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POST-REFORM PRODUCTIVITY PERFORMANCE AND SOURCES OF GROWTH IN CHINESE INDUSTRY: 1980–85

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This paper examines the productivity growth and its sources in 39 Chinese industries in the post-reform period 1980–85. We use both the gross-output and value-added models to isolate the contributions of labor, capital, materials and technical efficiency to growth in industrial output. Using new data from the *National Industrial Census of China* (1988) for large and medium-size enterprises, we find that Chinese industries, in particular, those in the manufacturing experienced sharp increases in total factor productivity growth in the 1984–85 period as compared to the 1980–84 period. Moreover, collective and private enterprises show higher output and total factor productivity gains than do state enterprises. Our regression results show that total factor productivity gains are closely tied to increases in retained profits and the proportion of total employees that are technical workers. However, labor bonuses have a negative effect on total factor productivity growth.

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I. INTRODUCTION

A striking feature of Chinese economic policy in the past decade is the implementation of economic reforms that followed a period of stagnation in industrial productivity (e.g. see Rawski, 1984; Perkins, 1988; and Lardy, 1989). To promote economic growth, in December 1978 the Third Plenum of the Eleventh Central Committee of the Communist Party of China declared a strategic shift to a policy of economic modernization. One major goal of the new policy was to improve industrial productivity with various measures, including: (1) allowing the formation of private enterprises, (2) permitting state-owned and collective enterprises to retain a portion of their profits (3) devolving a greater degree of decision-making to factory managers and drastically reducing the scope of planning, (4) introducing material incentives such as bonuses to labor, and (5) increasingly relying on markets for inter-industry resource allocation.[1]

How successful have these reforms been? Recent studies show that they have been very successful in agriculture.[2] However, evidence from aggregate studies indicates that Chinese industrial total factor productivity (TFP) declined sharply

[1]Details of these measures are amply discussed in Field, 1984; Tidrick and Chen, 1987; Naughton, 1986; Byrd, 1987; Wu and Reynolds 1987; and others.

[2]For example, McMillan, Whalley, and Zhu (1989) found that output in the Chinese agricultural sector increased by over 61 percent between 1978 and 1984.

in 1982, four years after the initial reform in 1978.[3] This decline, among other things, led to a new wave of reforms in 1983 and 1984. These reforms include four major measures: (1) reducing the number of leadership positions in enterprises, (2) further expanding decision-making for enterprise managers, (3) substituting income taxes for remission of profits to the state, and (4) lifting the ceiling of bonuses.[4]

The purpose of this paper is to examine TFP growth and its sources in 39 Chinese industries (11 in non-manufacturing and 28 in manufacturing) in the post-reform period 1980–85. To do so, we calculate TFP growth rates for each industry for two periods 1980–84 and 1984–85. We then use regressions to analyze factors explaining differences in TFP growth across industries.

We undertake this research for the following important reason. Most previous studies on the post-reform economic performance of China are based on aggregate data at the national level (e.g. see Yeh, 1984; Naughton, 1987; and Perkins, 1988) or at the sectoral level (e.g. see Field, 1984; Kuan *et al.*, 1988; and McMillan, Whalley, and Zhu, 1989). These studies are important for evaluating China's post-reform economic performance at the macro level. However, analysis of individual industries should provide valuable insights into differences in productivity performance among industries and factors determining these differences (e.g. see Perkins, 1988; and Kuan *et al.*, 1988).

We use the new and most comprehensive data yet available on Chinese industries in the *National Industrial Census of China* (1988), which provides information on outputs, inputs, and other variables by branch of industry and by type of enterprise.[5] While the data set is valuable, as with most data sets, it is subject to certain limitations. Among other things, it does not contain data on input prices, and hence real inputs are measured with error. Also, the lack of detailed data on labor compensation and the allocation inputs to production and non-production activities makes it difficult to estimate the individual sources of TFP growth.

In spite of these data problems, our results are qualitatively robust, and provide several important findings. First, at the total industry level, the results uniformly show a positive change in TFP growth from 1980–84 to 1984–85. This improvement comes from manufacturing as non-manufacturing TFP declines in both periods. Second, the number of industries with positive TFP growth increases to 23 in 1984–85 compared to 12 in 1980–84, indicating that Chinese industries, in particular, those in manufacturing, responded quickly to the 1983 and 1984

[3]For example, Kuan *et al.*, 1988, found that between 1980-82 Chinese industrial TFP declined by an average annual growth rate of −1.90 percent using the revised data, and −3.99 using the original data. Further discussions of this TFP decline can also be found in other studies including Reynolds (1988) and Balassa (1987).

[4]We note that it is difficult to provide the exact timing of these measures as they were implemented gradually. Moreover, these reform measures were applied in certain regions before others sometimes even before they were officially declared. For example, Sichuan province began granting more authority to enterprise managers long before the official declaration of the new policy of economic modernization by the Third Plenum in December, 1978. Beginning in October, 1978, Sichuan granted broader decision-making authority to a group of six industrial enterprises, and expanded this to 100 enterprises in early 1979. For a more detailed discussion on the 1983 and 1984 reform measures, see Field, 1984, for example.

[5]Data by type of enterprise are available only at the total industry level.

reforms. Third, TFP growth rates are consistently greater for collective and private enterprises than for state enterprises during the both periods.[6] Finally, we find that increases in technical employment and retained profit have significantly positive effects on Chinese industrial TFP growth, whereas the effect of bonuses to labor is negative.

In the next section, we present the empirical models. A discussion of the data and calculations is given in section III. Section IV reports and discusses the estimated TFP growth rates. Section V examines the sources of TFP growth across industries and provides evidence on productivity differences by type of enterprise. The final section concludes the paper and offers suggestions for further research.

II. Model Specifications

Standard TFP analysis uses either the gross-output model or the value-added model, depending on the availability and quality of data, and units of analysis.

