Journal of Comparative Economics **28,** 786–813 (2000)
doi:10.1006/jcec.2000.1684, available online at http://www.idealibrary.com on IDEAL®

Ownership, Productivity Change, and Financial Performance in Chinese Industry[1]

Gary H. Jefferson

Brandeis University, Waltham, Massachusetts 02254

E-mail: Jefferson@brandeis.edu

Thomas G. Rawski

University of Pittsburgh, Pittsburgh, Pennsylvania 15260

E-mail: Tgrawski+@pitt.edu

and

Wang Li and Zheng Yuxin

Institute of Quantitative and Technical Economics, Chinese Academy of Social Sciences, 5 Jianguomennei Street, Beijing, China 100732

E-mail: Liwangzh@cenpok.net, Zhengyuxin@iqte.cass.net.cn

Received October 20, 1999; revised August 28, 2000

Jefferson, Gary H., Rawski, Thomas G., Wang, Li, and Zheng, Yuxin—Ownership, Productivity Change, and Financial Performance in Chinese Industry

This paper investigates Chinese industrial productivity from 1980 to 1996. Results include series for foreign-linked, shareholding, and private enterprises. We find long-term productivity increase, with growth rates declining during the 1990's. Productivity outcomes outside the state and collective sectors are modest, with shareholding enterprises suffering productivity declines. The paper examines differences in marginal factor productivity across ownership types, considers the impact of business cycles on the interpretation of productivity trends, and documents a statistical relationship among the profitability of state enterprises, the relative productivity performance of state firms, and

[1] The authors gratefully acknowledge financial support from the Henry Luce Foundation, The American Council of Learned Societies, and the National Endowment for the Humanities as well as valuable comments from Liu Fujiang, John Bonin, and two referees, and expert research assistance from Albert G. Z. Hu and David Bai.

0147-5967/00 $35.00

the entry of new firms outside the state sector. *J. Comp. Econ.,* December 2000, **28**(4), pp. 786–813. Brandeis University, Waltham, Massachusetts 02254; University of Pittsburgh, Pittsburgh, Pennsylvania 15260; Institute of Quantitative and Technical Economics, Chinese Academy of Social Sciences, 5 Jianguomennei Street, Beijing, China 100732.

Journal of Economic Literature Classification Numbers: L60, O17, P20.

1. INTRODUCTION

China's diverse industrial system, which spans numerous ownership categories and nearly eight million enterprises, is engaged in a challenging process of technological development and institutional change. Formerly dominated by state-owned enterprises (SOEs), industry now consists of three major segments: the large but shrinking state sector; urban and rural collectives (COEs), public-sector firms largely controlled by local governments, including rural township-village enterprises (TVEs); and a fast-rising group of enterprises outside the state/collective system that Chinese statistical compilations categorize as "other ownership" (*qita suoyouzhi*). With few exceptions, e.g., Perkins et al. (1995), previous studies of productivity have focused almost exclusively on state and collective firms. This limitation is unfortunate because of the growing importance of foreign-invested, shareholding, and private domestic firms, which produced one-third of 1996 industrial output, more than the formerly dominant state sector (Table 1).

This paper offers the first analysis of aggregate industrial productivity trends that encompasses all major ownership forms, including major subsectors of the "other" category. We extend earlier results to obtain consistent productivity measures for state and collective industry from 1980 to 1996. The new estimates confirm earlier findings of a broad rise in total factor productivity for Chinese industry. Results for all industry and for three major ownership segments, i.e., state, collective, and other, share this upward trend. Productivity outcomes are unexpectedly weak for foreign-invested firms and particularly for shareholding enterprises. Results for the 1990's show a deceleration of productivity growth, with total factor productivity falling in the state sector and among shareholding firms from 1992 to 1996, but rising elsewhere. Since China's economy reached a peak in 1993 and then entered a protracted cyclical downturn, our results include a cyclical component that may conceal more robust productivity trends.

Four features are noteworthy. One is the growing dispersion of trends in single-factor productivity marked by sharp increases in output per worker and accelerating declines in output per unit of fixed assets. A second is the surprising productivity drop for shareholding firms. The third is the central role of relative SOE productivity performance in driving its lagging profitability. The fourth is the striking disparity in returns to capital across ownership types.

Research on industrial productivity began with studies of SOE value added, capital, and labor. Studies of aggregate productivity change include several

TABLE 1

Share of Industrial Output by Ownership (Percentage)

A. Data used in this study (independent accounting units only)

Ownership	1980	1984	1988	1992	1996
State-owned (SOE)	80.2	75.8	68.2	61.6	43.2
Collective (COE)	19.8	24.2	28.9	29.2	31.3
Other (OTE), of which:	n.a.	n.a.	2.9	9.1	25.4
Domestic (ODE)	n.a.	n.a.	1.9	2.0	1.8
Foreign (FIE)	n.a.	n.a.	1.0	7.1	18.5
Shareholding (SHE)	n.a.	n.a.	n.a.	n.a.	5.2
Included share of aggregate output	91.0[a]	87.5[a]	80.0	80.1	73.7

B. Aggregate data for Chinese industry (all industrial enterprises)

Ownership	1988	1992	1996
State-owned (SOE)	56.8	48.1	28.5
Collective (COE)	36.2	38.0	39.4
Other (OTE), of which:	7.1	13.9	32.1
Domestic (ODE)	n.a.	n.a.	16.6
Foreign (FIE)	n.a.	n.a.	12.2
Shareholding (SHE)	n.a.	n.a.	3.3

Sources. For panel A, authors' worksheets and Department of Comprehensive Statistics (1999, p. 36); for panel B, State Statistical Bureau (1989, p. 263), State Statistical Bureau (1993, p. 409), and State Statistical Bureau (1997, pp. 413, 416–417).

Note. Output shares are based on gross value of industrial output (GVIO) at current prices. Aggregate GVIO for 1996 is calculated according to the new method (*xin guiding;* see Appendix E); all other data are based on the original method (*yuan guiding*). Components may not add to 100% due to rounding error. Here, n.a. means not available.

[a] Aggregate output data used to calculate this ratio exclude village-level industry.

extensions: improved capital stock measures, inclusion of collective industry, incorporation of intermediate inputs, and detailed analysis of deflators (Chen et al., 1988; Jefferson et al., 1992, 1996. Studies using aggregate data find that productivity in state industry rose at a modest rate from the late 1970's into the early 1990's. Over the same period, collective-sector TFP growth appears considerably higher, but data issues dilute the robustness of this finding. These results are sensitive to the choice of deflators for output, materials, and investment goods, as inappropriate deflators can deliver misleading results. A complementary approach uses enterprise data from sample surveys to analyze productivity change. Results show broad agreement with the findings of the aggregate studies (Wu, 1996; Jefferson et al., 1999).

These productivity outcomes for the 1980's and early 1990's provide the empirical underpinning for two basic features of China's industrial transition.

First, modest productivity growth in state industry furnished critical support for China's incremental reforms. Had state industry, which was China's principal source of industrial output, fiscal revenue, urban social services, and exports, failed to deliver rising productivity in the initial stages of reform, economic pressures might have foreclosed the option of gradual reform (Jefferson, 1999). Second, the interplay between old and new types of firms leads to the relative deterioration of SOE profitability via declining competitiveness associated with the relatively slow growth of productivity in state industry.

Extending productivity analysis through the mid-1990's is complicated by changes in institutional and economic structures. The gradual alignment of Chinese statistics with standard international concepts has altered the definition of important variables. Many firms have shifted ownership classifications, e.g., some state enterprises have reorganized as joint ventures or shareholding companies. Government reform and economic change have led to administrative measures such as the 1993 revisions within the broad classification of other enterprises. Structural changes, including the shortened work week and the new practice of furloughs (*xiagang*), have affected the conditions of employment. Although we have attempted to produce consistent series that adjust for these changes, the error margins surrounding the data and results for 1992 to 1996 should be larger than in previous years. As in earlier studies, concerns about upward bias in the TVE output figures suggest a particularly large error margin for results related to the collective sector.

The following sections of this paper lay out our data and methods, analyze results for single and total factor productivity, pursue extensions based on the productivity results and the underlying data, and summarize findings.

