The Impact of Economic Reform on the Performance of Chinese State Enterprises: 1980–1989

Wei Li[1]
Fuqua School of Business
Duke University
Box 90120
Durham, NC 27708-0120
WL4@mail.duke.edu

September, 1994

[1]Thanks to Roger Gordon, Matthew Shapiro, Robert Dernberger, David Li, and seminar participants at the University of Michigan. This research was supported by the Ford Foundation and Chinese Academy of Social Sciences, and by a Rackham Predoctoral Fellowship from the University of Michigan.

Abstract

The effectiveness of China's incremental industrial reform between 1980–89 is empirically investigated using a panel data set of 769 state enterprises from 36 2–digit industries. I derive and apply a method that measures marginal products of factors, changes in total factor productivity (TFP), and improvements in factor allocation between enterprises by comparing actual changes in output to actual changes in inputs. Under this approach, the production functions can differ arbitrarily across firms. Market power in product markets and deviations from efficient allocation of factors are also permitted. This study finds that there were marked improvements in marginal productivity of factors and in TFP between 1980–89, and that over 73 percent of output growth was attributable to TFP growth, and over 87 percent of TFP growth was attributable to improved incentives, intensified product market competition, and improvements in factor allocation.

Who cares whether a cat is black or white, as long as it catches mice.

Deng Xiaoping

1 Introduction

Since 1978, China has implemented a series of changes in the administration of its state-owned industrial enterprises aimed at improving productivity. In contrast to the "big bang" reform in post-communist Eastern Europe and the former Soviet Union, the reform in China has proceeded in a controlled but progressive manner. Instead of privatizing state-owned enterprises *en masse*, China has concentrated on enterprise restructuring by consolidating enterprise property rights at the municipal government level and by adopting a new enterprise governance structure that stresses enterprise autonomy and incentives. Instead of liberalizing prices overnight, China has instituted marginal economic liberalization and marketization by introducing the "dual-track pricing system" in the state industrial sector and by lowering bureaucratic barriers to entry to the once state-monopolized industries.

How successful has the reform been in China's state industry? Unlike the reform in agriculture that changed property rights of farm land within a short period of time and was hailed a success (McMillan *et al*(1989)), the reform in industry was implemented as a series of changes over more than a decade. So far no consensus has emerged among economists on whether the industrial reform has promoted productivity in China's state industry.[1]

The purpose of this study is to make use of by far the most comprehensive enterprise-level panel data available to evaluate the effectiveness of the reform in China's industry between 1980–89. I derive and apply a method that measures marginal products of factors, changes in total factor productivity (TFP), and improvements in factor allocation between enterprises by analyzing the relationship between actual changes in output and actual changes in inputs and in the institutional environment that enterprises face. In this method, the production functions can differ arbitrarily across enterprises, a necessary requirement for this study since the sample enterprises are drawn from nearly all 2-digit industries in China and presumably use different technologies. In light of the fact that the Chinese economy between 1980–89 was still in transition from a state-monopolized socialist economy to a market economy, this method is designed to take account of deviations from efficient allocation of factors and the presence of market power in product markets.

[1] While Chen (1988), Jefferson *et al* (1992), Gordon and Li (1994), Groves *et al* (1994b), among others find positive productivity growth in China's state enterprises during the reform, Rawski (1986) and Woo *et al* (1994) find negligible productivity growth.

This study differs substantially from earlier empirical studies in methodology and the scope of analysis. Chen *et al* (1988), Gordon and Li (1994), Groves *et al* (1994b), and Woo *et al* (1994), for example, were primarily concerned with productivity estimation. While Groves *et al* (1994a) studied the effect of enterprise autonomy and incentives on the behavior of state enterprises, their analysis focused mainly on labor productivity—a partial measure of productivity. Many other authors have also undertaken systematic studies of Chinese state enterprises; they include Granick (1990), Jefferson and Xu (1991), and Tidrick and Chen (1987). The key difference that clearly separates this study from the earlier studies is that this study includes the effects of intensified product market competition and the changing market structure. In addition, this study makes use of the detailed nature of the available panel data set. It takes advantage of the rich price information in the data by measuring the value of output and intermediate inputs in *market* prices rather than in *mixed* prices—averages of market prices and planned prices, which are used in all previous studies. The advantage of using market prices is apparent since market prices reflect the relative scarcity of resources better than the distorted planned prices.

Subject to certain qualifications, this study finds that there were marked improvements in marginal productivity of factors, in TFP and in factor allocation between 1980–89. The marginal productivity of labor increased by over 54 percent between 1980-89. The increase in the rate of return to capital investment was also substantial. The marginal productivity of intermediate materials stayed roughly at the same level. Growth in TFP was 4.68 percent per year between 1980–89 and accounted for over 73 percent of output growth, which was 6.37 percent, and the remaining 27 percent of output growth was attributable to increases in factor inputs. The shifts in resources from less productive enterprises to more productive ones increased output by 1.79 percent per year between 1980–89 and accounted for over 28 percent of output growth and 38 percent of TFP growth. Growth in bonus per worker and increases in product market competition contributed 2.29 percentage point to TFP growth, accounting for 49 percent of TFP growth and 36 percent of output growth. This study also finds that the market power of state enterprises, measured by market price to marginal cost markup (P/MC), eroded by 15 percent between 1980–89.

These findings have implications beyond simply providing a better understanding of the performance of Chinese state enterprises during the reform period. They suggest that enterprise restructuring even without formal privatization can enhance enterprise performance, and that the marginal economic liberalization as practiced in China can improve resource allocation when entry barriers to the state-monopolized industries are also lowered to foster competition.

2 The Reform

Instead of giving a chronological account of the reform that have lasted for more than a decade and are still deepening,[2] this section highlights the effective changes that had been made as of 1989, the last year in which the data are available.

