Centre on Regulation and Competition

WORKING PAPER SERIES

Paper No. 21

LABOUR AND TOTAL FACTOR PRODUCTIVITY IN THE CHINESE ELECTRONICS INDUSTRY IN THE 1990s

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March 2002

ISBN: **1-904056-20-2**

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Published by: Centre on Regulation and Competition,
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LABOUR AND TOTAL FACTOR PRODUCTIVITY IN THE CHINESE ELECTRONICS INDUSTRY IN THE 1990s

INTRODUCTION

China has undertaken a series of economic reforms since 1978 aimed at improving economic performance. This study considers the relative performance of state-owned enterprises (SOEs), collectives and joint ventures including wholly foreign-owned enterprises in the Chinese electronics industry in the period after 1993 for labour productivity and 1995 for total factor productivity. The Chinese electronics industry (CEI) is one of the country's most important and dynamic manufacturing sectors. In 1999 it ranked first amongst all industries in China in terms of sales revenues and by 1995 already accounted for the largest amount of foreign direct investment of any industry in China (www.stats.gov.cn). The CEI is therefore a useful sector to study to judge how far the SOEs are now matching the performance of other ownership forms in China, following the introduction of reforms such as 'dual pricing' and the 'contract responsibility system' in the mid-1980s and the 'modern enterprise system' (MES) in the mid-1990s. Both of these sets of reforms were intended to turn SOEs into more commercially-oriented businesses, operating more according to market signals than planning directives (Boisot and Child, 1988; Naughton, 1994; Pan and Parker, 1997; Steinfeld, 1998; Zhang and Parker, 2001).

The dismantling of central planning in China since the 1980s has increased economic productivity and the country has experienced very fast GDP growth. GDP grew at an annual average rate of 10.4% between 1980 and 1999 (*www.chinaonline.com*, 2001). However, according to a number of studies the relative performance of the state sector has deteriorated in spite of the various reform measures (Jefferson *et al.*, 1992; Weitzman and Xu, 1994). In sharp contrast, non-state firms appear to have thrived in the increasingly deregulated market place (Li, 1996). These studies have looked at the performance of SOEs across China's economy and therefore at the aggregate level. They were not, therefore, able to control for different performances in different industrial sectors. The research reported in this study looks only at one industry, the CEI.

The CEI has experienced rapid growth similar to the economy as a whole (Xie, *et al*, 1999). The industry is composed of a wide range of firms in terms of products, the sophistication of the technology employed and the intensity of market competition faced. The products range from those with low technology such as light bulbs, through to those of medium technology, such as TV sets, to those involving high technologies, such as computers and aerospace products (*Yearbook of the Chinese Electronics Industry*, 1993). In the CEI there are sub-sectors such as consumer electronics, that now rely mainly on the market for inputs and outputs, and sub-sectors such as radar products, that continue to receive special treatment from government and to a large extent operate as monopolies (Xie, *et al*, 1999). Since the CEI includes a variety of sub-sectors, its growth trend may be in line with that of the whole economy, but at the same time it may reflect some differences.[1]

The paper begins with a review of the development of the CEI, before turning to earlier studies of productivity in the Chinese economy to place our study of performance in context. The paper then reports the statistical methods used before discussing the productivity results. The purpose of this study of performance is to assess the extent to which differences across different ownership types exist in the CEI and whether differences have narrowed following economic reforms. In particular, the results shed light on whether the 1990s economic reforms and especially the MES have achieved the expected performance improvement in the state sector.

THE CHINESE ELECTRONICS INDUSTRY

Before the 1980s there were comparatively few firms manufacturing electronic products in China compared with today. Most of them produced specific equipment and instruments for state-owned broadcasting stations, telecommunication organisations and other enterprises. Consumer products were limited to simple goods such as radios. The quality of the products was poor and the quantity was small (*Yearbook of the Chinese Electronics Industry*, 1985, p.I-12). The isolation of the Chinese economy from international competition meant that there was generally a large gap between the levels of advanced technology employed in European, North American and Japanese factories and the technology used in the CEI (*Yearbook of the Chinese Electronics Industry*, 1986, p.I-27; Simon, 1992). Most of the firms were state owned

with the exception of a relatively smaller number of collectives. The firms depended upon planned prices and planned outputs and were reliant on state capital.
The economic environment changed with the implementation of the economic reforms of the 1980s. The result was a rapid development of the industry and particular in the non-state sector (Luo and Tan, 1998; Simon, 1992). The 'open door' policy brought into China imported consumer electronic products, such as colour TVs and cassette recorders, and there was a highly favourable response from consumers to the quality and sophistication of the products offered. In order to meet the demand for improved products Chinese firms began to introduce Western and Japanese production equipment, financed mainly by government subsidies (Xie, *et al*., 1999). In addition, the open-door policy bought into China foreign capital. In 1981 the first joint venture in the CEI was established with the Japanese company Hitachi as the foreign partner.

After 1984 industrial reform accelerated. Two of the most important reform measures during this period were the 'dual price system' and the 'Contract Management Responsibility System' (CMRS). Under the dual price system the production of SOEs was divided into two parts: one part was production within the central plan and this continued to be sold at state-regulated prices. The other or additional output remained outside the plan and could be sold by management at market prices. This encouraged the expansion of production. Under the CMRS managers of state firms (and certain collectives) signed contracts with supervisory government agencies and were granted some nominal autonomy over production, product mixture and personnel. This increased autonomy for management was intended to produce improved performance (Child, 1994; Lardy, 1994; Ji, 1998; Forrester and Porter, 1999).

Many changes took place in the CEI during this period of time. In the 1980s a discrepancy between the demand for and the supply of consumer electronic products, especially colour TV sets and cassette recorders, created a sellers' market. This situation led to large-scale entry of new firms into the sub-sector and, eventually, serious over-capacity (Simon, 1992; Xie, *et al*, 1999). Taking colour TV sets as an example, the output in 1993 was three times that in 1985 and over sixty-times that of 1982. In the 1980s and the early 1990s the consumer electronics sub-sector, especially the manufacturing of colour TV sets, was the main contributor to the output of the CEI (*Yearbooks of the Chinese Electronics Industry*, various years).

Economic reform encouraged the development of firms outside the traditional state-owned sector. According to statistical data from the CEI ministry, the number of joint ventures and wholly foreign-owned firms was 23 in 1985 but had increased to 154 in 1990. The non-state sector had a faster growth rate of gross value of industrial output (GVIO) than state-owned firms after 1988 and its share in GVIO increased from over 30% in 1988 to about 45% in 1992.