2. THE DATA

China's National Bureau of Statistics (NBS and formerly the State Statistics Bureau) compiles data for state firms (SOEs), collectives (COEs, including township and village enterprises), and firms organized under other ownership (OTEs). Official figures partition the OTE sector into classifications that changed substantially in 1993. Appendix A describes these classifications and explains how we aggregate them into three components, foreign-invested enterprises (FIEs), shareholding firms (SHEs), and other domestic enterprises (ODEs).[2] Our data include all forms of ownership but not all industrial enterprises, as they are confined to enterprises with independent accounting (*duli hesuan*) at and above the township (*xiang*) level. The data exclude village-level enterprises, individual (*geti*) proprietorships employing seven or fewer workers, and establishments whose results are incorporated into the accounts of other units, e.g., universities or research institutes.

[2] The ODE component includes domestic private enterprises (*siying*) employing eight or more workers, domestic joint ventures (*lianying*), and a small residual (*qita*) category.

TABLE 2

Number of Industrial Enterprises Included in This Study (Independent Accounting Units at and above the Township Level)

Ownership	1980	1984	1988	1992	1996	All units, 1996
State-owned (SOE)	62,437	63,295	72,494	74,066	86,982	113,837[a]
Collective (COE)	263,378	321,039	343,866	321,389	351,987	1,591,800
Other (OTE), of which:	n.a.	n.a.	4,569	12,534	67,476	6,280,900
Domestic (ODE)	n.a.	n.a.	3,458	3,192	16,304	6,228,247
Foreign (FIE)	n.a.	n.a.	1,111	9,342	43,412	44,371[a]
Shareholding (SHE)	n.a.	n.a.	n.a.	2,579[b]	7,760	8,282[a]
Total	325,815	384,334	420,929	407,989	506,445	7,986,537

Source. Except as noted, authors' worksheets.
Note. Here, n.a. means not available.
[a] State Statistical Bureau (1997, pp. 416–417).
[b] Data for 1993, when this category first appears.

Information for 1996 indicates that the data encompass 74% of gross industrial output (Table 1) but less than one-half million of China's nearly 8 million industrial enterprises (Table 2). A further difficulty arises because the number of independent accounting units within specific ownership categories changes, sometimes substantially, from year to year.[3] At the same time, focusing on independent accounting units reduces concerns about data quality. Chinese and international researchers have commented extensively on *shuifen* or upward bias in the output data for state and especially for collective industry (Woo et al., 1993; Jefferson et al., 1996; Lardy, 1999). While sharp downward adjustments to TVE output following the 1995 industrial census confirm these suspicions, the greatest difficulties with collective statistics probably arise at the village level, where many enterprises do not keep formal accounts (Wu, 1994, 1997). Thus data limitations, while reducing the comprehensiveness of coverage, focus our analysis on the more reliable data segments.

Measurement of fixed capital begins with official data for the year-end original value of productive fixed assets, a category that excludes housing. First differencing provides annual data for gross additions to productive fixed assets. We subtract annual depreciation from these additions, deflate them using a price index for fixed assets (Table 3), and use the deflated figures to assemble the series for net (of depreciation), deflated, productive fixed assets shown in Table 4. Full details appear in Appendix B.

[3] The number of SOEs rose from 79,731 to 87,905 in 1994/1995 before declining in 1996. The combined total of independent units in the FIE, SHE, and ODE categories rose fivefold from 12,534 in 1992 to 67,476 in 1996.

TABLE 3

Price Deflators (1990 = 1.000)

	Output	Capital	Intermediate inputs
1980	0.571	0.413	0.389
1984	0.579	0.510	0.421
1988	0.810	0.795	0.750
1990	1.000	1.000	1.000
1992	1.134	1.255	1.211
1993	1.406	1.589	1.635
1994	1.681	1.755	1.933
1995	1.931	1.967	2.089
1996	1.987	2.083	2.315
Average annual inflation rate 1992–1996	14.0%	12.7%	16.2%

Source. Appendix D.

Previous studies routinely use the number of workers to measure labor input. This ignores changes in labor quality and implicitly assumes a fixed work week. New regulations that reduced the work week from 6 to 5.5 days in 1994 and to 5 days in 1995 invalidate the assumption of a fixed work week. Our adjustments to the labor data, described in Appendix C, create a series of man-year equivalents based on the pre-1994 standard of a 6-day work week.

The officially reported number of workers in mining, manufacturing, and utilities declined by 1.6 million (or 2.4%) in 1996, with SOE employment dropping by 2.7% (State Statistical Bureau, 1996, p. 96; State Statistical Bureau, 1997, p. 102). In addition, 1996 saw the first large-scale implementation of the furlough (*xiagang*) policy, under which workers are effectively laid off with reduced compensation. Prior to 1998, furloughed workers, most in the state sector, are classified as employed.[4] Therefore, our input measures in Table 4 overstate labor devoted to industrial production, especially for SOEs, and especially in 1996. As we show in Appendix C, this error has only a minor effect on our results.

China's economic reforms have altered the relative prices for industrial products and inputs. Therefore, we use separate price indexes to deflate outputs, material inputs, and new fixed assets to avoid the mistaken assumption of fixed relative prices. Data limitations prevent us from applying separate deflators to different ownership categories. The price indexes, shown in Table 3 and discussed in Appendix D, come from surveys conducted since 1984 by the NBS Urban Survey Team.

[4] Employment figures exclude inactive workers starting in 1998 (State Statistical Bureau, 1999, p. 140).

TABLE 4

Real Inputs and Output, 1992 to 1996 (Absolute Figures and Growth Rates)

A. State and collective industry

	State				Collective			
	Output	Capital	Labor	Inter	Output	Capital	Labor	Inter
1992	1507	1107	37.5	926	715	193	28.7	496
1993	1571	1186	37.8	906	845	211	29.7	493
1994	1505	1286	33.8	900	942	241	27.4	606
1995	1690	1470	30.9	1043	1057	276	23.7	727
1996	1597	1598	28.3	994	1157	298	21.9	770
Growth rates:								
1993–1996	0.57%	9.95	−9.60	3.10	10.47	11.43	−10.13	14.90
1992–1996	1.46%	9.18	−7.04	1.77	12.05	10.87	−6.76	11.02

B. Other ownership (OTE) and components (1)

	Other enterprises (OTE)				Other domestic (ODE)			
	Output	Capital	Labor	Inter	Output	Capital	Labor	Inter
1992	223	66.4	3.1	160	48.7	13.4	1.11	34.7
1993	406	161.0	5.8	244	45.6	14.8	1.03	27.7
1994	608	344.9	8.3	390	46.4	15.2	1.11	30.5
1995	817	503.9	8.6	599	56.8	18.3	0.92	42.3
1996	940	595.5	8.9	629	66.4	21.6	1.00	43.4
Growth rates:								
1993–1996	27.96	43.61	14.58	31.60	12.50	12.59	−1.19	15.01
1992–1996	36.00	54.83	26.24	34.28	7.74	11.88	−2.59	5.58

C. Other ownership and components (2)

	Foreign-linked enterprise (FIE)				Shareholding enterprise (SHE)			
	Output	Capital	Labor	Inter	Output	Capital	Labor	Inter
1992	174	53	2.01	125	n.a.	n.a.	n.a.	n.a.
1993	257	80	3.26	155	104	67	1.45	61
1994	388	133	4.51	252	173	196	2.69	107
1995	589	211	5.52	435	171	275	2.15	121
1996	703	267	5.48	463	191	307	2.42	123
Growth rates:								
1993–1996	32.58	40.33	17.30	36.49	20.32	50.97	17.04	23.23
1992–1996	34.17	40.43	25.08	32.73	n.a.	n.a.	n.a.	n.a.

Note. Absolute figures for gross output, fixed assets, and intermediate purchases are in billions of 1990 *yuan.* Figures for labor are in millions of man-year equivalents based on the 48-hour work week in force prior to 1994.

China's 1995 industrial census introduced changes in the calculation of gross output, value-added, and intermediate inputs. We review these accounting changes in Appendix E, which explains the adjustments made to create consistent output measures.

3. SINGLE-FACTOR PRODUCTIVITY

By applying the methods outlined above and detailed in appendices B through E, we obtain the time series for output and factor inputs shown in Tables 4A–4C. This yields trends in single-factor productivity for five ownership groups shown in Tables 5A–5C.

We begin with the productivity of fixed assets. Our previous study, focused on the period from 1988 to 1992, found that "China's financial system has permitted excessive allocation of investment funds to poorly selected industrial projects in the state sector" (Jefferson et al., 1996, p. 171). The present data reveal further declines in capital productivity after 1992, extending now to all sectors except collective industry. The decline in SOE capital productivity, which fell at an average annual rate of 3.42% from 1988 to 1992, accelerated to 7.72% per year between 1992 and 1996.