2.1 Decentralization: Changes in Property Rights

Prior to the reform, a typical enterprise in China was controlled by a multitude of bureaucrats in both central ministries and in various levels of local government offices. The rights of control over state enterprises were thus ill-defined. The residual claim to enterprise earnings was also unclear. While local governments were allowed at various times to retain some of the earnings from enterprises within their jurisdictions, they often managed to retain more than was allowed through uncompensated use of enterprise resources.[3] In addition, the huge industrial bureaucracy was plagued by widespread and costly rent-seeking activities—continual bargaining over the setting of material and credit plans—and the sharing of enterprise earnings. These rent-seeking activities gave rise to tremendous influence costs (Milgrom and Roberts (1990)).

Beginning at the end of 1978, the Chinese government took serious steps to consolidate the control of state enterprises and to flatten the industrial bureaucracy. By the end of 1983, the vast majority of enterprises was transferred to local governments, primarily at the municipal level. The enterprises that remained in the center were either natural monopolies or firms that were considered strategically important to the national economy, *e.g.*, coal mines, oil fields, and defense firms. The control rights of these firms were consolidated either in their respective industrial ministries, or in one of the several newly created national holding companies or conglomerates, *e.g.*, National Coal and North Industries.

The consolidation of control rights was followed immediately by a series of fiscal reform which effectively gave the residual claim to enterprise earnings to local governments (and national holding companies). Under the new fiscal system, local governments were responsible for collecting taxes and profits from enterprises in their jurisdiction. The center continued to get almost all income from centrally controlled firms. Earnings from locally controlled firms were shared between the center and the local governments according to some pre-negotiated rules, which were often fixed for 3 to 5 years (Oi (1993)). Beginning in 1985, the prevailing practice was for the local government

[2]See Granick (1990) and Naughton (1994) for more discussion of China's reform.
[3]See Granick (1990) for a comparison with the traditional Soviet system.

to deliver to the center (or a higher government) a lump sum amount plus a small percentage of realized earnings in excess of target earnings. This arrangement was equivalent to treating local governments as conglomerate enterprises and taxing them at low marginal rates.

By pairing residual rights and returns, China in effect transferred property rights of state enterprises to local governments (or national holding companies). These new owners had the incentive to maximize the value of their enterprises, which should have improved enterprise productivity and efficiency (Grossman and Hart (1986) and Hart and Moore (1990)).[4] The centralization should have reduced the influence costs that were associated with a large and centralized organization. It should also have reduced the costs of collecting, transmitting and processing information, since many economic decisions and calculations were left to those who had the relevant information.

2.2 Changes in Enterprise Governance

In response to the change in property rights, local governments and holding companies began to experiment with enterprise governance in the early 1980's. Imitating the "responsibility system" that had been very successful in agriculture, they introduced the "managerial responsibility system," under which managers were delegated power to make many decisions. By 1985, managers in the majority of the firms could make decisions on outputs, product mix, and prices on outside-of-the-plan outputs. The reform deepened significantly between in 1988 when the "contract responsibility system" was widely adopted. Under the contract system, the government would sign a contract with enterprise managers specifying the responsibilities of each party and arranging the distribution of enterprise earnings. Since it is impossible to enact and enforce a complete contract specifying precisely who is to do what and how the benefits and costs are to be shared under every possible contingency, the new governance structure effectively gave Chinese managers the discretion to make many decisions independent of the government.

To make the separation functional, incentives were introduced simultaneously to align the interests of managers (and workers) to the interests of the increasingly value-oriented owners. Bonuses were reinstated in the late 1970's and were used primarily as group incentives, tying employees' pay to enterprise performance.[5] Since the local government was interested in maximizing the value

[4] See Shleifer (1994) for an excellent discussion on establishing property rights in transitional economies. While he identifies bureaucratic ownership as one of three strategies for improving the efficiency of enterprise control structures, Shleifer (1994) also rightly points out that the efficiency of bureaucratic ownership may be fragile, since unlike private owners, local governments may face the political pressure to provide excess employment.

[5] Determining each individual worker's bonus, however, was a thorny issue. Many managers found it more advantageous to leave the task to the workers' councils or unions. To limit unproductive rent-seeking activities, managers and/or workers' councils usually set some rather rigid formulae that tied each individual's bonus pay to his/her

of its enterprises, which was the stream of taxes and profits from its enterprises, bonuses in the majority of the enterprises were in fact tied to the sum of turnover taxes and profits. Thus, the link between profits and employee compensation may have been stronger than in many Western firms.

2.3 Marginal Liberalization

The pre-reform economy in China was based on state ownership of all means of production. This monopolistic system allowed the state to extract maximum investable surplus from the economy by systematically distorting the allocation of resources (Li (1994a)). To maintain the monopolistic economic system, allocation of real resources had to be made unresponsive to the distorted relative prices. Central planning had performed this allocative role remarkably well. Entry into the lucrative processing industries was restricted by the planning apparatus to prevent competition. Private enterprises were banned and investment was rationed by the center.

However, allocative inefficiency was not the only sin of state monopolization. Monopoly power made it easier for bureaucrats, managers and workers to pursue "a quiet life" (Hicks (1935)), to engage in slack or "X-inefficiency" (Leibenstein (1966)). The costs of state monopolization of industry in China may have derived more from X-inefficiency than from allocative inefficiency.

When the rights of control of state enterprises were transferred to local governments, the once monopolistic industrial structure was effectively broken up into hundreds of regional conglomerate or "Municipalities Inc." This created a competitive environment in which municipalities, which were small relative to the national economy, competed against each other. Entrepreneurial local governments responded swiftly to the changes. They invested heavily in the lucrative processing industries to take advantage of, and to undo, existing distortions. State-owned tobacco factories, breweries, and consumer durable-goods manufacturing facilities mushroomed across the country.

