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Technical Efficiency, Technological Change and Total Factor Productivity Growth in Chinese State-Owned Enterprises in the Early 1990s

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Based on a framework proposed by Battese and Coelli (1995), we estimated the stochastic frontier production function for four Chinese industries: building materials, chemicals, machinery and textiles during 1990–1994. The type of technological change is tested and total factor productivity (TFP) growth is calculated for each industry. We found no evidence of technological change in the building materials, chemicals and textiles industries and a neutral technological progress in the machinery industry. There was significant reduction of technical efficiency in the chemicals, machinery and textiles industries. As the result, chemicals and textiles experienced a negative TFP growth, whereas building materials and machinery display negligible TFP change. Our result cast doubt on the industrial reform measures in China.

I. Introduction

A serious problem for Chinese state-owned enterprises (SOEs) in the pre-reform period was lack of efficiency resulting from the absence of autonomy and incentives. Aiming to improve SOEs' efficiency, China initiated industrial reform measures in 1979. The reform measures before the 1990s featured increases in firms' autonomy, profit sharing between the governments and enterprises, and the implementation of various forms of the responsibility system. The first two years of the 1990s did not see much change. Following Deng Xiaoping's trip to south China, a new round of industrial reforms began in 1992. Compared with previous reforms, the new round of reforms emphasized the transformation of enterprises' managerial mechanisms and ownership structures. During this period, various contract-responsibility systems were implemented by most SOEs.

New managerial mechanisms and ownership structures were also introduced and experimented with. In addition to the existing manager-responsibility and contract system, corporate, share-holding, leasing and selling were also experimented with as possible solutions to the problems of different kind of state-owned enterprises (SOEs).

A considerable literature on Chinese industrial reforms and productive efficiency has appeared since the late 1980s. Many studies have adopted the conventional production-function approach, under which technical inefficiency is not allowed for. See, for example, Chen et al. (1988), Jefferson et al. (1992) and Wan (1995). Others used the stochastic frontier-production-function framework. This method is preferable, as it allows for decomposition of the growth of total factor productivity into changes in technical efficiency and shifts of the production frontier. See Lau and Brada (1990), Kalirajan and Cao (1993), Wu (1993, 1996), and Chen (1994). All these studies, however, used pre-1990 data with similar findings: very low efficiency levels in the early 1980s and continuing improvement throughout the 1980s, with a number of reform measures found to be significant in promoting efficiency. In particular, Liu and Liu (1996) analysed efficiency in several Chinese industries and concluded that reform-induced gains in technical efficiency were significant and that the bonus system had speed and impressive efficiency effects.

How did total factor productivity (TFP) change in Chinese state-owned enterprises during the first a few years of the 1990s? What are the main factors affecting SOEs' operating efficiency when experiencing various reform measures regarding managerial forms? Did SOEs experience technological progress during this period? These are the questions this article attempts to answer.

In this study, the stochastic-frontier-production function for panel data proposed by Battese and Coelli (1995) is used to estimate the production frontier and efficiency functions. Then the rate of total factor productivity is estimated as the sum of the rates of technological change and efficiency change. The study contributes to the current discussion of China's SOE reform by offering some insights into productivity performance and policy impact. It also attempts to shed some light on the issues of success or failure of the past reform measures.

The remaining part of the paper is organized as follows: Section II briefly introduces the theoretical model; in Section III the data set and variables used are described; empirical analysis is presented in Section IV; Section V concludes the paper.

II. Methodological Framework

Neoclassical production theory does not usually admit long-term existence of inefficiency, holding that if a firm is operating inefficiently, it will eventually be squeezed out of the market. But this conclusion is reached in a perfectly competitive market, which does not exist in reality. Inefficiency not only exists in practice but sometimes is prevalent. Recognizing this, Aigner, Lovell and

Schmidt (1977) and Meeusen and van den Broeck (1997) first introduced the stochastic-production-frontier model. Their basic idea was to introduce a non-positive component in the error term of the production function, which captures the inefficiency effect. Mathematically, it can be expressed as follows.

$$Y_{it} = f(X_{it}, \beta, t)e^{v_{it} - u_{it}} \tag{1}$$

where i indexes firms, t indicates time. Y_{it} denotes output, X_{it} denotes a vector of inputs. β is a vector of parameters to be estimated. In terms of error, v is distributed as N(0, σ_v^2) and captures random variation in output due to factors outside the control of the firm. On the other hand, $u \geq 0$ reflects technical inefficiency, which is specified later. The potential output of firm i is $Y_{it}^p = f(X_{it}, \beta, t)e^{v_{it}}$.