The annual decline in OTE capital productivity also accelerated from 6.27% during 1989–1992 to 18.83% between 1992 and 1996, led by a stunning drop of 30% per annum in capital productivity among shareholding firms from 1993 to 1996. Capital productivity also fell elsewhere in the OTE sector, with ODE and foreign-linked firms posting respective annual declines of 4.15 and 6.26%. The presence of sweeping, if uneven, reductions in capital productivity points to misallocation of investment funds as a central issue facing China's economic policymakers.

In contrast to the broad decline in output per unit of fixed capital, labor productivity shows consistently rapid growth. With the exception of the shareholding sector, which enters the data only from 1993, growth of output per worker accelerated during 1992–1996 relative to the previous four years. SOE labor productivity grew at an 8.50% annual rate between 1992 and 1996, while the collective sector achieved a rate of 18.81%. The OTE sector recorded 9.76% annual gains, with advances in each category, although gains among SHE firms were the weakest. Rising labor productivity reflects initial efforts to eliminate redundant workers, especially in the state sector,[5] as well as continuing capital deepening. Rising output per worker indicates that some of the decline in capital productivity arises from substitution of capital for labor.

Growth of output per unit of materials was uniformly lower between 1992 and 1996 than during the previous four years. Productivity change in the state sector

[5] Recall that employment figures include workers on furlough (*xiagang*).

TABLE 5

Levels and Growth Rates for Single-Factor Productivity in Chinese Industry, 1980 to 1996, Real Output (1990 Prices) per Unit of Input

Period	Capital	Labor	Intermediate
	A. State-owned enterprises (SOE)		
1988	1.56	34.96	1.42
1992	1.36	40.18	1.63
1996	1.00	56.45	1.61
Growth rates:			
1980–1996	−5.03	8.04	1.43
1980–1984	3.53	4.13	1.45
1984–1988	0.39	4.88	4.59
1988–1992	−3.42	3.48	3.50
1992–1996	−7.72	8.50	−0.77
1993–1996	−9.39	10.17	−2.53
	B. Collective enterprises (COE)		
1988	3.68	18.34	1.31
1992	3.71	24.86	1.44
1996	3.89	52.76	1.50
Growth rates:			
1980–1996	1.91	11.58	2.25
1980–1984	4.99	9.00	1.44
1984–1988	1.29	10.92	4.21
1988–1992	0.19	7.61	2.35
1992–1996	1.18	18.81	1.02
1993–1996	−0.96	20.60	−4.43
	C. Enterprises under other ownership (OTE)		
1988	4.31	46.05	1.27
1992	3.35	71.47	1.39
1996	1.58	105.61	1.49
Growth rates:			
1988–1996	−20.80	2.12	−6.23
1988–1992	−6.27	10.99	2.32
1992–1996	−18.83	9.76	1.73
1993–1996	−15.65	13.38	−3.65
	C1. OTE components: Other domestic enterprises (ODE)		
1988	4.59	36.85	1.27
1992	3.63	44.05	1.40
1996	3.08	66.57	1.53
Growth rates:			
1988–1996	−5.00	7.39	2.29
1988–1992	−5.85	4.46	2.41
1992–1996	−4.15	10.32	2.16
1993–1996	−0.09	13.69	−2.52

TABLE 5—*Continued*

Period	Capital	Labor	Intermediate
C2. OTE components: Foreign-invested enterprises (FIE)			
1988	3.88	83.97	1.27
1992	3.28	86.55	1.39
1996	2.56	124.53	1.48
Growth rates:			
1988–1996	−5.22	4.93	1.91
1988–1992	−4.17	0.76	2.37
1992–1996	−6.26	9.09	1.44
1993–1996	−7.75	15.28	−3.91
C3. OTE Components: Shareholding enterprises (SHE)			
1993	1.56	71.46	1.70
1996	0.62	78.85	1.55
Growth rates:			
1993–1996	−30.65	3.28	−2.91

moved into negative territory, but productivity of intermediate inputs continued to grow in the collective and OTE sectors, although at a reduced pace.

Our review of single-factor productivity shows that, among the five ownership categories, only the collective sector exhibits rising productivity for all three inputs between 1992 and 1996. Even here, modest downward adjustment of the output figures could push the growth of output per unit of capital and intermediates below zero. Within each sector, differentials between rates of single-factor productivity growth have expanded, in some cases beyond 15 percentage points. Much has changed since the 1980's, when growth rates for individual single-factor productivities were positive and more uniform. These new disparities make estimates of total factor productivity increasingly sensitive to the choice of weights used to combine the input indices.

As mentioned above, classifications within the OTE sector changed in 1993. To ensure consistency within this sector, and also to explore the impact of changes in the macroeconomic environment on productivity outcomes, Tables 4 and 5 include measures of productivity performance covering 1993–1996 as well as 1992–1996. We first observe that moving the initial year forward from 1992 to 1993 causes virtually all measures of single-factor productivity growth to decline. This is not unexpected, as 1993 represents a cyclical peak year. Comparison of productivity outcomes over 1993 to 1996 allows us to include the shareholding sector, for which data begin only in 1993. The weak performance of shareholding enterprises comes as a surprise, particularly the dramatic decline in output per yuan of fixed capital, which plunged in only three years from 1.56 to 0.62, a level far below the SOE average. Steeply declining capital productivity

in the shareholding sector signals an important avenue for further research, especially since conversion to corporate organization was initially regarded as a privilege reserved for firms with strong management and superior financial performance.

4. TOTAL FACTOR PRODUCTIVITY

We calculate total factor productivity by combining the measures of partial productivity into a single index. To generate the required weights, we estimate factor output elasticities under the assumption that a Cobb–Douglas production function adequately represents the underlying technology. To the extent possible, we estimate separate production functions for each ownership category. The functional form is

$$\ln \mathrm{GVIO}_i = \ln A + \alpha_K \ln K_i + \alpha_L \ln L_i + \alpha_M \ln M_i + \epsilon_i, \qquad (1)$$

where GVIO is gross industrial output, K, L, and M are inputs of capital, labor, and intermediate inputs, and ϵ is an error term with the usual statistical properties. We assume constant returns to scale, so that $\sum \alpha_j = 1$ (where $j = K, L, M$). The α_j are, therefore, the weights used to combine measures of single-factor productivity into a composite Cobb–Douglas index of total factor productivity. We estimate Eq. (1) for each of three ownership categories using data from China's 1995 industrial census, which reports input and output data by branch for state, township, and foreign-linked firms (including wholly owned foreign firms and joint ventures; see Industrial Census Office, 1997). In Eq. (1), i represents the ith industrial branch ($i = 1, \ldots 190$).

Estimating Eq. (1) is complicated by underutilization of fixed assets and labor. Data for 111 products from the 1995 census showed an average capacity utilization rate of only 70% (State Statistical Bureau, 1997, pp. 454–455). Moreover, redundant industrial labor, especially in the state sector, led to large-scale furloughs beginning in 1996. As a result of this slack, we expect estimated output elasticities for capital and labor to understate their true values. We find little evidence that firms purchased excessive input supplies. In contrast to the allocation of capital and labor, markets in intermediate inputs appear relatively complete and unfettered.[6] To avoid distorting the ratios among the elasticities, we restrict the estimate of α_M to equal its measured factor income share, i.e., (GVIO-VA)/GVIO, where both gross output (GVIO) and value added (VA) are measured at current prices using 1995 data from the Industrial Census Office (1997).

Elasticity estimates based on 1995 data are shown in Table 6. We apply SOE weights to measure TFP among shareholding enterprises, most of which origi-

[6] Note the uniformity of returns to intermediate inputs across ownership types in Table 12.

TABLE 6

Estimation Results

	Capital	Labor	Intermediate	R^2, obs.
State	0.200	0.078	0.722	0.993
	(9.440)	(n.a.)	(n.a.)	$n = 190$
Township	0.082	0.183	0.735	0.997
	(6.463)	(n.a.)	(n.a.)	$n = 190$
Foreign-invested	0.174	0.075	0.751	0.984
	(8.092)	(n.a.)	(n.a.)	$n = 184$

Note. Data in parentheses are *t*-statistics, which are available only for the estimated output elasticity of capital. The elasticity for materials is based on factor shares (see text). The elasticity for labor is derived as a residual under the assumption of constant returns to scale. Here, n.a. means not available.

nated in the state sector. We use TVE elasticities to calculate productivity performance for all collectives and for the ODE sector, which consists mainly of small firms more akin to TVEs than to the generally larger and more capital-intensive state enterprises.