Beginning in 1979, the bureaucratic barriers to entry that had restricted non-state firms from tapping into the monopoly rents sanctioned by the state were lowered gradually. Collectives, private entrepreneurs, as well as foreign investors responded by setting up their own firms in the lucrative processing industries to compete head-on against established state firms (Naughton (1994)). Stimulated by distorted relative prices, the changes in the allocation of real resources exerted tremendous pressure on the rigid price system. Shortages of raw materials, energy and transportation became

attendance, measurable individual contribution or evaluation by peers, responsibility, and seniority. Since workers had better information about one another's individual effort than the manager, this arrangement may have further strengthened incentives by motivating workers to monitor each other.

serious bottlenecks, yet at the same time markets for processed goods gradually became saturated.

In the early 1980's, the government started implementing price reform. One of the most important price reform was the introduction of the "dual-track pricing system" (Byrd (1989) and Li (1994b)). Under the new pricing system, most of the newly founded non-state firms could operate outside the realm of central planning. Their output could be sold directly to buyers at market clearing prices, hence creating product markets on the margin parallel to planning. For state enterprises, the new pricing system gradually reduced planned procurement of output and the planned allocation of intermediate inputs, forcing the state enterprises to trade an increasingly large fraction of their output and intermediate inputs through markets. State enterprises, therefore, were directly exposed to increasingly active competition in product markets at the margin. The dual pricing system also complemented the relaxation of state monopolization. It helped the expansion of non-state firms since many intermediate inputs that were unavailable to them at any price before the reform could now be purchased at market prices.

3 The Data

The data come from an enterprise survey conducted by the Chinese Academy of Social Sciences (CASS) in 1990. Annual data from 769 state-owned enterprises between 1980–89 were collected, covering 321 variables that give details of firms' real and financial accounts, price information, and internal incentives. In addition, a supplementary data set describing the relationship between each firm and the government was collected. The 769 sample firms in the data represent 36 industries out of a total of 40 2-digit industries in mining, logging, utilities, and manufacturing,[6] and are located in four provinces (Jiangsu, Jilin, Shanxi, and Sichuan).

All data describing changes in prices, output, inputs, and institutions were checked for obvious coding errors. Obvious miscodes were discarded. The available data on changes in output, inputs, prices, and institutions then form a balanced panel data consisting of 272 enterprises spanning from 1981 to 1989. Below I describe in turn the available data on prices, output and input quantities, and the reform. More discussion on the data can be found in Li (1994c).

3.1 Prices

Price data are pivotal to this study. To compare the behavior and performance of enterprises using panel data, it is necessary to correct price differences both across time and *across enterprises*.

[6] Adopted in 1985, China's industry classification is comparable to the ISIC.

While movement of prices across time is familiar in all economies, variation in price of an identical product due to factors other than transport costs and taxes is one of the unique characteristics of China's transitional economy. Under the "dual-track pricing system," a firm can pay different prices for the same input, and can sell the same output at different prices. Therefore, the reported sales, the reported value of output and the reported expenditure on inputs are measured in mixed prices—weighted averages of market prices and planned prices. The extent of participation in the planning process varies across time for a firm, and varies across firms, leading to complicated differences in mixed prices both over time and across firms.

The CASS data contain detailed price information that allow the construction of firm-specific indexes of the mixed prices for output, raw materials, and the ratios between the market prices and the mixed prices for output and for raw materials. The enterprise specific indices of market prices for output and for raw materials can then be constructed. With the detailed price data on output and raw materials, the real value of output and raw materials, measured in market prices and adjusted for inflation, can be compared both across time for any given firm and across firms at any given time more accurately in this study than in any previous study. The data, however, do not contain information about market prices of capital or about firm-specific mixed prices of capital. An aggregate index of mixed prices for capital is used here instead. A detailed description of the procedures used in constructing price indexes is documented in Li (1994c).

The first two panels of Table 1 report the average inflation rates of mixed prices and market prices, the average markup of market prices over planned prices, and the proportion of transactions that were conducted outside the planning apparatus, for output and raw materials. Inflation rates of mixed prices of capital goods, the only price data available for capital goods, are listed in the last panel.

Inflation between 1981–83 was quite moderate due to price control that was still firmly in place. When price control was relaxed in the mid–1980's, inflation accelerated. Double digit inflation was recorded in 1988–89 for output price, and in 1986–89 for material prices, and in 1983–89 for capital prices. The rapid increases in prices immediately following price liberalization was perhaps the result of converting monetary overhang into real purchasing power. The main purpose of price liberalization, however, is to undo distortions imposed by decades of central planning. This appears to be what had happened in China between 1985–89: the inflation rates of material prices, which were traditionally kept low relative to those of processed goods, were substantially higher than the inflation rates of output between 1985-89. Section 6 will present more evidence of this structural change in resource allocation.

Table 1: Inflation Rates by Year (Percent)

Year	Mixed Price Inflation	Market Price Inflation	$\left(\frac{\text{Market Prices}}{\text{Planned Prices}} - 1\right) \times 100\%$	Percent Sold/Bought at Market Prices
			Output	
1980–1	0.1	0.6	3.3	16.9
1981–2	1.9	2.4	5.4	19.2
1982–3	2.5	2.2	4.4	17.7
1983–4	2.5	3.2	5.8	19.4
1984–5	7.0	7.3	15.5	27.4
1985–6	6.2	9.3	25.5	29.4
1986–7	8.1	4.6	17.1	27.5
1987–8	17.6	22.0	15.9	37.6
1988–9	14.7	21.2	39.3	38.6
			Raw Materials	
1980–1	2.0	1.3	22.3	22.3
1981–2	1.7	1.0	15.9	23.3
1982–3	2.1	2.0	30.8	27.6
1983–4	7.2	7.1	24.0	30.5
1984–5	5.6	5.2	29.8	42.4
1985–6	11.0	19.0	41.4	48.7
1986–7	18.6	11.9	63.4	54.9
1987–8	35.9	39.6	84.4	61.4
1988–9	19.5	18.7	117.1	63.8
			Capital	
1980–1	6.6	—	—	—
1981–2	0.9	—	—	—
1982–3	7.1	—	—	—
1983–4	17.2	—	—	—
1984–5	12.1	—	—	—
1985–6	14.2	—	—	—
1986–7	22.8	—	—	—
1987–8	19.5	—	—	—
1988–9	15.8	—	—	—

