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How Successful Has Chinese Enterprise Reform Been? Pitfalls in Opposite Biases and Focus[1]

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We analyze two new data sets: one on state-owned enterprises (SOEs) and another on town and village enterprises (TVEs). We find zero TFP growth in SOEs and positive TFP growth in COEs. The evidence suggests that the positive TFP growth in SOEs found by some recent studies might be due to underdeflation of gross output and overdeflation of intermediate inputs. The criterion for successful SOE reform should also include intertemporal efficiency and SOEs' contribution to macroeconomic stability. Increases in technical efficiency do not necessarily improve SOEs' financial performance. SOE personnel have received an increasing proportion of value added, hence creating a fiscal crisis for the state. *J. Comp. Econom.*, June 1994, **18**(3), pp. 410–437. University of California, Davis, California 95616; Fort Lewis College, Durango, Colorado 81301; University of California, Davis, California 95616; and Chinese Academy of Social Sciences, Beijing 100836, People's Republic of China. © 1994 Academic Press, Inc.

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1. INTRODUCTION

Reversals in popular opinion about total factor productivity (TFP) growth in Chinese enterprises are not new. Up to the middle of the 1980's, the bulk of the published literature was skeptical that the post-1978 reforms had raised TFP growth substantially. Chow (1985) found that

> there is no evidence that the outputs in the years 1979 to 1981 were higher than can be accounted for by the labor and capital inputs, using a production function estimated for the period 1952 to 1981. (pp. 152)

The World Bank (1985) estimated that the level of TFP in industrial state-owned enterprises (SOEs) in 1982 was lower than the level in 1957 and 1978.[2] Rawski (1986) reflected the dominant view of that time when he concluded that

> Total factor productivity shows no significant upward trend and remains near or perhaps below levels attained during the 1950s. . . the desired transition from 'extensive' to 'intensive' growth has hardly began. (pp. 502)[3]

The second half of the 1980's saw revisionism emerging. Chen et al. (1988) (CWZJR) found TFP growth in the industrial sector to rise from an annual average of 0.9% in the 1957–1978 period to 5.5% in the 1979–1985 period. Dollar (1990) corroborated CWZJR's finding at the firm level. More recently, Jefferson et al. (1992) (JRZ) estimated a gross-output production function, instead of the usual two-factor value-added production functions, for a sample consisting of industrial SOEs aggregated at the city/county level at two points in time. JRZ found that annual TFP growth for SOEs averaged 2.4% in the 1984–1987 period.

Another reason for revisionism on enterprise reforms was the quick growth of technically efficient collectively owned enterprises (COEs). COEs, unlike SOEs, do not have privileged access to inputs and credits, but their operations are subject to fewer restriction. COEs consist of urban collectives,

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[2] World Bank (1985, Table 7.1, pp. 111). Lardy (1989) confirmed this finding.

[3] Dernberger (1988) and Perkins (1988) found TFP growth in the 1976–1984 period to be unexceptional. There were differences in their estimates, however. Dernberger (1988) found TFP growth in the 1976–1984 period to be slower than that in the 1963–1970 period but faster than that in the 1953–1957 period. Perkins (1988), on the other hand, had TFP growth in the 1976–1985 period faster than that in the 1965–1976 period but slower than that in the 1953–1957 period.

county collectives, and town and village enterprises (TVEs) in the countryside.[4] The TVEs have registered the most dramatic growth and comprised the bulk of the COEs. Svejnar (1990) found that TVEs had an annual TFP growth rate of about 13% in the 1981–1986 period.[5] JRZ found that COEs had a TFP growth rate of 4.6% per year in the 1984–1987 period, almost double that of SOEs.

We have four goals in this paper. The first goal is to report the results of our analysis of a new data set that contains production and financial information of 300 large and medium industrial SOEs over the 1984–1988 period. In our opinion, the analysis of SOE performance in the reform era should focus mainly on the large and medium enterprises because the small ones could be, and many have been, rendered efficient by leasing them to the workers. Our sample is more representative than that of Dollar (1990), which consisted of only 20 SOEs and was biased toward the best-performing ones.[6] Our results contradict those of the revisionist papers that have come to dominate the discussion since 1988. We found that TFP growth in SOEs has been zero at best in the 1984–1988 period.

Our second goal is to report our analysis of a second new data set that contains production and financial information of 200 TVEs in 10 provinces over the 1984–1987 period. Our TVE data set is thus more representative than Svejnar's (1990), which consisted of 122 firms from 4 counties.[7] Our results confirm those of Svejnar and JRZ who found TFP growth in COEs to have been impressive.

Our third goal is to raise the possibility that the high TFP growth in some studies might have been due to a mixture of underdeflation of gross output and overdeflation of intermediate inputs. JRZ's results could have been due to the unintentional removal of an offsetting bias and, possibly, of the overdeflation of intermediate inputs. Svejnar's results could be due to intermediate inputs being excluded from his estimations of gross output production functions.

[4] Urban collectives are often subsidiaries set up by SOEs to evade regulations on operations. County collectives are generally owned and managed by county governments, and in some cases have many of the operating characteristics of SOEs. The official statistics on TVEs now count all enterprises at and below the township level. The ownership rights of TVEs and their supervision by local authorities vary across regions and time. In many cases, the only tie between TVE managers and local authorities is an agreement on an annual financial contribution by the former.

[5] Estimated from the 1981–1986 regression in Table 11.2 by dividing the coefficient of the 1986 dummy by 5.

[6] Granick (1990), who also used Dollar's data set, noted that three of the firms were among the ten firms that were selected in 1983 to receive "national awards for distinction in management" (p. 13); and "the sample enterprises were throughout [1976 to 1982] 40 to 120 percent more profitable than were Chinese state-owned industrial enterprises as a whole" (p. 180).

[7] Source is Table 2.2.

Our fourth goal is to argue that the criteria for judging the success of enterprise reform should be broadened beyond increases in the TFP growth rate. At a minimum, financial performance of enterprises should also be considered. An increase in technical efficiency means an increase in value added, but this does not necessarily mean that government revenue would increase commensurately. We found that the proportion of net output, or value added, of SOEs dispensed, directly and indirectly, to workers and managers has increased over time. This development has created a fiscal crisis for the government that threatens infrastructure investment and macroeconomic stability. Incorporation of the financial performance criterion into the analysis will focus attention on the linkage between incomplete enterprise reforms and macroeconomic instability.

