498**	0.498**	0.492**	0.472**
(5.508)	(7.267)	(4.511)	(6.146)	(7.658)	(8.058)	(7.063)	(6.568)
0.417	0.406	0.416	0.406	0.548	0.534	0.547	0.525
248	248	248	248	270	270	270	270

TABLE II

	1994			
	OLS	WLS	IV	Weighted IV
Industry dummy variables:				
Mining and quarrying	0.657	0.126	0.727	0.239
	(0.580)	(0.740)	(0.639)	(1.271)
Foodstuff	1.608**	1.123**	1.684**	1.258**
	(3.206)	(3.762)	(3.281)	(3.981)
Textiles, sewing, leather, and fur products	1.257**	0.942**	1.298**	1.009**
	(5.480)	(6.803)	(5.479)	(7.108)
Other manufacturing	1.381**	1.018**	1.430**	1.083**
	(3.405)	(3.122)	(3.474)	(3.494)
Production and supply of electric power,	1.114	0.236	1.234	0.449
steam, and hot water	(1.535)	(0.558)	(1.654)	(1.020)
Coking, gas, and petroleum refining	–2.354**	–1.700	–2.286**	–1.460
	(–4.075)	(–0.701)	(–3.900)	(–0.616)
Chemical industry	1.338**	0.928**	1.398**	1.021**
	(4.385)	(4.927)	(4.412)	(5.313)
Building materials and non-metal	0.792*	0.518*	0.848**	0.623**
mineral products	(2.559)	(2.239)	(2.652)	(2.719)
Metal products	1.751**	1.327**	1.812**	1.435**
	(5.007)	(5.494)	(5.026)	(5.779)
Machinery & equipment	1.573**	1.162**	1.628**	1.246**
	(6.107)	(7.357)	(6.045)	(7.537)
Other	1.289**	0.958**	1.342**	1.052**
	(3.457)	(4.658)	(3.526)	(4.959)
Enterprise-type dummy variables:				
SOE	–0.928**	–0.866**	–0.933**	–0.873**
	(–5.543)	(–8.408)	(–5.565)	(–8.672)
SHE	–0.333	–0.321	–0.337	–0.328
	(–1.016)	(–1.746)	(–1.029)	(–1.831)
PE				
JV	–0.168	–0.373**	–0.157	–0.392**
	(–0.706)	(–2.623)	(–0.663)	(–2.842)
UCOE	–0.646**	–0.723**	–0.645**	–0.728**
	(–2.702)	(–4.602)	(–2.700)	(–4.739)
UCE	–0.852**	–0.870**	–0.865**	–0.900**
	(–2.831)	(–3.254)	(–2.868)	(–3.313)
UOE	–1.146	–0.996**	–1.167	–1.024**
	(–1.026)	(–9.333)	(–1.044)	(–9.734)
ln(*K*/*L*)	0.599**	0.570**	0.563**	0.512**
	(2.288)	(6.557)	(1.876)	(5.331)
Adjusted R^2	0.381	0.369	0.379	0.366
No. of observations	289	289	289	289

(Continued)