Table 2: Growth by Year (Percent)

Year	Output in 1989 Market Prices	Output in 1980 Planned Prices	Labor Input	Capital Input	Intermediate Materials
1980–1	-0.1	4.5	6.2	7.1	5.1
1981–2	6.9	12.8	3.8	6.0	5.2
1982–3	7.8	11.7	1.0	6.1	6.8
1983–4	10.2	13.7	1.4	8.2	3.3
1984–5	5.1	10.2	2.3	7.4	7.1
1985–6	6.6	6.9	3.4	5.8	2.9
1986–7	12.0	14.4	2.1	6.5	5.9
1987–8	8.3	16.1	1.6	7.0	-1.6
1988–9	1.2	2.1	-0.3	5.7	0.3
1980–9	6.4	10.2	2.4	6.7	3.8

3.2 Output and Inputs

I construct a time series of real output (Q_{nt}) for each enterprise n, based on market prices prevailing in 1989—the last year in the sample. The rationale for using 1989 market prices is that after a decade of economic liberalization, market prices prevailing in 1989 should be much closer to reflecting relative scarcity of resources than mixed prices or market prices in earlier years.

Due to the lack of adequate price data, almost all previous studies measured real output as the value of output based on 1980 constant prices, which are primarily planned prices in effect as of January 1980. Given the price distortions in China, the planned prices tended to over-value processed goods relative to raw materials. As a result, the aggregate growth rate of industrial output based on 1980 prices was biased upward, because the processing sector grew at a faster rate than the primary goods sector and was given exaggerated weights. This upward bias in output growth may have led to upward bias in measured productivity in previous studies as well.[7]

Table 2 reports the average annual growth rates of Q_{nt}. For comparison, I also list in the table average annual growth rates of output based on 1980 constant prices. Compared with the growth rates measured in 1989 market prices, growth rates measured in 1980 constant prices are on average biased upward by 3.8 percentage points!

[7]See Woo *et al* (1994) for a discussion on biases in measuring TFP growth in China's state industry caused by underdeflation of output and overdeflation of intermediate inputs.

Labor input, L_{nt}, is measured as the total number of employees in enterprise n in year t, excluding service workers and excluding employees who were absent for over half of the year.[8] Column 4 in Table 2 reports the average annual growth of labor input.

Similarly, the measure of capital input, K_{nt}, includes only capital stock in place that is used in production. It excludes unfinished capital expenditure and capital stock that are used to provide services to enterprise employees.[9] Since information on the market prices of capital goods is not available, the aggregate index of mixed prices listed in Table 1 is used to construct real capital stocks measured in 1989 prices. Column 5 in Table 2 reports the average annual growth of K_{nt}.

Intermediate inputs is defined as the sum of raw materials, auxiliary materials, fuel and power consumed in each year. The real value of intermediate materials consumed in year t, M_{nt}, based on 1989 market prices is constructed from its nominal value using the available data on market prices of raw materials.[10] Column 6 in Table 2 reports the average annual growth of M_{nt}.

3.3 Reform Variables

Since the consolidation of property rights and the delegation of power to managers affected almost all enterprises at roughly the same time, I simply use a time dummy to capture their effects.

Among many possible measures of incentives that Chinese workers and managers faced, I choose bonus per worker. The change in incentives from one year to the next is then measured by the annual growth rate of bonus per worker, B_{nt}. Bonus as a form of profit sharing was the most widely used explicit incentive in China, making comparison across enterprises possible. In addition, bonus was certainly one of the most important incentives that an average enterprise employee faced. Housing allocation and promotion were also used to motivate workers, but data on these incentives are unavailable. More importantly, other ways to measure the extent of profit sharing by employees are unsatisfactory. For instance, the marginal rate of profit retention tends to exaggerate the extent of profit sharing, since part of the retained profits must be reinvested. A more serious flaw is that the

[8] The treatment of service workers in the measure of labor inputs merits discussion. Typically a Chinese state enterprise provides a variety of services to its employees and their immediate families. Those services include food preparation, day-care, medical care, housing, public entertainment, and in some cases, even elementary and/or secondary education. Although these services are valuable to enterprise employees and their families and constitute an important part of their non-pecuniary benefits, the value of these services is not directly included in the firm's output. In order to be consistent with the measure of output, I exclude resources that are used in providing these services.

[9] Data on capital utilization are not available.

[10] Since data on the market prices of auxiliary materials, fuel and power are not available, I assume (1) that the inflation of market prices of other intermediate inputs is equal to that of raw materials, and (2) that the ratio of market price to mixed price is also identical among different categories of intermediate materials.

