

# Why Is the Productivity Analysis Misleading for Gauging State Enterprise Performance?<sup>1</sup>

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## Abstract

A large literature has documented impressive productivity growth in China's state enterprises during the reform. The evidence has been used to support the view that China's enterprise reform has been successful. We cast doubt on this view by arguing that productivity is not a reliable measure of state enterprise performance. A model is used to show that when firms are not profit maximizers, higher productivity may actually lead to greater allocative distortion, lower profits and lower economic efficiency. There is evidence this may be the case for many Chinese state enterprises during the reform.

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A considerable literature devoted to the study of China's state-owned enterprises (SOEs) has emerged over the past decade.<sup>2</sup> With few exceptions the extensive research points to there having been impressive productivity gains enjoyed by the SOEs since the inception of the reforms in the early 1980's.<sup>3</sup> Findings of productivity gains ranging from 2 to 6 percent per year present a rosy picture of SOE reform success. Jefferson and Singh (1993) put voice to the conventional wisdom on the issue: "(h)ave state-owned enterprises improved their performance? Yes, most analyses of productivity growth within state industry show that TFP has accelerated over the pre-reform period."<sup>4</sup>

Within China, however, this perceived SOE reform success has not made itself apparent. Instead, year after year, the general public, research economists, and reform-minded government leaders all complain about mounting problems with the SOEs. Aggregate statistics support their complaints: over 30 incurring explicit financial losses and relying upon government subsidies.<sup>5</sup> Many SOEs have difficulty competing in the product market, resulting in a debt crisis in the financial sector. By 1994, the total amount of non-performing debt was as high as 20 percent of GDP.<sup>6</sup> A recent speech by the economic Premier Zhu Rongji (see Zhu (1996)) addresses this phenomenon: "(t)he current problems of SOEs are: excessive investments in fixed assets with very low return rates, resulting in the sinking of

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<sup>2</sup>By our incomplete count, over 100 papers have been written on the productivity of Chinese state enterprises.

<sup>3</sup>With few exceptions, these works are based on production function analyses and define the Total Factor Productivity as the residual term of the log-linear production function. In this paper, we stick to this line of research and the corresponding definition of the TFP. Gordon and Li (1994) is an exception.

<sup>4</sup>Jefferson and Rawski (1994) is another example of this view. After surveying the overall industrial reform in China, they conclude: "(t)his review leads to the conclusion that reform has pushed China's state-owned enterprises in the direction of 'intensive' growth based on higher productivity rather than expanded resources consumption. Although the production of unwanted goods and other characteristic socialist flaws persist (Liu, 1993), we observe a consistent picture of improved results — higher output, growing exports, rising total productivity, and increased innovative effort — against a background of gains in static and dynamic efficiency that reflect the growing impact of market forces." Woo, Hai, Jin, and Fan (1994) represent an exception. They argue that the TFP growth rate is at most insignificant. See Jefferson and Singh (1993) for a survey of the empirical findings in this area.

<sup>5</sup>See Bai and Wang (1996).

<sup>6</sup>See Li and Li (1995).

large amounts of capital; low sales-to-production ratio giving rise to mounting inventories. The end result is that the state has to inject increasing amount of working capital through the banking sector into the SOEs.” In response to these pesky problems with SOEs, Chinese leaders have recently placed enterprise reform on the top of the reform agenda.<sup>7</sup>

This paper is motivated by the sharp contrast between the optimistic picture presented by the large amount of research that reports considerable productivity gains and the gloomy mood among those who look at many mounting problems in China’s state sector, especially the miserable financial situation. In an attempt to reconcile the two sides, we choose not to present new evidence or to re-examine that which has been previously presented, or to debate the reliability of reported productivity gains in China’s state sector. Instead, we shall question the very validity of using productivity changes as an index of the efficiency of the SOEs. We argue that, with the significant non-profit objectives of the SOEs, measured growth of TFP may be a misleading indicator of their performance. TFP is a good index of performance in the context of profit-maximizing and market-oriented firms. However, for SOEs under reform, these conditions are not satisfied (in fact, this is the very reason of SOE reform). For a SOE, non-profit objectives are abundant. One of the important non-profit objectives of the managers is their excessive pursuit of output. Many have argued for such motives of SOEs (Kornai (1992) and Shleifer and Vishny (1994), for example).

The logic of our argument is as follows. Efficiency is determined by both the firm’s technology and its choice of the output level. An increase in productivity means a higher marginal rate of transforming input into output, i.e., the firm has a larger feasible set of operation. This tells us something about the technology side of the firm. The question, however, is how the improved technology affects the firm’s choice of output level, which is a behavioral issue. When a firm is a profit maximizer, its behavior is “right” and a higher productivity always leads to improved social welfare. In such a case, it is appropriate to equate a higher productivity with higher efficiency. When the objective of the manager is different from that of profit maximization, however, higher productivity can induce more distorted behavior, partially or totally offsetting efficiency gains from improved technology.