1. *The gross output model.* The conventional methodology for measuring TFP is based on a production function. For a three-input model, the production function is written in the following general form[7]

$$Q(t) = A(t)f[K(t), L(t), M(t)], \tag{1}$$

where $Q(t)$, $K(t)$, $L(t)$, $M(t)$ are output, capital, labor, and materials at time t; and $A(t)$ is an index of Hicks-neutral technical change or TFP at time t.

Differentiating (1) with respect to t, and with some algebraic manipulation, one obtains the following basic TFP growth model

$$\dot{a}_q(t) = \dot{q}(t) - w_{qk}\dot{k}(t) - w_{ql}\dot{l}(t) - w_{qm}\dot{m}(t) \qquad \text{(Model I)}, \tag{2}$$

where, $\dot{q}$, $\dot{a}$, $\dot{k}$, $\dot{l}$, and $\dot{m}$ are the growth rates of output, TFP, capital, labor, and materials at time t, and w_{qk}, w_{ql}, w_{qm} are output elasticities of capital, labor, and materials.

If constant returns to scale is assumed so that the output elasticities of the inputs sum to 1.0, then equation (3) can be rewritten as

$$\dot{a}_q(t) = \dot{q}(t) - (1 - w_{ql} - w_{qm})\dot{k} - w_{ql}\dot{l}(t) - w_{qm}\dot{m}(t) \qquad \text{(Model II)}, \tag{3}$$

Equations (2) and (3) partition output growth, $\dot{q}(t)$, into TFP growth, $\dot{a}(t)$, and elasticity-weighted growth rates of inputs.

2. *The valued added model.* Aggregate TFP analyses, including those studying Chinese economy, often use a value-added (or net output) model rather than the gross-output model (e.g. see Perkins 1988; Kuan *et al.*, 1988; and Jefferson, 1988). The value-added model allows the estimation of TFP growth without including materials inputs and is written as

$$\dot{a}_v(t) = \dot{v}(t) - w_{vk}\dot{k}(t) - w_{vl}\dot{l}(t) \qquad \text{(Model III)} \tag{4}$$

[6]Collective enterprises are those owned by "collectives," which include county, city, urban neighborhood, town, and people's commune. State enterprises are owned and operated by government departments, army units, scientific research institutes, etc.

[7]This methodology traces to the pioneering work of Solow (1957) and later used in many productivity studies such as those by Denison, 1967; Griliches and Jorgenson, 1967; and Lieberman, Lau, and Williams, 1990.

where $\dot{v}$, $\dot{k}$, $\dot{x}$, $\dot{a}_v$ denote the growth rates of value added, capital, labor and TFP, and w_{vk} and w_{vl} denote output elasticities of capital and labor.

Assuming constant returns to scale so that $w_{vk} + w_{vl} = 1.0$, then equation (4) is rewritten as

$$\dot{a}_v(t) = \dot{v}(t) - (1 - w_{vql})\dot{k}(t) - w_{vql}\dot{l}(t) \qquad \text{(Model IV)}. \tag{5}$$

The value-added model differs from the gross-output model in the concept of output. The gross-output measure includes all measurable inputs (e.g. capital, labor, materials, and energy) as sources of income, and is defined as total value of shipments of finished goods adjusted for inventory changes. In contrast, the value-added specification allocates the origins of output to the services of two conventional factors: capital and labor. Accordingly, value added is defined as gross output minus the value of purchased materials and service inputs.

If outputs and inputs are accurately measured, the gross-output model is the correct one because, as with capital and labor, materials is a legitimate substitutable input. In practice, however, the value-added model is often preferred when the analysis is undertaken at aggregate levels such as the whole economy or total manufacturing sector. At these levels of aggregation, double-counting problems are unavoidable in the gross-output measure because the output of one industry is often purchased by another industry for assembly into final goods. However, for analysis at micro levels of detail where there are little intra-industry sales, the gross-output model is required.

For analysis of individual industries such as ours, there are reasons for using either the gross-output or value-added model.[8] We, therefore, estimate TFP growth using both models. In all, we estimate four competing models, two for each output concept. Model I is the gross-output model specified in equation (2), where each w_{qi} is calculated independently. Model II is the same as model I, but the sum of output elasticities is assumed to be equal to 1.0, equation (3). Model III is the value-added model given in equation (4) where w_{vk} and w_{vl} are calculated independently. Finally, model IV is the value-added model in which w_{vk} is the residual of 1.0 minus w_{vl}, equation (5). Estimating these models allows us to analyze the sensitivity of calculated TFP growth and its trend to different measures of output and the associated elasticities.

III. Estimation And Data

1. *Estimation procedure.* Estimation requires data on output (Q or V), capital (K), labor (L), materials (M) and output elasticities (w). While data on Q, K, L, and M are available, data on w are unobserved. Ideally, the elasticities should be estimated using a general production model that does not impose restrictive

[8]An argument for the value-added model is that, even at the individual industry level, double-counting still exists. However, many argue that the value-added model is valid only if capital and labor are weakly separable from materials. Several studies have formally tested and rejected this condition even at the total manufacturing level. For example, to test this condition, Berndt and Wood (1975) used U.S. manufacturing data. They concluded that "the separability conditions for the value added specification are not satisfied by the data for United States manufacturing, 1947–71." (see p. 266.)

assumptions about input and output markets, and production technologies. Since we have only three observations for each industry (one for each of the years 1980, 1984, and 1985), it is not feasible to estimate output elasticities for each industry based on a production model. The lack of data obliges us to use output shares as proxies for output elasticities. In turn, the use of output shares will produce biased TFP growth rates because output elasticities can only be identified with output shares when markets are competitive. Even with the recent economic reforms, Chinese markets are far from competitive, and therefore output shares are biased estimates of output elasticities, and the resulting TFP growth rates are also biased.