2. THE EQUATIONS TO BE ESTIMATED

Assuming weak separability, the general translog production function for value added, Q, in terms of capital, K, and labor, L, is

$$\ln Q = \alpha_0 + \alpha_T T + \alpha_K \ln K + \alpha_L \ln L + \frac{1}{2}\alpha_{KK}(\ln L)^2 + \alpha_{KL}(\ln K)(\ln L), \quad (1)$$

where T is time trend. The TFP growth rate is given by α_T. The assumption of constant returns to scale (CRS) requires the imposition of two conditions:

$$\alpha_{KK} = \alpha_{LL} = -\alpha_{KL} \quad (2)$$

$$\alpha_K + \alpha_L = 1. \quad (3)$$

In the literature, it is usual to impose Eq. (3) to yield a modified translog production function:[8]

$$\ln Q = \alpha_0 + \alpha_T T + \alpha_K \ln K + \alpha_L \ln L + \frac{1}{2}\alpha_{KK}\left[\ln\left(\frac{K}{L}\right)\right]^2. \quad (4)$$

If we add the restriction that

$$\alpha_{KK} = 0, \quad (5)$$

then we have the Cobb–Douglas (C–D) production function of:

$$\ln Q = \alpha_0 + \alpha_T T + \alpha_K \ln K + \alpha_L \ln L. \quad (6)$$

CRS in Eqs. (4) and (6) can be determined by testing whether Eq. (3) holds. Another way of checking CRS is to rewrite (4) and (6) in intensive form:

[8] For example, Dollar et al. (1988).

$$\ln\left(\frac{Q}{L}\right) = \alpha_0 + \alpha_T T + \alpha_K \ln\left(\frac{K}{L}\right) + (\alpha_K + \alpha_L - 1)\ln(L) + \frac{1}{2}\alpha_{KL}\left[\ln\left(\frac{K}{L}\right)\right]^2 \quad (7)$$

$$\ln\left(\frac{Q}{L}\right) = \alpha_0 + \alpha_T T + \alpha_K \ln\left(\frac{K}{L}\right) + (\alpha_K + \alpha_L - 1)\ln(L). \quad (8)$$

CRS is rejected when the estimated coefficient of $\ln(L)$ is different from zero.

In the case where intermediate input, M, is included in the estimation, Q is gross output, and the Cobb–Douglas specification is

$$\ln Q = \alpha_0 + \alpha_T T + \alpha_K \ln(K) + \alpha_L \ln(L) + \alpha_M \ln(M). \quad (9)$$

3. NET OUTPUT PRODUCTION FUNCTIONS FROM THE SOE DATA SET

The revisionist CWZJR results were obtained by a mixture of deflation of the capital stock, exclusion of selective years, and downward adjustment of the amount of capital and labor employed. The reduction of the reported capital and labor data has its rationale in the fact that SOEs provide a wide range of social services to their workers in addition to producing the designated goods. CWZJR argued that an accurate assessment of production efficiency required that capital and labor not directly used in the production process, e.g., housing stock, medical facilities, medical personnel, and sales staff, be excluded.

This production criterion for excluding non-direct capital and labor is questionable. The fact is that enterprises could not have supplied the observed output if they had not provided these social services to their workers. In the absence of functioning markets in housing, medical services and education, the SOEs had to provide these services in order to enable the production workers to participate in the production process. It is exactly for this underdeveloped-markets reason that textile mills in Europe and Japan provided housing to their workers at the beginning of those countries' industrial revolutions.

While lower-quality social services might not have compromised production, a complete absence of social services would have had adverse effects on production. Therefore, some, but not all, of the complementary capital and labor should be excluded. The appropriateness of this compromise criterion depends on the focus of analysis. Consider the case of two enterprises that have identical amounts of capital and labor, and assume that the manager of the first enterprise allocated much more capital to luxury housing because of pressures from a powerful workers' council. An inefficiency has occurred in the first enterprise because of an inappropriate institutional structure, and this is an inefficiency of the production unit but not of its production process. The question of whether the firm is allocating and using its entire

TABLE 1

ORIGINAL DATA WITH PERIOD AVERAGE CAPITAL STOCK USED IN MODIFIED TRANSLOG FUNCTION (TWO INPUTS)

	α_0	α_T	α_K	α_L	$\frac{1}{2}\alpha_{KK}$	adj. R^2
Food processing	−1.460	−.096	.585	.638	−.310	.444
	(−2.32)	(−2.40)	(6.96)	(5.59)	(−3.88)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 6.68$	
Textile	−.342	−.100	.735	.310	.198	.627
	(−0.74)	(−2.90)	(4.03)	(1.74)	(1.44)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 0.57$	
Materials	−.835	−.027	.309	.773	.002	.738
	(−2.74)	(−0.95)	(4.16)	(8.38)	(0.04)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 5.01$	
Machinery	.696	.014	.272	.568	−.112	.485
	(2.08)	(0.68)	(5.07)	(8.60)	(−1.64)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 15.61$	
Total	−.216	−.040	.445	.553	−.060	.602
	(−1.20)	(−2.84)	(14.52)	(14.20)	(−2.05)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = .004$	

Note. Capital deflator from Jefferson et al. (1992). t-Statistics in parentheses. Critical value of $F(1,300)$: $F = 3.87$ at 95%, $F = 6.73$ at 99%, and $F = 11.0$ at 99.9%.

capital stock efficiently is just as valid as the question of whether that portion of the capital stock allocated to direct production is being employed efficiently. It is only within such a broader focus on efficiency that we can accommodate the phenomenon of rising consumption-oriented investment noted by many Chinese scholars, e.g., Chen et al. (1987). We can treat the difference in TFP performance when complementary capital and labor are included and excluded as an indicator of the output cost of pampering workers.

In Table 1, we provide estimates of the two-input modified translog production function. Like CWZJR, we deflated the nominal net output with the price of gross output. We derived the capital stock by deflating the investment of each period and adding it to the depreciated capital stock of the previous period. We did not exclude complementary capital and labor. In every case, estimated TFP growth was negative and statistically significant.

Table 2 presents re-estimated parameters of the translog production function obtained by excluding nonproductive capital and nonproductive labor. TFP growth was statistically significant and negative for the food processing and textile industries, and not different from zero for the materials and machinery industries. The overall sample yielded a TFP growth rate that was not different from zero instead of the significant −4% when nonproductive inputs were included in the estimation.

TABLE 2

ADJUSTED DATA WITH PERIOD AVERAGE CAPITAL STOCK USED IN MODIFIED TRANSLOG FUNCTION (TWO INPUTS)

	α_0	α_T	α_K	α_L	$\frac{1}{2}\alpha_{KK}$	adj. R^2
Food processing	−1.963	−.081	.520	.807	−.398	.466
	(−3.14)	(−2.09)	(6.32)	(7.23)	(−4.23)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 13.76$	
Textile	−.020	−.080	.733	.303	.075	.653
	(−0.05)	(−2.52)	(3.02)	(1.25)	(0.58)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 0.40$	
Materials	−.710	−.008	.292	.791	−.023	.739
	(−2.24)	(−0.30)	(4.54)	(9.03)	(−0.44)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 4.45$	
Machinery	1.000	.023	.207	.613	−.205	.496
	(3.11)	(1.20)	(3.26)	(8.44)	(−2.98)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 20.58$	
Total	−.065	−.020	.421	.576	−0.088	.608
	(−0.37)	(−1.44)	(13.48)	(14.10)	(−2.87)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 0.008$	

Note. Managerial and sales personnel excluded from labor input. Nonproductive fixed assets excluded from capital stock. Capital deflator from Jefferson et al. (1992). t-Statistics in parentheses. Critical value of $F(1,300)$: $F = 3.87$ at 95%, $F = 6.73$ at 99%, and $F = 11.0$ at 99.9%.

Both the food and materials industries showed clearly increasing returns to scale, and the materials industry showed economies of scale at the 95% significance level but not at the 99% level. Only the textile industry exhibited unambiguously constant returns to scale. And yet, the overall sample suggested that constant return to scale characterized the industrial sector. This was not caused by the preponderance of textile firms in the sample because they formed the smallest industrial cluster.[9] It was more likely caused by the vastly different output parameters across industries: α_K was 0.8 for food processing but 0.3 for textile, and α_L was 0.7 for textile but 0.2 for machinery. The fact that the aggregate production function did not look anything like the production functions of the four component industries stresses the importance of not relying excessively on conclusions about economies of scale and TFP growth based on aggregate relationships until they are confirmed by microlevel data.