1995				1996			
OLS	WLS	IV	Weighted IV	OLS	WLS	IV	Weighted IV
0.325	0.245	0.417	0.323	0.270	0.144	0.337	0.258
(0.326)	(1.263)	(0.416)	(1.551)	(0.260)	(0.707)	(0.321)	(1.123)
1.160**	1.066**	1.262**	1.142**	0.583	0.534	0.645	0.649
(2.655)	(3.298)	(2.805)	(3.510)	(1.443)	(1.357)	(1.546)	(1.575)
0.887**	0.820**	0.954**	0.876**	0.863**	0.777**	0.909**	0.857**
(4.069)	(4.390)	(4.165)	(4.526)	(3.927)	(4.433)	(3.903)	(4.494)
0.914*	0.880**	0.993*	0.936**	0.919**	0.811**	0.976**	0.906**
(2.373)	(3.228)	(2.520)	(3.219)	(2.654)	(3.088)	(2.718)	(3.258)
0.394	0.244	0.561	0.414	–0.148	–0.298	–0.045	–0.123
(0.645)	(0.331)	(0.882)	(0.543)	(–0.241)	(–0.620)	(–0.071)	(–0.235)
–1.053*	–1.156	–0.955	–1.079	–0.484	–0.500	–0.419	–0.406
(–2.039)	(–0.834)	(–1.814)	(–0.796)	(–0.907)	(–0.589)	(–0.769)	(–0.474)
1.109**	1.057**	1.195**	1.126**	1.048**	0.908**	1.105**	1.025**
(3.949)	(4.442)	(4.049)	(4.605)	(3.808)	(3.716)	(3.793)	(3.825)
0.282	0.102	0.363	0.192	0.492	0.421*	0.546	0.486**
(0.985)	(0.344)	(1.215)	(0.636)	(1.737)	(2.459)	(1.837)	(2.650)
1.452**	1.397**	1.536**	1.469**	1.137**	1.057**	1.196**	1.155**
(4.797)	(6.034)	(4.870)	(6.039)	(3.729)	(4.477)	(3.730)	(4.539)
1.306**	1.249**	1.386**	1.313**	0.967**	0.893**	1.022**	0.986**
(5.409)	(5.859)	(5.422)	(5.957)	(3.925)	(4.301)	(3.886)	(4.356)
1.045**	0.952**	1.131**	1.024**	0.812*	0.767*	0.871*	0.862**
(2.993)	(3.598)	(3.136)	(3.798)	(2.439)	(2.526)	(2.508)	(2.666)
–0.944**	–0.894**	–0.947**	–0.894**	–1.063**	–1.029**	–1.066**	–1.037**
(–6.480)	(–7.427)	(–6.496)	(–7.470)	(–7.867)	(–8.515)	(–7.885)	(–8.515)
–0.368	–0.392	–0.377	–0.403*	–0.422	–0.447	–0.433	–0.447
(–1.303)	(–1.956)	(–1.332)	(–2.076)	(–1.333)	(–1.367)	(–1.366)	(–1.365)
				0.211	0.181	0.227	0.213
				(0.289)	(1.311)	(0.310)	(1.483)
–0.263	–0.309	–0.249	–0.290	–0.512**	–0.541**	–0.500*	–0.522**
(–1.238)	(–1.763)	(–1.166)	(–1.767)	(–2.659)	(–2.910)	(–2.583)	(–2.786)
–0.531*	–0.561**	–0.528*	–0.556**	–0.851**	–0.851**	–0.855**	–0.864**
(–2.566)	(–2.884)	(–2.551)	(–2.950)	(–4.357)	(–5.039)	(–4.374)	(–5.151)
–0.642*	–0.711**	–0.652**	–0.730**	–0.896**	–0.876**	–0.904**	–0.897**
(–2.599)	(–2.685)	(–2.636)	(–2.785)	(–3.449)	(–4.707)	(–3.476)	(–4.889)
0.506**	0.544**	0.463**	0.507**	0.671**	0.721**	0.645**	0.676**
(4.746)	(5.931)	(3.986)	(5.146)	(6.709)	(9.045)	(5.913)	(7.488)
0.435	0.428	0.436	0.426	0.417	0.415	0.417	0.416
297	297	297	297	353	353	353	353

TABLE II (Continued)

	1997			
	OLS	WLS	IV	Weighted IV
Industry dummy variables:				
Mining and quarrying	–0.364	–0.202	–0.441	–0.036
	(–0.400)	(–0.762)	(–0.477)	(–0.107)
Foodstuff	–0.277	–0.106	–0.354	0.072
	(–0.658)	(–0.167)	(–0.789)	(0.106)
Textiles, sewing, leather, and fur products	0.384	0.533*	0.325	0.665*
	(1.404)	(2.359)	(1.092)	(2.421)
Other manufacturing	–0.193	0.036	–0.284	0.231
	(–0.437)	(0.093)	(–0.594)	(0.510)
Production and supply of electric power, steam, and hot water	–0.637	–0.419	–0.753	–0.165
	(–1.048)	(–0.948)	(–1.157)	(–0.314)
Coking, gas, and petroleum refining	–0.880	–0.698	–0.963	–0.514
	(–1.562)	(–1.815)	(–1.640)	(–1.139)
Chemical industry	0.664*	0.819**	0.592	0.978**
	(1.994)	(3.024)	(1.634)	(2.969)
Building materials and non-metal mineral products	0.162	0.305	0.095	0.457
	(0.492)	(1.053)	(0.266)	(1.340)
Metal products	0.503	0.644*	0.428	0.810*
	(1.395)	(2.057)	(1.097)	(2.186)
Machinery & equipment	0.695*	0.832**	0.630	0.981**
	(2.362)	(3.284)	(1.958)	(3.193)
Other	0.587	0.694*	0.516	0.845*
	(1.559)	(2.377)	(1.282)	(2.453)
Enterprise-type dummy variables:				
SOE	–0.772**	–0.791**	–0.763**	–0.831**
	(–6.057)	(–7.215)	(–5.927)	(–7.350)
SHE	–0.666**	–0.676**	–0.662**	–0.694**
	(–2.728)	(–3.469)	(–2.710)	(–3.709)
PE	0.759	0.782*	0.750	0.785*
	(1.234)	(2.150)	(1.218)	(2.022)
JV	–0.315*	–0.259	–0.321*	–0.222
	(–1.991)	(–1.835)	(–2.024)	(–1.949)
UCOE	–0.860**	–0.859**	–0.852**	–0.866**
	(–4.696)	(–4.322)	(–4.639)	(–4.277)
UCE	–0.948**	–1.147**	–0.938**	–1.202**
	(–4.237)	(–5.346)	(–4.170)	(–5.803)
UOE				
ln(*K*/*L*)	0.731**	0.677**	0.757**	0.621**
	(6.793)	(7.570)	(6.337)	(5.543)
Adjusted R^2	0.489	0.477	0.489	0.474
No. of observations	321	321	321	321