Nonetheless, even though TFP growth estimates are biased, estimates of *changes* in TFP growth from one period to another are not expected to be qualitatively affected by the bias. This is because changes in TFP growth are primarily associated with the percentage change, not the magnitude, of output elasticities. If output elasticities are stable and the bias is constant, then it can be shown that the error of the change in TFP growth equals the bias multiplied by the change in the growth rates of inputs.[9] Since the studied period is relatively short (1980–85) and the reforms were gradually implemented, we do not expect substantial changes in output elasticities.[10] Thus, our analysis of changing TFP growth should provide a reasonable qualitative evaluation of Chinese industrial TFP performance in the post-reform period.

2. *Data and sources.* The data are taken from the People Republic of China's *National Industrial Census* (1988), which reports data for 43 branches of industry for three years 1980, 1984 and 1985. These data were collected from large and medium enterprises, which account for about half of China's industrial output. Our analysis includes only 39 of the 43 industries because inconsistencies are present in the data for the remaining four industries. The 39 industries under study account for 95 percent of total output (either measured in gross output or value added) of all 43 industries.

a. *Output measures.* Data on gross output are available in both current and 1980 constant yuans. We derive an output price deflator by dividing gross output valued in current yuans by its 1980 constant yuan value. Data on value added are available only in current yuans. To obtain "real" value added we divide value added in current yuans by the derived output price deflator.

b. *Capital input.* Data on the capital stock, KS, are directly available in the data set. They are calculated by adding each year's investment, I_t, to the sum of assets from previous years less depreciation. That is,

$$KS_t = (1-\delta)KS_{t-1} + I_t, \tag{6}$$

where δ is a depreciation rate.

[9]For example, if the bias in the estimate of output elasticity for each input is 10 percent, and the change in the growth rate of each input is 10 percent, then in a three factor model the error in the change of TFP equals 3 percent, which is small.

[10]Because the models employed in this study use different sets of output shares in calculating TFP growth, comparisons of the results provide a test for the sensitivity of TFP growth and its trends to different values of output elasticities.

Thus, the capital stock is calculated using the widely used perpetual inventory method. However, there are problems with the data reported in the *National Industrial Census*. In particular, each year's investment is valued at current prices, and KS_t and KS_{t-1} are valued at original purchase prices. This means that changes in prices of capital goods lead to bias in the measure of capital stock. To obtain a "real" capital stock we need data on prices of capital goods. Unfortunately, these data are not provided. Therefore, we develop an output-weighted price index, *PK*, using output prices of five capital goods producing industries as deflators for the capital stock.[11] Thus, our real capital stock, *KR*, is calculated as

$$KR_t = K_tS_t / PK_t. \tag{7}$$

It is widely accepted that the appropriate measure of capital input for production and productivity analyses is capital services rather than capital stock (e.g. see Jorgenson and Griliches, 1972; and Berndt and Wood, 1975). Since the data used to construct a capital service price (and hence value of capital services) are not available, we assume that the value of capital services, *K*, equals the value of capital depreciation.[12] Thus, our proxy for *K* is

$$K_t = \delta_t KR_t \tag{8}$$

where δ_t is derived by dividing total expenditure on capital depreciation by total values of capital stock in year *t*.

c. *Labor input.* Data on the total number of employees for each industry are available. However, the reported number includes both production related workers and workers providing employee services such as education, health care, and other activities. We include only production related workers in our measure of labor input by subtracting the number of workers providing non-production related services from total number of employees.

d. *Materials.* Data on materials used in production are available only in current yuans. Since data on materials prices are not available, we divide these data by the derived output deflator to obtain data on "real" materials input. This procedure implies that the price of materials relative output price equals 1.0 through time. If this assumption is violated, then our estimated growth rate of materials is biased. For example, if the relative price of materials increases over time and materials use is stable (or declining), then deflating materials by output deflators will overestimate the growth rate of materials and therefore underestimate TFP growth. Also, if output shares are used as proxies for output elasticities, and constant returns to scale is assumed, deflating materials by output deflators yields a materials/output ratio equal to the materials' output share. Under these circumstances, the magnitudes of both TFP growth and decline obtained from

[11]These five industries are (1) engineering industry, (2) traffic transport equipment, (3) electric equipment and appliances, (4) electronic and telecommunication equipment, and (5) instruments and meters.

[12]We note that depreciation expenditures may be arbitrary and depend on accounting practices. However, our calculations show that the depreciation rate for Chinese industries are rather stable over time (1980–85). An alternative approach is using the capital stock as a proxy for capital input; however, this will not alter our results because as shown in equation (8) our measure of capital input, *K*, is proportional to the capital stock.

the value added model are much greater than those from the gross-output model in the years after the base year [see Baily, 1986, equation (4), p. 86].

e. *Output shares of inputs.* Labor's output share is calculated by dividing total labor compensation (including wages, W, social welfare and security expenditures, SW, and expenditures on services provided by the non-production related capital stock, k_0)[13] by the value of gross output, VQ, (in the gross output models) and by value added, VA, (in the value-added models). That is,

$$S_{qlt} = (W_t + WS_t + k_{ot}) / VQ_t, \tag{9}$$

and

$$S_{vlt} = (W_t + WS_t + k_{ot}) / VA_t. \tag{10}$$

Materials' output share is obtained by dividing the total value of materials, (VM), by the total value of gross output, VQ,

$$S_{qmt} = VM_t / VQ_t. \tag{11}$$

Capital's output share is calculated in different ways, depending on the particular model used. In model I, we calculate the capital share independently by

$$S_{qkt} = (\text{TAX} + \text{PROFIT}) / VQ_t. \tag{12}$$

This calculation is based on the assumption that returns to capital equal the sum of tax and profit.[14] Similarly, in model III the capital's output share is

$$S_{vkt} = (\text{TAX} + \text{PROFIT}) / VA_t. \tag{13}$$

In models II and IV, we assume that output shares of inputs sum to 1.0, and the share of capital is a residual. That is,

$$S_{qkt} = 1 - S_{qlt} - S_{qmt}, \tag{14}$$

and

$$S_{vkt} = 1 - S_{vlt}. \tag{15}$$

After calculating S_{qit} and S_{vjt} $(i = K, L, M$ and $j = K, L)$, we use them to approximate w_{qit} and w_{vit} in equations (2)-(5) as follows:

$$w_{qit} = \tfrac{1}{2}(S_{qit} + S_{qit-1}), \tag{16}$$

[13]Non-production capital includes those providing services to employees and their families such as living quarters, schools, nurseries, hospitals, etc. Since data on the value of non-production related capital services, K_0, are not available, we use depreciation expenditure on non-production related capital as a proxy for k_0.