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<sup>7</sup>For example, in the Chinese Communist Party’s Decision to Implement System Reforms for Socialist Market Economy and Proposals for the Ninth Five-Year Plan and the Long-Run Plan Leading to 2010, problems with state enterprises are on the top of the list of issues that continued reforms have to resolve.

Therefore, high TFP cannot be taken for granted to mean higher social welfare and higher efficiency. For example, when the manager of the firm has an output bias, high productivity may induce the manager to deviate further from the profit maximizing output level. As we show later, if the firm's output bias is sufficiently strong, an increase in productivity can lead to a lower profit and, with additional qualifications, lower efficiency. There is some evidence that this higher productivity and lower efficiency scenario is the essence of the recent developments in China's state sector.

The rest of the paper is planned as follows. Section 2 presents a simple theory analyzing the relationship between productivity and profitability for non-profit-maximizing firms. Section 3 reviews the empirical method used in estimations of TFP and argues that our theory is pertinent to Chinese SOEs during the reform. Conclusion is given in Section 4.

## 2. The Model

In this section, we present a model of productivity growth and firm behavior. The key result is that, given a firm with non-profit maximization objectives, productivity increases may not imply efficiency gains. We also identify the condition under which higher productivity leads to lower economic efficiency.

### 2.1. The Model

Assume that the firm's production function is

$$Q = Af(x),$$

where  $x$  is the input,  $Q$  the output, and  $A$  a measure of productivity. As will be shown later, the growth rate of  $A$  corresponds to the growth rate of the conventionally defined TFP. In our model,  $x$  is the firm's choice variable, whereas  $A$  is exogenously determined.<sup>8</sup>  $f(x)$  is assumed to be strictly concave<sup>9</sup> and satisfies the properties that  $f'(\cdot) > 0$  and

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<sup>8</sup>In an enlarged model,  $A$  can be endogenously determined as well, e.g., when better incentives induce greater efforts from the manager. Our interest, however, is not how productivity  $A$  may be improved, but, instead, how it affects the firm's behavior and profitability. For this purpose, it does no harm to assume  $A$  to be exogenous.

<sup>9</sup>Firms eventually face decreasing returns to scale because some inputs cannot be varied easily with

$f''(\cdot) < 0$ . The profit of the firm is

$$\pi = Af(x) - wx,$$

where  $w$  is the price of input  $x$  and the output price is normalized at 1. This implies that

$$\begin{aligned} \pi(Q) &= Q - \min_x wx \\ \text{s.t. } f(x) &= \frac{Q}{A} \end{aligned}$$

is the firm's maximum profit at a given output level. Define

$$\begin{aligned} c\left(\frac{Q}{A}\right) &= \min_x wx, \\ \text{s.t. } f(x) &= \frac{Q}{A}. \end{aligned} \tag{2}$$

The maximum profit, again at a given output level, is thus

$$\pi(Q) = Q - c\left(\frac{Q}{A}\right). \tag{3}$$

Note that, since  $f(x)$  is strictly concave,  $c\left(\frac{Q}{A}\right)$  is strictly convex (it is increasingly more costly to produce the next unit of output), i.e.,  $c'(\cdot) > 0$  and  $c''(\cdot) > 0$ .

An important configuration of the model is the objective function of the firm. In general, it is difficult to pin down exactly the objective of an SOE. Many authors have argued SOEs have an impetus to expand their sizes. For example, Kornai (1992) emphasizes that SOE managers are imbedded in a bureaucratic hierarchy, in which the size of the firm, or output level, is a proxy for status. Shleifer and Vishny (1994) argue that managers are influenced by politicians, whose political agenda dictates the drive for firm size and output. Without loss of generality, we make a simple assumption that the state firm maximizes a convex combination of profit and output, i.e., we assume that the objective function of the firm is

$$U(\pi, Q) = \pi + \beta Q, \tag{4}$$

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the firm's scale. For example, as output increases, the manager eventually becomes overloaded and his productivity falls. Hiring additional managers result in incentive problems, as is discussed by Williamson (1975).

where  $\beta$  is a measurement of the extent of the firm's output bias. The larger the value of  $\beta$ , the more willing the firm is to forego profit in order to obtain a higher output level. When  $\beta = 0$ , we have a conventional profit maximizing firm.<sup>10</sup>

$\pi(Q)$  function in (3) tells us how production technology determines the transformation between output and profit. We have

$$\frac{d\pi}{dQ} = 1 - \frac{1}{A}c'\left(\frac{Q}{A}\right). \quad (5)$$

Let  $Q_\pi$  be the output at which,  $\pi'(Q) = 0$ , i.e.,  $\frac{1}{A}c'\left(\frac{Q}{A}\right) = 1$ .  $Q_\pi$  is the output level that maximizes the profit. Since  $c(\cdot)$  is convex,  $\pi$  is concave, with  $\pi'(Q) > 0$  for all  $Q < Q_\pi$ ;  $\pi'(Q) < 0$  for all  $Q > Q_\pi$ ; and  $\pi''(Q) < 0$ . This technologically determined relationship between the output and profit gives the feasibility constraint of the SOE's optimal problem.