Tables 3 and 4 provide information about the robustness of the conclusions drawn from Table 2 by, respectively, using period-end capital stock

[9] Our sample consisted of 111 machinery firms, 85 materials firms, 58 food processing firms, 37 textile firms, and 9 miscellaneous firms.

TABLE 3

ADJUSTED DATA WITH PERIOD END CAPITAL STOCK AND MODIFIED TRANSLOG PRODUCTION FUNCTION (TWO INPUTS)

	α_0	α_T	α_K	α_L	$\frac{1}{2}\alpha_{KK}$	adj. R^2
Food processing	−1.911	−0.089	0.565	0.751	−0.362	0.468
	(−3.06)	(−2.28)	(7.05)	(6.91)	(−4.02)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 13.10$	
Textile	−.060	−.085	.730	.309	.080	.655
	(−0.14)	(−2.68)	(3.29)	(1.40)	(0.65)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 0.49$	
Materials	−.716	−.014	.306	.780	−.045	.740
	(−2.28)	(−0.49)	(4.74)	(8.99)	(−0.86)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 4.88$	
Machinery	1.017	.019	.248	.573	−.201	.505
	(3.18)	(0.96)	(4.10)	(8.26)	(−2.97)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = 20.70$	
Total	−.085	−.025	.436	.565	−.094	.613
	(−0.48)	(−1.83)	(14.47)	(14.34)	(−3.12)	
	Test $H0$: $\alpha_K + \alpha_L = 1$				$F = .004$	

Note. Unproductive capital and unproductive labor excluded. Capital deflator from Jefferson et al. (1992). t-Statistics in parentheses. Critical value of $F(1,300)$: $F = 3.87$ at 95%, $F = 6.73$ at 99%, and $F = 11.0$ at 99.9%.

instead of period average, and assuming a Cobb–Douglas specification instead of a translog specification. The major conclusions reported in Table 2 are confirmed. TFP growth is negative in the food processing and textile industries and zero in materials and machinery. Similarly, the overall production function shows constant returns to scale even though only 37 out of the 300 firms did so.

4. GROSS OUTPUT PRODUCTION FUNCTIONS FROM THE SOE DATA SET

The next step was to extend the analysis to cover the case of three inputs, a situation in which JRZ had found significant positive TFP growth. Table 5 reports the results of the Cobb–Douglas specification where the value of material inputs was deflated by the deflator computed by JRZ. Our results are remarkably similar to those of JRZ. Our overall sample gave an annual TFP growth rate of 2.4% during the 1984–1988 period compared to JRZ's estimate of 2.4% in the 1980–1988 period and 3.0% in the 1984–1988 period; see Table 7 in JRZ. Like JRZ, we also found increasing returns to scale.

We have grounds to believe, however, that the results in Table 5 and in JRZ were caused by overdeflation of material inputs *and* underdeflation of

TABLE 4

ADJUSTED DATA WITH PERIOD AVERAGE CAPITAL STOCK USED, COBB–DOUGLAS PRODUCTION FUNCTION

	α_0	α_T	α_K	α_L	adj. R^2
Food processing	−1.684	−0.068	0.560	0.695	0.437
	(−2.63)	(−1.71)	(6.66)	(6.23)	
	Test $H0$: $\alpha_K + \alpha_L = 1$			$F = 8.20$	
Textile	−.068	−0.077	0.603	0.432	0.654
	(−0.10)	(−2.45)	(6.70)	(4.73)	
	Test $H0$: $\alpha_K + \alpha_L = 1$			$F = 0.37$	
Materials	−.717	−.007	.287	.793	.740
	(−2.27)	(−0.24)	(4.53)	(9.07)	
	Test $H0$: $\alpha_K + \alpha_L = 1$			$F = 4.27$	
Machinery	.742	.020	.319	.524	.489
	(2.34)	(1.50)	(6.19)	(7.56)	
	Test $H0$: $\alpha_K + \alpha_L = 1$			$F = 16.13$	
Total	−.040	−.016	.445	.541	.606
	(−0.22)	(−1.16)	(14.76)	(13.85)	
	Test $H0$: $\alpha_K + \alpha_L = 1$			$F = 0.37$	

Note. Unproductive capital and unproductive labor excluded. Capital deflator from JRZ. t-Statistics in parentheses. Critical value of $F(1,300)$: $F = 3.87$ at 95%, $F = 6.73$ at 99%, and $F = 11.0$ at 99.9%.

output. The former understated the quantity of intermediate inputs used, and the latter overstated the quantity of final output. Together, these two biases forced estimated TFP growth to be higher than actual. The basis of our belief comes from Table 6. In Part A of Table 6, we see that the value added in current prices, series (a), of the industrial SOEs in the JRZ sample is less than their value added in 1980 prices, series (b), for every year in the 1981–1988 period. The result is a declining value-added deflator, series (c), for most of the period. The value-added deflator in 1986 was 8% lower than its value in 1980, in marked contrast to the behavior of the consumer price index (CPI), series (e), which went up 26% in the same period. These divergent trends in the value added deflator and the CPI, as we will show, are anomalous given the sequencing of price reforms in China and the experiences of other socialist countries.

The downward trend in JRZ's value added deflator is at odds with the official value-added deflator for the industrial sector, series (d). However, the official series is not definitive because the State Statistical Bureau (SSB) did not construct its real, or constant price, value-added series by double deflation, i.e., by deflating gross output value and intermediate input cost with the gross-output price index and input-price index, respectively. SSB does not have adequate data on the transactions under the dual-track pricing of inputs

TABLE 5

MATERIAL INPUTS DEFLATED BY JRZ'S DEFLATOR, THREE-INPUT COBB-DOUGLAS FUNCTION

	α_0	α_T	α_K	α_L	α_M	adj. R^2
Food processing	−0.359	.0018	0.132	0.048	0.956	0.933
	(−2.00)	(0.19)	(5.61)	(1.46)	(50.00)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 30.27$	
Textile	.205	.020	.069	.116	.854	.970
	(1.60)	(2.07)	(2.26)	(4.14)	(41.96)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 5.53$	
Materials	−.072	.025	−.041	.162	.949	.986
	(−1.02)	(4.05)	(−2.95)	(8.06)	(95.74)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 66.75$	
Machinery	1.012	.034	0.101	.010	.834	.958
	(10.91)	(5.87)	(6.41)	(0.47)	(75.50)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 23.15$	
Total	.358	.024	.053	.086	.884	.965
	(6.99)	(6.18)	(6.00)	(7.54)	(128.35)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 14.44$	

Note. Capital deflator for JRZ. Period average capital stock. Unproductive labor and unproductive capital excluded. t-Statistics in parentheses. Critical value of $F(1,300)$: $F = 3.87$ at 95%, $F = 6.73$ at 99%, and $F = 11.0$ at 99.9%.

and the occasionally widespread reselling of raw materials acquired at the low official prices. In the absence of an intermediate-input price index that SSB considered to be reliable, it chose the gross-output price index with which to deflate the nominal value added in the industrial sector.

Given that input prices have been gradually liberalized beginning in late 1984, their steady rise relative to output prices since then means that the official deflation method would understate the real value added assuming that output value, input value and output price were measured correctly. One may be puzzled by why the state statistical agency would choose a procedure that would understate growth, a politically damaging choice. It is well-known that the real gross output series collected by the government is contaminated by underdeflation; see, e.g., Field (1992) and Rawski (1991). Enterprises have engaged in false innovations to evade price controls on existing products, and they have many times valued their products, especially innovations, at current prices when they calculated their real output. This underdeflation of gross output would overstate the real value added, assuming that output value, input value and input price were measured correctly.