The initial results of our analysis appear in Table 7, which shows the average annual growth of total factor productivity for Chinese industrial enterprises

TABLE 7

Average Annual Growth of Total Factor Productivity: 1995 Weights

				Of which:		
	State	COE	Other	ODE	FIE	SHE
1980–1996	1.72	3.93	n.a.	n.a.	n.a.	n.a.
1980–1984	2.08	3.11	n.a.	n.a.	n.a.	n.a.
1984–1988	3.78	5.19	n.a.	n.a.	n.a.	n.a.
1988–1992	2.11	3.13	−1.07[a]	2.11	1.11	n.a.
1992–1996	−1.11	4.29	−2.24[a]	3.14	0.67	n.a.
1993–1996	−2.91	0.43	−4.85	0.64	−3.14	−7.96

Note. Here, n.a. means not available.

[a] Note that TFP growth for the combined other sector (OTE) is less than that of either of its components, ODE and FIE. This apparent inconsistency arises because the combined measure of TFP growth depends on TFP growth in each component and on changes in their relative weights based on different rates of output growth. In this case, the FIE sector, with lower initial TFP levels, grew considerably faster than the ODE sector, thus depressing the combined measures of TFP and TFP growth.

organized under state, collective, and other ownership arrangements.[7] The SOE and COE series extend from 1980 to 1996. The figures for OTEs are limited to the years 1988 to 1996.[8] These results confirm that China's state and collective industry has attained substantial increases in total factor productivity. As in many other studies, collective industry surpasses SOE productivity gains by a wide margin. As noted above, possible upward bias in the COE output data threatens the robustness of this outcome.

Our results include for the first time other ownership (OTE) firms, which account for a rapidly growing share of aggregate output. Expectations that rapid TFP growth is driving the expansion of the OTE's share in Chinese industrial output turn out to be only partially correct. The other domestic enterprise (ODE) sector sustained TFP growth in the 2 to 3% range from 1988 to 1996, surpassing the state sector and nearly matching collective sector TFP gains between 1992 and 1996. However, weak productivity growth among foreign-invested firms, which are widely seen as more efficient and productive than domestic enterprises, and among shareholding enterprises depress overall performance in the other enterprise sector.

From a shorter-term perspective, the results for recent years show a tendency for TFP growth to decline from peak rates attained between 1984 and 1988. Between 1992 and 1996, productivity change in state industry becomes negative. Deteriorating performance is not limited to state enterprises; productivity growth also declines in the foreign-invested sector. Indeed, the most recent figures show reductions in TFP for nearly every ownership category between 1993 and 1996.

A completely unexpected outcome is the dramatic annual TFP decline of 7.96% in the shareholding sector during 1993–1996. Data for the level of TFP (not shown) indicate that SHE firms, many selected from the top ranks of state firms, stood 6.0% above the comparable SOE average for 1993. By 1996, the TFP level among shareholding enterprises had fallen to 9.8% below the (declining) SOE figure.

We use sectoral gross value weights to combine the productivity results for state, collective, and other (OTE) ownership firms into a comprehensive TFP measure. The results, shown in Table 8, mirror the long-term trends for individual ownership categories. Estimated productivity shows a substantial increase of 57% between 1980 and 1996. Productivity growth accelerates during the 1980's, reaching a peak annual rate of 4.7% during the period 1984 to 1988. After falling

[7] Because the growing divergence among trends in single-factor productivity makes TFP measures increasingly sensitive to variations in input weights, we made a second TFP calculation with weights derived from our 1987 cross-section analysis of SOE and COE firms, supplemented by 1995 weights for foreign-linked firms. The outcome did not differ substantially from the results shown here.

[8] The weights for the OTE sector are a linear combination of the elasticities used for the other domestic (TVE or collective elasticities), foreign-invested, and shareholding (SOE elasticities) sectors, weighted by gross output shares for the relevant year.

TABLE 8

Total Factor Productivity in Chinese Industry: An Initial Aggregate Estimate
(Calculated Using Elasticity Estimates for 1995)

Year:	1980	1984	1988	1992	1993	1996
TFP level						
SOE	1.470	1.597	1.857	2.021	2.110	1.934
COE	1.659	1.878	2.312	2.621	3.072	3.112
OTE	n.a.	n.a.	2.618	2.849	3.168	3.229
AGGREGATE[a]	1.507	1.665	2.006	2.233	2.426	2.371
Contribution to included GVIO[a]						
SOE	0.802	0.758	0.682	0.616	0.556	0.432
COE	0.198	0.242	0.289	0.292	0.300	0.313
OTE	n.a.	n.a.	0.029	0.091	0.144	0.254

Note. Here, n.a. means not available.

[a] GVIO is the output of the independent accounting units covered in this study.

back between 1988 and 1992 to rates attained in the early 1980's, aggregate productivity growth stalls after 1992, and turns negative after 1993.

With coverage amounting to 74% of 1996 industrial output, this initial estimate probably captures the overall pattern of productivity change, with acceleration during the 1980's followed by deceleration and near-stagnation in the 1990's. However, as Table 1 indicates, our data provide fuller coverage for the state sector than for the collective and other (OTE) ownership sectors. In 1996, state firms contribute 43.2% of sample output but only 28.5% of aggregate production. The segments omitted from our data include portions of the collective and other (OTE) sectors, particularly individual proprietorships and village-level industries, that have grown faster than the national totals. Although there is no direct link between output growth and productivity trends, we expect that truly comprehensive data would generate stronger productivity performance than the outcomes shown in Table 9, especially for the 1990's.

The results summarized in Tables 7 and 8 display an unprecedented dispersion of outcomes across ownership groups. Prior to 1992, we see a uniform pattern of rising TFP in each ownership category. After 1992, both state enterprises and firms operating under other ownership (OTE) suffer declines in measured productivity. The fragility of recent TFP gains for collectives and for the ODE and FIE components of the other category is evident from Table 7. Shifting the time frame from 1992–1996 to 1993–1996 sharply reduces estimated TFP growth in every ownership category.

This decline in TFP growth during the 1990's arises in part from cyclical factors. On the basis of reported rates of inflation and real output growth, Chinese industry attained cyclical peaks in 1985 (21.4% real growth), 1988/89 (14.6%),

TABLE 9

Annual Rates of Growth of Aggregate Industrial TFP (Percentage)

1980–1996	2.83	1992–1996	1.50
1980–1984	2.49	1988–1993	3.80
1984–1988	4.66	1993–1996	−0.77
1988–1992	2.68	1992–1993	8.29

Note. Derivation is based on results using 1995 elasticities. Aggregate TFP in year t is given by $\Sigma_j g_{jt}$*TFP_{jt}, where TFP_{jt} = TFP in a single ownership class j in year t; $j = 1, 2, 3$ are the ownership classes; g_{jt} is the gross output value share of class j in $\Sigma_j \text{GVIO}_{jt}$ for year t.

and 1993 (27.3%). Cyclical troughs appear in 1981 (4.3% real growth), 1986 (11.7%), and 1990 (7.8%). The terminal year of this study, 1996, forms part of an extended downturn during which reported real growth has fallen continuously from the 1993 peak (Industry Yearbook Editorial Committee, 1998, p. 21).

The results in Tables 7 through 9 understate trend rates of productivity growth by comparing performance in 1993, a year of high growth, steep inflation, and local TFP maxima, with 1996, a year of relatively slow growth, declining inflation, and low capacity utilization. To counteract this bias, Table 10 summarizes peak-to-peak and trough-to-trough measures of TFP across two peak-to-peak and two trough-to trough cycles as well as the still incomplete trough-to-trough cycle beginning with 1990. These figures confirm the long-term trend of rising productivity. Our aggregate measure of TFP shows average annual growth of 2.99% measured from the 1981 trough to 1996. Once we avoid peak-to-trough measures, the earlier pattern of modest, and at times robust, productivity growth continues into the 1990's, at least until the 1993 peak. Table 10 also confirms the wide dispersion of productivity outcomes for the 1990's. The results suggest that slower productivity growth in state industry may not arise solely from cyclical fluctuations.