Note: The dependent variable is ln(*Y*/*L*). Numbers in parentheses are the *t* statistics.
* Significant at 5 percent. ** Significant at 1 percent.

TABLE III

THE ESTIMATES OF PRODUCTION FUNCTION (2)

	OLS	WLS	IV	Weighted IV
Industry dummy variables:				
Mining and quarrying	3.769**	−1.071**	−1.073**	−1.069**
	(12.109)	(−5.525)	(−2.836)	(−8.993)
Foodstuff	2.933**	−0.495**	−0.714**	−0.717**
	(20.084)	(−3.012)	(−3.639)	(−3.211)
Textiles, sewing, leather,	4.583**	−0.431**	−0.439**	−0.399**
and fur products	(38.237)	(−5.028)	(−3.210)	(−5.257)
Other manufacturing	4.022**	−0.459**	−0.492**	−0.436**
	(28.183)	(−4.749)	(−2.889)	(−4.326)
Production and supply of	4.026**	−0.939**	−0.907**	−0.907**
electric power, steam,	(20.014)	(−3.790)	(−3.716)	(−5.145)
and hot water				
Coking, gas, and	1.961**	−2.913**	−2.635**	−2.651**
petroleum refining	(14.208)	(−7.017)	(−11.870)	(−4.952)
Chemical industry	4.293**	−0.332**	−0.279	−0.287**
	(33.883)	(−3.430)	(−1.883)	(−3.186)
Building materials and	4.030**	−0.524**	−0.669**	−0.566**
non-metal mineral products	(32.429)	(−5.501)	(−4.518)	(−5.977)
Metal products	4.801**	−0.137	−0.122	−0.113
	(34.376)	(−1.130)	(−0.775)	(−1.181)
Machinery and equipment	4.555**	−0.195*	−0.179	−0.147
	(37.417)	(−2.199)	(−1.282)	(−1.813)
Other	4.422**	−0.426**	−0.370*	−0.355**
	(29.969)	(−3.440)	(−2.166)	(−3.497)
Productivity change dummy variables:				
COTVE's productivity change in 1992	0.749**	0.726**	0.741**	0.682**
	(3.391)	(7.036)	(4.236)	(7.716)
COTVE's productivity change in 1993	0.598**	0.504**	0.515**	0.466**
	(2.993)	(5.451)	(3.245)	(5.716)
COTVE's productivity change in 1994	0.158	0.089	0.102	0.179
	(0.832)	(0.787)	(0.676)	(1.830)
COTVE's productivity change in 1995	0.062	−0.104	−0.029	−0.060
	(0.330)	(−0.794)	(−0.193)	(−0.547)
COTVE's productivity change in 1996	0.041	0.254	0.206	0.183
	(0.243)	(1.696)	(1.548)	(1.688)
COTVE's productivity change in 1997	−0.138	−0.214	−0.218	−0.237*
	(−0.864)	(−1.702)	(−1.715)	(−2.050)
SOE's dummy in 1991	0.466*	−0.114	−0.167	−0.145
	(2.375)	(−1.071)	(−1.070)	(−1.465)
SOE's productivity change in 1992	−0.237	−0.219	−0.231	−0.207
	(−0.891)	(−1.582)	(−1.095)	(−1.721)
SOE's productivity change in 1993	−0.310	−0.222	−0.157	−0.218*
	(−1.232)	(−1.675)	(−0.787)	(−2.080)
SOE's productivity change in 1994	−0.488*	−0.293	−0.413*	−0.333*
	(−1.983)	(−1.864)	(−2.115)	(−2.586)
SOE's productivity change in 1995	−0.024	0.012	0.033	−0.009
	(−0.098)	(0.068)	(0.172)	(−0.059)

TABLE III (Continued)