The exaggeration of real gross output growth and hence the corresponding understatement of the implicit gross output price deflator appears to be quite

TABLE 6

OVERDEFLATION OF INTERMEDIATE INPUTS AND UNDERDEFLATION OF OUTPUT

A. Co-movements of JRZ's value added deflator and official prices

	JRZ's sample of industrial SOEs			From official statistics	
	Value added in current prices (a)	Value added in 1980 prices (b)	Deflator for value added (a)/(b) = (c)	Deflator for value added in industry (d)	Consumer price index (e)
1980	131.9	131.9	100.0	100.0	100.0
1981	131.8	133.2	98.9	100.9	102.4
1982	137.3	141.5	97.0	100.7	104.4
1983	150.1	158.1	94.9	100.8	105.9
1984	172.1	184.6	93.2	103.0	108.9
1985	205.8	218.3	94.3	107.8	118.5
1986	220.7	240.9	91.6	113.0	125.6
1987	252.9	269.4	93.9	115.4	134.8
1988	306.3	316.7	96.7	126.1	159.7

B. Co-movements of value added deflator and consumer price index during the gradual reform periods in Hungary and Poland

	Poland		Hungary	
	Deflator for value added in industry	Consumer price index CPI	Deflator for value added in industry	Consumer price index CPI
1972			100.0	100.0
1973			104.1	103.3
1974			107.8	105.2
1975			110.9	109.2
1976			109.6	115.0
1977			113.6	119.5
1978			116.4	125.1
1979			119.2	136.2
1980			108.3	148.8
1981			110.4	155.6
1982			117.9	166.4
1983			122.0	177.2
1984	100.0	100.0	130.7	192.5
1985	116.3	115.1	142.5	206.1
1986	138.9	135.4	147.8	216.9
1987	179.8	169.5	159.8	234.7
1988	301.3	271.5	184.3	273.0
1989	1224.3	953.4	223.1	319.2

Note. Because JRZ did not report capital consumption (*CC*) and major repair funds (*MRF*) data in real terms, we assumed the following relationship ($CC + MRF$) = 0.156* (gross value − cost of intermediate inputs) to hold in real terms in order to construct series (*b*). This assumption will equate the 1980 figure for net value added.

large. Field (1992) estimated that the official index for real industrial output overstated growth by 4.2 percentage points over the 1985–1987 period, with 3.3 percentage points for 1986–1987 alone. Using *ad hoc* procedures (i) to control for spurious product innovations and (ii) to control for the inflation of capital goods, Jefferson (1992) found that the reported capital productivity growth rate of the most innovative industries would have to be adjusted downward significantly.[10] Specifically, the growth rates for the high-growth industries in the 1980–1985 period are:

	Reported rate	Rate after adjustment
Electronics and communications equipment	14.32	7.55
Machine-building	5.92	1.74
Electric machinery	5.86	2.35
Transport machinery	8.26	3.01

Rawski (1991), while presenting no estimates of the upward bias in reported real growth rates, noted:

> [The chemical industry] data show that the arithmetic average of annual physical output growth for nine major commodities lags behind the reported growth rate of output value at constant prices for every year beginning with 1979/80. The positive difference . . . ranges from 2.56 percentage points in 1986/87 to 12.66 percentage points in 1984/85. . . . (p. 6)
>
> . . . data from the coal sector suggest that price indicators extracted from the reported growth of industrial output in constant and current prices already understate industrial inflation for the state sector. . . . (p. 14)
>
> Well-informed statistical personnel report the existence of incentives for exaggeration of industrial output growth. . . . Falsification, if extant, presumably takes the form of inflating gross rather than net output . . . (p. 11)

The important point for us is that since the two biases identified above are in opposite directions, the official method of calculating real value added does not necessarily result in a systematic bias. Whenever real gross output is more positively exaggerated than intermediate input cost, the official value added would be greater than the true value added, and vice versa. These two biases may even be approximately offsetting.

[10] For the three industries with lowest growth (food processing, textile, and oil and gas extraction), Jefferson found that his procedures would raise their capital productivity growth rates significantly. These three industries have the largest proportions of their capital stock (at book value) that were added in the 1980's. The *ad hoc* adjustment method hence reduced the capital stock of these industries most, causing their capital productivity to increase substantially.

We now formalize the preceding discussion to understand the anomalous character of JRZ's value-added deflator. Let

$$V_t = P_t^G Q_t - P_t^I M_t \tag{10}$$

$$V_0 = P_0^G Q_t - P_0^I M_t, \tag{11}$$

where V_t = value added in current prices, V_0 = value added in base period prices, Q_t = gross output in physical units, M_t = intermediate inputs in physical units, P_t^G = current price of gross output, P_t^I = current price of intermediate input, P_0^G = base period price of gross output, and P_0^I = base period price of intermediate input. We assume that the first period is the base period. We have

$$\frac{V_t}{V_0} = \frac{P_t^G - a_t P_t^I}{P_0^G - a_t P_0^I} \tag{12}$$

where

$$a_t = \frac{M_t}{Q_t}. \tag{13}$$

Series (c) in Table 6 shows that (10) < (11), implying that

$$\left(\frac{P_t^G - P_0^G}{P_0^G}\right) < \left(1 + \frac{a_t - a_0}{a_0}\right) a_0 \left(\frac{P_0^I}{P_0^G}\right)\left(\frac{P_t^I - P_0^I}{P_0^I}\right) \tag{14}$$

held throughout the 1980–1988 period.

The first anomaly about JRZ's value-added deflator is that its decline in the 1980–1983 period is not in line with what we know about the sequencing of price reforms. Although one cannot designate every commodity unambiguously as either an intermediate input or a final output because the designation depends on the position of the enterprise in the production chain, broadly speaking, output prices were freed much more rapidly than input prices.[11] The further along the production chain an enterprise is situated, the

[11] Based on a 1985 survey of industrial SOEs, Diao (1988, p. 35) wrote:

> In 1984, the average rate of independently marketed products of the 429 enterprises (the share of products marketed by the enterprises on their own in aggregate sales) was 32.08 percent; the average rate of market-purchased principal raw and other materials (the share of materials acquired through inter-enterprise exchange and cooperative deals, or purchased on the market, in total supply) was 16.4 percent.

She found that, in mid-1985, the percentage of SOEs that (a) brought less than 20% of their inputs at market prices was 48.4%, (b) bought more than 60% of their inputs at market prices was 19.7 percent, (c) sold less than 20% of their output at market prices was 31.9%, and (d) sold more than 60% of their output at market prices was 45.4%. Diao's paper is part of 1986 report prepared by the Chinese Economic System Reform Research Institute which is available in English as Reynolds (1987). The reader should note that Table 2.2 in Reynolds (1987) suffers from misprints, and the data in our preceding sentence is from the original Chinese publication.

smaller is the proportion of its output sold at low official prices. For example, the bicycle industry would have less of its output sold at quota prices than the steel industry.

Because it was mostly prices of output that were freed in the 1980–1983 period, the decline of series (c) in this period is puzzling. Not until the full establishment of the dual track system in 1985 did input prices move upward systematically as the proportion of inputs sold at the official prices was reduced over time.[12] This downward movement of JRZ's deflator in the 1980–1983 period suggests that the input price index constructed by JRZ overstated the true increase in input prices paid by SOEs.