TABLE 10

Cyclical Behavior of Total Factor Productivity (Percentage Annual Growth)

	SOE	COE	ODE	FIE
1985(P)–1988/89(P)	2.29	3.38	n.a.	n.a.
1988/89(P)–1993(P)	2.45	5.40	3.63	3.31
1981(T)–1986(T)	3.40	4.79	n.a.	n.a.
1986(T)–1990(T)	1.58	2.95	n.a.	n.a.
1990(T)–1996(T?)	0.65	4.40	3.41	1.14

Note. Here, P and T indicate cyclical peaks and troughs based on price movements and reported real growth of industrial output. The final year in our series, 1996, is not a true trough since reported output growth declined in both 1996/1997 and 1997/1998. Calculations are based on 1995 elasticity estimates; n.a. means not available.

5. EXTENSIONS

These productivity estimates and the underlying calculations can illuminate the operation of China's industrial system. We explore two extensions: interactions between productivity and profitability, and trends in marginal factor products.

Time-series data for Chinese industry display an apparent paradox between rising productivity and declining profitability. Some authors have sought to resolve the issue by attributing apparent productivity growth to errors of measurement (Woo et al., 1993). The present results strengthen the case for long-term growth of TFP during the reform era. Market-based interaction among different types of enterprises offers a more promising explanation of divergent trends in productivity and profits.

In prior work, we used 1990 enterprise data to show how financial pressures arising from market competition can function as effective inducements to reform (Jefferson and Rawski, 1995, p. 148). Singh et al. (1993) found that SOE profitability is lower in provinces with rapid growth of industry outside the state sector and that low provincial shares of SOE output are associated with high TFP levels in state firms, suggesting that robust rivals squeeze SOE profits and motivate greater SOE efficiency.

With observations for state and collective industry now extending from 1980 to 1996, it is possible to deploy time series data to further investigate the puzzling relationship between generally rising productivity and generally falling profitability. We identify two channels that have eroded the competitive advantage of state industry. One is a decline in the relative productivity of state industry, noted in a number of studies. The second is the erosion of barriers to entry, which led to a steep increase in the number of industrial enterprises (Table 2) and a concomitant erosion of SOE market power (Naughton, 1992). Specifically, we hypothesize that changes in SOE profitability, measured as the ratio of profit plus tax to gross output, are driven by differences in relative rates of productivity and by enterprise formation.

We test this hypothesis with the simple regression model

$$\mathrm{PRORAT}_{\mathrm{SOE},t} = \alpha + \beta \mathrm{TFP}_{\mathrm{SOE},t} + \gamma \mathrm{TFP}_{\mathrm{COE},t} + \theta \mathrm{NUM}_t + \epsilon_t, \qquad (2)$$

where $\mathrm{PRORAT}_{\mathrm{SOE}}$ is the ratio of profit plus taxes to gross output in state industry, $\mathrm{TFP}_{\mathrm{SOE}}$ and $\mathrm{TFP}_{\mathrm{COE}}$ represent the indices of total factor productivity for state and collective industry, t denotes time, and NUM is the number of industrial firms classified as independent accounting units outside the state sector. All variables are measured as natural logs of three-year moving averages.[9]

[9] We attempt other specifications, including 1-year observations and various autocorrelation corrections, since the Durbin–Watson statistic falls in the indeterminate area. Alternative specifications generate similar outcomes, but the coefficient for SOE productivity loses some of its robustness.

TABLE 11

Profit–Productivity Regression, Dependent Variable = State Industry (Profit + Tax)/GVIO

Independent variable	Estimation result[a]
Constant	−42.43 (2.68)
TFP_{SOE}	4.68 (2.18)
TFP_{COE}	−6.85 (4.93)
NUMber of enterprises	3.93 (3.51)
Adjusted R^2	0.94
D–W statistic	0.86
Observations	15

[a] Observations are 3-year moving averages with initial and final observations centered in 1981 and 1995. Figures in parentheses are *t*-statistics.

The estimation results, shown in Table 11, are consistent with the intuition that a rise in SOE productivity, holding COE productivity fixed, raises SOE profitability. Conversely, a rise in COE productivity with no corresponding increase in SOE productivity erodes competitiveness and profitability in state industry. The unexpected result is that, holding productivity fixed throughout industry, an increase in the number of enterprises outside state industry raises rather than reduces state industry profitability.

We anticipated that, by shifting out the supply function of the competing nonstate sector, the entry of new firms would erode monopoly profits within the state sector. This perspective overlooks the dual role of new firms. Competition from newcomers may undercut the profitability of incumbent producers. However, new firms may enhance the profitability of established producers by assuming complementary roles as suppliers or subcontractors, thereby diminishing the excessive vertical integration characteristic of China's plan system. Our results show that, after controlling for productivity changes, new entrants served to enhance profitability in state industry from 1980 to 1996.

Bai et al. (1997) attribute the apparent paradox of rising productivity and falling profitability in China's state sector to declining returns to scale and weak pursuit of profits within the state sector. This explanation, already challenged on empirical grounds by Jefferson et al. (1999), rests entirely on the internal governance of state enterprises. Our result, which explains SOE profitability in terms of relative productivity change and the establishment of new firms outside the state sector, underscores the importance of market competition and institutional diversity within China's industrial sector. This result supports the view that productivity offers a more reliable gauge of long-term industrial performance than profitability, particularly in transition economies.

Analysis of marginal factor returns offers a separate avenue for extending the application of information underlying the TFP results. Table 12 shows the value

TABLE 12

Value of Marginal Products in 1996 (1990 yuan)[a], $\alpha_i(Q/X_i)$

	Capital	Labor	Intermediates
SOE	0.222	4,046	1.177
COE	0.318	8,034	1.103
ODE	0.250	10,372	1.081
FIE	0.480	8,141	1.089
SHE	0.142	5,802	1.105
Max/min	3.380	2.564	1.089

[a] Gross output (1990 prices) per yuan of fixed capital, adjusted man-year, or yuan of intermediate input.

of marginal factor products for 1996 across five ownership groups. We interpret the ratio of maximum to minimum returns as indicative of the relative efficiency of factor markets.

Data for 1996 show that the value of marginal product for material inputs is similar across five ownership categories. This extends an earlier finding showing close correspondence between marginal returns to material inputs in state and collective industry during the 1980's (Jefferson et al., 1992, p. 255). These figures confirm that China has developed well-functioning markets for industrial materials.

Results for labor and capital are strikingly different. For labor, the 1996 value of marginal product in the ODE sector is more than 2.5 times the figure for SOEs. The marginal product of capital within the foreign-invested sector in 1996 is 3.38 times that of the SHE sector and more than twice that of the state sector. Wide dispersion in the marginal returns to labor and capital across ownership types points to misallocation of labor and capital as constraints on industrial productivity growth. Massive layoffs of redundant workers, most in the state sector, began in 1996 and may have contributed to a convergence of marginal returns to labor. No comparable reform has affected capital allocation. Investment funds continue to flow mainly into SOE and shareholding firms, even though these sectors have the lowest returns to capital. Evidence of large gaps between the marginal product of fixed assets in different ownership groups, coupled with negative real interest rates (Rawski, 1999; Xie, 1999) and large-scale excess capacity (Guo, 1999; Rawski, 2000), signals the continuation of inefficient investment decisions that could lead to cumulative deterioration of productivity outcomes.

6. CONCLUSION

Efforts to reform and restructure industry, the largest sector of China's economy, must confront issues of agency, monitoring, deregulation, and institution-

building that straddle the core of socialist transition. Measures of industrial productivity change have attracted considerable attention because they offer a convenient, albeit partial, metric for the progress of reform. Productivity studies can also identify promising directions for research built on complementary methodologies.

Previous research focuses on state and collective industry and neglects new types of firms that now contribute over one-third of China's industrial output. This paper systematically examines productivity outcomes across a universe that encompasses all major ownership forms, including the private, foreign-linked, and shareholding entities that have achieved the fastest growth during the 1990's. In addition to expanding the range of productivity research, we also extend the period of analysis to cover the years 1980 to 1996.

Looking at the entire reform period from 1980 to 1996, we find consistent evidence of a rising trend in total factor productivity for the entire industrial sector and for each of three major ownership categories. We also find indications of productivity slowdown during the 1990's. By combining results from different ownership categories, we create an initial measure of aggregate TFP spanning all major ownership systems in China's sprawling and diverse industrial sector. This new aggregate measure reinforces earlier findings of long-term productivity growth. It also confirms the impression of a recent decline in productivity growth conveyed by separate measures for specific ownership types. Although cyclical factors obscure the exact dimensions of weakening productivity performance, it now appears that the 1990's witnessed an erosion of productivity momentum in China's industrial sector.