After 1993 economic reform deepened further in China with the MES reform and the consequent corporatisation of a number, normally the better performing, SOEs. The establishment of limited liability companies with their own boards in the state sector was intended to reduce political control, reform corporate governance and improve industrial management (Pan and Parker, 1997; Zhou and Zhang, 1999). Also, the greater penetration of information technology in China meant that this part of the CEI registered particularly strong growth (Hu, 1993). The share of the computer sub-sector in the CEI's GVIO rose from 8.7% in 1992 to more than 18% in 1999 (*Yearbooks of the Chinese Electronics Industry*, 1993, 2000). By contrast, the consumer electronics sub-sector grew much more slowly due to continuing over-capacity. Its share of CEI GVIO declined from 49% in 1991 to less than 35% in 1999 (ibid.). In the mid to late 1990s the competition in the domestic market for consumer electronic products was so fierce that most domestic producers were involved in continuous price cutting (Xie, et al., 1999). In response, central government placed a restriction on the establishment of new TV factories and mergers between firms were promoted (Simon, 1992). Even so, in 1999 about a half of the domestic manufacturers of consumer electronics recorded losses (Xie, *et al*., 1999; *Yearbook of the Chinese Electronics Industry*, 2000, p.64). As a result of bankruptcy and mergers, the number of firms in the CEI, especially SOEs and collectives, declined in the second half of the 1990s, from 3501 to 2839. Also, there was a slight fall in employment in the industry, from 1.7m in 1992 to 1.6m in 1999 (*Yearbooks of the Chinese Electronics Industry*, various years).

In spite of the difficult trading conditions in some sub-sectors of the industry, joint ventures and wholly foreign-owned firms developed rapidly during this period. Table 1 provides summary data on the industry's GVIO. By the end of 1999, of the 2839 firms in the industry, 1001 were SOEs, 618 collectives, 46 private enterprises, 311 limited liability companies and 738 firms had benefited from FDI. In 1989 SOEs had the lion's share of the industry's output,

but by 1999 their share was less than one-third. The collective sector is a relatively minor contributor to CEI output and recorded a declining trend in its share after 1993. Limited liability companies recorded a 'U' shaped change in their share of GVIO after 1993. In contrast to the other ownership types, joint ventures and wholly foreign-owned firms registered a steady rise in share of GVIO, from 6.2% in 1988 to 44.6% in 1999. Since 1996 joint ventures and wholly foreign-owned firms have become the largest sector in the CEI in terms of output.

Table 1: The Share of CEI Gross Value of Industrial Output (GVIO) by Ownership (%)

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
SOEs	69.38	67.25	63.38	55.43	49.03	46.94	40.11	37.27	37.78	32.92	27.76
Collectives	15.59	13.97	14.46	14.05	16.19	15.52	13.40	11.90	10.08	8.11	9.19
Limited liability companies				6.62	10.77	10.12	7.09	5.70	7.41	12.93	15.12
Joint ventures*	6.87	9.73	12.82	10.49	21.59	24.08	36.94	43.19	41.93	42.49	44.57
Other	8.16	9.05	9.34	13.41	2.42	3.34	2.46	1.94	2.80	3.55	3.37
Total	100	100	100	100	100	100	100	100	100	100	100

Source: calculated from data in *Yearbook of the Chinese Electronics Industry*, various years.

* The category of joint ventures includes wholly-foreign-owned firms.
Limited liability companies were recorded in official data from 1992.

EARLIER PERFORMANCE STUDIES

A number of studies have attempted to assess the effects of economic reform on the performance of China's SOEs, some of which have made a comparison with performance under other ownership forms. The conclusions of these studies are not always consistent, however. The following are studies that have reported performance improvements in the state sector. Chen *et al*. (1988) concluded that there was growth in total factor productivity at the annual rate of 4-5% in state industry in China, during the period from 1978 to 1985; while Jefferson (1989) found high marginal returns to labour within the state sector based on cross-section data for 1984. Using panel data of observations on 769 SOEs from ten manufacturing industries, Liu and Zhuang (1998) reported that cost efficiency in the state sector increased by an average of 1.18% per annum during the decade from 1980 to 1989. By analysing a panel data set of 272 state enterprises, Li (1997) revealed that there was a marked improvement in the marginal productivity of inputs, with an average growth rate of 4.68% from 1980 to 1989. Using data gathered by the World Bank from 20 Chinese SOEs, Dollar (1990) confirmed that TFP grew rapidly in the 1980s, at an average rate of 4.7% per annum.

By contrast, some studies have reported that the SOEs have lagged behind other ownership forms in terms of performance. For example, Jefferson *et al*. (1992) found that the growth of productivity in the state sector amounted to 2.4% per annum but 4.63% in collectives, during the period 1980 to 1989. Comparing SOEs and township and village enterprises (collectives), Weitzman and Xu (1994) found an even larger gap, of about 8% per annum in TFP between the two sectors and in favour of the collectives. Some studies have gone further and questioned whether there have been performance improvements at all in the state sector. For instance, Parker (1999) concluded that multi-factor productivity improvement was not significant from 1980 to 1992 in SOEs, and that capital investment increased without relation to profitability, productivity, or a corresponding increase in output. McGuckin *et al*. (1989) suggested that TFP in the state sector declined during 1980-1985, based on data from the 1985 Industrial Census of China. Similar arguments are also made by Woo *et al*. (1993) and by Kong *et al*. (1998). The latter based their study on data for 1990-1995, a more recent period than that covered by the other studies mentioned.

There is, therefore, no agreement on the effects of the reform process on the performance of SOEs, although the studies do have in common the finding that SOEs have performed worse than other ownership forms and especially the collectives. The statistical results reported in this paper are intended to shed further light on performance in China and especially comparative performance between ownership forms. Moreover, the earlier studies are at the aggregate, economy level and, as already commented, the figures, therefore, are averages that might mask differences in performance at the industry level. To date there appears to have been little study of the performance of the CEI, in spite of it being one of the leading sectors in China's economic growth and the largest single recipient of FDI, accounting for 11% of the total by 1995 (Wang, 1997). Shi (1998) in a study of tape recorder manufacture in China found evidence of higher productivity in firms having private capital and especially foreign investment than in SOEs. This work was mainly qualitative, however, and based on a questionnaire and case studies. Liu *et al.* (2001), in a study of the effects of FDI on the CEI in 1996-97 confirmed that foreign presence was associated with higher labour productivity, although human capital and firm size were found to be more important determinants of performance.