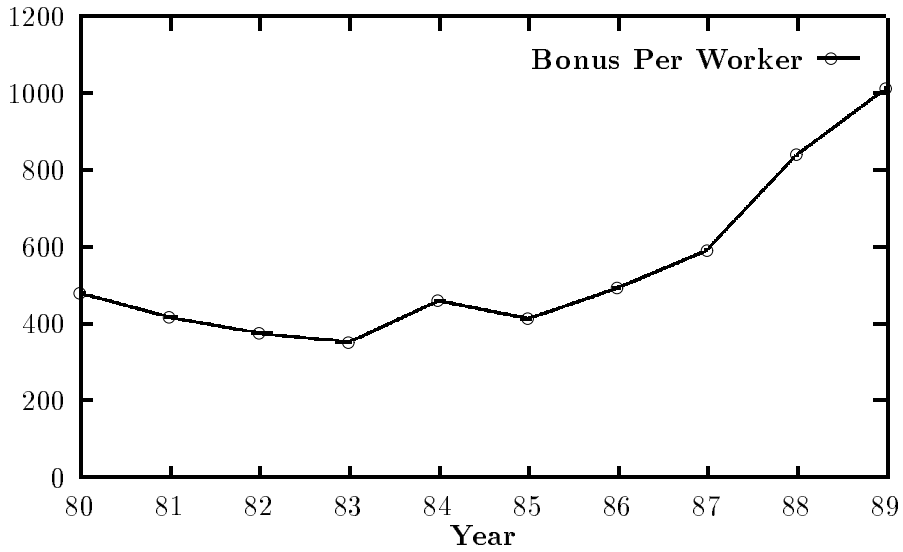

Figure 1: The movement of annual bonus per worker in 1989 RMB.

rate of profit retention loses its incentive effects when the enterprise is expected to be a loss-maker based on after-turnover-tax profits. Bonus, however, was often based on the *sum* of turnover taxes and after-turnover-tax profits if this sum was positive or on a loss-reduction target if the sum was expected to be negative. Given that turnover taxes were highly distortionary, tying bonus to the sum of turnover taxes and after-turnover-tax profits while subsidizing loss-makers by reimbursing part of the turnover taxes had an unexpected effect of undoing tax distortions.

Figure 1 plots bonus per worker measured in 1989 RMB against time. Between 1980–89, the average bonus more than doubled. Much of the increase came after 1985 when the central government lifted caps on bonuses and granted enterprises more autonomy.

In order to study the effects of market competition on enterprise productivity, I need to measure the change in market power for each enterprise over time. The markup ratio—the ratio of price to marginal cost—is an ideal measure of market power (Bresnahan (1988)). Such a measure, however, is not directly observable. In this study, I approximate the change in market power, C_{nt}, as the difference between the inflation rate of market output prices and the inflation rate of market prices of intermediate materials. Specifically, $C_{it} = \pi_{nt} - \pi^m_{nt}$, where π_{nt} and π^m_{nt} are enterprise specific inflation in market prices of output and market prices of intermediate materials.

Both changes in bonus per worker and changes in market power over time are endogenous: in order to have any motivational effects, changes in bonus must be based on changes in enterprise

performance; and if an enterprise has market power, then changes in output prices in response to productivity improvements or changes in factor prices must be endogenously determined. Identification of the effects of these changes on productivity requires the use of instrumental variables, which I will discuss in Section 5

4 Methodology

Measuring total factor productivity in a non-market economy is more difficult than in a developed market economy. The added difficulty arises because methods that are applicable to Western economies are *conditional* on certain assumptions that may not be justified in the context of a non-market economy. For example, the most widely used method measures productivity growth using the Divisia index $\dot{Q}/Q - \sum_i S_i \dot{X}_i/X_i$, where Q represents output, X a vector of inputs used in production, and S_i is input i's imputed share of output.[11] To estimate the imputed share S_i, the following two assumptions, which are unique to a canonical market economy, are usually made. First, the producers are cost-minimizers or profit-maximizers. Second, the economy is a mature market economy with developed product and factor markets, and is operating in a long-run competitive equilibrium. Under these assumptions, S_i can be easily estimated as $W_i X_i/PQ$, where W_i is the market price for the service of input i, and P the market price of output.[12] However, it is a widely accepted view that these assumptions are incompatible with a reforming socialist economy, such as the Chinese economy between 1980-1989. Hence the traditional method is not applicable here.

Notwithstanding the difficulties just mentioned, the available data put an additional constraint on methodology. The 769 sample firms cover 36 two-digit industries and span over 20 urban centers across China. They presumably used quite different technologies, and were subject to the control of different governments. Therefore, an appropriate method should also have the flexibility to allow

[11] See Solow (1957) and Jorgenson and Griliches (1967). This method measures productivity growth from the output perspective, *i.e.*, based on the production function. Other commonly used methods measure productivity growth using the cost functions (Caves *et al* (1980)), or cost frontier functions (Atkinson and Cornwell (1994)), or profit frontier functions (Lovell and Sickles (1983)). These approaches require that the firms under study be profit-maximizers or cost-minimizers, hardly realistic in the context of this study. In addition, they require the use of market prices for capital and labor, which are unavailable since there were no functional markets for labor or capital in the 1980's in China.

[12] These assumptions can be a bit too strong even in a developed market economy. The marginal products of quasi-fixed factors (*e.g.*, capital stock) may deviate from market prices in the short-run due to adjustment costs. Firms can have substantial market power in product markets. Modifications to the conventional method have been advanced to deal with these "imperfections." See Morrison and Diewert (1990) and the references cited there. These modified approaches, however, still require well-functioning factor markets.

production functions to differ *arbitrarily* from one enterprise to another.

Unfortunately, this requirement rules out existing methods that do not rely on the market-economy assumptions. For instance, one such method postulates a parametric production function that is identical across firms,[13] in which the productivity is either measured as the regression residual (in the case of neutral technical changes) or as parameters in the production function (in the case of non-neutral technical changes). Since this method does not require the market-economy assumptions, it is applied not only to market economies but also to non-market economies.[14] Its applications to China's economy are numerous; see for example, Chen *et al* (1988), Dollar (1990), Groves *et al* (1994b), and Woo *et al* (1994) among others.

In what follows, I present a method for measuring productivity in a transitional economy that allows production functions to differ arbitrarily across firms. This method extends that of Gordon and Li (1994) by incorporating market power into productivity measurement, by applying it to panel data, and by using instrumental variables to obtain consistent estimates. It departs from the traditional approaches in that it estimates the value marginal products of factors directly from quantity data rather than using observed factor prices.