[14]Opinions are divided among economists regarding the issue of whether output shares of inputs should add up to 1.00. For example, Jorgenson and Griliches (1972) assert that "[*f*]or any concept of gross output the fundamental accounting identity for productivity measurement is that the value of output is equal to the value of input" (p. 67). It follows that output shares of inputs must add up to 1.00. In response to the Jorgenson-Griliches critique, Denison (1972) rejects the practice of "counting whatever is not labor earnings as capital earnings," and strongly argues that "[*p*]roductivity change is precisely a measure of the degree to which the identity does not hold. There is no such accounting relationship between inputs and output at constant prices by any method of valuation. The two must be defined and calculated independently" (p. 100). In any event, our purpose of using both methods of calculating capital's output share is to test the sensitivity of the estimated TFP growth to different sets of output shares.

and

$$(17) \qquad w_{vit} = \tfrac{1}{2}(S_{vit} + S_{vit-1}).$$

Substituting w_{qit} into equations (2) and (3), and w_{vit} into equations (4) and (5) yields 4 Tornqvist indexes of TFP growth.

To analyze the sources of TFP growth, we run regressions with TFP growth rates as the dependent variable. The exploratory variables include the number of engineers and technical employees, computers, retained profits, and bonuses, which are available in the data set. Details on the data and variable measurement are fully discussed in McGuckin *et al.* (1990), and can be obtained upon request.

IV. Total Factor Productivity Growth Estimates

Tables 1 and 2 show the contributions to output growth for each of the four models for gross output and value added measures of output. As expected, the magnitude of the calculated TFP growth rates is affected by different measures of output. The results indicate that the magnitude of both TFP decline and TFP growth obtained from the value-added models are consistently greater than those from the gross-output models. This is expected since, as noted above, for the

TABLE 1

Contribution to Output Growth: KLM Gross Output Model

(Weighted Means)

	Model I			Model II		
	Unrestricted Capital's Share $S_{qk} = (\text{Tax} + \text{Profit})/Q$			Restricted Capital's Output Share $S_{qk} - 1 - S_{ql} - S_{qm}$		
	1980–84	1984–85	Change	1980–84	1984–85	Change
Total Industry						
TFP growth	−0.0107	0.0120	0.0227	−0.0156	0.0055	0.0211
Output growth	0.0669	0.1137	0.0468	0.0669	0.1137	0.0468
Capital growth	0.0325	0.0272	−0.0053	0.0377	0.0337	0.0040
Labor growth	0.0030	0.0021	−0.0009	0.0030	0.0021	−0.0009
Materials growth	0.0421	0.0723	0.0302	0.0419	0.0723	0.0304
Non-Manufacturing						
TFP growth	−0.0042	−0.0013	0.0029	−0.0053	−0.0051	−0.0002
Output growth	0.0098	0.0179	0.0081	0.0098	0.0179	0.0081
Capital growth	0.0094	0.0079	0.0015	0.0113	0.0117	0.0004
Labor growth	0.0008	0.0007	−0.0001	0.0008	0.0007	−0.0001
Materials growth	0.0038	0.0106	0.0068	0.0030	0.0106	0.0076
Manufacturing						
TFP growth	−0.0065	0.0133	0.0198	−0.0102	0.0106	0.0208
Output growth	0.0571	0.0957	0.0386	0.0571	0.0957	0.0386
Capital growth	0.0231	0.0194	−0.0037	0.0263	0.0220	−0.0043
Labor growth	0.0022	0.0014	−0.0008	0.0022	0.0015	−0.0007
Materials growth	0.0383	0.0617	0.0234	0.0388	0.0617	0.0229

Note: Means weighted by gross output.

TABLE 2
CONTRIBUTION TO OUTPUT GROWTH: KL VALUE ADDED MODEL
(Weighted Means)

	Model III			Model IV		
	Unrestricted Capital's Output Share $S_{vk} = (\text{Tax} + \text{Profit})/Q$			Restricted Capital's Output Share $S_{vk} = 1 - S_{vl}$		
	1980–84	1984–85	Change	1980–84	1984–85	Change
Total Industry						
TFP Growth	−0.0398	0.0163	0.0561	−0.0423	0.0152	0.0575
Output Growth	0.0556	0.0969	0.0413	0.0556	0.0969	0.0413
Capital Growth	0.0874	0.0747	−0.0127	0.0898	0.0759	0.0139
Labor Growth	0.0080	0.0559	−0.0061	0.0080	0.0059	−0.0021
Non-Manufacturing						
TFP Growth	−0.0125	−0.0119	−0.0006	−0.0144	−0.0137	−0.0007
Output Growth	0.0151	0.0116	−0.0035	0.0151	0.0116	−0.0035
Capital Growth	0.0255	0.0215	0.0040	0.0275	0.0234	0.0041
Labor Growth	0.0021	0.0019	−0.0002	0.0021	0.0019	−0.0002
Manufacturing						
TFP Growth	−0.0274	0.0282	0.0556	−0.0279	0.0289	0.0560
Output Growth	0.0405	0.0854	0.0449	0.0405	0.0854	0.0449
Capital Growth	0.0619	0.0532	−0.0087	0.0624	0.0524	−0.0100
Labor Growth	0.0059	0.0040	−0.0019	0.0059	0.0040	−0.0019

Note: Means weighted by value added.