To maintain a given utility level, the marginal rate of substitution between  $\pi$  and  $Q$  must satisfy the condition

$$-U_1d\pi = U_2dQ,$$

where  $U_i$  is the partial derivative of  $U$  with respect to its  $i^{th}$  argument. Given our special form of the utility function, we can write

$$\frac{d\pi}{dQ} = -\frac{U_2}{U_1} = -\beta. \quad (6)$$

Equation (6) is intuitive. A conventional profit maximizing firm is one with  $\beta = 0$  ( $U_2 = 0$ ) and  $\frac{d\pi}{dQ} = 0$ , i.e., the utility loss due to a lower profit cannot be compensated by a higher output level. The SOE with an output bias has  $\beta > 0$  and  $\frac{d\pi}{dQ} = -\beta$ , meaning that a loss in utility due to one unit loss of profit can be compensated by  $\frac{1}{\beta}$  units of output.

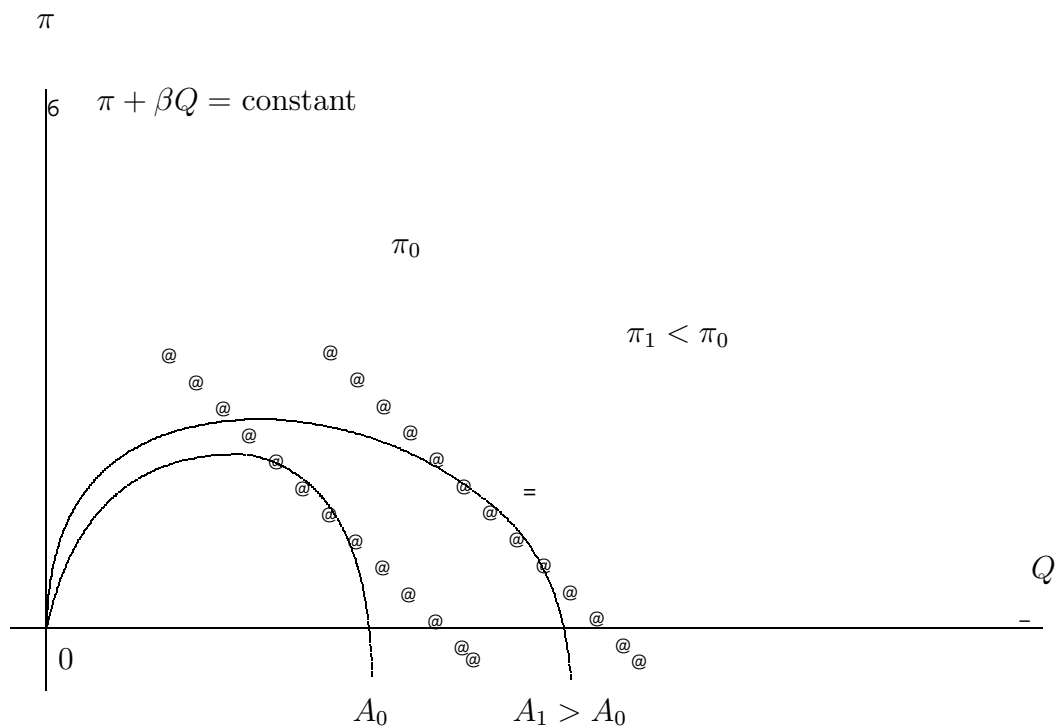
At the optimum, the marginal rate of transformation and that of substitution must be equal. This means that

$$1 - \frac{1}{A}c'\left(\frac{Q}{A}\right) = -\beta.$$

Let  $Q^*$  be the output that satisfies this condition. It is the output at which  $U(\pi, Q)$  is maximized. See Figure 1.

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<sup>10</sup>We are aware of a scenario that a positive  $\beta$  exists in order to correct distortions due to a below-market price on  $Q$ . This is not a common scenario in China, since the product market emerged rather quickly after the reform.



**Figure-1:**  $\pi$  is the profit;  $Q$  is the output;  $A_0$  and  $A_1$  are two alternative productivity levels. The inverted-U curves represent two alternative  $\pi$ - $Q$  trade-off schedules. The parallel straight lines are indifference curves of the manager.  $\pi_0$  is the profit level associated with the optimal choice given  $A_0$  and  $\pi_1$  is that given  $A_1$ . The graph illustrates that  $\pi_1 < \pi_0$ , i.e., higher productivity gives rise to lower profit.

Alternatively, we can substitute  $\pi$  into (4) and obtain

$$U(\pi(Q), Q) = Q - c\left(\frac{Q}{A}\right) + \beta Q = (1 + \beta)Q - c\left(\frac{Q}{A}\right).$$

The first order condition for maximizing  $U(\pi(Q), Q)$  is

$$(1 + \beta) - \frac{1}{A}c'\left(\frac{Q}{A}\right) = 0, \tag{7}$$

which is identical to what we have established earlier. The second order condition is obviously satisfied, since  $c''(.) > 0$ .