The second anomalous feature of JRZ's value-added deflator is that it contradicts international experience about the co-movements of the industrial value-added deflator and the CPI. To put this contradiction clearly, part B of Table 6 shows the co-movements of these two price indices for Hungary and Poland during their periods of gradual reform. When we regressed the CPI on the industrial value-added deflator for the three countries, we found:[13]

	China		Hungary	Poland
	JRZ's deflator	Official deflator	Official deflator	Official deflator
Coefficient	−0.044	0.459	0.484	1.324
t-Statistic	−0.87	25.45	12.71	95.96

The positive co-movements between the industrial value-added deflator and the CPI is a well-known phenomenon of market economies and Eastern European economies undertaking gradual shows before 1989.[14] The failure of this relationship to hold in China casts serious doubt on the validity of JRZ's results.

The strange phenomenon of a declining industrial value-added index is not unique to JRZ. Groves et al. (in press) (GHMN) also estimated gross production functions for SOEs in six industries and found positive TFP growth in all six industries in the 1980–1989 period. Naughton (1994) reported that in the GHMN study:

[12] See Bell et al. (1993) and Wu and Zhao (1988).

[13] We could have checked for cointegration between the two series by examining the residuals for unit roots, but the number of observations was too low for the asymptotic test statistics to be reliable. The Dickey–Fuller table begins with $n = 25$.

[14] There could, of course, be opposite movements. Such an opposite movement occurred in Hungary in 1976 and 1980 after the two large OPEC price shocks, mediated through the oil-pricing policy of the Soviet Union, forced the government to raise energy prices precipitously.

> In each of the six sectors, intermediate input prices grew more rapidly than output prices, so that *the value-added deflator was falling* (emphasis added).

Because the input prices used to construct the deflator were collected in a 1990 survey where "managers and accountants were asked to identify their two most important inputs, and estimate average plan and market prices for 1980 through 1989," Naughton cautioned the reader that:

> Reliance on retrospective reconstruction might bias inflation rates (for intermediate inputs) upward if managers idealize the "good old days" before inflation. This would produce a corresponding upward bias in the TFP growth rates reported [in GHMN].

In our opinion, overdeflation is not the only reason for the secularly declining value-added deflator in JRZ and GHMN. Another important reason is that their correction of only the input price deflator but not the output price deflator meant that the upward bias introduced by the latter on TFP growth was given full play. In short, the inequality in Eq. (14) held only because the left-hand side was understated by the contamination of the real gross-output series and the right-hand side was overstated by their input-price indices. If JRZ and GHMN had not accepted the real gross output series, which is well-known to be biased upward, at face value, they might not have produced value-added deflators that were at odds with both the sequencing of price liberalization and the experiences of other socialist countries implementing gradual reforms.

We suspect that JRZ's deflator for intermediate inputs has given too-high a weight to the market price of intermediate inputs, and it is hence inappropriate for large and medium SOEs, which bought a large part of their intermediate inputs at plan prices. For our sample, the proportion of the value of intermediate inputs bought at plan prices went from 88% in 1984 to 70% in 1988.[15] Since the gap between market and plan prices increased tremendously over this period, the proportion of the physical units, measured in 1980 prices, of intermediate inputs bought at plan prices must have declined much less over time. So, even as late as 1988, the correct weight for the plan price in the materials deflator relevant to large and medium SOEs might have been about 0.8. Therefore, at least for our sample, output prices may be more appropriate than JRZ's deflator for deflating the value of intermediate inputs in order to arrive at the quantity of intermediate inputs.

Table 7 reports parameters of the three-input gross-output production function, using the firm-specific product price index to deflate material inputs. TFP growth was found to be −4% in the food processing industry, −2% in the textile and materials industries, zero in the machinery industry, and

[15] The proportion for the SOE sample was 88% in 1984, 84% in 1985, 81% in 1986, 75% in 1987, and 70% in 1988.

TABLE 7

MATERIAL INPUTS DEFLATED BY DEFLATOR OF FIRM-SPECIFIC PRODUCT PRICE INDEX, THREE-INPUT COBB–DOUGLAS FUNCTION

	α_0	α_T	α_K	α_L	α_M	adj. R^2
Food processing	−0.353	−.040	0.132	0.048	0.956	0.933
	(−1.97)	(−3.62)	(5.62)	(1.46)	(47.04)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 30.33$	
Textile	.210	−.017	.069	.116	.855	.970
	(1.64)	(−1.79)	(2.25)	(4.14)	(41.97)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 5.52$	
Materials	−.066	−.016	−.041	.162	.949	.986
	(−.95)	(−2.64)	(−2.97)	(8.09)	(95.02)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 67.21$	
Machinery	1.017	−.002	0.101	.010	.834	.958
	(10.98)	(−0.33)	(6.41)	(0.48)	(75.60)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 23.21$	
Total	.363	−.014	.053	.086	.884	.965
	(7.11)	(−3.49)	(6.00)	(7.55)	(128.50)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 14.48$	

Note. Capital deflator from JRZ. Period average capital stock. Unproductive labor and unproductive capital excluded. t-Statistics in parentheses. Critical value of $F(1,300)$: $F = 3.87$ at 95%, $F = 6.73$ at 99%, and $F = 11.0$ at 99.9%.

−1% for the overall sample. The only qualitative similarity with JRZ's results is that constant returns to scale were rejected.

Tables 8 and 9 provide further confirmation that it was JRZ's intermediate input deflator that produced positive TFP growth. Table 8 results used the deflator for capital goods from JRZ to deflate the intermediate inputs. JRZ's capital deflator is between JRZ's intermediate input deflator and the product price index. As the capital deflator was closer to the former, the results were less negative than those in Table 7. TFP growth was negative in three industries, and zero in the overall sample. Table 9 reports results in the case when intermediate inputs are measured at current prices, and the TFP growth estimates are much more negative than those in Table 7. In estimations not reported here, we still could not obtain significant positive TFP growth when we used the consumer price index, the industry-wide output price index and the sample-wide output price index as proxies for the input price deflator.

It must be reiterated that our sample consists of only large and medium firms, and such firms are more likely to be tied to the state plan. This may be why the SOEs in our sample bought less than 30% of their inputs at market prices when work by Rawski "suggests that state firms may have purchased 44% of their materials and energy on the market in 1988. Another study . . .

TABLE 8

MATERIAL INPUTS DEFLATED BY JRZ CAPITAL DEFLATOR, THREE-INPUT COBB–DOUGLAS FUNCTION

	α_0	α_T	α_K	α_L	α_M	adj. R^2
Food processing	−.136	−.049	0.131	0.067	0.904	0.920
	(0.70)	(−4.09)	(5.10)	(1.86)	(42.50)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 14.22$	
Textile	.015	−.024	.093	.211	.799	.922
	(0.07)	(−1.58)	(1.91)	(4.75)	(23.96)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 14.96$	
Materials	.328	−.025	−.033	.166	.926	.962
	(2.89)	(−2.53)	(−1.46)	(5.04)	(56.67)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 18.06$	
Machinery	1.578	.028	0.198	−.027	.728	.895
	(10.75)	(3.00)	(8.05)	(−0.81)	(43.85)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 29.76$	
Total	.657	−.006	.076	.124	.819	.927
	(8.89)	(−1.17)	(5.86)	(7.49)	(83.80)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				$F = 4.32$	

Note. Period average capital stock. Unproductive labor and unproductive capital excluded. t-Statistics in parentheses. Critical value of $F(1,300)$: $F = 3.87$ at 95%, $F = 6.73$ at 99%, and $F = 11.0$ at 99.9%.

gives the share of market purchase for materials for a large sample of state enterprises as 38% in 1984 and 56% in 1988."[16]

One could presumably argue that SOEs closely tied to the state plan are unlikely to be efficient, and, since most SOEs are not as closely tied to the state plan as those in our sample, the dismal TFP growth performance of our data set is not representative of the entire SOE sector. Regardless of the merits of this argument, it would be extremely damaging to the JRZ results if it were true. If the TFP growth rate of the enterprises in our sample were truly zero, then the fact that the use of JRZ's input deflator could produce significant positive TFP growth rates, see Table 5, means that the JRZ's input deflator was badly exaggerated upward.