Among ownership categories, the collective sector consistently achieves the strongest productivity outcomes, although data concerns limit the robustness of this observation. Total factor productivity in the state sector grows modestly in the long term but declines between 1992 and 1996. Relatively weak productivity outcomes in the state sector are in part attributable to the transfer of high-performance firms and resources to new entities in the foreign-linked and shareholding sectors and to China's limited capacity to restructure failing enterprises by means of bankruptcy or mergers. Despite these institutional complexities, regression analysis linking trends in state sector profitability to changes in relative productivity and to new entry outside the state sector shows that a complex web of market interactions affects financial outcomes in specific ownership groups.

The rapid increase in the output share of firms outside the state and collective sectors raises the possibility that this group, a heterogeneous composite of foreign-linked firms, shareholding companies, and (mostly private) nonshareholding domestic enterprises, might have greatly surpassed the productivity accomplishments of the traditional state and collective enterprises. Our findings do not confirm these expectations. Except for distinctively high labor productivity, neither the level nor the growth of productivity within this new sector differs

widely from the accomplishments of China's state enterprises. Within the other ownership (OTE) group, firms that we classify as other domestic enterprises (ODE), a category dominated by unincorporated private firms employing eight or more workers, show the best results, with TFP levels comparable to the collective sector and 40 to 50% above the average for state enterprises.

Productivity outcomes for foreign-linked firms, presumably bolstered by their access to offshore funds, imported technology, and international management skills, are unexpectedly weak. Other than high labor productivity, results for foreign-linked firms reveal only a modest advantage over outcomes for the state sector. The TFP level for foreign-linked firms is consistently about 15% above comparable SOE figures. Both groups delivered anemic TFP growth between 1988 and 1996.

Except for high labor productivity, results for shareholding enterprises, which enter the data beginning in 1993, are uniformly poor. The data for 1993 to 1996 show a steep drop in output per unit of fixed assets and a sharp decline in TFP. By 1996, the level of TFP as well as output per unit of capital and materials for shareholding firms, which were initially selected from the upper echelons of the state sector, had fallen below comparable averages for the state sector. If confirmed by subsequent research, these consistently weak results represent a serious threat to China's reform agenda because it depends heavily on the expectation that shareholding arrangements, which are key elements in the restructuring of both state enterprises[10] and rural collectives (TVEs),[11] can provide effective mechanisms for monitoring enterprise managers and operations.

Our finding of lackluster productivity growth across several key ownership sectors raises complex questions of causation. Weak productivity performance may arise from composition effects. The increased frequency of enterprise conversions and the acceleration of entry and exit may obscure associations between ownership and productivity based on the aggregate data used in this study. Until it becomes possible to track the performance of fixed samples of firms in different ownership categories, we cannot eliminate the possibility that enterprise conversions may have influenced our comparison of productivity differences over time and across ownership groups.

Enterprise governance may contribute to a productivity slowdown. Weak performance of foreign-invested firms and shareholding enterprises may signal

[10] According to NBS official Xing Junling, restructuring had affected 20% of state enterprises as of 1996.

[11] Regional information illustrates the scope of TVE restructuring. In one district of Guangzhou, officials expected that collective enterprises would be "basically nonexistent" by the end of 1998 (May 1998 interview). In Hunan, 72% of rural collectives have been restructured (Liu, 1999) and "there aren't many collective firms left" (Hunan Provincial TVE Management Office, 1999, p. 5). In Rugao, Jiangsu, the strategy is to "sell firms first and then turn them into shareholding entities" (Huang and Xu, 1998, p. 7).

TABLE A

Data Structure for Enterprises outside the State and Collective Sectors, 1988–1996

Data categories, 1988–1992	Data categories, 1993–1996	Our database for 1988–1992	Our database for 1993–1996
Domestic:	Domestic:	Other domestic	Other domestic
SOE-COE JV [1]	Private [a]	ODE = 1 + 2 + 3 + 9	ODE = a + b + f
SOE-dom. Private JV [2]	Domestic JV [b]		
COE-dom. Private JV [3]			
Foreign-linked:	Foreign-linked:	Foreign-linked	Foreign-linked
SOE-HQ JV [4]	Non-Chinese [c]	FIE = 4 + 5 + 6 + 7 + 8	FIE = c + d
COE-HQ JV [5]	Overseas Chinese [d]		
JV with non-Chinese [6]			
Control by HQ [7]	Shareholding [e]	Shareholding SHE, no information	Shareholding SHE = e
Foreign control [8][a]			
Other firms [9]	Other firms [f]		

Note. JV, joint venture; HQ, overseas Chinese (*huaqiao*).

[a] Foreigners who have no Chinese ethnicity or heritage.

that recent ownership reforms, including new public–private partnerships as well as restructuring within the public sector, have failed to deliver significant improvements in performance. These findings lend credence to critics who claim that neither joint ventures nor the new network of asset management companies established to exercise public ownership rights can eliminate the agency problems embedded in public ownership. Even so, strong productivity results for collective firms, many now reorganized as shareholding cooperatives (*gufen hezuoshe*), often with partial government ownership, caution against hastily dismissing mixed ownership as unworkable. A balanced judgment on the viability of Chinese experiments with hybrid ownership forms must await the outcome of statistical research based on time-series data from stable enterprise samples, as well as field studies that probe the operation of the new enterprise structures and associated institutions.

Evidence of a general productivity slowdown may reflect constraints imposed by the economic environment, particularly the legal, financial, and regulatory systems that frame China's enterprise system, rather than difficulties associated with specific forms of ownership. Limited progress toward the completion of reforms that facilitate routine transfer of resources from losers to winners may undermine industrial performance regardless of ownership.

APPENDIX A: OWNERSHIP MATRIX

Table A lays out the ownership categories used by China's National Bureau of Statistics (NBS) to classify industrial enterprises outside the state and collective sectors between 1988 and 1996. The classification system was restructured beginning in 1993. The new system eliminated some categories, e.g., joint

ventures between collectives and domestic private firms, and introduced others, e.g., shareholding enterprises. The result of this complex and shifting classification structure is that desirable data categories cannot always be created. For example, since the shareholding category, which first appears in the data for 1993, includes firms with and without foreign investment, it is not possible to create a data category for 1993 to 1996 that includes all firms with some degree of foreign investment.

Faced with these complications, we adopt two approaches. First, we compile a data set that includes all available data for enterprises located outside the state and collective ownership systems. We call this the other enterprise (OTE) sector. In principle, the OTE data set includes all independent accounting units at or above the township (*xiang*) level that are neither state nor collective enterprises. The OTE sector is extremely heterogeneous. OTE firms include affiliates of giant multinational enterprises, e.g., Hitachi, small private Chinese firms, joint ventures between state- and collective-owned enterprises, and large shareholding corporations created by transferring assets from the state sector. As a result, overall OTE productivity trends can easily conceal large variations in the performance of different types of firms. Accordingly, we have decomposed the OTE sector into three components.

The first, other domestic enterprises (ODEs) includes domestic firms outside the shareholding sector. The ODE component includes officially registered private firms employing eight or more workers as well as shareholding cooperatives that are not part of the collective sector. The second category, foreign-invested firms (FIEs), includes enterprises with direct foreign investment. The FIE category includes various types of joint ventures with overseas participation, as well as firms wholly controlled by overseas investors. The final component, shareholding firms (SHEs), is available only from 1993. This component is limited to enterprises officially recognized as shareholding companies. This includes enterprises whose shares trade on China's domestic stock exchanges or on international exchanges. The shareholding category also includes firms whose shares are not traded on any exchange; these shares are typically held by government agencies or state enterprises. The SHE category does not include the numerous small firms, many now identified as shareholding cooperatives (*gufen hezuoshe*), that have issued nontraded shares to employees and managers.

APPENDIX B: MEASURING INDUSTRIAL CAPITAL

We begin with NBS figures for the year-end value of productive fixed assets at original cost (OPF*) for a specific base year. In this study, 1979 serves as the base year for the state and collective sectors. Within the other ownership (OTE) sector, 1987 is the base year for other domestic (ODE) and foreign-invested (FIE) firms. For the shareholding sector (SHE), which first appears in 1993, we assume zero value for OPF* at year-end 1992. The category of productive fixed assets

refers to assets that are used in the production process (*shengchan yong*); it excludes housing, schools, hospitals, and other nonindustrial facilities. The NBS data for OPF, like other fixed asset data, are not deflated to a consistent price base. Annual additions are added to the asset stock at current prices.