	OLS	WLS	IV	Weighted IV
SOE's productivity change in 1996	0.076	−0.254	−0.143	−0.153
	(0.332)	(−1.452)	(−0.789)	(−0.984)
SOE's productivity change in 1997	0.315	0.290	0.293	0.304
	(1.411)	(1.556)	(1.652)	(1.887)
SHE's dummy in 1991	0.657	−0.373*	−0.401	−0.353*
	(1.644)	(−1.964)	(−1.267)	(−2.000)
SHE's productivity change in 1994	−0.256	0.042	0.037	−0.005
	(−0.487)	(0.132)	(0.089)	(−0.020)
SHE's productivity change in 1995	−0.055	0.041	−0.017	−0.029
	(−0.115)	(0.115)	(−0.046)	(−0.096)
SHE's productivity change in 1996	−0.107	0.013	−0.142	−0.111
	(−0.219)	(0.041)	(−0.367)	(−0.325)
SHE's productivity change in 1997	−0.128	−0.252	−0.097	−0.075
	(−0.263)	(−0.806)	(−0.252)	(−0.212)
PE's dummy in 1991	0.462	0.456	0.296	0.247
	(0.545)	(0.323)	(0.441)	(0.897)
PE's productivity change in 1997	0.305	0.409	0.574	0.588
	(0.255)	(0.218)	(0.605)	(1.638)
JV's dummy in 1991	0.434	0.139	0.154	0.120
	(0.507)	(0.193)	(0.227)	(0.626)
JV's productivity change in 1992	−0.096	−0.070	−0.030	−0.133
	(−0.100)	(−0.094)	(−0.040)	(−0.487)
JV's productivity change in 1993	−0.449	−0.237	−0.330	−0.280
	(−0.880)	(−1.099)	(−0.817)	(−0.990)
JV's productivity change in 1994	0.040	0.026	0.044	−0.031
	(0.106)	(0.140)	(0.146)	(−0.116)
JV's productivity change in 1995	0.019	0.067	−0.005	0.070
	(0.055)	(0.312)	(−0.017)	(0.285)
JV's productivity change in 1996	−0.252	−0.315	−0.287	−0.205
	(−0.776)	(−1.403)	(−1.115)	(−0.891)
JV's productivity change in 1997	0.178	0.272	0.158	0.182
	(0.593)	(1.218)	(0.663)	(0.860)
UCOE's dummy in 1991	−0.132	−0.293**	−0.278	−0.316**
	(−0.516)	(−2.614)	(−1.368)	(−2.780)
UCOE's productivity change in 1992	−0.390	−0.185	−0.266	−0.226
	(−0.995)	(−1.181)	(−0.856)	(−1.501)
UCOE's productivity change in 1993	−0.008	0.060	0.059	0.103
	(−0.022)	(0.357)	(0.189)	(0.665)
UCOE's productivity change in 1994	−0.220	−0.114	−0.134	−0.236
	(−0.614)	(−0.614)	(−0.473)	(−1.236)
UCOE's productivity change in 1995	0.034	0.103	0.087	0.136
	(0.096)	(0.499)	(0.307)	(0.611)
UCOE's productivity change in 1996	−0.096	−0.464*	−0.358	−0.311
	(−0.285)	(−2.083)	(−1.340)	(−1.363)
UCOE's productivity change in 1997	−0.169	−0.183	−0.039	−0.077
	(−0.505)	(−0.761)	(−0.148)	(−0.280)
UCE's dummy in 1991	0.510	−0.057	−0.005	−0.054
	(1.713)	(−0.289)	(−0.021)	(−0.387)
UCE's productivity change in 1992	−0.367	−0.330	−0.364	−0.318
	(−0.906)	(−1.279)	(−1.135)	(−1.763)

TABLE III (Continued)

	OLS	WLS	IV	Weighted IV
UCE's productivity change in 1993	0.012	–0.012	0.039	0.056
	(0.027)	(–0.047)	(0.114)	(0.183)
UCE's productivity change in 1994	–0.727	–0.378	–0.445	–0.491
	(–1.577)	(–1.304)	(–1.219)	(–1.449)
UCE's productivity change in 1995	0.022	0.240	0.189	0.157
	(0.052)	(0.801)	(0.550)	(0.541)
UCE's productivity change in 1996	–0.120	–0.501	–0.393	–0.351
	(–0.286)	(–1.734)	(–1.180)	(–1.205)
UCE's productivity change in 1997	–0.077	0.027	–0.035	–0.049
	(–0.181)	(0.090)	(–0.102)	(–0.153)
UOE's dummy in 1991	0.076	–0.686**	–0.730	–0.666**
	(0.063)	(–9.426)	(–0.770)	(–9.425)
UOE's productivity change in 1994	–0.318	–0.234*	–0.248	–0.336**
	(–0.188)	(–2.081)	(–0.185)	(–3.462)
$\ln(K/L)$	0.393**	0.531**	0.533**	0.557**
	(5.877)	(15.491)	(11.426)	(15.079)
Adjusted R^2	0.437	0.435	0.441	0.440
No. of observations	2018	2018	2018	2018

Note: The dependent variable is $\ln(Y/L)$. Numbers in parentheses are the t statistics.
* Significant at 5 percent. ** Significant at 1 percent.