5. ESTIMATION RESULTS FROM THE TVE DATA SET

Table 10 estimated the modified translog specification of the two-factor production function for the TVE data. In the unconstrained estimations of Parts A and B, TFP growth was positive and statistically significant. Annual

[16] We are grateful for Thomas Rawski for bringing this information to our attention. The quote is from a private communication from Rawski.

TABLE 9

MATERIAL INPUTS UNDEFLATED, THREE-INPUT COBB–DOUGLAS FUNCTION

	α_0	α_T	α_K	α_L	α_M	adj. R^2
Food processing	−.003	−.105	0.131	0.066	0.904	0.920
	(−0.02)	(−8.68)	(5.11)	(1.85)	(42.62)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				F = 14.30	
Textile	−.109	−.074	.094	.211	.800	.922
	(−0.53)	(−4.87)	(1.91)	(4.76)	(24.04)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				F = 15.07	
Materials	.186	−.083	−.033	.165	.927	.962
	(1.64)	(−8.18)	(−1.45)	(5.02)	(56.77)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				F = 18.06	
Machinery	1.466	−.018	0.198	−.027	.728	.895
	(9.98)	(−1.85)	(8.05)	(−0.82)	(43.85)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				F = 29.75	
Total	.531	−.058	.076	.124	.820	.927
	(7.17)	(−9.91)	(5.87)	(7.47)	(83.90)	
	Test $H0$: $\alpha_K + \alpha_L + \alpha_M = 1$				F = 4.34	

Note. Period average capital stock. Unproductive labor and unproductive capital excluded. t-Statistics in parentheses. Critical value of $F(1,300)$: F = 3.87 at 95%, F = 6.73 at 99%, and F = 11.0 at 99.9%.

TFP growth was 8% when intermediate inputs were deflated either with the firm-specific product price index or with the industry-specific product price; see Eqs. (1), (2), (4), and (5). Annual TFP growth increased to an average of 9.5% when JRZ's intermediate deflator was employed; see Eqs. (3) and (6).

Part B of Table 10 suggests that the TVE production was characterized by increasing returns to scale. $(\alpha_K + \alpha_L - 1)$ was significantly different from zero; see Eqs. (4), (5) and (6). TFP remained positive and statistically significant when constant returns to scale were imposed; see Part C of Table 10.

Table 11 reports the results of using a Cobb–Douglas specification of the production function. The estimated TFP growth rates were practically identical to those in Table 10 regardless of whether constant returns to scale were imposed or not.

It was therefore surprising when the positive TFP result from the estimation of the value-added production function was not confirmed by the estimation of the gross-output production function; see Table 12. TFP growth was statistically indistinguishable from zero when intermediate inputs were deflated by the firm-specific product-price index and JRZ's capital deflator, Eqs. (2) and (3), respectively. TFP growth was significant only when JRZ's intermediate deflator was used, and it was only 6% per year compared to the 8–11% range in Tables 10 and 11.

In the case of TVEs, we think that JRZ's intermediate deflator did not seriously overdeflate the value of intermediate inputs. This was because TVEs bought a much larger proportion of their intermediate inputs at market prices. Specifically, our TVE sample showed that:

Proportion of value of inputs bought at plan prices (%)

Input	1984	1985	1986	1987
Coal	25.2	23.3	20.2	17.9
Gas and oil	30.3	30.4	24.9	19.0
Electricity	64.6	65.4	53.0	50.9

This contrasts strongly with the situation at large and medium enterprises, which bought about 80% of their intermediate inputs at plan prices during this period.

Given (1) the strong results in support for positive TFP growth in TVEs compared to the, at best, zero TFP growth in SOEs when the two-factor model was used, and (2) the weakly positive TFP growth in TVEs opposed to the strong negative TFP growth in SOEs when the three-factor model was used, it seems reasonable to conclude that the TVEs were more efficient than the SOEs. The enterprise reforms have been successful not in the sense of motivating SOEs to produce positive TFP growth but in the sense of allowing the establishment of new enterprises (TVEs) that had positive TFP growth.

Finally, we note that Svejnar's (1990) TFP growth rate is much higher than ours and JRZ's. We think that Svejnar's result came from the fact that his dependent variable was gross output but he had only two inputs, labor and capital. This assumption of zero intermediate inputs is equivalent to assuming a intermediate deflator of infinity, and we know that overdeflation of material inputs raises the estimated TFP growth rate.

6. FURTHER DISCUSSION ON TFP GROWTH

The analysis of our SOE data set suggests that the revisionists might have overstated their case for improved TFP performance in the SOE sector since 1978. CWZJR looked only at data aggregated at the national level, Jefferson (1990) looked only at the iron and steel industry, and Dollar (1990) and Granick (1990) used a sample of 20 high-performance firms. Jefferson and Xu (1991) found that labor productivity in firm-level data was positively correlated with various indicators of reforms, e.g., bonus payments, but they did not include the firm's capital stock in their regressions. JRZ's and GHMN's results were likely to have been overestimates because of the overdeflation of intermediate inputs and underdeflation of output.

TABLE 10

TWO-INPUT PRODUCTION FUNCTION: MODIFIED TRANSLOG SPECIFICATION

A. Unconstrained estimation

Equation	Constant	α_T	α_K	α_L	$\frac{1}{2}\alpha_{KK}$	adj. R^2
(1)[a]	−1.105	.077	.739	.395	.105	.57
	(−4.37)	(2.10)	(8.56)	(4.20)	(4.21)	
(2)[b]	−.954	.077	.756	.348	.108	.58
	(−3.89)	(2.17)	(9.02)	(3.80)	(4.48)	
(3)[c]	−.640	.088	.746	.351	.103	.66
	(−3.10)	(2.92)	(10.46)	(4.51)	(4.89)	

B. Testing for variable return to scale via intensive-form specification

Equation	Constant	α_T	α_K	$(\alpha_K + \alpha_L - 1)$	$\frac{1}{2}\alpha_{KK}$	adj. R^2
(4)[a]	−1.105	.077	.739	.134	.105	.20
	(−4.37)	(2.10)	(8.56)	(3.00)	(4.21)	
(5)[b]	−.954	.077	.756	.103	.108	.21
	(−3.89)	(2.17)	(9.02)	(2.37)	(4.48)	
(6)[c]	−.873	.095	.747	.114	1.08	.25
	(−3.96)	(2.96)	(9.81)	(2.91)	(4.79)	

C. Imposing constant return to scale

Equation	Constant	α_T	α_K	α_L	$\frac{1}{2}\alpha_{KK}$	adj. R^2
(7)[a]	−.440	.095	.720	.280	.108	.19
	(−3.57)	(2.63)	(8.30)		(4.31)	
(8)[b]	−.444	.091	.741	.259	.110	.20
	(−3.72)	(2.59)	(8.83)		(4.57)	
(9)[c]	−.312	.112	.732	.269	.111	.24
	(−2.90)	(3.51)	(9.57)		(4.91)	

Note. Dependent variable is value added of firm. Sample is 200 TVEs, 1984–1987 period. Capital deflator is from JRZ. Only productive capital and productive labor were used. t-Statistics in parentheses.