The objective of the statistical analysis of performance reported below is to add to knowledge about the relative efficiency of different ownership forms in China through a study of the CEI. The research looks at more recent data than the studies cited above, namely data for the mid to late 1990s. It is therefore able to shed light on how the more recent economic reforms in China (including the MES) have impacted on the relative economic performance of different ownership forms. The discussion now turns to the methods by which labour productivity and TFP were calculated and then reports the results.

METHOD AND RESULTS

To assess performance in the CEI across ownership forms labour productivity and TFP indices were computed. Both sets of figures were based on data in the *Yearbooks of the Chinese Electronics Industry*. These provide the necessary data to calculate labour productivity from 1993 to 1999, the last date for which figures were available. Prior to 1993, data for separate ownership types were not published by the statistical department of the CEI and therefore comparative labour productivity figures across ownership forms could not be calculated for earlier years. The period for which TFP could be computed was even more truncated because regional data were used for the input weights and this data did not become available until 1995. The TFP figures are therefore for 1995 to 1999. Also, joint ventures and wholly foreign-owned firms were combined into one category because some of the regional data did not distinguish between the two ownership forms. The category is labelled 'joint ventures' because this form of ownership dominates in China over wholly foreign-owned firms. Moreover, the data do not distinguish corporations in the CEI according to their origins, therefore the category of 'limited liability companies' includes not just those enterprises transformed from SOEs under the MES but those from other ownership backgrounds. The number of limited liability companies increased from 42 in 1993 to 311 in 1999. We do know, however, that the majority were created from SOEs under the MES reform (*Yearbook of the Chinese Electronics Industry*, 1997; Lin, 2001). Consequently, the results for this sector can be used to assess the extent to which the MES and 'corporatisation' of SOEs has improved enterprise performance.

Labour productivity was calculated at 1990 constant prices. The deflator for output was the retail price index (RPI) obtained from the *Statistical Yearbook of China* (various years), in the absence of a superior 'own-prices' deflator for the electronics industry. RPI figures were

obtained at both national and regional levels. The deflators at the national level were used in the calculation of labour productivity and those at the regional level were used for the computation of TFP, where the estimation of the weights of labour and capital was based on data at the regional level (see below). In all cases the employment figures used were adjusted to exclude non-productive employees. In particular, SOEs in China often employ significant numbers of workers to provide social welfare services, such as housing, education and health care. It is important to remove these employees if, as was the intention here, the goal is to compare the relative efficiency of firms producing final products for the market place *on a like for like basis*. Inclusion of these employees reduces the labour productivity and TFP figures for the state sector reported below.[2]

The results are now presented, starting first with labour productivity.

Labour Productivity

Table 2 summarises the labour productivity results based on value added per employee and for the different ownership forms, namely SOEs, collectives, joint ventures (including wholly foreign-owned firms) and limited liability companies. To assist comparison the results are graphed in Figure 1. The results show that SOEs recorded an average growth rate between 1993 and 1999 of 11.3%. This is a commendable improvement but is dwarfed by the gains achieved by the collectives, 25.2%, and to a lesser extent the joint ventures, 13.3%. Only the limited liability companies did (marginally) less well, recording growth averaging 10.2%. Generally speaking, these growth rates for labour productivity are higher than those reported in studies reviewed earlier. For example, Jefferson, *et al.* (1992) found that labour productivity grew at an average rate of 5.2% in the state sector and at 12.1% in the collective sector during the period from1980 to 1988. This is a different period to the one studied here, however, and the 1990s were associated with particularly fast expansion in the Chinese economy. This may be one explanation for the difference. Also, the much higher growth rates found by our research probably reflects the fact that the CEI has grown at a faster pace than other industries in China's economy. For example, from 1980 to 1992 the CEI registered an average annual growth rate of labour productivity of 16.4% (own calculation based on data from *Yearbooks of the Chinese Electronics Industry*, various years).

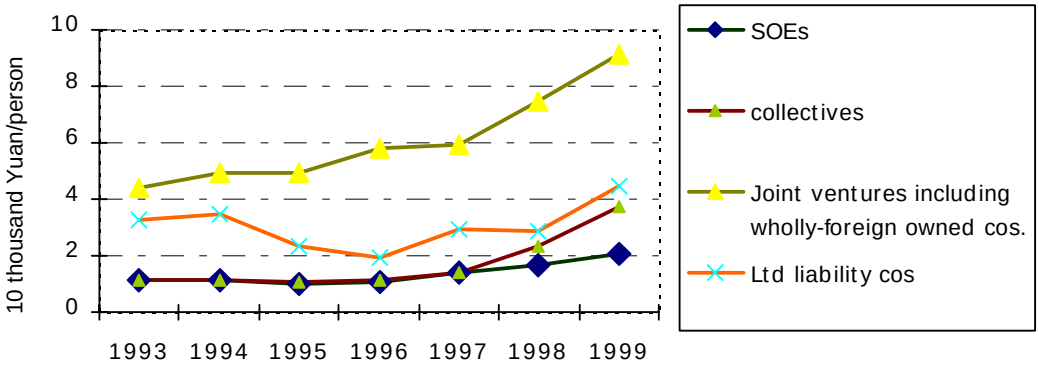
Table 2 Labour Productivity in the CEI by Ownership, 1993-1999

	SOEs		Collectives		Joint ventures*		Limited liability companies	
	10000Y/ person	Growth rate %	10000Y/ person	Growth rate %	10000Y/ person	Growth rate %	10000Y/person	Growth rate %
1993	1.15149		1.12960		4.41338		3.2855	
1994	1.12419	-2.37	1.12473	-0.431	4.93809	11.89	3.48470	6.06
1995	1.0243	-8.79	1.03480	-7.99	4.95894	0.4223	2.33379	-33.03
1996	1.0811	5.43	1.12568	8.78	5.81863	17.34	1.9088	-18.21
1997	1.3852	28.12	1.39097	23.57	5.91589	1.67	2.90334	52.10
1998	1.6350	18.04	2.34286	68.43	7.47725	26.39	2.87781	-0.88
1999	2.0846	27.49	3.71901	58.74	9.10939	21.83	4.4718	55.39
Average growth rate (%)		11.32		25.18		13.26		10.24

Note: value figures are at 1990 prices.