The derivative of the logarithm of Equation (1) with respect to time t is given by

$$\frac{\dot{Y}_{it}}{Y_{it}} = (e_{f/x} \frac{\dot{X}_{it}}{X_{it}} + \dot{v}_{it}) + e_{f/t} - \dot{u}_{it} \tag{2}$$

where $e_{f/x}$ and $e_{f/t}$ denote respectively the output elasticities of $f(X_{it}, \beta, t)$ with respect to X_{it} and t and the dotted variables indicate time derivatives.

As indicated by Equation (2), output changes can be decomposed into three components. The first one corresponds to input changes weighted by output elasticities. Since v is distributed as N(0, σ_v^2), the effect of the random error $\dot{v}_{it}$ is equal to zero and hence can be ignored. $e_{f/t}$ is the rate of the technological change corresponding to the shifts of the frontier, and finally, $-\dot{u}_{it}$, represents the technical efficiency change. Hence the rate of total-factor-productivity change, TFP, is the sum of the last two components.

This paper adopts the panel-data model proposed by Battese and Coelli (1995) with a translog specification of the production function. The advantage of this model is that estimation of firm-level inefficiencies and identification of efficiency determinants are achieved in one stage. The model can be expressed as:

$$\ln(Y_{it}) = \beta_0 + \sum_{j}^{m} \beta_j \ln x_{jit} + \beta_T t + \beta_{TT} t^2 + \sum_{j} \beta_{Tj} t \ln x_{jit}$$
$$+ \sum_{j}^{m} \sum_{k \geq j}^{m} \beta_{jk} \ln x_{jit} \ln x_{kit} + (V_{it} - U_{it}) \tag{3}$$

where t denotes time trend; xs denote inputs; subscripts j and k index inputs (j, $k = 1, 2$ representing capital, labour, respectively); V_{it} are random variables assumed to be *iid*. N(0, σ_v^2); the technical inefficiency errors, U_{it} are assumed to be distributed independently of V_{it}, such that U_{it} is the non-negative truncation of the N(m_{it}, σ_u^2) distribution.

Following Battese and Coelli (1995), it is further assumed that the inefficiency distribution parameter, m_{it}, is a function of variables that explains the level of technical inefficiency, namely

$$m_{it} = \delta_0 + \sum_{k=1}^{m'} \delta_k z_{kit} \tag{4}$$

where z_{it} are reform variables and firm-specific factors that influence technical inefficiency, and δ s are the unknown parameters to be estimated. The Battese and Coelli specification allows the estimation of firm-level inefficiencies and the identification of efficiency determinants in one stage. Alternatively, one could estimate firm-level inefficiencies first and then regress the predicted efficiencies on variables that represent hypothesized efficiency determinants. The two-stage estimation procedure is unlikely to provide estimates that are as efficient as those obtained using the single-stage estimation procedure. In addition, the two-stage estimation procedure is inconsistent with the assumption of independently and identically distributed technical inefficiency effects.

The technical efficiency of production for the i-th firm at the t-th period, TE_{it}, is defined as the ratio of the actual output of firm i, Y_{it}, to its potential output, Y_{it}^{p}.

$$TE_{it} = \frac{Y_{it}}{Y_{it}^{p}} = \exp(-u_{it}) \tag{5}$$

For easy estimation, it is necessary to define $\sigma_s^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/\sigma_s^2$.

Note that the stochastic frontier model, Equation (3), allows for non-neutral technical change. Neutral technical change occurs if and only if $\beta_{Tj} = 0$, ($j = K, L$). Technical change is absent if and only if $\beta_T = \beta_{TT} = \beta_{Tj} = 0$, ($j = 1, 2$). Further, the Cobb-Douglas production frontier is a special case of the translog frontier in which $\beta_{TT} = \beta_{Tj} = \beta_{jk} = 0, j \leq k = K, L$. A set of log-likelihood tests can be used to select the functional form of production functions and type of technical change for each industry concerned.