1990s (especially 1992 and 1993), whereas changes for JVs and SHEs were not significant, and changes for SOEs were negative and significant in some cases. After 1994 (or 1995), the productivity change for COTVEs was either not significant or was negative and significant (in 1997). It is clear that the productivity of COTVEs rose in the early 1990s, then leveled off or declined while COTVEs remained relatively efficient within the Wuxi economy. This is evidence that macroeconomic factors shifted the best-practice production frontier downward, and then caused the declining productivity of COTVEs in the late 1990s while their vaguely specified property rights did not cause a reduction in efficiency.

Table IV shows the results of production frontier estimation.[14] Here, the estimated coefficient of each enterprise-type dummy variable expresses the average inefficiency (not efficiency) level of each type of enterprise.

The average efficiency of COTVEs relative to other types of enterprises has the same implications as Table II, and is important since it verifies the robustness of the results. From the results in Table IV, COTVEs gained in average efficiency relative to JVs and SHEs as well as SOEs, UCOEs, and UCEs in the late 1990s.

We now study how the efficiency of each individual COTVE varies in each year of the sample period. Figure 1 shows how the residuals of production function (1),

[14] Since COTVEs comprise the benchmark for our estimation, their dummy variables and estimated coefficients do not appear in Table IV.

TABLE IV

THE ESTIMATES OF PRODUCTION FRONTIER (3), 1991–97

	ML						
	1991	1992	1993	1994	1995	1996	1997
Production function:							
Industry dummy variables:							
Mining and quarrying	–0.365	–0.096	0.571	–1.431**	–0.287	0.117	–0.247
	(–0.572)	(–0.149)	(0.006)	(–5.668)	(–0.474)	(0.056)	(–0.004)
Foodstuff	0.191	0.527	1.528**	0.551*	0.769*	0.658*	0.131
	(0.415)	(1.714)	(4.506)	(2.525)	(2.482)	(2.054)	(0.350)
Textiles, sewing, leather and fur products	–0.092	0.284**	1.500**	0.582**	0.699**	0.929**	0.641*
	(–0.936)	(3.266)	(8.541)	(4.819)	(4.605)	(5.215)	(2.463)
Other manufacturing	–0.148	0.130	1.568**	0.680**	0.607*	0.895*	–0.034
	(–0.756)	(0.534)	(6.046)	(4.015)	(2.454)	(2.960)	(–0.087)
Production and supply of electric power, steam, and hot water	0.063	0.103	0.174	–0.711	–0.237	–0.543	–0.765
	(0.168)	(0.367)	(0.233)	(–1.372)	(–0.486)	(–0.500)	(–0.608)
Coking, gas, and petroleum refining	–0.263	–0.896**	–1.331**	–2.125**	–1.145**	–0.591	–0.823
	(–0.923)	(–5.000)	(–4.900)	(–9.971)	(–3.258)	(–1.197)	(–1.002)
Chemical industry	0.225	0.506**	1.390**	0.486**	0.805**	1.074**	0.907**
	(1.937)	(4.387)	(5.563)	(3.115)	(4.457)	(4.920)	(2.918)
Building materials and non-metal mineral products	–0.020	0.183	1.208**	0.437**	0.393*	0.511*	0.382
	(–0.180)	(1.574)	(5.972)	(3.054)	(2.177)	(2.402)	(1.171)
Metal products	0.163	0.571**	1.939**	0.895**	1.282**	1.184**	0.734*
	(1.161)	(4.023)	(6.905)	(4.576)	(6.181)	(5.022)	(2.120)
Machinery and equipment	0.052	0.501**	1.659**	0.690**	0.992**	1.111**	1.019**
	(0.628)	(5.971)	(9.076)	(5.399)	(6.459)	(5.603)	(3.565)
Other	0.072	0.213	1.254**	0.480*	0.654*	0.699**	0.696
	(0.352)	(0.797)	(3.704)	(2.255)	(2.117)	(2.651)	(1.725)
ln(K/L)	0.525**	0.536**	0.599**	0.705**	0.676**	0.784**	0.848**
	(6.952)	(7.976)	(5.837)	(10.494)	(9.939)	(10.582)	(9.303)