* The category of joint ventures includes wholly foreign-owned firms
Source: based on data from *The Yearbook of the Chinese Electronics Industry* and *The Statistical Yearbook of China*, various years

Figure 1: Labour productivity of the CEI by Ownership, 1993-1999



It is also clear from Table 2 that SOEs and collectives in the CEI began with a relatively low *level* of labour productivity compared to joint ventures and limited liability companies. The good performance of joint ventures is consistent with what we would expect of firms that benefit from FDI in terms of technology transfer. The high level of productivity in the limited liability sector is consistent with the fact that most of the SOEs chosen for 'corporatisation' under the MES reform were chosen because of their good economic performance (*Yearbook of the Chinese Electronics Industry*, 1997; Lin, 2001). However, labour productivity in the limited liability company sector fluctuated over the period studied and a negative growth was recorded in 1995 and 1996 suggesting, overall, that the MES reform had no noticeable effect in terms of performance improvement.[3]

Total Factor Productivity (TFP)

Labour productivity is a partial measure of productivity and does not take into consideration changes in the quantity and quality of other inputs, notably capital. It is not, therefore, a reliable indicator of the true economic performance. TFP is recognised to be a superior performance measure because it takes into account changes in all inputs, with TFP measured as the residual change in output unaccounted for by the change in inputs.

To calculate TFP in the CEI appropriate weights for capital and labour inputs had to be computed. The method used was based on that adopted by Jefferson *et al*. (1992) in their study.[4] The method is based on a Cobb-Douglas (CD) production function. Compared with alternative production functions and especially the constant elasticity of substitution (CES) function, the CD function is much easier to express in linear form. In addition, it is less complex to estimate the output elasticities using the CD function than using another commonly favoured production function in econometric work, the translog function. One disadvantage of the CD production function, however, is that it does not allow for the elasticities of factor inputs to vary over time. The weights obtained from the estimation are average ones over the period studied. This potential limitation is addressed below.

A set of panel data was used to estimate the output elasticities of labour and capital. Because of the lack of constant data both across the different ownership forms and over time in the CEI, there are no time-series data long enough to estimate the output elasticities of labour and capital as was done in the study by Chen *et al.* (1988). Also, there are no cross-section data large enough, in terms of sample size, to conduct the precise form of estimating elasticities as undertaken by Jefferson *et al*. (1992). Instead, therefore, using data obtained from the information centre belonging to the Chinese Information Industry Ministry, a panel of observations for 30 provinces between 1995 and 1999 was used for each of the ownership types to compute the elasticities. Five years is a short period for a panel-data set and this is a limitation of the study method. Given data availability it was the longest period that could be adopted.

The production function was specified as follows, after transforming the normal CD function into linear form:

$$q_{it} = \alpha_O + \alpha_K k_{it} + \alpha_L l_{it} + \varepsilon_{it}, \qquad (1)$$

where *i* represents observations of industrial aggregates for the cross-section of provinces in China; *q*, *k* and *l* represent logarithms of average enterprise values within each province for value added (*q*) at 1995 prices, average annual net value of fixed assets (*k)* at constant prices, annual average number employed (*l)*; and ε is the usual stochastic variable that is assumed to satisfy the regression model.

Equation (1) was then transformed into the following form:

$$(q-l)_{it} = \alpha_o + \beta q_{it} + \alpha_k (k-l)_{it} + e_{it}, \qquad (2)$$

where $\beta = (\sigma - 1)/\sigma$. σ is a scale parameter, equalling $\alpha_K + \alpha_L$; $\alpha_k = \alpha_K / \sigma$; $\alpha_l = 1 - \alpha_k$; $\alpha_o = \alpha_O / \sigma$; and $e = \varepsilon / \sigma$. Since the factor coefficients are normalised to sum to unity, the output elasticity estimates obtained from equation (2) are the appropriate weights to use for the calculation of TFP. Details of the transformation of Equation (1) into Equation (2) are provided in Appendix A to the paper.

Using equation (2) helps to minimise some problems with the data. First, unlike value added and capital, the labour figures used were measured in physical terms, namely the number of employees. This is the only available data on labour at the regional level in the CEI. When the logarithm of average employment per enterprise is subtracted from both sides of equation (1), the inconsistency between *q*, *k* and *l* in terms of the unit of measurement no longer presents a problem. Second, the data used for estimation included non-industrial fixed assets and employees, in particular assets and employees in firms used for providing social welfare services. By using the ratio of capital to labour instead of the true level of inputs, this kind of measurement error and estimation bias, which may be especially important for SOEs in China, is reduced. This is so because the errors in the observed values of fixed assets and labour should be positively correlated.

Equation (2) was used separately to calculate output elasticities for traditional SOEs, collectives, joint ventures (and wholly foreign-owned firms) and limited liability companies. The sizes of the observations for these four sectors were different because some ownership types had no presence in some of the provinces. Also, for each of the ownership types some of the extreme observations, that we felt probably reflected measurement error in the official data, were removed. This is an important adjustment that often needs to be adopted when

using official Chinese data, to avoid serious errors entering the results. By using a sample excluding extreme outliers, the results of the estimations are expected to be more broadly representative of the true situation in the sectors studied. Also, the usual diagnostic tests were adopted and the Durbin-Watson test revealed evidence of positive serial correlation. Therefore a standard data transformation was conducted. The results of the final computations are reported in tables 3 to 6. The results of the initial estimations and the process of data transformation are provided in Appendix B to the paper.

Table 3: Estimation Results for SOEs

Total panel of observations 126				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (α_o)	0.24	0.148452	8.087599	0.0000
k-l(α_k)	0.692	0.104391	3.078848	0.0027
q(β)	0.089	0.035415	23.81686	0.0000
R-squared	0.908897	Prob(F-statistic)		0.000000
Adjusted R-squared	0.907018	Durbin-Watson statistic		1.735630
F-statistic	483.8638	Stability test		F=4.75 (3.95)#

The figure in the parenthesis is the critical value at the 1% level.

Table 4: Estimation Results for Collectives

Total panel of observations 108				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (α_o)	0.518	0.031598	3.842375	0.0002
k-l(α_k)	0.598	0.044408	2.877216	0.0049
q(β)	0.083	0.030916	22.57499	0.0000
R-squared	0.979463	Prob(F-statistic)		0.000000
Adjusted R-squared	0.979075	Durbin-Watson statistic		1.905332
F-statistic	2527.659	Stability test		F=6.86(3.95)#

The figure in the parenthesis is the critical value at the 1% level.

Table 5: Estimation Results for Joint Ventures*

Total panel of observations 113				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (α_o)	1.44	0.069365	1.561180	0.1214
k-l(α_k)	0.622	0.048451	2.726346	0.0075
q(β)	0.078	0.035033	15.87890	0.0000
R-squared	0.975369	Prob(F-statistic)		0.000000
Adjusted R-squared	0.974921	Durbin-Watson statistic		2.228345
F-statistic	2177.969	Stability test		F=1.61(3.95)#

The figure in the parenthesis is the critical value at the 1% level.