From Equation (3), the rate of the technological change, $e_{f/t}$, is

$$e_{f/t} = \partial \ln(Y)/\partial t = \beta_T + 2\beta_{TT}t + \sum_j \beta_{Tj} \ln x_j \tag{6}$$

Once the TE and $e_{f/t}$ are estimated, we can estimate the rate of total-factor-productivity growth, which is the summation of the rate of technical efficiency change and the rate of technological change. Since we can only calculate the rate of technical efficiency change between consecutive years as $TEC_{it-1,t} = \dfrac{TE_{it}}{TE_{it-1}} - 1$, we need to take the simple average of consecutive years' rates of technological change to get the matching rate, $TP_{it-1,t} = (e_{f/t-1} + e_{f/t})/2$. Then we can compute the rate of total-factor-productivity change as

$$TFP_{it-1,t} = (e_{f/t-1} + e_{f/t})/2 + \left(\frac{TE_{it}}{TE_{it-1}} - 1\right) \tag{7}$$

III. Data and Variables

The survey data used in the study are from the Institute of Economics, Chinese Academy of Social Science. The firms surveyed were mainly state-owned enterprises. Four industries with the largest sample sizes for the period 1990–1994 are considered. Output and inputs are selected and measured as follows:

Y: net output in value terms at constant 1990 prices. The deflators applied are implicit deflators calculated directly from the data set.

K: capital stock at constant 1990 prices. Several variables can be used as proxies of capital stock. One is net value of fixed assets. Another is total assets. But these two variables suffer from not considering the change of investment-price index. So we do not use these two variables. Instead, we use the perpetual-inventory method. We calculate capital stock using the net value of capital in the previous year minus depreciation plus newly increased capital stock deflated by the investment-price index. The investment-price index was adopted from Jefferson et al. (1996) for the years 1990–1992 and updated to 1994 using the price index for capital goods from SSB (1997). There may be the problem of insufficient capacity utilization. But the data set did not provide information on this aspect. So we cannot adjust for the capacity-utilization rate difference.

L: There are two potential candidates for the measurement of labour. One is full-time-equivalent employee numbers; the other is yearly actual total working hours. Considering the overstaffing problem in Chinese SOEs, in this paper we use actual working hours as the proxy of labour.

The *z*s in Equation (4), the sources of inefficiency concerning the firms' attributes and reform measures, include the following factors:

RBOW: proportion of bonuses and overtime payments in the total wage bill. The bonus system was the main way adopted by management in the 1980s to motivate workers. A number of previous studies have confirmed that it is a significant factor affecting SOEs' efficiency.

Region: It is well known that geographic advantage/disadvantage may well affect efficiency. Regional dummies are used for this purpose. SICHUAN, SHANXI, JILIN are three dummies used to capture the efficiency differences between the SOEs in these three provinces and those in JIANGSU, a advanced region in China.

Reform measures: the effects of a series of managerial mechanisms changes are captured by a group of dummy variables: the manager-responsibility system dummy (MANAGER), the corporate system dummy (CORP) and the share-holding system dummy (SHARE). These are compared with the most popular managerial form, the contract system.

Table 1 Description of Sample Composition for Four Industries

	Building Materials	*Chemicals*	*Machinery*	*Textiles*
Sample Size	52	72	156	104
Jiansu	12	20	46	50
Sichuan	9	8	26	20
Shanxi	13	31	43	14
Jilin	18	13	41	20
Share	3	0	0	5
Contract	27	53	92	53
Manager	18	9	47	35
Corporate	4	10	17	11

Note: Firm numbers for different managerial forms are 1994 numbers.

Time: time t is also included in the model to capture the trends in average efficiency change.

A description of the sample composition is presented in Table 1.

IV. Empirical results

To estimate the model, Equation (3), and its various variations for the Chinese building materials, chemicals, machinery and textiles industries, the FRONTIER 4.1 program written by Coelli (1996) is used. The basic features of the empirical results are summarized as follows.