4.1 Production Function

Enterprise output is determined not only by factor inputs that are used in production, but also by the institutional environment that the enterprise faces.[15] Given its labor L_{nt}, capital K_{nt}, intermediate inputs M_{nt}, and the vector of institutional environment R_{nt} it faces, I assume that enterprise n's output in year t can be written as

$$Q_{nt} = f_n(L_{nt}, K_{nt}, M_{nt}, R_{nt})A_{nt} \equiv f_{nt}A_{nt} \tag{1}$$

where f_n is an enterprise-specific production function, and A_{nt} represents random shocks in productivity. Allowing the production function to vary over enterprises captures the heterogeneity in production technology and the heterogeneity in enterprise response to the changing institutions.

[13] Other existing methods that do not require the market-economy assumptions but require identical production technology across firms include the production frontier function approach (Førsund *et al* (1980) and many others), and the distance function approach or the Malmquist index approach (Färe *et al* (1994)).

[14] For applications to market economies, see Griliches and Mairesse (1983) among many others. For applications to the former USSR, see Bergson (1987) among many others.

[15] It may be assumed that the enterprise output is determined by tangible factor inputs and the "effort levels" of enterprise managers and workers. The institutional production function can thus be thought of as a reduced form production function in which the "effort levels" of enterprise managers and workers are "maximized out" given the institutional environment that they face. See McMillan *et al* (1989).

The production function can exhibit either increasing, decreasing or constant returns to scale with respect to tangible factors L, K and M.

This specification attributes productivity growth to both institutional innovations or the reform, $\triangle R_{nt}$, and "technological" innovations, $\triangle A_{nt}$. The logarithm of the productivity disturbance A_{nt} is assumed to follow a random walk:[16]

$$\log A_{nt} = \log A_{n,t-1} + \eta_{nt} \tag{2}$$

where the forecast error η_{nt} is assumed to have mean 0 and variance σ_η^2.

To take full advantage of the detailed nature of the available panel data set, I assume that η_{nt} is comprised of two orthogonal parts. Specifically,

$$\eta_{nt} = \psi_n + \phi_{nt} \tag{3}$$

where (ψ_n, ϕ_{nt}) are *i.i.d.* across n and t, $\mathrm{Var}(\psi_n) = \sigma_\psi^2$, and $\mathrm{Var}(\phi_{nt}) = \sigma_\phi^2$ for all t. The first component, ψ_n, captures the effect of enterprise-specific factors on productivity growth. These enterprise-specific factors are unobservable to researchers, hence are not included in the production function. But they capture the presumed heterogeneity in technology, location, government regulation, and so on, among sample enterprises. For example, electronic firms should have experienced more technological innovations than breweries in any given time period, and the firms under the control of an entrepreneurial local government are likely to have had faster productivity improvements than those under the control of a bureaucratic local government. The second component, ϕ_{nt}, is the productivity shock that is idiosyncratic to enterprise n and time t, such as a disruption in electric power due to stormy weather.

4.2 Measuring Changes in Total Factor Productivity

Instead of estimating a parametric production function, I derive a method that estimates the marginal products of factors and changes in total factor productivity by comparing observed changes in output to observed changes in inputs and observed reforms from one year to the next.

To begin with, I take an exact finite difference of (1) between year t and year $t-1$, and evaluate the difference using the prevailing market price of output P_{nt} in year t. This yields,

$$P_{nt}\triangle Q_{nt} = \sum_{X=L,K,M} P_{nt}A_{nt}\frac{\triangle f_{nt}}{\triangle X_{nt}}\triangle X_{nt} + \sum_j P_{nt}A_{nt}\frac{\triangle f_{nt}}{\triangle R_{jnt}}\triangle R_{jnt} + P_{nt}f_{n,t-1}\triangle A_{nt} \tag{4}$$

[16] This assumes that innovations in A_{nt} have permanent effects on output. This is not an unreasonable assumption since most new techniques, once introduced, should be available forever.

where $\triangle Q_{nt} = Q_{nt} - Q_{n,t-1}$. The "coefficient" of $\triangle X_{nt}$, *i.e.*, $P_{nt}A_{nt}\frac{\triangle f_{nt}}{\triangle X_{nt}}$, represents a first-order approximation to the marginal product of factor X valued at year t's market price, while the "coefficient" of $\triangle R_{jnt}$ represents a first-order approximation to the marginal response of output to reform j.

To measure growth in output, I divide both sides of (4) by $P_{nt}Q_{n,t-1}$. Since $\triangle A_{nt}/A_{n,t-1} \approx \eta_{nt}$, this yields the following first-order approximation:

$$\frac{\triangle Q_{nt}}{Q_{n,t-1}} = \sum_{X=L,K,M} P_{nt}A_{nt}\frac{\triangle f_{nt}}{\triangle X_{nt}}\frac{\triangle X_{nt}}{P_{nt}Q_{n,t-1}} + \sum_j \frac{A_{nt}}{Q_{n,t-1}}\frac{\triangle f_{nt}}{\triangle R_{jnt}}\triangle R_{jnt} + \eta_{nt} \tag{5}$$

The marginal products of factors are evaluated in current market prices, which vary over time with inflation. In order to compare the value marginal product across time while preserving the changes in relative prices across firms, I multiple and divide the terms behind the first summation sign in (5) by P^*_{89}/P^*_t, where P^*_t is an aggregate index of market output prices. This yields,

$$\frac{\triangle Q_{nt}}{Q_{n,t-1}} = \sum_{X=L,K,M} W^X_{nt}\left[\frac{\triangle X_{nt}}{P_{nt}Q_{n,t-1}}\frac{P^*_t}{P^*_{89}}\right] + \sum_j \frac{A_{nt}}{Q_{n,t-1}}\frac{\triangle f_{nt}}{\triangle R_{jnt}}\triangle R_{jnt} + \eta_{nt} \tag{6}$$

where

$$W^X_{nt} = \frac{P^*_{89}}{P^*_t}P_{nt}A_{nt}\frac{\triangle f_{nt}}{\triangle X_{nt}} \tag{7}$$

denotes the value marginal product of factor X in 1989 RMB.