Inefficiency function:							
Constant	−1.184	−0.749**	−0.896**	−0.975**	−0.850*	−0.715**	−0.293
	(−1.643)	(−3.632)	(−8.234)	(−11.699)	(−2.510)	(−3.091)	(−0.567)
Enterprise-type dummy variables:							
SOE	0.204	0.497*	0.763**	0.879**	0.766*	0.981**	0.913*
	(0.635)	(2.251)	(4.931)	(11.145)	(2.539)	(5.080)	(2.510)
SHE			0.115	0.473	0.358	0.537	0.780*
			(0.231)	(0.772)	(0.667)	(1.570)	(2.556)
PE						−1.082	−3.141
						(−0.044)	(−0.147)
JV	−0.421	−0.121	0.016	0.468	0.379	0.751**	0.500
	(−0.037)	(−0.342)	(0.054)	(1.254)	(1.312)	(3.729)	(1.826)
UCOE	0.356	0.603**	0.577*	0.830**	0.579*	0.904**	0.996**
	(0.861)	(2.658)	(2.242)	(6.587)	(1.963)	(4.066)	(3.172)
UCE	−0.057	0.486*	0.694*	0.866**	0.629*	0.932**	1.075**
	(−0.111)	(1.991)	(2.177)	(6.356)	(2.054)	(3.667)	(2.709)
UOE			4.824**	1.467**			
			(30.250)	(15.100)			
σ_s	0.976**	1.075**	1.032**	1.085**	0.952**	1.076**	1.114**
	(151.966)	(39.428)	(25.377)	(27.749)	(45.593)	(20.766)	(12.364)
γ	0.981*	0.872**	0.898**	0.787**	0.895**	0.804**	0.788**
	(2.497)	(6.379)	(20.391)	(11.598)	(10.949)	(27.316)	(5.159)
Log-likelihood	−110.725	−161.899	−158.286	−140.140	−57.575	−126.151	−91.793
No. of observations	240	248	270	289	297	353	321

Note: The dependent variable is ln(*Y*/*L*). Numbers in parentheses are the *t* statistics.
* Significant at 5 percent. ** Significant at 1 percent.

Fig. 1. The Distribution of Each COTVE's Residual (The Estimate of ε_i by OLS)