IV.1 Tests of the model selection and the type of technical change in the four industries

Some tests are designed to select the possible form of production function and the type of technical change for each industry. A likelihood ratio test is used to select the functional form between the translog (Equation 3) and the Cobb-Douglas ($\beta_{TT} = \beta_{Tj} = \beta_{jk} = 0$), the translog with neutral technical change ($\beta_{Tj} = 0$) and the translog with no technical change ($\beta_T = \beta_{TT} = \beta_{Tj} = 0$). In doing so we can first, identify the suitable functional form for each industry so that our following inefficiency estimation will be more accurate, and secondly, ascertain the type of the technical change for each industry, that is, whether the technical change is non-neutral, neutral, or unchanging for each industry. For those industries that have technical change during the sampling period, the rate of technical change will be further estimated. The results of the tests are shown in Table 2.

Note that since a translog functional form with neutral technical change was accepted in step 3, in step 4 we test the translog functional form with no technical

Table 2 Results of the Model Selection and the Type of Technical Change

Null hypothesis sector	*Log-likelihood value under* H_0	*Test statistic* χ^2	*Critical value*	*Decision*
1. Full translog production function				
Building Materials	–228.4			
Chemicals	–293.9			
Machinery	–655.0			
Textiles	–327.9			
2. Cobb-Douglas production function with neutral technical change, $H_0{:}\beta_{TT} = \beta_{Tj} = \beta_{jk} = 0$				
Building Materials	–239.4	22.0	12.59	rejected
Chemicals	–319.9	52.0	12.59	rejected
Machinery	–664.5	19.0	12.59	rejected
Textiles	–358.1	60.4	12.59	rejected
3. Translog with neutral technical change, $H_0{:}\beta_{Tj} = 0$				
Building Materials	–228.7	0.6	5.99	accepted
Chemicals	–294.5	1.2	5.99	accepted
Machinery	–655.9	1.8	5.99	accepted*
Textiles	–330.2	4.6	5.99	accepted
4. Translog with no technical change, $H_0{:}\beta_T = \beta_{TT} = \beta_{Tj} = 0$, Compared with 3				
Building Materials	–229.1	0.8	5.99	accepted*
Chemicals	–294.5	0	5.99	accepted*
Machinery	–661.0	10.2	5.99	rejected
Textiles	–330.4	0.4	5.99	accepted*

Notes: a. Critical values of the test statistic at the 5% level of significance
b. Sign * means the corresponding functional form has been accepted

Table 3 The Rate of Technical Change

Year	*Building Materials*		*Chemicals*		*Machinery*		*Textiles*	
	$e_{f/t}$	$TP_{it-1,t}$	$e_{f/t}$	$TP_{it-1,t}$	$e_{f/t}$	$TP_{it-1,t}$	$e_{f/t}$	$TP_{it-1,t}$
1990	0		0		0.14		0	
1991	0	0	0	0	0.1288	0.1344	0	0
1992	0	0	0	0	0.1176	0.1232	0	0
1993	0	0	0	0	0.1064	0.112	0	0
1994	0	0	0	0	0.0952	0.1008	0	0

change compared with the situation in step 3. If a test in step 4 was accepted, then translog with no technical change is accepted. Otherwise step 3's result is accepted.

Surprisingly, we found that among the four industries we analysed, three did not experience technological change, as we had expected. Only the machinery industry experienced a neutral technical change. The rates of technical change in the four industries are presented in Table 3.