We calculate annual net additions to the stock of productive fixed assets by subtracting consecutive year-end values for OPF* to obtain gross additions to productive fixed assets and deducting depreciation allowances (capital consumption, CC):

$$\text{Net Investment at current prices} = \text{NI}(t) = \text{OPF*}(t) - \text{OPF*}(t-1) - \text{CC}(t). \tag{B-1}$$

We then deflate each year's net investment, using the investment goods price deflator, p_{kk} (see Appendix D and Table 3):

$$\text{Net Investment at 1990 prices} = \text{DNI}(t) = \text{NI}(t)/p_{kk}. \tag{B-2}$$

We reconstruct a year-end measure of deflated net capital stock as follows:

$$\text{Deflated year-end net value of productive fixed assets (at 1990 prices)} = \text{DNPF*}(t) = \text{DNPF*}(t-1) + \text{DNI}(t). \tag{B-3}$$

Finally, we construct an average annual measure of the deflated net capital stock by calculating the arithmetic average of successive year-end values:

$$\text{Average annual net value of productive fixed assets (at 1990 prices)} = \text{DNPF}(t) = [\text{DNPF*}(t) + \text{DNPF*}(t-1)]/2. \tag{B-4}$$

The resulting series for the average annual net value of productive fixed assets for various ownership categories appear in Table 4.

APPENDIX C: MEASURING LABOR INPUT

The NBS data refer to average annual employment in various ownership categories. The unit of measure is number of workers. Three issues arise. The first concerns nonindustrial labor. Chinese industrial enterprises deliver large quantities of housing, education, medical care, and other nonindustrial services to employees and their families. The value of these services is omitted from industrial output, but the input data include the resources devoted to nonindustrial services. To eliminate this asymmetry, productivity analysis should either increase output values to reflect the delivery of services or reduce inputs by eliminating resources devoted to the delivery of services. We have consistently attempted the latter course.

The NBS data for fixed assets include series for the original value of productive fixed assets, i.e., assets used for production (*shengchan yong*). This series

provides a straightforward and plausible means of removing housing and other nonindustrial fixed assets from our analysis. Unfortunately, the labor data include no comparable series. We have attempted a downward adjustment of the labor data to remove personnel assigned to nonindustrial duties in the following way. In an earlier study (Jefferson et al., 1996) we used data from China's 1985 industrial census and from subsequent World Bank enterprise surveys to estimate that nonindustrial service (*fuwu*) tasks occupied 16% of SOE workers and 8% of COE workers in 1992. We apply the same percentages to the SOE and COE labor data for 1993 to 1996. We assume that enterprises in the other enterprise (OTE) sector do not assign significant numbers of employees to nonindustrial tasks, and make no adjustment to the reported employment totals on this account.

A second issue arises from recent changes in the length of the work week. Studies of Chinese industrial productivity routinely use the number of workers to measure labor input. This approach ignores possible changes in labor quality and also assumes a fixed work week. Beginning in 1994, the latter assumption is no longer tenable. Until 1994, a 6-day, 48-hour week was the norm for workers throughout Chinese industry. On February 3, 1994, the State Council issued regulations that took effect on March 1, 1994, specifying that "staff and workers work 8 hours a day and 44 hours, on the average, a week" (*New Law Digest 1994*, p. 8). On March 25, 1995, the State Council announced further changes, effective from May 1, 1995, specifying that "staff and workers shall work 8 hours a day and 40 hours a week" (*New Law Digest 1995*, p. 7).

For 1993 and all prior years, we assume that the typical work year consists of fifty 48-hour weeks, or 2,400 annual hours. The typical work year declines to 50*44 = 2,200 hours after March 1, 1994 and to 50*40 = 2,000 hours from May 1, 1995. We estimate the typical work year for 1994 as 2400*(2/12) + 2200*(10/12) = 2,233 hours, or 7% below the 1993 figure. For 1995, the typical work year is 2200*(4/12) + 2000*(8/12) = 2067 hours, 13.8% below the 1993 figure. For 1996, the work year is 2,000 hours, or 16.7% below the 1993 figure. Our adjustment for reductions in the work week consists of deducting these amounts from the NBS work force totals. Although longer hours continue in some firms (Couzin, 1999), published sources and interview data indicate that the new regulations have been widely implemented in all ownership categories, including private businesses. We therefore apply these adjustments to all categories of firms.

Implementation of the furlough (*xiagang*) policy for reducing redundant personnel represents a third issue surrounding the measurement of industrial labor. Beginning in 1993, Chinese enterprises, particularly in the state sector, began to implement a new policy called furlough (*xiagang*), under which workers were relieved of their duties but continued to receive partial wage payments from their employers. NBS officials confirm that furloughed workers continued to be included in the industrial data as workers and employees (*zhigong*) prior to 1998. Beginning with the data for 1998, the number of workers and employees is

explicitly restricted to personnel who are on the job (*zaigang zhigong;* State Statistical Bureau, 1999, p. 177).

Although we have no precise data, the order of magnitude of the *xiagang* phenomenon is well established. A typical report states that the number of furloughed urban workers had reached 8.15 million by the end of 1996, of whom 5.42 million were furloughed from state enterprises (Yang et al., 1998, p. 220). The unadjusted SOE labor data for 1996 show average annual employment of 42.05 million. We speculate that 5.4 million or 12.8% of these workers had been furloughed. Adjusting the labor data to reflect the impact of *xiagang* would raise the figures for SOE labor productivity and TFP during 1993–1996, with the largest adjustment coming in the terminal year. However the impact on TFP trends is not decisive.[12] Since this adjustment does not alter the broad performance trend in the state sector, where furlough activity is heavily concentrated, we have made no adjustment to reflect the impact of *xiagang* on TFP measurement.

APPENDIX D: PRICE DEFLATORS

Because price trends for industrial products and for material inputs have diverged substantially during the reform period, we continue our practice from previous papers (Jefferson et al., 1992, 1996) of separately deflating the time series for industrial output, intermediate inputs, and fixed assets. We use price deflators which, since 1984, have been calculated by the State Statistics Bureau's Urban Survey Team. The lack of price data specific to ownership categories obliges us to ignore possible differences among price trends affecting different segments of industrial production. The implicit assumption of identical price trends is particularly inappropriate for foreign-linked firms, whose reliance on imported materials and export sales exposes them to price trends that may differ from those facing other firms.

The deflators used in this study extend price indices developed in our prior work (Jefferson et al., 1996), which terminate with data for 1992. Price indices for subsequent years come from the following sources:

Output: State Statistical Bureau (1997), p. 283 (ex-factory price for all industrial goods).

Fixed Assets: Investment Yearbook Editorial Committee (1997), pp. 7–8 (for 1992–1995) and Price Yearbook Editorial Committee (1997), p. 424 (for 1996).

Intermediate inputs: data provided by the National Bureau of Statistics.

[12] Multiplying the adjusted SOE labor input for 1996 (Table 4A) by 0.872 to remove 12.8% of workers on furlough raises average annual TFP growth from −1.11% to −0.84% for 1992 to 1996, from −2.91% to −2.55% for 1993 to 1996, and from 1.72% to 1.78% for 1980 to 1996.

APPENDIX E: ACCOUNTING CHANGES IN THE MEASUREMENT OF INDUSTRIAL OUTPUT

Since the early 1950's, Chinese statistics for industrial output have focused on the gross value of industrial output (*zongchanzhi*). In connection with the national industrial census of 1995, NBS introduced a revised method of calculating gross value (Industrial Census Office, 1996). The gross output data for 1995 appear in two forms, figures calculated according to the old method (*yuan guiding*) and figures based on the new method (*xin guiding*). Beginning in 1996, all figures are based on the new method (Industrial Census Office, 1996).

Since our series covers 1980 to 1996, the easiest (and in reality, the only feasible) approach is to construct a consistent series of industrial output (GVIO) by converting the 1996 figures to the old method. To do this, we simply (1) multiply the 1996 gross value figures (new method) by the 1995 ratio of GVIO (old method) to GVIO (new method) and (2) add value-added tax to the resulting total. We make this conversion separately for each ownership category.