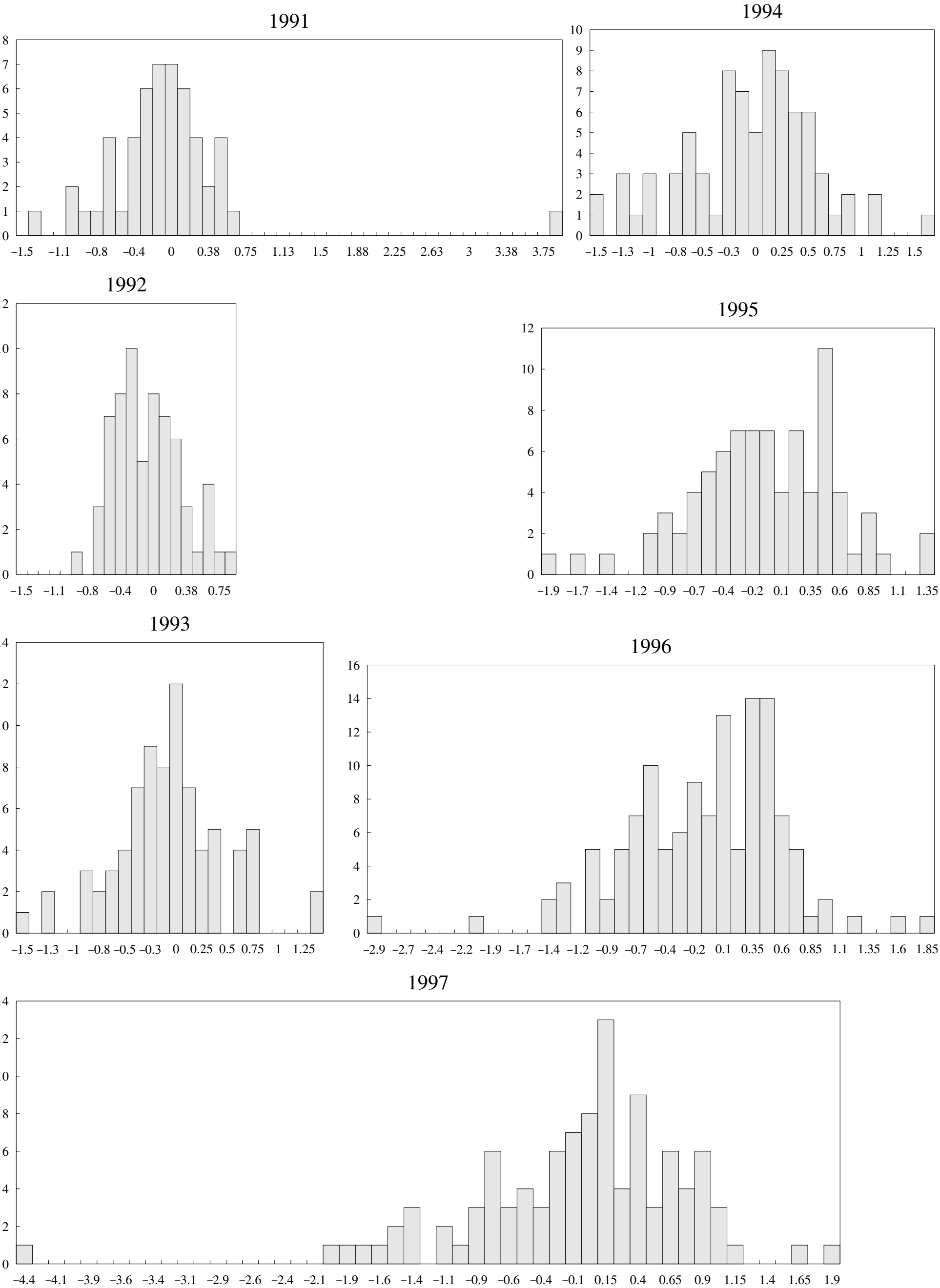

TABLE V

REGRESSION RESULTS OF COTVE RESIDUAL ON DIFFERENTL VARIABLES, 1996 AND 1997

	OLS					
	1996			1997		
	Eq. (a)	Eq. (b)	Eq. (c)	Eq. (a)	Eq. (b)	Eq. (c)
Constant	–0.608*	–0.445	–0.613*	–0.684	–0.448	–0.711*
	(–2.271)	(–1.704)	(–2.298)	(–1.977)	(–1.151)	(–2.082)
Working capital / *K*	0.374**		0.289*	1.540**		1.278**
	(3.395)		(2.302)	(8.305)		(5.563)
Working capital / *L*		0.022**	0.012		0.062**	0.022
		(2.812)	(1.374)		(5.727)	(1.884)
Industry dummy variables:						
Mining and quarrying	–0.180	–0.156	–0.328	–0.755	–0.674	–0.886
	(–0.246)	(–0.210)	(–0.445)	(–0.989)	(–0.775)	(–1.171)
Foodstuff	0.592	0.505	0.512	0.325	0.117	0.191
	(1.099)	(0.919)	(0.949)	(0.553)	(0.175)	(0.327)
Textiles, sewing, leather, and fur products	0.250	0.265	0.241	–0.243	0.006	–0.204
	(0.902)	(0.940)	(0.871)	(–0.665)	(0.015)	(–0.565)
Other manufacturing	0.037	0.019	–0.007	0.252	–0.220	0.109
	(0.104)	(0.052)	(–0.021)	(0.594)	(–0.453)	(0.255)
Production & supply of electric power, steam, and hot water						
Coking, gas, and petroleum refining						
Chemical industry	0.346	0.305	0.318	0.085	0.006	0.021
	(1.165)	(1.010)	(1.074)	(0.226)	(0.014)	(0.057)
Building materials and non-metal mineral products	0.294	0.246	0.284	–0.084	–0.097	–0.093
	(0.921)	(0.760)	(0.893)	(–0.207)	(–0.209)	(–0.231)
Metal products	0.051	0.074	–0.032	–0.660	–0.598	–0.779
	(0.159)	(0.226)	(–0.097)	(–1.925)	(–1.300)	(–1.944)
Machinery & equipment	0.119	0.251	0.097	–0.934*	–0.395	–0.927*
	(0.403)	(0.860)	(0.328)	(–2.437)	(–0.937)	(–2.450)
Adjusted R^2	0.231	0.105	0.261	0.374	0.192	0.391
No. of observations	127	127	127	104	104	104

Notes: 1. The dependent variable of the regression is the COTVE residual of OLS regerssion, the results of which are shown in Table II. Numbers in parentheses are the *t* statistics.
2. The residual is assumed to show each COTVE's relative technical efficiency among all COTVEs.

* Significant at 5 percent. ** Significant at 1 percent.

the estimates of ε_i by OLS, are distributed each year from 1991 to 1997. Figure 1 shows that variation in the residuals increased with time. In 1996 or 1997, the variation of the lower efficiency enterprises became prominent. It follows that throughout the 1990s, some COTVEs dropped out of the efficiency race. This process might synchronize with the leveling off or decline in the productivity of COTVEs, as shown in Table III, or both might be caused by the same factor. What, then, determined the individual efficiency of each COTVE in the late 1990s? This is answered in Table V, which reports regression results of the residuals for certain variables in 1996 and 1997.[15]

These estimates show a significant positive correlation between working capital / K or working capital / L, and each COTVE's residual, which is assumed to correspond to the individual efficiency of each COTVE. In particular, when both working capital / K and working capital / L are included in the independent variables in equation (c) in 1996 or 1997, the coefficient of working capital / K is particularly significant and positive.