Table 4 Production Function Estimation Results

	Building Materials		*Chemicals*		*Machinery*		*Textiles*	
	coeff.	std-err	coeff.	std-err	coeff.	std-err	coeff.	std-err
Production function								
Constant	1.3218	1.1215	4.2366*	0.9989	−1.4024*	0.7059	2.1803*	1.0018
L	−0.7459*	0.3046	−0.7886*	0.1875	0.4081*	0.1300	−0.2885*	0.1140
K	1.2932*	0.2640	0.8451*	0.2524	1.1369*	0.1780	0.8769*	0.2914
t					0.1512*	0.0788		
*L*L*	0.1264*	0.0288	0.0667*	0.0100	0.0264*	0.0122	0.0422*	0.0060
*K*K*	−0.0042	0.0371	−0.0295	0.0221	0.0169*	0.0205	−0.0047	0.0237
*t*t*					−0.0056	0.0144		
*L*K*	−0.0913	0.0513	0.0196	0.0217	−0.0912	0.0292	−0.0252	0.0156
Efficiency function								
Constant	−4.4943	2.3500	0.0761	0.3758	−0.3195	0.3115	−4.5531	3.3047
RBOW	−1.6842	0.9249	−1.6946*	0.4788	0.2848	0.3043	−2.7245*	0.9922
SICHUAN	4.3545*	1.9907	1.3326*	0.2681	0.5264*	0.1376	4.3543*	2.1278
SHANXI	2.6860*	1.2965	1.1067*	0.2175	0.7947*	0.1403	2.9506*	1.2851
JILIN	4.6748*	2.0333	0.5819*	0.2530	0.6346*	0.1300	4.4509*	2.1813
SHARE	−2.5365*	1.2572					−0.0761	0.4061
MANAGER	0.7162*	0.2802	0.1151	0.1582	−0.1750*	0.0794	0.2434	0.1875
CORP	−2.5054*	1.3399	−0.8393*	0.3634	−0.0630	0.1833	−0.1989	0.2963
t	0.0714	0.0757	0.0890*	0.0437	0.1494*	0.0608	0.2624*	0.0898
Variance parameters								
σ^2	0.6278*	0.1069	0.6153*	0.0933	0.4930*	0.0616	0.7370*	0.1818
γ	0.5451*	0.0742	0.9407*	0.0277	0.8258*	0.0565	0.7607*	0.0619
Log-likelihood	–229.1		–294.5		–655.9		–358.4	

Note: * means statistically significant at the 5%, two-tail test

IV.2 The stochastic frontier production function estimation results

Table 4 presents the estimates for the parameters of the stochastic production frontiers for the four industries. The functional forms applied are those selected from the previous tests in this section.

As can be seen, the estimated γs are significant and exceed 0.5 in all industries, meaning that technical inefficiency effects are significant and the traditional production function, with no technical inefficiency, is not an adequate representation of the data.

Our main findings from stochastic frontier production function estimation are:

(1) The variables which are consistent and statistically significant in all industries are regional dummies. The positive coefficients of the regional dummies, SICHUAN, SHANXI, JILIN mean that these variables have significant positive effects on inefficiency hence a negative effect on the efficiency of the firms, which means that the efficiency levels of firms in these three provinces are significantly lower than those in Jiangsu province. It is no surprise that the firms in Jiangsu are more efficient, because Jiangsu is one of the most developed areas in China. Higher-quality workers, more advanced techniques and well-informed commercial information will make the firms more efficient than those in comparatively backward areas.

(2) The coefficients of the dummy CORP are negative and significant in both the building materials and chemicals industries and negative but not significant in the machinery and textiles industries. This means that compared with the most prevalent contract system, the corporate system has a significant positive effect on improving firms' efficiency in the building materials and chemicals industries and a positive but not significant effect in the machinery and textiles industries.

(3) Share holding has positive effect on efficiency in both the building materials and textiles industries. But the effect is only significant in building materials industry.

(4) The effect of the bonus system on the firms' efficiency is positive, but less important than was found in previous studies. In this study the positive effect of the bonus is only significant in the chemicals and textiles industries. It is still positive but no longer significant in building materials and even negative but not significant in the machinery industry. This may imply that the effects of using bonuses as the main way to stimulate workers to improve efficiency are diminishing. The bonus may gradually be seen by workers as a normal part of their income rather than the reward for improving efficiency.

(5) The final significant results are the tendency of the average efficiency levels reflected by variable t. We found that there are significant downward trends of efficiency levels over time in the chemicals, machinery and textiles industries and an insignificant downward trend in the building materials industry.