Two interesting points can be learned from (7). First, while a profit maximizing firm with  $\beta = 0$  chooses the output level where marginal cost is equal to the marginal product (i.e.,  $c'/A = 1$ ), the SOE with an output bias produces more (at which  $c'/A = 1 + \beta > 1$ ). The magnitude of deviation from the profit maximizing level of output increases with  $\beta$ . Second, for both types of firms, the optimal output level increases with productivity,  $A$ .

## 2.2. Productivity and Efficiency

To isolate the effect of higher productivity, we assume that price  $w$  is not distorted and both the market for the output and that for the input are competitive.

A higher productivity level (a larger  $A$ ) means that any given amount of output is now produced with less input, or, equivalently, a given amount of input can produce more output. This means that profit is higher at every output level; the curve  $\pi(Q)$  in Figure 1 is shifted upward for  $Q > 0$ . When this happens, it is immediately clear, graphically, that the equilibrium profit level of a conventional firm (a profit maximizer) will be higher. However, what will happen to the profitability of the SOE with output bias ( $\beta > 0$ ) is ambiguous. In the following, we formally derive this result and give the condition under which the equilibrium profit level of the firm with an output bias ( $\beta > 0$ ) declines with improved productivity.

From (4), we can obtain

$$\frac{d\pi}{dA} = \frac{dU}{dA} - \beta \frac{dQ}{dA}.$$

By the Envelop Theorem,

$$\frac{dU}{dA} = c'\left(\frac{Q}{A}\right) \frac{Q}{A^2}.$$



Differentiate (7) with respect to  $A$ , we have

$$(1 + \beta) - c''\left(\frac{Q}{A}\right)\left[\frac{dQ}{dA}\frac{1}{A} - \frac{Q}{A^2}\right] = 0,$$

or

$$\frac{dQ}{dA} = (1 + \beta)\frac{A}{c''\left(\frac{Q}{A}\right)} + \frac{Q}{A}.$$

Thus,  $\frac{d\pi}{dA}$  can be rewritten as

$$\begin{aligned} \frac{d\pi}{dA} &= c'\left(\frac{Q}{A}\right)\frac{Q}{A^2} - \beta\left[(1 + \beta)\frac{A}{c''\left(\frac{Q}{A}\right)} + \frac{Q}{A}\right] \\ &= (1 + \beta)\frac{Q}{A} - \beta\left[(1 + \beta)\frac{A}{c''\left(\frac{Q}{A}\right)} + \frac{Q}{A}\right] \\ &= \frac{Q}{A} - \beta(1 + \beta)\frac{A}{c''\left(\frac{Q}{A}\right)}. \end{aligned} \tag{8}$$

(7) is used for the second equality.

In (8), setting  $\beta = 0$ , we have  $\frac{d\pi}{dA} > 0$ . However, if  $\beta > 0$ , it is not clear what sign  $\frac{d\pi}{dA}$  takes. Thus, we have the following proposition.

**Proposition 1** 1) If  $\beta = 0$ , then  $\frac{d\pi}{dA} > 0$ , i.e., for a profit maximizing firm, higher productivity means higher profit; 2) If  $\beta > 0$ , then the effect of productivity on profit is ambiguous.

Next, we show that  $\frac{d\pi}{dA} < 0$ , if  $\beta$  is sufficiently large. In other words, if the output bias of the firm is sufficiently strong, an improved productivity (a higher  $A$ ) leads to a lower equilibrium profit level (a smaller  $\pi$ ). We first establish two lemmas. Define  $y = \frac{Q}{A}$ .

**Lemma 1**  $\text{sign } \frac{d\pi}{dA} = \text{sign } y\frac{c''(y)}{[c'(y)]^2} - \frac{1}{A} + \frac{1}{c'(y)}$ .

(All proofs henceforth can be found in Appendix)

**Lemma 2** If  $\lim_{y \rightarrow \infty} c'(y) = \infty$ , and  $\lim_{y \rightarrow \infty} y\frac{c''(y)}{[c'(y)]^2}$  exists, then the latter limit cannot be positive, i.e.,  $\lim_{y \rightarrow \infty} y\frac{c''(y)}{[c'(y)]^2} \leq 0$ .

**Proposition 2** There exists  $\underline{\beta}$  and  $\bar{\beta}$  with  $\underline{\beta} \leq \bar{\beta}$ , such that, if  $\beta \geq \bar{\beta}$ , then  $\frac{d\pi}{dA} < 0$ ; if  $\beta \leq \underline{\beta}$ ,  $\frac{d\pi}{dA} > 0$ .