Chinese economy in this period value added TFP growth should be greater than that found for the gross output [Baily, 1986, equation (4)]. The trend of TFP growth is unaffected by output specifications and the associated output shares. As discussed earlier, lack of bias in the change in TFP measures is expected because any bias in the estimated TFP growth is likely to be constant during the 1980–85 period. Indeed, all four models show a strong TFP improvement in manufacturing, and a continuous TFP decline in non-manufacturing throughout the period. Finally, the models based on restricted capital shares yield greater values of TFP decline and smaller values of TFP growth than the models estimated with restricted capital shares. However, the differences are rather small.

Since the results from the four models are qualitatively similar, and due to space limitation, we report and discuss only the results for individual industries obtained from model I.[15] Tables 3 and 4 show that output for both manufacturing and non-manufacturing grew throughout 1980–85. However, output in manufacturing grew much faster than that in non-manufacturing (from a rate of 5.71 percent per year in 1980–84 to 9.57 percent in 1984–85 for manufacturing and from 0.98 percent to 1.79 percent for non-manufacturing). During 1980–84, output growth in both sectors is primarily attributable to the growth in capital and materials as the contributions of labor and TFP are close to zero. However, in 1984–85 TFP growth made a significant contribution to output growth in manufacturing. Non-manufacturing TFP continued to be negative in 1984–85, but smaller

[15]Interested readers can obtain the results from all models upon request.

TABLE 3

CONTRIBUTIONS TO GROWTH OF OUTPUT: 1980–84

(Annual average growth rates obtained from Model I)

Nonmanufacturing	TFP Growth	Output Growth	Capital Growth	Labor Growth	Materials Growth
1. Coal	0.002540	0.035399	0.01001	0.0080890	0.01476
2. Pet. and Gas	−0.013566	0.022840	0.03837	0.0027285	−0.004696
3. Ferrous[1]	0.004822	0.031186	0.02318	−0.0003189	0.003505
4. Non-Ferrous[2]	−0.016826	0.031688	0.02562	0.0058732	0.017021
5. Bldg. Materials	−0.010433	0.015284	0.02443	0.0036433	−0.002354
6. Salt	−0.007833	0.007579	0.00370	−0.0003656	0.012080
7. Logging	−0.022268	0.013440	0.02737	0.0097451	−0.001405
8. Water	−0.035357	0.050715	0.04871	0.0056356	0.031724
9. Feeds	−0.007375	0.072233	0.02414	0.0036136	0.051849
10. Electricity	−0.036427	0.099630	0.08041	0.0060510	0.049600
11. Coke	−0.072618	0.098768	0.14050	0.0015790	0.029305
Manufacturing					
12. Food	0.082356	0.69973	0.045787	0.0076826	0.56391
13. Beverage	−0.026163	0.04790	0.030602	0.0036539	0.03980
14. Tobacco	0.006953	0.04646	0.017710	0.0012428	0.02055
15. Textiles	−0.012505	0.01963	0.017161	0.0038680	0.01111
16. Clothing	−0.020150	0.03165	0.019669	0.0041396	0.02799
17. Leather	−0.024196	0.03299	0.017476	0.0022475	0.03746
18. Woodprod	−0.019494	0.04795	0.021787	0.0023476	0.04311
19. Furniture	0.026832	0.08544	0.026947	0.0024681	0.02919
20. Paper	−0.014247	0.08507	0.046739	0.0022743	0.05030
21. Printing	−0.048759	0.06080	0.041499	0.0064995	0.06156
22. Culture	−0.013785	0.05381	0.037335	0.0019446	0.02867
23. Artcraft	−0.021241	0.03737	0.043772	0.0006164	0.01438
24. Pet. Refinery	0.003785	0.02203	0.008727	0.0038417	0.00624
25. Chemical	−0.018214	0.06975	0.038356	0.0018556	0.04808
26. Medicine	0.008437	0.12299	0.032786	0.0029119	0.07922
27. Fibres	0.004924	0.19071	0.055250	0.0041985	0.12708
28. Rubber	−0.020902	0.05556	0.033146	0.0016675	0.04187
29. Plastics	−0.015206	0.11752	0.033715	0.0028202	0.09654
30. Nonmetal	−0.006887	0.05873	0.029717	0.0050560	0.03160
31. Ferrous[3]	−0.001070	0.04485	0.025181	0.0022552	0.01893
32. Non-Ferr.[4]	−0.014417	0.04625	0.017112	0.0022455	0.04177
33. Metal Work	−0.009668	0.06418	0.026314	0.0029782	0.04498
34. Engineering	0.005472	0.09256	0.017231	0.0033700	0.06702
35. Trans. Eq	0.015513	0.09646	0.011594	0.0027269	0.06711
36. Elec. Eq	−0.000186	0.09908	0.025831	0.0027794	0.07106
37. Comm. Eq	0.044330	0.23383	0.028067	0.0043119	0.15773
38. Instrument	0.018333	0.09490	0.021062	0.0040803	0.05203
39. Other	−0.084403	0.03492	0.077092	0.0070295	0.03511
Weighted Means					
Nonmanufacturing	−0.0042	0.0098	0.0094	0.0008	0.0038
Manufacturing	−0.0065	0.0571	0.0231	0.0022	0.0383
Total Industrial Sector	−0.0107	0.0669	0.0325	0.0030	0.0421

[1]Ferrous metal ore mining.
[2]Non-ferrous metal ore mining.
[3]Ferrous metal smelting.
[4]Non-ferrous metal smelting.