Table 5 Technical Efficiency (TE) Level and Rate of Technical Efficiency Change (TEC)

Year	*Building Materials*		*Chemicals*		*Machinery*		*Textiles*	
	TE	TEC	TE	TEC	TE	TEC	TE	TEC
1990	0.703		0.440		0.528		0.816	
1991	0.689	−0.019	0.414	−0.059	0.457	−0.134	0.773	−0.053
1992	0.686	−0.004	0.423	0.020	0.457	0.001	0.761	−0.016
1993	0.673	−0.019	0.413	−0.023	0.404	−0.117	0.735	−0.034
1994	0.685	0.018	0.383	−0.073	0.339	−0.161	0.699	−0.049
Average	0.687		0.415		0.437		0.757	

(6) It is observed that compared with the contract system, the manager responsibility system is better in the machinery industry but worse in the building materials industry. This misleading result may suggest that it is possible that these two managerial forms are in fact indifferent in terms of their influence on the firms' technical efficiency. Although there are differences in theory, these two managerial systems are actually quite similar in many ways. They were introduced at nearly the same period. In practice they were used indifferently in many regions. At the same time, the same managerial form was used very differently in different regions and industries. Therefore, it is understandable that the same system may have inconsistent effect in different industries.

The average technical efficiency levels during the sampling period are reported in Table 5.

It is obvious that in the four industries we analysed, building materials and textiles have comparatively higher average efficiency level, whereas the technical efficiency levels of chemicals and machinery are very low. To explain this obvious difference, we need first to understand the real meaning of technical efficiency level calculated in stochastic-frontier-production function framework. Actually, the technical efficiency level we calculated for a firm is its distance to the production frontier defined by best-performing firms. Therefore, if the performances of the firms within an industry are convergent, their average efficiency level will be comparatively high. On the other hand, if the performances of the firms in an industry are dispersed, the average efficiency level will be low.

Generally, there are two main factors that may affect the average efficiency level. One is technological progress. Another is competition. If an industry is experiencing rapid technical progress, the feasible production frontier moves out quickly, ordinary firms find it harder to catch up with the best-performing firms. This will bring the average efficiency level down. On the contrary, if there is no technological progress, it is easier for the ordinary firms to catch up with the best-performing firms. So the average efficiency level will be higher. But this is only a possibility. The competitive situation in an industry also has strong effect on the average efficiency level. If an industry is competitive, meaning that the market entry barrier in the industry is low or non-existent, then the firms in the industry should have similar technical efficiency. Otherwise the firms with low technical efficiency will be squeezed out of the market. In this case the average efficiency level will be higher. If, on the other hand, there exists a significant entry barrier, then the market is not competitive and the performances of the firms in the industry will be dispersed, resulting in a low average efficiency level.

In the industries we analysed, machinery experienced rapid technical progress (see Table 3). This may explain why the average efficiency level in this industry is very low. In the chemicals industry, the main reason should be the market entry barrier. In fact during the early 1990s, the chemicals industry in China was still under tight control by the government. The barrier to market entry meant that most existing firms had little incentive to improve their management or to use new technology. As a result, the gap between ordinary firms and best-performing firms is steadily increasing. So the average efficiency level in this industry is low.

Building materials and textiles are two of the industries that the Chinese government freed from control in the later 1980s. Competition within these two industries led to the elimination of bad firms. Therefore, it is no surprise that remaining firms in these two industries have comparatively higher average efficiency.

IV.3 Total factor productivity growth in four industries

Following Equation (7), the growth rates of total factor productivity (TFP) in the four industries can be calculated in Table 6.

We found that during the first five years of the 1990s, the SOEs in chemistry and textile industries experienced negative TFP growth. These downward trends

Table 6 The Growth Rate of Total Factor Productivity

Year	*Building Materials*	*Chemicals*	*Machinery*	*Textiles*
1990/1991	−0.019	−0.059	0.001	−0.053
1991/1992	−0.004	0.020	0.124	−0.016
1992/1993	−0.019	−0.023	−0.005	−0.034
1993/1994	0.018	−0.073	−0.060	−0.049
Average	−0.006	−0.033	0.015	−0.038

were caused by significant reductions in average technical efficiencies and stagnant technical progress. In the machinery industry, although there is a significant reduction in the average efficiency level it is offset by technical progress so that there is 1.5% TFP growth annually. In the building materials industry there is no significant technical change or efficiency change so that TFP growth is negligible.