To further illustrate this result, let us now consider the special case of a Cobb-Douglas production function with decreasing returns to scale. The case is interesting because most empirical work on productivity analysis assumes a Cobb-Douglas production function. Assume that the production function is  $Q = Ax^{\frac{1}{\alpha}}$ , with  $\alpha > 1$ . The firm's cost function can be written as

$$c(y) = y^\alpha,$$

Therefore,  $c'(y) = \alpha y^{\alpha-1}$ . (7) can be rewritten as

$$\alpha \left(\frac{Q}{A}\right)^{\alpha-1} = (1 + \beta)A$$

or

$$\frac{Q}{A} = \left(\frac{(1 + \beta)A}{\alpha}\right)^{\frac{1}{\alpha-1}}.$$

Note also that

$$c''(y) = \alpha(\alpha - 1)y^{\alpha-2} = \alpha(\alpha - 1)\left(\frac{Q}{A}\right)^{\alpha-2} = \alpha(\alpha - 1)\left[\frac{(1 + \beta)A}{\alpha}\right]^{\frac{\alpha-2}{\alpha-1}}.$$

Substituting the expressions of  $\frac{Q}{A}$  and  $c''(y)$  into that of  $\frac{d\pi}{dA}$  and simplifying leads to

$$\frac{d\pi}{dA} = (\alpha - 1 - \beta)\left[(1 + \beta)\frac{A}{c''(y)}\right]$$

which is negative if  $\beta > \alpha - 1$  and positive if  $\beta < \alpha - 1$ .

**Proposition 3** *Suppose the production function is  $Q = Ax^{\frac{1}{\alpha}}$ . Then  $\underline{\beta} = \bar{\beta} = \alpha - 1$ , where  $\underline{\beta}$  and  $\bar{\beta}$  are defined in Proposition 2.*

Intuitively, the possibly negative relationship between productivity and profitability results from the equilibrium profit having been determined by both productivity and the firm's behavior, reflected in its choice of output level. It is also important to understand that productivity affects the firm's behavior (its choice of the output level). Recall the discussion in the previous section that, with  $\beta > 0$ , the equilibrium output level is higher than that maximizes profit. The degree of deviation to a higher output level depends on the marginal rate of transformation, which in turn depends on productivity. At the profit maximizing output level  $Q_\pi$ ,  $\frac{d\pi}{dA} = 0$ , i.e., output can be increased with no corresponding loss in profit. The firm thus moves to a higher output level. As the output increases, each

additional unit of output results an increasing loss in profit, due to the decreasing marginal rate of transformation. Beyond a certain point, the trade-off is no longer worthwhile. This point is where the marginal rate of transformation and that of substitution are equal.

As is clear from (5), a higher productivity (a higher  $A$ ) means that at every given  $Q$ , an additional unit of output (above  $Q_\pi$ ) can be obtained at less cost of profit. This has two effects on profit. First, the profit of the firm is higher at any given output level. Let us call this the direct effect of a productivity gain on profitability. The effect contributes positively to profit. Second, since now producing an additional unit of output has a smaller corresponding loss of profit, the firm finds it worthwhile to deviate further from the profit maximizing output level, which leads to a lower profit. Let us call this the induced, or behavioral effect, of a productivity gain on profitability. The opposing signs of the direct and induced effects of higher productivity on profit explains why the net effect of higher productivity on profitability is, in general, ambiguous, as shown in Proposition 1. When  $\beta$  is small, the change in output deviation from the profit maximizing level is small, and the direct effect dominates. We thus have  $\frac{d\pi}{dA} > 0$ . The opposite is true when  $\beta$  is large.

### 3. Further Discussions

Three issues warrant further analyses. The first is how to relate our theoretical discussion to existing empirical literature on Chinese SOEs. The second issue is how pertinent our theory is to Chinese SOEs, i.e., whether higher productivity has driven efficiency lower during the reform. Finally, given that profit has decreased with higher profitability, how reliable is profit as a measure of social welfare? We address these issues in this section.

#### 3.1. Empirics of TFP: an Alternative Interpretation of Our Theory

In the empirical literature on Chinese enterprise reform, the most popular and influential approach is to estimate the total factor productivity (TFP) by utilizing enterprise-level data sets. This is often referred to as production function analysis.<sup>11</sup>

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<sup>11</sup>One exception is Gordon and Li (1995). They utilize a creative approach to implement the TFP index by Kendrick (1973), who defines TFP as  $\Pi = \frac{Q}{\sum_i \gamma_i x_i}$ , where  $\gamma_i$  is equated to the marginal product in the base year. Notice that when firms have output bias,  $\gamma_i$  is lower than the market price.

$Q = Ax^{\alpha_1}x^{\alpha_2}$ , then  $\Pi = \frac{1}{\alpha_1+\alpha_2}$ , a constant. Thus, Kendrick’s TFP may not be a good measure of individual firms’ productivity growth. However, it is a good measure of aggregate TFP growth due to better inter-firm allocation of factors (see Basu and Fernald (1995)), which is not the focus of our paper. We summarize the technique of production function analysis in the following.<sup>12</sup>

Without losing generality, assume that the production function to be estimated takes the form

$$Q = F(a(t), x(t); \theta),$$

where  $a$  is an un-observed productivity factor, which will be estimated;  $x$  is (are) the observed input(s);  $t$  is an index of time; and  $\theta$  is a time-invariant parameter to be estimated. Both  $a$  and  $x$  may vary with time  $t$ .