[a] Material inputs in Eqs. (1), (4), and (7) were deflated by firm-specific product price index.

[b] Material inputs in Eqs. (2), (5), and (8) were deflated by industry-specific product price index. Industry-specific product price index is the average of firm indexes.

[c] Material inputs in Eqs. (3), (6), and (9) were deflated by JRZ's intermediate input deflator.

Lau and Brada (1990) pointed out that TFP growth consists of two components: growth in technical efficiency and growth in technological progress. An increase in technical efficiency refers to the movement from a point within the production function to the frontier of the production function. An increase in technological progress refers to the upward movement of the production function. Using aggregate time-series data for Chinese industry from 1954 to 1985, they employed linear programming to estimate a deter-

TABLE 11

TWO-INPUT PRODUCTION FUNCTION: COBB-DOUGLAS SPECIFICATION

A. Unconstrained estimation

Equation	Constant	α_T	α_K	α_L	adj. R^2
(1)[a]	−1.289	.077	.421	.726	.56
	(−5.10)	(2.06)	(9.93)	(13.26)	
(2)[b]	−1.144	.077	.427	.684	.56
	(−4.65)	(2.13)	(10.37)	(12.94)	
(3)[c]	−1.047	.091	.428	.695	.62
	(−4.73)	(2.78)	(11.37)	(14.45)	

B. Imposing constant return to scale

Equation	Constant	α_T	α_K	α_L	adj. R^2
(4)[a]	−.588	.097	.390	.610	.16
	(−4.88)	(2.62)	(9.38)		
(5)[b]	−.596	.092	.403	.597	.17
	(−5.10)	(2.58)	(10.00)		
(6)[c]	−.445	.109	.401	.599	.21
	(−4.19)	(3.36)	(10.87)		

Note. Dependent variable is value added of firm. Sample is 200 TVEs, 1984–1987 period. Capital deflator is from JRZ. Only productive capital and productive labor were used. *t*-Statistics in parentheses.

[a] Material inputs in Eqs. (1) and (4) were deflated by firm-specific product price index.

[b] Material inputs in Eqs. (2) and (5) were deflated by industry-specific product price index. Industry-specific product price index is the average of firm indexes.

[c] Material inputs in Eqs. (3) and (6) were deflated by JRZ's intermediate input deflator.

ministic frontier production function. The slack variables were thus measurements of technical efficiency.

Lau and Brada found that changes in technical efficiency were frequent and large compared to changes in technological progress. The result was that TFP movements primarily reflected changes in the former. For example, TFP growth in 1977 was −5.5% of output and it was caused by a −8.7 percentage point decrease in technical efficiency and a 3.2 percentage point growth in technological progress. TFP growth was 15.8 percent of output in 1985 because of a 12.2 percentage point increase in technical efficiency and a 3.6 percentage point increase in technological progress. As both technical efficiency and technological progress increased from 1978 to 1985, they attributed these positive developments to the enterprise reforms.

There are two principal problems with the Lau and Brada results. The first problem is that their computation method yielded no statistical properties to allow them to test whether TFP growth in the 1980's was statistically distin-

TABLE 12

THREE-FACTOR INPUT PRODUCTION FUNCTION: COBB–DOUGLAS SPECIFICATION

Equation	Constant	α_T	α_K	α_L	α_M	adj. R^2
(1)[a]	.327	.005	.339	.602	.206	.71
	(1.30)	(0.15)	(8.08)	(11.99)	(7.45)	
(2)[b]	.531	.004	.307	.584	.245	.72
	(2.16)	(0.13)	(7.52)	(11.98)	(9.27)	
(3)[c]	.352	.018	.339	.602	.206	.71
	(1.39)	(0.54)	(8.08)	(11.99)	(7.46)	
(4)[d]	−.085	.064	.237	.557	.297	.75
	(−0.50)	(2.54)	(7.00)	(14.87)	(13.33)	

Note. Dependent variable is gross output of firm. Sample is 200 TVEs, 1984–1987 period. Capital deflator is from JRZ. Only productive capital and productive labor were used. *t*-Statistics in parentheses.

[a] Material inputs in Eq. (1) were in current prices.

[b] Material inputs in Eq. (2) were deflated by firm-specific product price index.

[c] Material inputs in Eq. (3) were deflated by JRZ's capital deflator.

[d] Material inputs in Eq. (4) were deflated by JRZ's intermediate input deflator.

guishable from zero or from TFP growth in the 1970's. The second problem is that while microeconomic liberalization should reduce technical inefficiency, standard neoclassical theory provides no presumption that it could promote technological progress.[17]

JRZ used a cross-section sample with values in two years to estimate the frontier production function. Their sample consisted of 295 city/county units for 1984 and 382 units for 1987. For each year, a city/county unit yielded two sets of observations: the aggregate SOE data and the aggregate COE data. JRZ used a "novel frontier procedure" (p. 250) that dropped outliers upon iterative estimations to converge upon the frontier. While most of the observations dropped were below the final frontier, points too far above the final frontier also had to be dropped to prevent distortion of the curvature of the final frontier. The final frontier was estimated from one-third of the original sample.

There are three major problems with the JRZ paper in addition to the deflation problems discussed earlier. The first problem is that it did not discuss the widespread and persistent technical inefficiency that it unearthed. Two-thirds of the observations came from firms operating below

[17] In traditional neoclassical models, microeconomic liberalization produces an effect on the level not on the growth; that is, a one-time movement to a higher parallel balanced-growth path but not to a steeper balanced-growth path. A discussion of this issue is in Lucas (1988). The emerging endogenous growth literature is just such an attempt to formulate a theoretical link between policy actions and trend rate of growth.

the production function after 7.5 years of enterprise reform. We have the anomaly of Chinese enterprise reforms being able to raise the production function steadily over time but not being able to push two-thirds of the enterprises to operate at the frontier of the existing production function.[18]

The second problem is the implicit assumption that the improvement in TFP growth was caused only by Chinese factors. Since imported technology was undoubtedly a source of technological progress, it is possible that the faster TFP growth was more the result of the opening of the Chinese economy to world trade than the result of the piecemeal enterprise reforms. If so, this explains why two-thirds of the Chinese firms were operating below JRZ's frontier production function. The firms below the frontier were there less because of technical inefficiencies but more because of a shortage of funds and foreign exchange for technological upgrading. In work on our SOE sample not reported here, we found that the presence of a foreign partner definitely raised the TFP level and may also have raised the TFP growth rate. The implication of there being several production functions at any point in time is that the frontier procedure is inappropriate. The usual regression approach with appropriate use of dummy variables would give a more representative picture of TFP growth.

The third problem with the JRZ paper is its application of their frontier procedure to the COE data. As the operations of the COEs are practically unregulated by the state, there is no reason to believe that any significant number of them would willingly operate below the production function. It is therefore surprising that more observations of COEs were dropped than observations of SOEs.[19] This last fact supports the previous conclusions that several production functions existed simultaneously and that the usual regression approach is more appropriate than the frontier procedure.