If each factor is allocated efficiently, then its value marginal product will be equated across firms in each year, regardless of the difference in production technology. In general, however, the value marginal product will differ across firms. To identify the source of the variation, I factor W^X_{nt} into two parts:

$$W^X_{nt} = \frac{P_{nt}}{\mathrm{MC}_{nt}} \cdot \left[\mathrm{MC}_{nt}A_{nt}\frac{\triangle f_{nt}}{\triangle X_{nt}}\frac{P^*_{89}}{P^*_t}\right] \tag{8}$$

where MC_{nt} is enterprise n's marginal cost in year t. The first part, P_{nt}/MC_{nt}, is the markup ratio. It varies across enterprises if the market structure and governmental regulations they face are different. The second part is the value marginal product evaluated at marginal cost and then converted into 1989 RMB. It will vary across enterprises if factors are misallocated. Misallocation of factors occurs if enterprises fail to maximize profits or to minimize costs, due to perhaps poorly assigned property rights, bureaucratic interference, and poorly aligned incentives for managers and workers. Variation in marginal value products may also arise due to heterogeneity in factors, factor fixity, and possible measurement errors.

In order to test the hypotheses that there were improvements in factor allocation and that competition in the emerging product markets had disciplinary effects on the behavior of state

enterprises, I postulate a parsimonious parametric specification for W_{nt}^X. First, I assume that the value marginal products of factors evaluated at marginal cost can be represented by the following linear specification:

$$\mathrm{MC}_{nt} A_{nt} \frac{\triangle f_{nt}}{\triangle X_{nt}} \frac{P_{89}^*}{P_t^*} = w_1^x D_{1t} + w_2^x D_{2t} + (\beta_1^x D_{1t} + \beta_2^x D_{2t})(x_{nt} - \bar{x}_t) + \nu_{nt}^x \tag{9}$$

where $D_{1t} = 1$ if $1980 \leq t \leq 1984$ and 0 otherwise, $D_{2t} = 1 - D_{1t}$ and

$$x_{nt} = \frac{\triangle X_{nt}}{P_{nt} Q_{n,t-1}} \frac{P_t^*}{P_{89}^*}, \quad \bar{x}_t = \frac{1}{N} \sum_{n=1}^{N} x_{nt}, \quad \text{for } X = L, K, M$$

The variable x_{nt} denotes the change in factor X normalized by enterprise output. I include the period dummies D_{1t} and D_{2t} in order to capture the effect of deepening reform on factor productivity.

The first component in (9), w_1^x in the first half of the sample period ($D_{1t} = 1$) or w_2^x in the second half of the sample period ($D_{2t} = 1$), measures the average value marginal product in the first half or the second half of the sampling period. If the deepening of the reform had positive impact on factor productivity, one would expect that $w_2^x > w_1^x$. The second component, $(\beta_1^x D_{1t} + \beta_2^x D_{2t})(x_{nt} - \bar{x}_t)$, relates the value marginal product to changes in factor allocation. It attempts to capture how factors were reallocated in response to economic liberalization. If an enterprise had above average factor productivity, say labor productivity, then there would be an efficiency gain if more labor was allocated to the enterprise relative to other enterprises. In other words, if there would be an improvement in the allocation of factors, then $\mathrm{Cov}(\mathrm{MC}_{nt} A_{nt} \frac{\triangle f_{nt}}{\triangle X_{nt}} \frac{P_{89}^*}{P_t^*}, x_{nt}) > 0$, *i.e.*, $\beta_1^x > 0$ and $\beta_2^x > 0$. This parameterization therefore allows one to test that the economic liberalization resulted in improved allocation of factors, against the null hypothesis that $\beta_1^x = \beta_2^x = 0$. The third component, ν_{nt}^x, accounts for variations in the marginal value product from sources that are not explicitly modeled. It is orthogonal to changes in factor inputs, x_{nt}, by construction. It may, however, be correlated with the reform variables B_{nt} and C_{nt} that are omitted here.

Second, I assume that the change in markup ratio over time is proportional to the change in output prices relative to input prices:[17]

$$\frac{P_{nt}}{\mathrm{MC}_{nt}} - \frac{P_{n,t-1}}{\mathrm{MC}_{n,t-1}} = \theta C_{nt} \tag{10}$$

[17] If P_{nt}/MC_{nt} and $P_{n,t-1}/\mathrm{MC}_{n,t-1}$ are close to 1, then

$$\frac{P_{nt}}{\mathrm{MC}_{nt}} - \frac{P_{n,t-1}}{\mathrm{MC}_{n,t-1}} \approx \frac{P_{nt}/\mathrm{MC}_{nt}}{P_{n,t-1}/\mathrm{MC}_{n,t-1}} = \frac{P_{nt}/P_{n,t-1}}{\mathrm{MC}_{nt}/\mathrm{MC}_{n,t-1}} \approx \frac{\triangle P_{nt}}{P_{n,t-1}} - \frac{\triangle \mathrm{MC}_{nt}}{\mathrm{MC}_{n,t-1}}$$

for $t = 1981, \ldots, 1989$. Since in general $C_{nt} = \pi_{nt} - \pi^m_{nt} < 0$, a positive θ implies that the markup ratio declined over time and that competition in the emerging markets had disciplinary effects on the behavior of state enterprises. To derive a specification for the level of the markup ratio, I assume in addition that the markup ratio in 1989 is different across industries, but identical across enterprises within the same industry. Specifically,