TABLE 4
CONTRIBUTIONS TO GROWTH OF OUTPUT: 1984–85
(Results obtained from Model I)

Nonmanufacturing	TFP Growth	Output Growth	Capital Growth	Labor Growth	Materials Growth
1. Coal	0.030059	0.06825	0.02109	0.0030377	0.01407
2. Pet. and Gas	0.013300	0.10830	0.02676	0.0064515	0.061775
3. Ferrous[1]	−0.079679	0.02698	0.10300	0.0068450	−0.003177
4. Non-Ferrous[2]	0.098424	0.18369	0.00530	0.0026065	0.077360
5. Bldg. Materials	−0.047267	−0.02030	−0.01193	0.0048625	0.034032
6. Salt	−0.076018	−0.06837	−0.00459	−0.0010228	0.013265
7. Logging	0.013748	−0.01749	−0.02711	0.0038093	−0.007930
8. Water	−0.014628	0.09030	0.03559	0.0017002	0.067642
9. Feeds	−0.002981	0.06690	0.01988	0.0030761	0.046925
10. Electricity	−0.039597	0.13781	0.07876	0.0067553	0.091889
11. Coke	−0.061453	0.14274	0.10696	0.0008554	0.096380
Manufacturing					
12. Food	0.021332	0.23862	−0.015824	0.0012405	0.23187
13. Beverage	−0.003368	0.05978	0.027695	0.0016283	0.03382
14. Tobacco	−0.013312	0.07913	0.023119	0.0018138	0.06751
15. Textiles	−0.002201	0.05366	0.012732	0.0000978	0.04303
16. Clothing	−0.021422	−0.00527	0.011556	0.0016636	0.00293
17. Leather	0.017523	0.11585	0.021772	0.0024564	0.07410
18. Woodprod	0.008437	0.09305	0.037903	0.0023066	0.04441
19. Furn	−0.032760	0.14028	0.025078	0.0003549	0.14761
20. Paper	−0.009596	0.20145	0.051374	−0.0015124	0.16119
21. Printing	0.020326	0.08182	0.014507	−0.0014121	0.04840
22. Culture	0.028344	0.09430	0.011658	0.0020671	0.05223
23. Artcraft	0.007525	0.07231	0.020793	0.0006509	0.04334
24. Pet. Ref	0.020005	0.05338	0.019182	0.0045304	0.00966
25. Chemical	0.002048	0.06143	0.005426	0.0014100	0.05255
26. Medicine	0.015910	0.14667	0.010949	0.0017930	0.11802
27. Fibres	0.099429	0.24180	0.014841	0.0026930	0.12484
28. Rubber	0.016707	0.12953	0.017210	0.0018317	0.09379
29. Plastics	−0.037737	0.12792	0.071618	0.0022063	0.09183
30. Nonmetal	0.006004	0.11397	0.044410	0.0040046	0.05956
31. Ferrous[3]	−0.018696	0.07947	0.036619	0.0019126	0.05964
32. Non-Ferr.[4]	0.027327	0.11080	0.010688	0.0013435	0.07144
33. Metal Wk	0.025807	0.14420	0.022077	0.0024979	0.09382
34. Engineering	0.040080	0.16663	0.021069	0.0015626	0.10392
35. Trans. Eq	0.056603	0.17572	0.022841	0.0024832	0.09379
36. Elec. Eq	0.046583	0.23305	0.032391	0.0023926	0.15168
37. Comm. Eq	0.028764	0.31311	0.052390	0.0023031	0.22965
38. Instrument	0.054141	0.14254	0.008611	0.0005371	0.07925
39. Other	−0.045876	0.12147	0.072588	−0.0006650	0.09542
Means					
Nonmanufacturing	−0.0013	0.0179	0.0079	0.0007	0.0106
Manufacturing	0.0133	0.0957	0.0194	0.0015	0.0617
Total Industrial Sector	0.0120	0.1136	0.0272	0.0021	0.0723

[1]Ferrous metal ore mining.
[2]Non-ferrous metal ore mining.
[3]Ferrous metal smelting.
[4]Non-ferrous metal smelting.

in magnitude compared to that in 1980–84 (−0.13 percent in 1984–85 compared to −0.42 percent per year in 1980–84).

At the total industry level, TFP declined at an average annual growth rate of −1.07 percent during 1980–84, and increased by 1.20 percent in 1984–85. While we cannot compare our results directly with those in previous studies due to differences in units of analysis, data used, and period examined, our findings are consistent with those in aggregate studies such as those by Field, 1984, Yeh, 1984, Chen, 1986, Chen and Sang, 1986, and Pan, 1986. In particular, our estimate of a TFP decline of 1.07 percent per year during 1980–84 is consistent with the average industrial TFP decline between 0.1 and 1.2 percent for the period 1978–83 reported by Tidrick, 1986. However, our results differ from those by Kuan *et al.*, 1988, who found dramatic increases in Chinese industrial TFP at an average annual growth rate ranging from 2.7 to 3.1 percent for 1980–84, and from 15.3 to 18.2 percent for 1984–85.[16]

There are several possible reasons explaining why our results differ from those by Kuan *et al.*, but the major reason is that the differences stem from the fact that the two studies use two different sets of data. We use census data for medium and large enterprises for 3 years 1980, 1984, and 1985. Our data cover all three types of enterprises (i.e. state, collective, and private). In contrast, Kuan *et al.* used aggregate time-series data (1952–85) for *independent accounting units* within state-owned industry only, but including enterprises of all sizes (i.e. small, medium, and large). While these independent accounting units are owned by the state, they operate independently of the state, much as collective and private enterprises in terms of decision-making, signing contracts, and seeking profits.[17] Thus, while the high estimates for 1984–85 by Kuan *et al.* appear striking, they are not surprising in light of our findings. In fact when we apply our data to estimate a value-added model (which was also used by Kuan *et al.*), we obtain an estimate of TFP growth rate of 6.10 percent for the collective sector, and 10.50 percent for the private sector for the period 1984–85. The remaining difference between 10.50 percent (ours) and 15 to 18 percent (theirs) could be attributed to data coverage. That is, our data include medium and large enterprises of all types of ownership, while theirs include only independent accounting enterprises of all sizes within the state-owned industry.[18] Thus, our finding that the Chinese industrial sector experienced a clear improvement in TFP during 1984–85 compared to that during 1980–85 is consistent with Kuan *et al.*'s results.