These observations suggest the following: COTVEs faced with a more serious shortage of working capital had lower efficiency in the late 1990s. Inadequate working capital was an important factor in the macroeconomic condition of the Chinese economy in the late 1990s (in recession from the mid-1990s) which influenced the productivity of COTVEs. Specifically, some COTVEs tended to have a greater shortage of funds or working capital, and their net operating rate probably declined more sharply.[16] In the late 1990s Chinese economic and financial authorities emphasized restraint, and borrowing funds from lenders (banks) became more difficult especially for rural enterprises such as COTVEs.

We suspect that the problem lies in the Chinese financial system rather than in the vagueness of COTVEs' property rights. The Chinese financial system tends to supply insufficient funds to reasonably efficient COTVEs relative to other types of enterprises, as shown in Tables II and IV.

VI. CONCLUSION

The main findings of this paper can be summarized as follows. First, our analysis casts doubt on the view that the vaguely specified property rights of COTVEs caused serious problems in the period just before 1998 when massive privatization began. In the late 1990s, COTVEs in Wuxi City did not decline in average relative efficiency compared with other types of enterprises, including JVs (joint venture firms) and SHEs (share-holding enterprises), which had more clearly defined property rights. It is always possible that this result is specific to Wuxi City, which is the centrepiece of the *Sunan Model* for the success of COTVEs, although we have no reasons to think this is so.

[15] We have also performed a regression using the estimated $\exp(-u_i)$ of the production frontier model as the dependent variable (see equation 5); we found almost identical results. To save space we present only results using the residual as the dependent variable.

[16] Furthermore, in equations (a) and (c) in 1997, the coefficients of the metal products industry and the machinery and equipment industry dummies are all significant at 10 percent and negative. These industries use larger machinery and equipment, and so need more funds and working capital. During recessions or economic retrenchment in China, firms in these industries are therefore more strongly influenced by monetary restraints.

Second, though the efficiency of COTVEs relative to other types of enterprises in Wuxi City has not declined recently on average, their productivity has leveled off or declined. This implies that, although the vaguely specified property rights of COTVEs did not cause them to decline in efficiency, macroeconomic factors caused their declining productivity in the late 1990s. One relevant macroeconomic factor was recession beginning from the mid-1990s.

Third, inadequate working capital because of financial restraint applied by the authorities was an important factor in the macroeconomic condition of the Chinese economy in the late 1990s (in recession from the mid-1990s) which influenced the productivity of COTVEs. This is shown by the fact that COTVEs in Wuxi City faced with a more serious shortage of working capital had lower efficiency in the late 1990s.

These observations suggest the following policy evaluation of the massive privatization that got under way in Wuxi City and Jiangsu Province in 1998. The privatization of COTVEs may now by itself be insufficient to cope effectively with their declining productivity. In tackling the declining productivity of COTVEs, more attention should be paid to the financial system for enterprises in China; at present too much importance is attached to the property right problem of COTVEs. Privatization is necessary but is not sufficient.[17] Chow and Fung (1998) found a bias in favor of lending to SOEs in the Chinese corporate finance and lending system. Elimination or reduction of this bias will make the productivity of privatized ex-COTVEs rise. In view of the relative efficiency of COTVEs compared with other types of enterprises, even in the late 1990s, reduction of this bias would lead to more efficient fund allocation in the Chinese economy as a whole. Financial reform now under way in China should aim to provide a financial system that supplies funding in sufficient quantities to efficient enterprises that have not been well served to date, including rural ex-COTVEs.

Our findings and their implications for policy are, strictly speaking, limited to Wuxi City. To see whether they can be generalized to China as a whole, further research is needed, both to measure the effects of the privatization of COTVEs using nationwide firm-level micro data, and to study the Chinese corporate finance and lending system more closely.

[17] Pan, He, and Zhuang (1997) and Zou, Dai, and Sun (1999) point out that the vagueness of COTVE property rights often caused their property to be managed poorly. For example, land rent or some other rents were often not collected (Zou, Dai, and Sun 1999). Shi (1997) argues that township and village governments in China arbitrarily levy certain expenses for social welfare on COTVEs, often because the governments themselves are virtually the management of the COTVEs. He found that this constituted a burden on COTVEs, although their efficiency in production was not harmed. Privatization would resolve these problems.

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