The TFP is derived from the decomposition of the growth rate of output, i.e.,

$$\begin{aligned}\dot{Q} &= \frac{F_a a' + F_x x'}{F} = \frac{F_a}{F} a' + \frac{F_x}{F} x' \\ &= \epsilon_a \dot{a} + \epsilon_x \dot{x},\end{aligned}$$

where, the “dot” “.” is the growth rate operator, and  $\epsilon_a$  and  $\epsilon_x$  are the elasticities of  $Q$  with respect to input  $x$  and  $a$ , respectively. In other words,  $\dot{Q}$ ,  $\dot{a}$ , and  $\dot{x}$  are the growth rates of  $Q, a$ , and  $x$ , respectively. Therefore, the *growth rate* of the TFP is defined as

$$TFP \equiv \dot{Q} - \epsilon_x \dot{x}, \tag{9}$$

which intuitively is the contribution of the unobserved production factor  $a(t)$  to the residual growth rate of output.

Expression (9) implies an alternative explanation of our theory that measured TFP may be mis-leading. To measure economic efficiency, the cost of input should be considered. Let  $p$  be the price of input. Then, for the right hand side of (9) to reflect economic efficiency,  $\epsilon_x$  should be equal to  $\frac{px}{Q}$ , which is the case with profit maximization. When SOEs have a quantity bias, however, they tend to over-produce. As a result, the marginal product of  $x$  is lower than the price of input, and thus  $\epsilon_x < \frac{px}{Q}$ . Therefore, (9) over-estimates economic efficiency; the inefficiency of a non-profit-maximizing SOE is not reflected by TFP.<sup>13</sup>

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<sup>12</sup>See Jorgenson, Gollop, and Fraumeni (1987) for detailed expositions.

<sup>13</sup>We thank Yingyi Qian for suggesting this interpretation of our theory.

Furthermore, two remarks can be made with regard to equation (9). First, in the context of our model, where the production function is  $Q = Af(x)$ , applying (9), we have

$$T\dot{F}P = \dot{A},$$

since the elasticity  $\epsilon_a = 1$ . Thus, given our model, growth in TFP is essentially gotten by measuring the growth rate of  $A$ .<sup>14</sup> Second, (9) can be re-written as

$$T\dot{F}P = \frac{d\log(Q)}{dt} - \frac{\partial \log(Q)}{\partial \log(x)} \frac{d\log(x)}{dt}.$$

In most empirical works, the production function is assumed to be log-linear, i.e., the term  $\frac{\partial \log(Q)}{\partial \log(x)}$  is constant. In such cases, the growth rate of TFP becomes

$$T\dot{F}P = [d\log(Q) - \frac{\partial \log(Q)}{\partial \log(x)} d\log(x)]'_t,$$

i.e., the growth rate of TFP is identified as the regression coefficient on the  $t$  term.

### *3.2. Is the Theory Empirically Relevant?*

Our theory suggests the following hypothesis: higher productivity may imply lower profits or more financial losses for SOEs. A natural question arises: is this hypothesis likely to be valid for Chinese SOEs during the reform? Based on existing evidence, we argue that the answer is yes for a large number of SOEs, although to fully answer the question, systematic empirical evidence beyond the existing empirical literature is necessary.

Our theory is consistent with a description of the aggregate performance of China's state enterprises during the reform. First, it is widely recognized that the very rapid entry of non-state industrial firms has made Chinese industries much more competitive than they used to be (Jefferson and Rawski (1994)). Therefore, existing state enterprises are left with much less room for increasing output. Had the SOEs' primal concern been profit, we would have expected their response to have been a slow down of output growth. However, the second widely recognized fact of Chinese SOEs is that almost all state industrial sectors

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<sup>14</sup>Some empirical works, such as Jefferson, Rawski, and Zhen (1992), utilize a more sophisticated method to estimate TFP. Instead of treating the TFP as a deterministic constant, they regard the TFP as having a random component, so that the realization of TFP has an upper bound. This is the so-called frontier production function analysis. This does not change our analysis here.

registered higher output growth rates than those of the pre-reform era. Few state sectors, if any, have suffered output reductions during the reform. Third, profit rates have been decreasing and the proportions of state firms which are profit losers has increased. These broad observations together suggest that our theory, that higher productivity drives lower efficiency, seems to be relevant for at least many SOEs', if not all.

Direct evidence for our theory can be found at the enterprise level. In a careful study of the emerging managerial market in China, Groves, Hong, McMillan, and Naughton (1995) examine the incentives of SOE managers. They find that managerial compensation is more closely linked to firm profit after the reforms. However, overall, "sales were a strong factor and profits were a weaker factor in explaining managerial wages". Facing such an incentive structure, managers have to pay great attention to output targets.<sup>15</sup> In another study, Dong and Tang (1995) analyze questionnaires issued to managers of 800 SOEs in 1990. Managers were asked: "(w)hy do you continue making profit losing products?" The most likely answers were (in descending order of frequency): 1) it is due to government instructions; 2) we have no better technology; and 3) we have to maintain employment. When asked about their reactions to situations where the market supply is larger than the market demand, managers most commonly replied: 1) we will not reduce production, which is more costly than reducing prices; 2) we will not reduce output since it violates government instructions; and 3) we will not reduce output until the market is stabilized. Dong and Tang (1995) thus conclude: "... SOEs have not yet assigned profit a proper weight in their objectives. ... In recent years, many SOEs continue producing when the market is soft, causing enormous increases in inventories and occupying large amounts of capital." (page 283) Finally, in a recent study of Chinese state-owned construction units, Parker (1996) found evidence of increasing over-use of capital and labor. From 1985 to 1991, the shadow-to-observed price ratio of capital decreased from 1.171 to 0.709. The same ratio for labor decreased from 0.645 to 0.632.<sup>16</sup> Again the evidence suggests that our hypothesis does describe Chinese