Examining individual industries, we find that the number of industries with positive TFP growth doubles to 23 in 1984–85 from 12 in 1980–84. If one judges the performance of industries by looking at the change in their TFP growth rates between 1980–84 and 1984–85, then 28 of the 39 industries had a positive performance. Among the 11 industries with negative changes, two industries

[16]These estimates are based on their revised data, Table 4, p. 583.

[17]An enterprise is classified as an independent accounting unit if it (1) has an independent administrative organization, (2) is able to account independently for its profits and losses, and (3) is allowed to sign contracts with other units and to open an independent bank account.

[18]Due to the *Review*'s space limit, we report only the results of the estimated TFP growth rates by type of enterprises based on the gross-output model I. The results from models II, III, and IV can be obtained upon request.

(food and communication equipment) had TFP that continued to grow through 1980–85, but at a decreasing rate. Thus, by 1985 only 4 industries in non-manufacturing (ferrous metal ore mining, building materials, salt mining, and electric industries) and 5 in manufacturing (tobacco, clothing, furniture, plastic, and ferrous metal melting) were experiencing declining TFP growth.

In sum, the results indicate that the reform measures in 1983 and 1984 had a positive effect on the TFP performance in most industries. Output in both manufacturing and non-manufacturing sectors grew at increasing rates from 1980–84 to 1984–85. While the growth in capital and materials inputs was responsible for the growth in output during 1980–84, TFP growth began to improve in 1984–85 and contributed to output growth of individual industries, in particular, those in manufacturing.

V. Sources of Total Factor Productivity Growth

Analysis of the sources of TFP growth is divided into two parts. We first look at the effect of enterprise type on observed TFP growth. We then examine other factors affecting TFP growth using cross-section regressions.

1. *Enterprise organization. Ceteris paribus,* if one type of enterprise exhibits substantially greater productive efficiency than another, then this information provides guidance to policy-makers. In light of the emphasis on decentralization of economic decision-making in China, we expect that collective and private enterprises would obtain greater TFP growth than that in the state sector.

As with the results for the 39 industries, the results for the types of enterprise obtained from the 4 models are qualitatively similar. Again, because of the space limits we report only the results of model I in Table 5. From the table, it is clear that output growth in the collective and private sectors is more than two times as large as that observed in the state sector in both 1980–84 and 1984–85 periods. Most strikingly, TFP growth in collective and private enterprises is positive in both periods, while that in state enterprises is negative in 1980–84 and shows a small increase (less than 0.5 percent) in 1984–85. Moreover, the increase in TFP growth during the two periods in the collective sector is impressively rapid, from 0.78 percent in 1980–84 to 2.14 percent in 1984–85. The results are even more impressive for the private sector in which TFP grew from 0.12 percent in 1980–84 to almost 3.50 percent in 1984–85. This result supports Field's finding that by 1982, "collective sector out-performed the state sector—even in heavy industry" (Field, 1984, p. 751).

The above results strongly suggest that collective and private enterprises are able to increase their productivity in the era of economic reforms far better than state owned enterprises. In light of the advantages that state owned enterprises are purported to have, access to state allocated inputs at lower prices, and better manufacturing facilities, these findings are striking.

2. *Inter-industry differences.* In examining factors that systematically linked to observed differences in the estimated TFP growth rates across industries, we focus on two types of variables, one representing factors associated with technical progress and the other associated with incentives to individual enterprises. We note that this analysis does not determine causality. For example, our simple

TABLE 5

PRODUCTIVITY GROWTH RATES BY TYPE OF ENTERPRISE

(Results obtained from Model I)

Growth Rates by Enterprise Type	Period 1980–84	1984–85	Changes
Output Growth*			
Total	0.0673	0.1155	0.0482
State	0.0653	0.1118	0.0467
Collectives	0.1766	0.2505	0.0739
Other	0.1496	0.2418	0.0922
Multifactor Productivity Growth*			
Total	−0.0040	0.0055	0.0095
State	−0.0045	0.0044	0.0089
Collective	0.0078	0.0214	0.0136
Other	0.0012	0.0343	0.0331
Weighted Capital Growth*			
Total	0.0280	0.0346	0.0066
State	0.0278	0.0346	0.0068
Collective	0.0399	0.0411	0.0012
Other	0.0372	0.0339	−0.0033
Weighted Labor Growth*			
Total	0.0030	0.0021	−0.0009
State	0.0029	0.0021	−0.0008
Collective	0.0053	0.0027	−0.0026
Other	0.0051	0.0020	−0.0031
Weighted Materials Growth*			
Total	0.0404	0.0733	0.0329
State	0.0388	0.0706	0.0318
Dollective	0.1237	0.1853	0.0616
Other	0.1062	0.1716	0.0654

*Data for state, collective, and other enterprises are available only at the aggregate industry level and add up to the total of 43 branches of industries. Thus, the figures for *total* industry in this table are not equal to those reported in Tables 2 and 3 where *total* industry includes only 39 industries.

regression analysis cannot distinguish between the hypothesis that bonus payments lead to higher TFP growth and the hypothesis that bonuses are a reward for past productivity.