7. WIDENING THE FOCUS BEYOND TFP GROWTH

The overwhelming focus of the discussions on the enterprise reforms in China has been on their impact on TFP growth. This narrow focus has the unfortunate consequence of pushing to the sideline discussions on enterprise reform and macroeconomic stability. The implicit assumption is that greater output from increased efficiency would decrease inflation by increasing the supply of goods and by reducing the government budget deficit. Greater technical efficiency, it is assumed, would mean greater profits, hence reducing enterprise subsidies dispensed by the government and increasing the government's revenue from SOEs.

[18] Lau and Brada (1990) are free of this problem because the slack variable in their programming procedure not only obviated the need to drop observations but also tracked the changes in technical efficiency.

[19] Deduction is drawn from the degrees of freedom of the F-statistic reported in Table 6.

TABLE 13

DIVISION OF NET VALUE ADDED (IN PERCENT OF VALUE ADDED)

	1984	1985	1986	1987	1988
S.O.E.					
(a) Taxes and remitted profits	31.5	24.8	20.1	15.3	13.7
(b) Direct wage income	24.8	27.2	40.8	33.1	36.4
(c) Indirect wage income	7.0	10.1	13.7	12.6	12.4
(d) Retained profits	11.3	15.7	15.2	14.7	15.0
(e) Other items (e.g., depreciation)	25.4	22.2	10.2	24.3	22.5
(f) Total labor compensation ((b) + (c))	31.8	37.3	54.5	45.7	48.8
T.V.E					
(g) Basic wage	16.0	15.3	16.5	15.0	n.a.
(h) Other cash income (e.g., bonus)	23.1	13.8	20.1	15.6	n.a.
(i) Total labor compensation ((g) + (h))	39.1	29.1	36.6	30.6	n.a.

Note. For S.O.E. sample, Direct wage income is (basic wage + bonus). Indirect wage income is (welfare funds + retirement benefits + training programs + schooling for workers' children).

We want to make the point that technical efficiency and financial performance are two separate issues. The former could improve while the latter deteriorates. This is the case when the increase in value added is accompanied by the enterprise personnel being paid a greater share of the total value added. The workers work harder and the managers innovate more, and so technical efficiency increases, but the greater effort comes about only because enterprise personnel are able to appropriate the lion's share of the increased output.

The ability to effect such a redistribution of the value added between labor and capital is very much determined by how vigorously the firm's management identifies with the owners of capital; the looser the identification, the easier for such a redistribution to occur. We should thus expect total labor compensation as a proportion of value added to rise faster in SOEs than in TVEs.[20] Table 13 supports this hypothesis.

Labor compensation consists of two parts: direct and indirect wage income. We define direct wage income as total cash income paid to employees, e.g., basic wage, bonus, and subsidies, and indirect wage is defined as total

[20] This point is argued in greater detail in Fan and Woo (1992).

noncash income paid to employees.[21] The issue of excessive wage compensation cannot be determined by looking only at direct wage income because many of its components are regulated by the state industrial bureau. In our SOE sample, direct wage income increased from 25% of value added in 1984 to 36% in 1988; indirect wage income increased from 7% to 12% in this period. Total labor compensation increased by 17 percentage points of value added in the 1984–1988 period.

In our TVE sample, on the other hand, total labor compensation was trendless at about 34% of value added. This suggests that TVE managers have been much more diligent in defending capital income than have SOE managers. This is the reason why in a boom year such as 1992, when real GNP increased 12.8%, two-thirds of SOEs were operating at a loss.[22]

Woo (1994) shows that, in the national-level data of SOEs, the increase in real wage in 1978–1990 was greater than the increase in labor productivity. This means that SOE labor increased its share of value added in SOEs throughout the reform period and not just in the boom period of our SOE data set. The weak defense of capital income by SOE managers during the reform period meant that the state has been faced with unexpectedly large decreases in revenue.[23] The social consequences were reductions in infrastructure investment, which could constrain future growth and higher inflation caused by the need to monetize a larger budget deficit.

Ever since economic reforms began, a new term, investment thirst, has been coined to describe the general clamor for investment loans. Profitable firms argue that they can invest the funds more efficiently, and unprofitable firms argue that they require technical upgrading in order to become competitive. It was surges in investment spending that caused all three overheating episodes in the 1978–1989 period. Such excess demand for investment funds is natural in a soft-budget situation where SOEs with *ex post* bad investments are not closed down. It also means that, even if the production processes were technically efficient, the SOE system exhibited only static efficiency and not intertemporal efficiency; see Fan and Woo (1992), Li (1992, 1993), and Reynolds (1987).

8. CONCLUSIONS

The biggest achievement of enterprise reforms in China is the genesis and explosive growth of industrial TVEs. Their share of gross industrial output

[21] Noncash income includes distribution of goods and so-called training trips to historical places. Some items of indirect wage, e.g., training trips, were hidden as operating costs, so we added these hidden wages to the reported value added.

[22] *China Daily*, Jan. 26, 1993.

[23] This interpretation of the data assumes that the change in income share was not caused by technological changes, e.g., a sharp rise in the exponent of labor in the Cobb–Douglas production function.

increased from 16% in 1984 to 31% in 1991.[24] Given the high TFP growth in TVEs, the continued growth of this sector is crucial to the economic development of China.

Our findings regarding the industrial SOE sector support the original conclusions of Chow (1985), Dernberger (1988), Lardy (1989), and Perkins (1988). We found not only negligible TFP growth in industrial SOEs in the high-growth period of 1984–1988, but also excessive compensation paid to SOE personnel, which weakened the financial performance of industrial SOEs. The poor TFP results were obtained even when we focussed narrowly on the production of output by excluding capital and labor not directly employed in the production process.

Since the official method of constructing real value added in industry was to use an output price index that understated the growth of output prices, we showed that opposite biases exist. Both the amount of inputs used and the amount of output produced were overcounted. Herein lies the reason why the JRZ and GHMN studies produced the puzzling phenomenon of secularly declining industrial value-added deflators for the 1980's when the average annual CPI growth rate was over 6%. JRZ and GHMN, by correcting only the input price index, removed the downward bias on TFP growth that countered the upward bias of the reported output price index. The result of removing a single distortion in a situation with two distortions was that TFP growth was overstated. If JRZ's input price index did exaggerate input price increases, as we suggested, then TFP growth was further overstated. We do not claim that it is impossible for the industrial value added deflator to ever move in the opposite direction of the CPI, only that the sustained opposite movements in JRZ's and GHMN's value added deflator and the CPI are highly implausible.

Given the contradiction between our findings on SOE performance and those of other recent research, more work in this area is a clear priority for future work. Such research on enterprise performance should also have a wider focus, e.g., intertemporal efficiency and macroeconomic stability. In particular, we want to propose for future research the hypothesis that SOEs tend to overreport the amount of inputs they purchase at market prices and the amount of their output. The former allows them to avoid taxes and funnel profits to other uses. The latter allows them to claim higher technical efficiency while blaming unimproved profit performance on rising costs and increased competition, and thus to argue that they should be rewarded by being allowed to disburse large bonuses and to receive investment loans for expansion.[25] The outcome of this rent-seeking behavior is that uncritical

[24] TVE data before 1984 are not comparable because of definitional changes.

[25] A recent confirmation of this is "Inflated Figures Ruin Credibility," *China Daily*, Jan. 15, 1994.

calculation of value added by the double deflation method yields significant positive TFP growth rates and declining value-added deflators.

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