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<sup>15</sup>They note that the coefficients found in their study are "roughly similar" to those found in Western and Japanese firms. However, they recognize that "differences in model specification make comparison difficult."

<sup>16</sup>See Table 6 of Parker (1996).

SOEs during the reform.

### *3.3. Welfare Implications*

An interesting theoretical issue, which we have not addressed, is the overall effect of productivity change on social welfare. We have only studied the changes in firm profit and have omitted consumers' welfare, which is measured by the consumer surplus derived from the product. Also ignored is the managers' welfare.

An increase in TFP has the unambiguous effect of increasing the output level and lowering the price of the product, regardless of the value of  $\beta$ . This implies, unambiguously, that consumers are better off with a productivity improvement. The magnitude of the gain in consumer surplus decreases with the price elasticity of demand — it is higher when demand is less elastic and approaches zero when demand is perfectly elastic. The manager is also unambiguously better off, because a higher productivity means an outward shift of the transformation possibility frontier. The  $\pi(Q)$  is then tangent on a higher indifference curve. This result is, again, independent of the value of  $\beta$ .

As we have shown, however, the effect of an increase in TFP on profit does depend on the size of beta. In particular, when  $\beta$  is small, profit increases with productivity. This, together with what we have said about the consumers' and the manager's welfare, means that, for profit maximizing firms (those with  $\beta = 0$ ), an increase in productivity unambiguously leads to a higher total social welfare.<sup>17</sup> When  $\beta$  is large, the profit of the firm decreases with productivity, which leads to a lower welfare to the owner. The opposing signs of the change in the owner's welfare and those in the consumers' and the manager's welfare leaves the overall effect of higher productivity on social welfare ambiguous. Therefore, it is generally inappropriate to equate an improvement in productivity with an increase in social welfare. Neither is it appropriate to, without qualification, see improved productivity as an indicator of improved performance or "progress," because such an indicator neglects how the output level and the financial performance of the firm is affected by productivity. Specifically, it is not hard to see that, when the price elasticity of the demand is sufficiently elastic, the manager's welfare sufficiently small, and  $\beta$  sufficiently large, a higher productivity actually

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<sup>17</sup>Basu and Fernald (1995) derive this conclusion in a more general context, i.e., when firms have market power.

leads to a lower social welfare.

#### **4. Conclusions**

The motivation of our paper is a sharp division of opinions on China's enterprise reform. On the one hand, the existing economics literature has lent overwhelming evidence to the view that China's state enterprises have significantly improved their performance. On the other hand, it is widely believed in China that the state sector is the least successful area of reform.

The main message of the paper is that the conventional method of production function analysis centering around the total factor productivity (TFP), which is the basis of the large body of empirical research on Chinese SOEs, may not be appropriate for evaluating the progress of state enterprise reform. Using a simple model, we show that until the behavior of state enterprises is significantly improved, coming closer to that of profit maximization, a higher productivity as measured by the TFP growth may actually lead to lower profitability and therefore, in many cases, lower economic efficiency. Based on existing evidence, we argue that this worrisome scenario is very likely to be the case for many state enterprises during the reform.

A direct implication of our analysis is that the large amount of empirical work based on production function analysis may have to be re-interpreted. Growth rate of TFP alone may not be an appropriate standard, against which various reform programs are judged and lessons from China's reform are drawn. Consequently, new measures of state enterprise performance need to be designed to gauge the progress of the enterprise reform.



## Appendix

### A1. Proof of Lemma 1

Substituting  $\beta = [c'(y)/A] - 1$  (from (7)) into (8), we obtain

$$\begin{aligned}\frac{d\pi}{dA} &= y - [c'(y)/c''(y)][c'(y)/A - 1] \\ &= [(c'(y))^2/c''(y)][yc''(y)/(c'(y))^2 - (1/A) + 1/c'(y)].\end{aligned}$$

### A2. Proof of Lemma 2

Define  $g(y) = yc''(y)/(c'(y))^2$ . Suppose  $\lim_{y \rightarrow \infty} g(y) > 0$ . Then there exists  $y_0 > 0$  such that  $g(y) > k = (1/2) \lim_{y \rightarrow \infty} g(y)$ , for all  $y > y_0$ . Rearranging yields

$$g(y)/y = c''(y)/(c'(y))^2 = -[1/c'(y)]'.$$

Integrate the above equation with respect to  $y$ . Then, as  $y \rightarrow \infty$ ,

$$\begin{aligned}-1/c'(y) &= -1/c'(1) + \int_1^y [g(x)/x] dx \\ &= -1/c'(1) + \int_1^{y_0} [g(x)/x] dx + \int_{y_0}^y [g(x)/x] dx \\ &> k_1 + \int_{y_0}^y (k/x) dx \\ &= k_1 + k(\ln y - \ln y_0) \\ &\rightarrow \infty\end{aligned}$$

where  $k_1 = -1/c'(1) + \int_1^{y_0} [g(x)/x] dx$  is a constant. Therefore  $c'(y) < 0$  as  $y$  is large enough, which is a contradiction. Q.E.D.