With this caveat we proceed to the regressions with TFP growth rates used as the dependent variable. There are many possible explanatory variables, but based on the available data, we use the proportion of engineers and technical employees to total employment (Eng/L) as a factor affecting progress. Another variable is the number of computers per employee (Comp/L). Two versions of

TABLE 6

SOURCES OF MULTIFACTOR PRODUCTIVITY GROWTH, DEPENDENT VARIABLE: MULTIFACTOR PRODUCTIVITY GROWTH RATE, 1980-85

(t-statistics in parentheses)
Independent Variables

	Constant	(ENG/L)	(%PROF/K)	(%B/L)	(COMP/L)	$\bar{R}^2$
1. $N=39$	−0.027**	0.450**				0.21
	(3.70)	(3.29)				
2. $N=38$	−0.016**		0.008**			0.23
	(3.54)		(2.71)			
3. $N=39$	−0.024**			0.024*		0.09
	(2.65)			(2.17)		
4. $N=39$	−0.018**				12.972*	0.17
	(3.31)				(2.97)	
5. $N=38$	−0.007	0.476**	0.005	−0.041**		0.41
	(0.65)	(3.76)	(1.55)	(2.64)		
6. $N=36$	−0.030**	0.419**	0.003			0.32
	(4.72)	(3.00)	(1.02)			
7. $N=36$	−0.006**	0.470**	0.005	−0.042**		0.42
	(0.58)	(3.57)	(1.69)	(2.62)		
8. $N=36$	−0.017	0.452**	0.005	−0.031*		0.47
	(1.79)	(4.02)	(1.88)	(2.28)		
9. $N=36$	−0.40	1.258*	0.018**	−0.097**		0.61
	(1.82)	(4.77)	(2.87)	(3.03)		
10. $N=36$	−0.048*	1.189**	0.018**	−0.084**		0.59
	(2.25)	(4.58)	(2.84)	(2.67)		

*Denotes "significant" at the 5-percent level.
**Denotes "significant" at the 1-percent level.

this variable are used, one is the number of computers used in production, and the other is the total number of computers operated. In either case, data on the number of computers are only available for 1985. Since most computers were installed after 1980, the computer variable measures the growth of this specialized capital during the 1980-85 period.

We use two variables to capture the effects of incentive payments on TFP growth. The first is the percentage change in retained profits taken as a proportion of capital assets ($\%Prof/K$). The second is the percentage change in bonus wages per employee ($\%B/L$), which is designed to assess the extent to which labor is paid based on efficiency gains.

Table 6 reports OLS estimates of the regressions. The dependent variable in the first 7 regressions is the TFP growth rates estimated using model I, while that in regressions 8, 9, and 10 is those obtained from models II, III, and IV. The first four equations show the regressions of each variable alone on the dependent variable for the entire sample. (There is one less observation for equation (4) since the variable ($\%Prof/K$) was not available for one industry.) Both the ($Comp/L$) and (Eng/L) variables are significant alone. Since the two variables have a correlation coefficient of 0.85, multicollinearity is the reason why they are insignificant when both are included in the regression. Industries with substantial technical employment also have substantial numbers of computers, and vice versa.[19]

The bonus variable is significantly positive when all 39 industries are used in the analysis. However, this result was not robust. In addition to the full sample we estimate the model for three subsets of the data; with three main outliers removed based on an influence statistic, with the six industries which have substantial differences between the constrained and unconstrained capital share estimates deleted; and for manufacturing only. Regressions 6–10 are based on dropping the three observations with an influence statistic outside an acceptable range. The results uniformly indicate that after dropping outliers and including the engineer and profit variable in the model, the bonus variable is significantly associated with *decreases* in TFP change.[20] There are two reasons that could lead to a negative coefficient for the bonus variable. First, bonuses are positively related to retained profit (i.e. enterprises that retained a high rate of profit tend to award large bonuses to labor) and hence collinearity arises. Second, while bonuses are supposed to reward performance, in most state-owned enterprises they are distributed evenly among all workers regardless of productivity (see Ma, 1983). In light of the finding that TFP growth in the state sector is low, the negative coefficient for the bonus variable may not be unreasonable.

The coefficient for the retained profit variable is positive and statistically significant at the one percent level when TFP growth rates are calculated using the value-added models. However, its significance declines when the dependent variable is calculated based on the gross-output models.

VI. Concluding Remarks

In this study, we examine TFP growth and its sources in 39 Chinese industrial branches in the post-reform period 1980–85, using the new data taken from the *National Industrial Census of China* (1988). In spite of certain data problems, our results are qualitatively robust, and provide several important findings.

First, the estimates uniformly show that TFP grew strongly in manufacturing and declines in non-manufacturing throughout 1980–85. Second, there is evidence that collective and private enterprises are able to increase their productivity in the era of economic reforms far better than state-owned enterprises. Third, enterprises that employ a higher rate of technical employees and retain a larger portion of profits experience *increases* in TFP *growth*. Finally, bonuses to labor do not reflect observed gains in TFP growth.

While the above conclusions are drawn with certain degree of confidence, we emphasize that they are by no means definite. This is, in part, because the

[19]We tried to ascertain an independent effect for computers by regressing the engineer variable on the computer measure and then introducing the residual (the portion of computer not linearly associated with the proportion of engineers and technical employees), into the regression. We are unable to find any significant effect of this residual on the TFP growth rate independent of the proportion of engineering employment.

[20]Moreover, the negative coefficient is also found when we use the percentage change in the bonus/labor ratio measured over the 1980–84 period rather than the 1980–85 period in an attempt to introduce a lag in the relationship because of the causality problem mentioned above.

available data do not allow us to apply a more general model that can accurately describe the Chinese economy. More specifically, our use of output shares rather than output elasticities could lead to biases in TFP growth estimates. Also, as mentioned repeatedly, our data are subject to limitations, and the constructed variables such as capital input may contain measurement errors, which could also lead to biased TFP growth estimates.

The above limitations suggest several areas for additional research. One important area is collecting more data to estimate output elasticities based on a general production model. Analysis at a more disaggregate level and use of provincial data from China's industrial census should help in this regard. In a similar vein, further research on pricing and capital valuation is needed. International price comparisons, such as those undertaken by the United Nations International Comparisons Project (ICP), might be used to revalue capital and output or at least provide the basis for assessing the bias in the factor share estimates.

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