* The category of joint ventures includes wholly foreign-owned firms

Table 6: Estimation Results for Limited Liability Companies

Total panel of observations 106				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (α_o)	-0.43	0.051274	-0.145025	0.8849
k-l(α_k)	0.710	0.078010	4.133321	0.0001
q(β)	0.081	0.048891	8.605461	0.0000
R-squared	0.956777	Prob(F-statistic)		0.000000
Adjusted R-squared	0.956012	Durbin-Watson statistic		2.274463
F-statistic	1250.676	Stability test		F=0.63(3.95)#

#The figure in the parenthesis is the critical value at the 1% level.

The results show that coefficients β and α_k are significant at the 1% level in all of the estimations. However, the results of stability tests revealed that the estimated factor share parameters remained constant during the period studied for limited liability companies and firms with FDI, but not for the state and collective sectors. The CD production function assumes constant weights or elasticities of factor inputs as mentioned earlier, but the results suggested that there was a structural change in the collective and state sectors during 1995 to 1999. Therefore, in order to obtain more reliable input weights new estimations were conducted for these two sectors based on creating two sub-periods in which the factor share parameters were constant, as shown in table 7. It can be seen that the weights for capital input in the two sectors were different during each sub-period, however they were constant within each sub-period.

Table 7: Estimation Results for SOEs and Collectives in Sub-periods

		Variable	Coefficient	Prob.	
SOEs	95-96	C (α_o)	1.022	0.051	
		k-l(α_k)	0.657	0.000	D-W statistic: 1.71967
		q(β)	0.056	0.162	Stability test: F=0.594(4.13)#
	97-99	C (α_o)	0.072	0.000	
		k-l(α_k)	0.701	0.000	D-W statistic: 1.8104
		q(β)	0.092	0.000	Stability test: F=0.657(3.95)#
Collectives	95-97	C (α_o)	0.939	0.025	
		k-l(α_k)	0.559	0.000	D-W statistic: 1.8156
		q(β)	0.022	0.4587	Stability test: F=1.0554(4.13)#
		C (α_o)	-0.045	0.388	
		k-l(α_k)	0.6073	0.000	D-W statistic: 1.6485
		q(β)	0.0913	0.000	Stability test: F=0.071(4.13)#

#The figures in the parentheses are the critical values at the 1% level.

Looking at tables 5 and 6, α_l calculated as $\alpha_l = 1 - \alpha_k$ has values of 0.378 for joint ventures and wholly foreign-owned firms and of 0.2896 for limited liability companies. If α_k in tables 3 and 4 are used, α_l is 0.308 for SOEs and 0.402 for collectives. If the factor share parametres in table 7 for the sub-periods are used, for SOEs α_l is 0.343 in 1995 and 1996 and 0.299 during 1997 to1999 and for collectives 0.441 during 1995 to 1997 and 0.393 in 1998 and 1999. Comparing the weights of the factor input between traditional SOEs and firms with FDI, it seems that the latter are less capital intensive than the former. This seems contrary to expectation perhaps. One possible explanation is that the depreciation rates for fixed assets used in China's state sector are lower than used in joint ventures and wholly foreign-owned firms (Xie, *et al*., 1999). This will tend to lead over-estimates of the capital stock in the state sector. In which case the SOEs may seem to be more capital intensive than they really are. In the absence of any certainty regarding this matter, however, there were no obvious adjustments to our data that we could make.

To compute TFP figures the α_k and α_l estimates obtained were used as weights to combine capital and labour into a composite input measure (shown below as equation 3). Because of the model and the data used, it was not possible to calculate absolute levels of TFP for each of the years studied. The input and output data used in calculating TFP growth for each ownership type are presented in table 8. Figures in columns (1) and (2) are, respectively, the number of employees and the net value of fixed assets at current prices (in RMB 10,000Yuan), both of which have been adjusted to exclude non-industrial resources. Column (3) consists of net value figures for fixed assets at constant 1995 prices, also in RMB10000Yuan. The deflators used to transform the nominal net values of fixed assets to 1995 prices were based on the price index for fixed asset investments obtained from the *Statistical Yearbooks of China* (various years).[5] The deflator is labelled 'DEK' in column (6). This may not be entirely appropriate since different kinds of fixed assets may have different deflators. The estimates are the best attainable. Columns (4) and (5) contains figures of value added at current prices and at constant 1995 prices, respectively. The deflator used here, as in the calculation of labour productivity, is the national RPI and is labelled 'DEVA' and presented in column (7).

Table 8: Original and Adjusted Data by Ownership Types, 1995-1999

	L	K (10,000 Y)	DK (10,000Y)	VA (10,000Y)	DVA (10,000Y)	DEK	DEVA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SOE							
1995	931,370	2,506,697	2,506,697	1,638,193	1,638,193	1.00	1.00
1996	888,383	2,820,964	2,712,466	1,747,948	1,647,453	1.04	1.061
1997	855,477	3,046,069	2,879,954	2,173,857	2,032,615	1.0577	1.0695
1998	768,213	3,190,379	3,022,438	2,244,299	2,154,496	1.0556	1.0417
1999	712,260	3,197,649	3,041,492	2,573,366	2,546,800	1.0513	1.0104
Collectives							
1995	325,969	541,466.9	541,466.9	578,588	578,588	1.00	1.00
1996	295,774	547,682.5	526,617.8	605,933	571,096.1	1.04	1.061
1997	259,340	571,704.8	540,527.2	661,758.3	618,761.8	1.0577	1.0695
1998	192,794	582,417.2	551,758.9	807,067.9	774,774.3	1.0556	1.0417
1999	189,956	702,569.8	668,259.8	1,224,394	1,211,755	1.0513	1.0104
Firms with FDI (joint ventures and wholly foreign-owned firms)							
1995	205,978	1,899,372	1,899,372	1,752,042	1,752,042	1.00	1.00
1996	247,939	2,626,164	2,525,158	2,625,524	2,474,575	1.04	1.061
1997	274,646	3,278,798	3,099,990	2,980,605	2,786,945	1.0577	1.0695
1998	301,456	4,213,588	3,991,786	4,027,505	3,866,351	1.0556	1.0417
1999	341,857	4,336,287	4,124,524	5,397,286	5,341,568	1.0513	1.0104
Limited liability companies							
1995	95,714	417,747.2	417,747.2	383,153	383,153	1.00	1.00
1996	94,946	403,015.2	387,514.6	329,825	310,862.4	1.04	1.061
1997	113,108	613,974.6	580,491.8	602,423.9	563,282.5	1.0577	1.0695
1998	182,334	1,106,196	1,047,966	942,701.4	904,980.6	1.0556	1.0417
1999	193,533	1,274,492	1,212,253	1,409,962	1,395,406	1.0513	1.0104

Source: *The Yearbook of the Chinese Electronics Industry* and *the Statistical Yearbook of China*, various years.