### A3. Proof of Proposition 2

Proof: Lemma 1 says that  $\text{sign } \frac{d\pi}{dA} = \text{sign } [yc''(y)/(c'(y))^2 - (1/A) + 1/c'(y)]$ . Lemma 2 tells us that  $\lim_{y \rightarrow \infty} yc''(y)/(c'(y))^2 = 0$ . Since, by (7),  $\lim_{\beta \rightarrow \infty} y = \infty$ ,

$$\lim_{\beta \rightarrow \infty} yc''(y)/(c'(y))^2 = 0$$

is also true. So the first term in  $[\cdot]$  approaches zero as  $\beta$  approaches  $\infty$ . The same is true for the last term in  $[\cdot]$ . So  $[\cdot]$  is less than 0 if  $\beta$  is sufficiently large.

The second part of Proposition 2 follows Proposition 1.

## References

- Bai, Chongen, and Yijiang Wang (1996): "Bureaucratic Control and Soft Budget as a Weak Link in the Incentives in China's State Sector," mimeo, Department of Economics, Boston College;
- Basu, Susanto, and John Fernald (1995): "Aggregate Productivity and Productivity of Aggregates." Working Paper 5382, National Bureau of Economic Research, Inc.
- Dong, Fureng, and Zunkung Tang (1995): *Zhongguo Guoyu Qiye Zhidu Piange Yanjiu. (Studies of Institutional Reforms of Chinese State-Owned Enterprises)* Beijing: Renming Chubanshe (The People's Publisher).
- Gordon, Roger, and Wei Li (1995): "The Change in Productivity of Chinese State Enterprises, 1983–1987." *Journal of Productivity Analysis*. 6, 5-26.
- Groves, Theodore, Yongmiao Hong, John McMillan, and Barry Naughton (1995): "China's Evolving Managerial Labor Market." *Journal of Political Economy*. 103, 4:873–82. August.
- Jefferson, Gary, Thomas Rawski, and Yuxin Zheng (1992): "Growth, Efficiency, and Convergence in China's State and Collective Industry," *Economic Development and Cultural Change*, v.40:239–266. n.2. January.
- Jefferson, Gary, and Thomas Rawski (1994): "Enterprise Reform in Chinese Industry", *Journal of Economic Perspectives*, v.8, n.2;
- Jefferson, Gary, Thomas Rawski, and Yuxin Zheng (1995): "Chinese Industrial Productivity: Trends, Measurement Issues, and Recent Development," Working Paper, #297, Department of Economics, University of Pittsburgh
- Jefferson, Gary and Indejit Singh (1993): "China's State-Owned Industrial Enterprises: How Effective Were the Reforms of the 1980s? A Review of the Evidence", Transition Economics Division, the World Bank.
- Jorgenson, Dale, Frank Gollop, and Barbara Fraumeni (1988): *Productivity and U.S.*

*Economic Growth*. Cambridge, MA: Harvard University Press.

Kendrick, John (1973) *Postwar Productivity Trends in the United States 1948–1969*. New York, NY: Columbia University Press.

Kornai, Janos (1992): *The Socialist System*. Princeton, NJ: Princeton University Press;

Li, David D. and Shan Li (1995):“Corporate Debt Crisis in China’s State Enterprises: Analysis and Policy Proposals,” in J. Wen:“The Reformability of Chinese State Sector,” the World Scientific Publisher;

Parker, Elliott (1996): “The Effect of Scale on the Response to Reform by Chinese State-Owned Construction Units,” *Journal of Development Economics*, forthcoming.

Shleifer, Andrei and Robert Vishny (1994):“Politicians and Firms,” *Quarterly Journal of Economics*, 109:995-1025, November.

Woo, Wing Thy, Wen Hai, Yibiao Jin, and Gang Fang (1994):“How Successful Has China’s State Enterprise Reform Been?” *Journal of Comparative Economics*, 18:410-37, June.

Zhu, Rongji (1996):“Guo You Qi Ye Sheng Hua Gai Ge Ke Bu Rong Huan,” (No Time Shall be Lost in Further Reforming State Owned Enterprises), *Speech at the Forth Meeting of the Eighth People’s Congress*, People’s Daily, Overseas Edition, March 11, 1996.

Williamson, Oliver (1975): *Markets and Hierarchies*. New York, NY: Press Press.