The findings of this study differed from those of most of its predecessors in that we observed that TFP growth tended to decrease in three industries we analysed. A closer inspection found that those studies with positive TFP growth (i.e., Chen et al., 1988; Dollar, 1990; Jefferson et al., 1992; Groves et al., 1994; Cao, 1994; Li, 1997) all employed pre-1990 data, whereas our study employed data for the 1990s. In fact, some studies employing 1990s data reached similar conclusions to ours (see, e.g., Huang and Meng, 1997; Huang et al., 1998). It is likely that during the 1980s, Chinese industrial reform did achieve limited success by creating greater incentives for both managers and workers through such reform measures such as increasing management autonomy for the managers and performance-related pay for workers. But the effects of these measures are limited and without further reform in property rights and ownership structure, the TFP growth stagnated in the early 1990s. In fact, entering 1990s, more and more Chinese state-owned enterprises started to operate at a loss. Our result implies that some further reform measures related to property rights and ownership structure are necessary to promote further TFP growth in Chinese state-owned enterprises.

V. Concluding remarks

We found that after more than ten years of reform, Chinese SOEs still performed unsatisfactorily. Their performance, measured by total factor productivity, is still very poor. Their profitability is even worse according to Chinese official statistics. In 1990, the percentage of loss-making SOEs was 27%. It rose to 43% in 1995 (Keidel, 1998).

Facing the above facts, we cannot but question whether the ways selected to reform SOEs were right. In fact, the same question has been raised by other economists (Woo, 1994). Chinese industrial reform aiming at improving the SOEs' efficiency. Since the SOEs are similar to Western-style firms in that both have the characteristic of separation of ownership and control, it would be natural in selecting reform measures to copy managerial forms and incentive structures from those previously successful in modern Western firms. These measures include changing the incentive structure by increasing the autonomy of SOE managers and profit sharing between the governments and enterprises; changing the enterprise governance structure by implementing various contract-responsibility systems and modern corporate systems. While these measures are effective in a market economy that functions well, it is problematic whether they are also workable in a Chinese setting. In a successful market economy, the agency problems caused by the separation of ownership and control are alleviated through the disciplines from explicit incentive schemes as well as the indirect policing forces of the labour market, the product market and the capital market (Holmstrom and Tirole, 1989). But, to make these disciplines work, several preconditions are necessary. First, a fair competition environment in which the financial indicators can be used to measure and compare the performance of competing firms. Secondly, a smoothly functioning managerial labour market in which the managers' performance is reflected by their market value. Thirdly, a smoothly functioning capital market in which take-over can take place easily through transfer of shares in the event of mismanagement.

The problem with Chinese SOEs is that financial indicators are not appropriate measures of their performance because of the policy burdens they bear. On the one hand, the prices of inputs and outputs of SOEs are often set by the state and distorted, on the other hand, in addition to financial goals, SOEs also bear non-financial goals such as serving as social security providers for their employees. Thus, it is inappropriate to compare SOEs with non-state firms because latter do not bear any social security burdens. It is also inappropriate to make comparisons between SOEs because each SOE was established at a different time, has somewhat different technology and capital intensity, and has a different number of retired as well as redundant workers. Finally, if only past financial indicators of an enterprise are used as the comparison standards, realizing that 'ratchet effect' will cause the performance standards required to increase after a period of good performance, the managers of the SOE will deliberately hold down the production capability and hence cause a moral hazard problem.

In practice, policy burdens may or may not be the real reason for the poor performance of SOEs measured by financial indicators. But because of the information asymmetry problem, the state as owner finds it very difficult to tell from outside whether the poor performance of SOEs is caused by the policy burdens they bear or mismanagement. This will unavoidably result in the SOE managers ascribing all their losses to the state's policies, no matter whether the losses are due to policy burdens or to their own mismanagement. Consequently, in most cases, the state in practice has to be responsible for all the SOE losses.

Since efficient ways of constraining SOE managers have not yet been found in Chinese SOE reform, it is expected that with more and more autonomy being given to SOE managers, agency problems such as moral hazard, managerial slackness, on-the-job consumption will worsen.

In conclusion, our analysis shows that the transfer of decision-making to managers does not automatically guarantee an efficient utilization of resources. In the absence of effective mechanisms to monitor managers' performance, the transfer may simply provide them with licence to pursue their personal objectives. For SOE reform to be effective, it is necessary to remove the policy burdens on SOEs and create a level playing field. Only if market mechanisms can be effectively applied to discipline and monitor the behaviour of SOE management, can the reform measures improve the performance of SOEs.

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