L: the number of employees (excluding non-industrial labour)
K: average annual net value of fixed assets at current prices (excluding non-industrial assets)
DK: average annual net value of fixed assets at constant 1995 (excluding non-industrial assets)
VA: value added at current prices
DVA: value added at constant 1995 prices
DEK: deflator for fixed assets
DEVA: deflator for value added.

With the adjusted input and output data and the estimates of the elasticities of capital and labour, comparative rates of sectoral productivity were calculated using the following expression:

$$tfp = dva - \alpha_k dk - \alpha_l l\,, \qquad (3)$$

where tfp is the exponential growth rate of total-factor productivity and the right-hand variables are, respectively, the exponential growth rate of real value added, of real net value of fixed assets, and of the number of employees, over the period studied. The results are reported in table 9. For the traditional SOEs and collectives sectors, TFP growth rates were calculated both according to the weights obtained from tables 3 and 4 and according to the

more favoured elasticities for the sub-periods, table 7. These are marked by # in table 9. It can be seen that the results change upwards, although not by much, when the sub-period weights are used.

Table 9: Exponential Growth Rate in Percentage per Annum by Ownership Types

Ownership	dva =	$\alpha_k dk$ +	$\alpha_l l$ +	**tfp**	se	other
SOEs	11.0311	3.3426	-2.069	**9.7577**	1.822	7.936
		(4.835)	(-6.705)			
SOEs#				**9.8387**	1.105	8.7337
Collectives	18.4809	3.1442	-5.43	**20.7668**	2.892	17.875
		(5.2599)	(-13.500)			
Collectives#		3.184	-5.757	**21.0535**	1.24	19.8135
Joint ventures	27.8684	12.0597	4.7864	**11.0223**	1.953	9.069
		(19.386)	(12.666)			
Limited liability companies	33.8596	18.9218	5.0969	**9.8409**	0.339	9.501
		(26.634)	(17.6021)			

Note: figures in parentheses are exponential growth rates of factor inputs.
* The category of joint ventures includes wholly foreign-owned firms
#TFP growth rates calculated according to the sub-period weights.

The following are the main findings based on the results in table 9 and the data in table 8. The major impetus to output growth in joint ventures and limited liability companies came from a rapid expansion of capital. This is especially obvious in the case of limited liability companies, where the expansion of fixed assets accounted for more than a half of the incremental output. In these two sectors productivity growth was the second largest contributor to output growth, with joint ventures and wholly foreign-owned firms relying more on this source of growth. The trends in SOEs and collectives in the CEI are different. In both of the sectors there was a decline in the number of employees over the period. The decrease in employees contributed to the growth of labour productivity, as revealed by the earlier labour productivity calculations, and resulted in a negative share of labour in incremental output. The recorded increase in labour productivity was associated with a growth in TFP and not simply a substitution of capital for labour. This is most obvious in the collective sector, where the growth of TFP exceeded output growth. Although it accounted for a lesser share of incremental output in SOEs and collectives than in the other two sectors, expansion of fixed assets was a more important contributor to output growth for state firms than for the collectives.

Comparing across ownership forms, the collective sector recorded the highest growth in TFP suggesting that it was the most dynamic sector in the CEI in the second half of the 1990s. By contrast, over the same period SOEs achieved the lowest growth in TFP, while limited liability companies, as a whole, seem to have achieved a slightly higher gain in terms of TFP than the SOEs. Unfortunately, because we can not distinguish in the data between those companies that were former SOEs and those that were not, we cannot be certain whether the corporatised SOEs within the limited liability category had a higher TFP growth rate than the other SOEs, or, therefore, whether the reform measure of corporatisation under the MES had a positive effect on efficiency. What we can say, however, is that comparing the TFP growth of SOEs and limited liability companies over the period studied (i.e. 9.75% or 9.83% p.a. [depending upon the weights used] and 9.84% p.a.), there is no obvious sign of any significantly different increase in TFP. This finding is particularly surprising when it is remembered that the MES reform was mainly carried out amongst SOEs having a better economic performance. The results also suggest that joint ventures and wholly foreign-owned firms in the CEI were more efficient than the SOEs and the limited liability companies in terms of TFP growth.

TFP growth can be decomposed to reveal the relative roles of scale economies and 'other' factors, with other as a residual reflecting changes in technology (and therefore movements in the production possibility frontier) and superior management of existing resources (or movements towards the production possibility frontier). The results are labelled as 'se' and 'other' in the last columns of table 9: 'se' was calculated as β (dva-*n*), where β was estimated by equation (2) (see Tables 3 to 7) and dva and *n* are exponential rates of growth for deflated value added and the number of enterprises, respectively. The results show that, although scale economies have made a consistent contribution to growth and productivity change, the increases in TFP revealed by the study appear to be mainly attributable to the combination of technological advance and improvements in resource management. In other words, the increase in TFP is primarily attributable to increases in output per unit of combined factor input, holding enterprise scale constant.

Marginal returns to factors could also be calculated. In a competitive market economy interaction between income-seeking buyers and sellers should, over time, equalise the marginal return to any resource used in different sectors of the economy. A successful

programme of economic reform based on promoting market transactions should have generated convergence effects during the 1990s. Therefore, testing for the convergence of factor returns offers a further means of assessing whether the economic reforms improved economic performance. The following set of equations was used to calculate the nominal returns to capital and labour for all the four sectors.

$$MRP_{Lt} = \alpha_L (VA_t / L)$$
$$MRP_{Kt} = \alpha_K (VA_t / K) \qquad (4)$$

Where VA, K and L are from table 4.12; and the output elasticities α_K and α_L are calculated according to the expressions $\alpha_K = \alpha_k / (1/(1-\beta))$ and $\alpha_L = \alpha_l / (1/(1-\beta))$.