APPENDIX F: NOMENCLATURE

Symbols Used in Text

ln	natural logarithm
GVIO	gross value of industrial output (GVIO) in current prices
K	net value of fixed assets in original prices
L	total end-of-year labor input (persons)
M	intermediate inputs in current prices
ϵ	a stochastic error term
α_j	weight used to combine measures of single-factor productivity, where $j = K$, L, and M.
SOE	state-owned enterprise
COE	collective-owned enterprise
FIE	foreign-invested enterprise
OTE	other-ownership enterprise
ODE	other domestic enterprise
SHE	shareholding enterprise
PRORAT	ratio of profits plus taxes to gross output
TFP	total factor productivity
NUM	number of industrial firms outside the state sector classified as independent accounting units
β	the estimated coefficient on TFP_{SOE} in the PRORAT equation
γ	the estimated coefficient on TFP_{COE} in the PRORAT equation
θ	the estimated coefficient on NUM in the PRORAT equation

Additional Symbols, Used in Appendices

OPF*	year-end value of productive fixed assets at original cost
CC	depreciation allowance (capital consumption)
NI	net investment in current prices
DNI	net investment in 1990 prices
p_{kk}	investment goods price deflator
DNPF*	deflated year-end net value of productive fixed assets at 1990 prices
VA	value added in current prices

REFERENCES

Bai, Chong-en, Li, David D., and Wang, Yijiang, "Enterprise Productivity and Efficiency: When Is Up Really Down?" *J. Comp. Econ.* **24,** 3:265–280, June 1997.

Chen, Kuan, Jefferson, Gary H., Rawski, Thomas G., Wang, Hongchang, and Zheng, Yuxin, "New Estimates of Fixed Investment and Capital Stock for Chinese State Industry." *China Quart.*, 114:243–266, June 1988.

Couzin, Odilon, "Little Money, No Benefits." *Far Eastern Econ. Rev.* **162,** 40:59, Oct. 7, 1999.

Department of Comprehensive Statistics, National Bureau of Statistics, *Xin Zhongguo wushinian tongji ziliao huibian* (Compilation of Statistical Materials for Fifty Years of New China). Beijing: Zhongguo tongji chubanshe, 1999.

Guo, Kesha, "Aggregate Demand or Structural Problems? How Distorted Economic Structure Constrains China's Economic Growth." *Jingji yanjiu* (Economic Research), 9:15–21, 1999.

Huang, Song, and Xu, Dehua, "Following Enterprise Reform, Statistical Work at Township and Village Enterprises Needs Strengthening." *Zhongguo xiangzhen qiye* (China Township Enterprise), 11:7–8, 1998.

Hunan Provincial TVE Management Office, "Strengthen TVE Management Offices: Survey and Reflection on TVE Management Offices in Hunan." *Xiangzhen qiye* (Rural Industry), 8:4–6, 1999.

Industrial Census Office, *Disance chuanguo gongye pucha de zuzhi yu shishi* (Organization and Implementation of the Third National Industrial Census). Beijing: Zhongguo tongji chubanshe, 1996.

Industrial Census Office, *Zhonghua renmin gongheguo 1995 nian disance chuanguo gongye pucha ziliao huibian (guoyou, sanzi, xiangzhenjuan)* (People's Republic of China Third National Industrial Census, 1995 Data for State, Foreign-Linked, and Township-Village Industry). Beijing: Zhongguo tongji chubanshe, 1997.

Industry Yearbook Editorial Committee. *Zhongguo gongye jingji tongji nianjian 1998* (China Industrial Economy Statistics Yearbook 1998). Beijing: Zhongguo tongji chubanshe, 1998.

Investment Yearbook Editorial Committee, *Zhongguo guding zichan touzi tongji nianjian 1950–1995* (China Fixed Asset Investment Statistics Yearbook 1950–1995). Beijing, Zhongguo tongji chubanshe, 1997.

Jefferson, Gary H., "Don't Shortchange State-Owned Enterprise Reform." *Harvard China Rev.* **1,** 2:15–19, 1999.

Jefferson, Gary H., and Rawski, Thomas G., "How Industrial Reform Worked in China: The Role of Innovation, Competition and Property Rights." In *Proceedings of the World Bank Annual Conference on Development Economics 1994*, pp. 129–156. Washington, DC: World Bank, 1995.

Jefferson, Gary H., Rawski, Thomas G., and Zheng, Yuxin, "Growth, Efficiency, and Convergence in China's State and Collective Industry." *Econ. Develop. Cult. Change* **40,** 2:239–266, Jan. 1992.

Jefferson, Gary H., Rawski, Thomas G., and Zheng, Yuxin, "Chinese Industrial Productivity: Trends, Measurement Issues, and Recent Developments." *J. Comp. Econ.* **23,** 2:146–180, Oct. 1996.

Jefferson, Gary H., and Singh, Inderjit, Eds., *Enterprise Reform in China: Ownership, Transition, and Performance*. New York: Oxford Univ. Press, 1999.

Jefferson, Gary H., Singh, Inderjit, Xing, Junling, and Zhang, Shouqing, "China's Industrial Performance: A Review of Recent Findings." In Gary H. Jefferson and Inderjit Singh, Eds., *Enterprise Reform in China: Ownership, Transition, and Performance*, pp. 127–152. New York: Oxford Univ. Press, 1999.

Jefferson, Gary H., Zhang, Ping, and Zhao, John Z. Q., "Structure, Authority, and Incentives in Chinese Industry." In Gary H. Jefferson and Inderjit Singh, Eds., *Enterprise Reform in China: Ownership, Transition, and Performance*, pp. 43–64. New York: Oxford Univ. Press, 1999.

Lardy, Nicholas R., "China's Economic Growth in an International Context." *Pacific Rev.* **12,** 2:163–171, 1999.

Liu, Xuewen, "Promote System Innovation, Rekindle the TVE Spurt." *Xiangzhen qiye* (Rural Industry), 6:4–7, 1999.

Naughton, Barry, "Implications of the State Monopoly Over Industry and Its Relaxation." *Modern China* **18,** 1:14–41, Jan. 1992.

"New Law Digest: National Legislation." *China Law & Practice* **8,** 8:1–10, 1994.

"New Law Digest: National Legislation." *China Law & Practice* **9,** 4:1–10, 1995.

Perkins, Frances, Zheng, Yuxin, and Cao, Yong, "The Impact of Economic Reform on Chinese Industrial Productivity." In Kai-yuen Tsui, Tien-tung Hsueh, and Thomas G. Rawski, Eds., *Productivity, Efficiency and Reform in China's Economy*, pp. 151–224. Hong Kong: Hong Kong Institute of Asia-Pacific Studies, 1995.

Price Yearbook Editorial Committee, *Zhongguo wujia nianjian, 1997* (China Price Yearbook 1997). Beijing, 1997.

Rawski, Thomas G., "China: Prospects for Full Employment," Employment and Training Papers, no. 47. Geneva: International Labour Office, 1999.

Rawski, Thomas G., "China's Move to Market: How Far? What Next?" In Ted Galen Carpenter and James A. Dorn, Eds., *China's Future: Constructive Partner or Emerging Threat?*, pp. 317–339. Washington, D.C.: Cato Institute, 2000.

Singh, Inderjit, Ratha, Dilip, and Xiao, Geng, "Non-State Enterprises as an Engine of Growth: An Analysis of Provincial Industrial Growth in Post-Reform China," World Bank Research Paper Series, China CH-RPS 20. Washington, DC: World Bank, 1993.

State Statistical Bureau, *Zhongguo tongji nianjian* (China Statistics Yearbook). Beijing: Zhongguo tongji chubanshe, annual.

Woo, Wing Thye, Fan, Gang, Hai, Wen, and Jin, Yibiao, "The Efficiency and Macroeconomic Consequences of Chinese Enterprise Reform." *China Econ. Rev.* **4,** 2:163–168, 1993.

Wu, Yanrui, *Productive Performance in Chinese Enterprises: An Empirical Study*. New York: St. Martin's, 1996.

Wu, Yunhe, "Crackdown on Statistics Abusers." *China Daily*, p. 3, Sept. 7, 1994.

Wu, Yunhe, "Census Nets Critical Info for Industry." *China Daily*, p. 1, Apr. 3, 1997.

Xie, Deren, "The Paradox of High Debt Ratios for State Enterprises: Proposition and Explanation." *Jingji Yanjiu* (Economic Research), 9:72–79, 1999.

Yang, Yixiong, et al., *Shiye chongjibo: Zhongguo jiuye fazhan baogao* (Pounding Waves of Unemployment: China Employment Development Report). Beijing: Jinri Zhongguo chubanshe, 1998.