Table 10: Nominal Marginal Revenue Products: Labour and Capital

		MRP-L		MPR-K	
		mrp-l	index-l	mrp-k	Index-k
SOEs	1995	0.541743	1	0.45224	1
	1996	0.606009	1.118627	0.428783	0.94813
	1997	0.78266	1.444707	0.493853	1.151755
	1998	0.899808	1.660949	0.486793	1.076404
	1999	1.112791	2.054093	0.5569	1.231424
collectives	1995	0.713541	1.317121	0.638997	1.412958
	1996	0.823551	1.520187	0.661602	1.462944
	1997	1.025784	1.893487	0.692195	1.530592
	1998	1.682839	3.106341	0.828661	1.832347
	1999	2.59116	4.783003	1.042156	2.30443
Joint	1995	3.215255	5.935017	0.573753	1.26869
Ventures*	1996	4.002791	7.388723	0.621848	1.37504
	1997	4.102258	7.572328	0.565432	1.25029
	1998	5.050146	9.322028	0.594531	1.314635
	1999	5.967917	11.01613	0.77419	1.7119
Limited	1995	1.159299	2.139941	0.651204	1.439951
Liability	1996	1.006017	1.857	0.581059	1.284846
companies	1997	1.542437	2.847173	0.696643	1.540426
	1998	1.497287	2.763831	0.605063	1.337923
	1999	2.109847	3.894551	0.785468	1.736838

* The category of joint ventures includes wholly foreign-owned firms

The results are shown in table 10. It can be seen that there is no obvious sign of convergence in marginal returns across ownership types. The marginal productivity of inputs, especially labour, remained much higher in the collectives and joint ventures sectors than amongst SOEs and limited liability companies taken as a whole. This finding is consistent with the poorer productivity performance recorded by the latter sectors and suggests that capital markets

remain segmented and labour markets remain under-developed in China (cf. Warner, 1995; Zhang and Parker, 2001). The economic reforms in China appear, so far, to have generated inadequate pressure towards convergence in marginal returns to inputs. Of course, the period studied was short and we would expect to find more obvious signs of convergence the longer the period of time, especially where there are known rigidities in factor markets, which is the case in China.

CONCLUSIONS

Based on data from the CEI, the paper has reported comparisons of performance across ownership types based on calculations of labour and total factor productivity. The aim has been to shed light on whether the economic reforms of the 1990s, and especially the introduction of the Modern Enterprise System (MES) and the corporatisation of some SOEs as limited liability companies, led to performance improvements as the government intended. The analysis of labour productivity showed that, generally, non-state owned enterprises in the CEI had higher labour productivity and the gap between them and traditional SOEs widened in the 1990s. During the period from 1993 to 1999 labour productivity in the SOEs grew at an average annual rate of 11.3%, compared with a remarkable growth rate of 25.2% in the collective sector. Joint ventures and wholly foreign-owned firms registered a little higher labour-productivity growth than the SOEs. Although starting with a very high *level* of labour productivity, limited liability companies in the CEI did not record a higher growth rate than the traditional SOEs. Indeed, during the period from 1993 to 1999 labour productivity in this sector recorded an annual growth of 10.2%, still impressive but the lowest among the four ownership types.

Labour productivity figures may mask the scale of performance improvements where there is factor substitution in the production process, notably more capital intensive production processes. Therefore, TFP growth rates were also computed. The measure used was based on factor weights obtained from a two-input Cobb-Douglas production function and panel data for 1995 to 1999. The results confirmed that the collective sector in the CEI achieved an extraordinarily high TFP growth rate, of over 20% and close to the labour productivity achieved by the sector, 25.2%. Together these figures suggest a major improvement in the sector's performance over the period studied. Although their share of CEI output was small, the collectives were the most dynamic sector in the CEI in the second half of the 1990s in

terms of raising efficiency. By contrast, the traditional SOEs recorded the lowest growth rate of TFP among the four ownership forms studied, with an annual rate less than half that of the collectives. The growth rate in TFP achieved by joint ventures (including wholly foreign-owned firms) fell between that of the collectives and SOEs. As in the case for labour productivity growth, limited liability companies in the CEI lagged behind the collectives and joint ventures. It is not possible to distinguish in the Chinese official data between limited liability companies that were transformed from SOEs and those that were not, although we know that at least one half of the limited liability companies in the CEI were former SOEs. Nevertheless, the results for both labour productivity and TFP do suggest that there were no significant differences in growth rates between SOEs and limited liability companies including the corporatised SOEs. This is particularly significant when we recall that most of the SOEs that were chosen for the MES experiment were those that already had a relatively superior performance to the vast ranks of SOEs. Therefore, the results suggest that if the MES reform measure had a positive effect on enterprise performance, by 1999 the impact had not reflected itself in any obvious upward movement in sectoral productivity.

The TFP growth rates are consistent with those for labour productivity with both series suggesting very high productivity growth in the CEI during the 1990s. Also, labour productivity growth exceeded TFP growth, a result consistent with the usual finding of capital for labour substitution over time and especially in sectors prone to technological change, such as electronics. It is acknowledged, however, that the reported research findings have limitations. In particular, the calculations were based on Chinese official data, which are generally regarded as containing error (although outliers in the data were removed before the calculations were undertaken in an attempt to minimise the error). In addition, the period covered by the analysis is short, seven years in the case of labour productivity and five years in the case of TFP. This was due to a lack of relevant official data for the CEI for earlier years. Also, the productivity growth rates found are, in general, considerably higher than those reported in the studies of productivity in China reviewed earlier in the paper. One possible explanation is that most of those studies focused on productivity growth before 1993, when fewer elements of a market economy existed in China. Another possibility relates to the choice of the CEI for analysis. During the period of 1995 to 1999 firms in this industry may well have been exposed to more market competition than many other areas of the economy. After the fast increase in capacity in the 1980s, the industry faced over-capacity problems in

the 1990s leading to severe competition in some sub-sectors. However, until there are further studies of productivity in China during the 1990s, it will not be possible to say whether the high growth rates we found also reflect economic performance in other sectors of the economy.

Appendix A: Details of the Equation Transformation

The logarithm form of the Cobb-Douglas production function is specified as follows:

$$q_i = \alpha_O + \alpha_K k_i + \alpha_L l_i + \alpha_M m_i + \varepsilon_i \quad (1)$$

If l_i is subtracted from both side of the equation, the result is:

$$q_i - l_i = \alpha_O + \alpha_K k_i + \alpha_L l_i + \alpha_M m_i + \varepsilon_i - l_i \quad (1)\text{-}1$$

Equation (1)-1 can be transformed into the following forms:

$$q_i - l_i = \alpha_O + \alpha_K (k_i - l_i) + \alpha_M (m_i - l_i) + \varepsilon_i - (1 - \alpha_K - \alpha_M - \alpha_L) l_i \quad (1)\text{-}2;$$

$$q_i - (\alpha_K + \alpha_M + \alpha_L) l_i = \alpha_O + \alpha_K (k_i - l_i) + \alpha_M (m_i - l_i) + \varepsilon_i \quad (1)\text{-}3;$$

$$(\alpha_K + \alpha_M + \alpha_L)(q_i - l_i) - (\alpha_K + \alpha_M + \alpha_M - 1) q_i = \alpha_O + \alpha_K (k_i - l_i) + \alpha_M (m_i - l_i) + \varepsilon_i \quad (1)\text{-}4;$$

$$(q_i - l_i) = \frac{\alpha_O}{\alpha_K + \alpha_M + \alpha_L} + \frac{\alpha_K}{\alpha_K + \alpha_M + \alpha_L}(k_i - l_i) + \frac{\alpha_M}{\alpha_K + \alpha_M + \alpha_L}(m_i - l_i) + \frac{\alpha_K + \alpha_M + \alpha_L - 1}{\alpha_K + \alpha_M + \alpha_M} q_i + \frac{\varepsilon_i}{\alpha_K + \alpha_M + \alpha_M} \quad (1)\text{-}5.$$

If we let σ equal $\alpha_K + \alpha_M + \alpha_L$; β equal $\frac{\alpha_K + \alpha_M + \alpha_L - 1}{\alpha_K + \alpha_M + \alpha_L}$, or $\frac{\sigma - 1}{\sigma}$; α_k equal $\frac{\alpha_K}{\sigma}$; α_m equal $\frac{\alpha_M}{\sigma}$; α_o equal $\frac{\alpha_O}{\sigma}$; and e_i equal $\frac{\varepsilon}{\sigma}$, equation (1)-5 is transformed into:

$$q_i - l_i = \alpha_o + \alpha_k (k_i - l_i) + \alpha_m (m_i - l_i) + \beta q_i + e_i \quad (2)$$

Appendix B: The Durbin-Watson Test and the Resulting Data Transformation

Initial estimation of equation (2) in the text yielded results shown in Tables 4A.1, 4A.2, 4A.3 and 4A.4.

Table B.1 Initial Estimation Results (SOEs)

Total panel of observations 128

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (α_o)	-1.031888	0.770877	-10.03000	0.0000
k-l(α_k)	0.837566	0.101857	8.222991	0.0000
q(β)	0.102167	0.035384	16.45295	0.0000
R-squared	0.853975	Prob(F-statistic)		0.000000
Adjusted R-squared	0.851639	Durbin-Watson statistic		0.346567
F-statistic	365.5088			

Table B.2 Initial Estimation Results (Collectives)

Total panel of observations 110

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (α_o)	-0.303543	0.357493	-4.933088	0.0000
k-l(α_k)	0.777907	0.071111	0.814311	0.4173
q(β)	0.147974	0.044296	15.30536	0.0000
R-squared	0.858402	Prob(F-statistic)		0.000000
Adjusted R-squared	0.855756	Durbin-Watson statistic		0.274699
F-statistic	324.3310			

Table B.3 Initial Estimation Results (Joint Ventures)

Total panel of observations 118

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (α_o)	0.574311	0.587879	0.194446	0.8462
k-l(α_k)	0.799742	0.051696	4.250628	0.0000
q(β)	0.082472	0.032562	15.43145	0.0000
R-squared	0.825187	Prob(F-statistic)		0.000000
Adjusted R-squared	0.822147	Durbin-Watson statistic		0.560069
F-statistic	271.4237			

Table B.4 initial Estimation Results (Limited Liability Companies)

Total panel of observations 109

Constant (α_o)	0.222398	1.105602	0.201155	0.8410
k-l(α_k)	0.788370	0.097520	4.064512	0.0001
q(β)	0.075247	0.061223	5.786132	0.0000
R-squared	0.508335	Prob(F-statistic)		0.000000
Adjusted R-squared	0.499059	Durbin-Watson statistic		0.408346
F-statistic	54.79708			

Since the Durbin-Watson statistic in all the estimations were less than d_L at one percent level of significance, the data may suffer from the problem of autocorrelation. In order to derive efficient estimates of α_k and β, the data needed transforming. With the value of *d*, an estimate of ρ can be obtained using the following expression:

$$\hat{\rho} = \frac{N^2(1-d/2)+k^2}{N^2+k^2},$$

Where N is the number of observations and k is the number of coefficients (including the intercept). For example, ρ in the case of SOEs is

$$\hat{\rho} = \frac{(128)^2(1-0.346567/2)+3^2}{128^2+3^2} = 0.82772$$

Using this estimate, data were transformed as $((q-l)_{it} - \hat{\rho}(q-l)_{i(t-1)})$, $(q_{it} - \hat{\rho} q_{i(t-1)})$, and $((k-l)_{it} - \hat{\rho}(k-l)_{i(t-1)})$; the first observations were transformed as $\sqrt{(1-\hat{\rho}^2)}\ (q-l)_{i1}$, $\sqrt{(1-\hat{\rho}^2)}\ q_{i1}$ and $\sqrt{(1-\hat{\rho}^2)}\ (k-l)_{i1}$. With the transformed data, estimations were conducted again, using equation (2). The results of new estimation are shown in Tables 4.7, 4.8, 4.9 and 4.10 in the main body of the text.

Notes

[1] There are nine sub-sectors in the CEI according to the categorisation used in *the Yearbook of the Chinese Electronics Industry*, namely radar products, telecommunications equipment, TV and broadcasting equipment, computers, electronic components, electronic measuring appliances, electronic specific equipment, household electronic devices and instruments and electronic devices.

[2] These results can be obtained from the authors.

[3] The productivity figure for 1996 is particularly low and may represent under-reporting of output, reflecting data problems that can affect statistical work using Chinese official data. Nevertheless, our conclusion still broadly holds when the other years are reviewed.

[4] One important difference between the method used in this analysis and that of Jefferson, *et al* (1992) related to the data. In our study, province level data for each form of ownership for the years 1995 to 1999 were used, while in Jefferson *et al.* the data were cross-sectional. In addition, intermediate inputs were included in Jefferson *et al*'s model, but not in our model because of the lack of such data in the CEI. In order to offset the absence of intermediate inputs, value added instead of the gross value of industrial output (GVIO) was used as the output measure.

[5] Correctly, where price changes reflect a change in the *quality* of capital goods, the price deflator will misrepresent the true change in real value. However, given the short period involved this should not represent much of a problem in this study.

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