$$\frac{P_{n,89}}{\mathrm{MC}_{n,89}} = \sum_{h=1}^{H} \mu_h I_{nh} \tag{11}$$

where μ_h is industry h's markup ratio, I_{nh} is an industry dummy variable which equals 1 when enterprise n is in industry h and 0 otherwise, and $\sum_h I_{nh} = 1$. Although in principle one could include an industry dummy for each of the 36 2-digit industries in the sample, doing so would leave some industries with too few observations. In estimation, I regroup the sample into four industry groups ($H = 4$): light industries, chemical industries, material industries, and machine industries.[18] Combining (10) and (11) leads to a parametric specification of the markup ratio for each enterprise in each year:

$$\frac{P_{nt}}{\mathrm{MC}_{nt}} = \sum_{h}^{H} \mu_h I_{nh} - \theta \sum_{s=t+1}^{89} C_{ns} \tag{12}$$

This specification allows markup ratios between 1981–88 to differ across enterprises.

In order to derive a regression equation estimatable using the available data, I assume further that each dimension of the reform leads to the same percentage change in output in all affected enterprises, implying that $\frac{A_{nt}}{Q_{n,t-1}} \frac{\triangle f_{nt}}{\triangle R_{jnt}}$ does not vary with n. Specifically, given the available data, I assume

$$\sum_{j} \frac{A_{nt}}{Q_{n,t-1}} \frac{\triangle f_{nt}}{\triangle R_{jnt}} \triangle R_{jnt} = \lambda_t + (\gamma^b_1 D_{1t} + \gamma^b_2 D_{2t}) B_{nt} + (\gamma^c_1 D_{1t} + \gamma^c_2 D_{2t}) C_{nt} \tag{13}$$

where B_{nt} is the growth rate in bonus per worker and C_{nt} is the rate of inflation in output prices relative to material input prices. The time-specific term λ_t captures the effects of reform that affect all enterprises at roughly the same time and are not already captured by the two included reform variables. By interacting B_{nt} and C_{nt} with the period dummy variables, I can test whether the bonus effect and the competition effect are different at different stages of the reform.

[18] Light industries include food, beverages, tobacco, textiles, apparel, leather, wood products, furniture, paper, printing, arts and crafts, and recreational equipment. Chemical industries include chemicals, pharmaceuticals, synthetic fibers, rubber, and plastic. Material industries include all mining industries, logging, water utilities, electric utilities, petroleum products, coke, building materials, and all metal products. Machine industries include electric and non-electric machines, transportation equipment, electronics, and instruments.

Combining (6), (8), (13), (12), and (9) yields

$$\begin{aligned}\frac{\triangle Q_{nt}}{Q_{n,t-1}} &= \left(\sum_{h}^{H}\mu_h I_{nh} - \theta\sum_{s=t+1}^{89}C_{ns}\right)\sum_{x=l,k,m}\sum_{\tau=1}^{2}D_{\tau t}[w_\tau^x + \beta_\tau^x(x_{nt}-\bar{x}_t)]x_{nt} \\ &\quad + \sum_{\tau=1}^{2}D_{\tau t}(\gamma_\tau^b B_{nt} + \gamma_\tau^c C_{nt}) + \lambda_t + \psi_n + \phi_{nt} + \frac{P_{nt}}{\mathrm{MC}_{nt}}\sum_{x=l,k,m}\nu_{nt}^x x_{nt} \qquad (14)\end{aligned}$$

for $n = 1, \cdots, N$ and $t = 1981, \cdots, 1989$.

Conditional on the parameters yet to be estimated, the growth of total factor productivity (TFP) can be written as

$$\mathrm{TFP}_{nt} = \frac{\triangle Q_{nt}}{Q_{n,t-1}} - \left(\sum_{h}^{H}\mu_h I_{nh} - \theta\sum_{s=t+1}^{89}C_{ns}\right)\sum_{x=l,k,m}[w_1^x D_{1t} + w_2^x D_{2t}]x_{nt} \qquad (15)$$

This follows the output that is unexplained by increases in factor inputs valued at their average value marginal products relative to output. Compared to (14), the growth in TFP includes the growth of output attributable to reallocating resources from less productive firms to more productive firms, which is

$$\mathrm{AE}_{nt} = \left(\sum_{h}^{H}\mu_h I_{nh} - \theta\sum_{s=t+1}^{89}C_{ns}\right)\sum_{x=l,k,m}(\beta_1^x D_{1t} + \beta_2^x D_{2t})(x_{nt}-\bar{x}_t)x_{nt} \qquad (16)$$

This index measures the change in allocative efficiency (AE) from inter-enterprise shifts in resources. The growth in TFP also includes the part of the growth attributable to the included reform variables. This part of TFP growth is measured by

$$\text{TFP-R}_{nt} = \sum_{\tau=1}^{2}D_{\tau t}(\gamma_\tau^b B_{nt} + \gamma_\tau^c C_{nt}) \qquad (17)$$

The remaining portion of the TFP growth is the residual term in (14), or

$$\xi_{nt} = \lambda_t + \psi_n + \phi_{nt} + \frac{P_{nt}}{\mathrm{MC}_{nt}}\sum_{x=l,k,m}\nu_{nt}^x x_{nt} \qquad (18)$$

which sums up the effects of the reform and factor inputs omitted in this specification.

5 Econometric Method

The residual term in (14), ξ_{nt}, has a complex structure. It includes not only enterprise- and time-specific shocks on productivity, but also variations in marginal productivity that are unaccounted

for in the model or "coefficient errors",[19] ν_{nt}^x. In order to take advantage of the detailed nature of the panel data, I use the analysis of covariance approach to control for the specific effects by estimating coefficients for the "within" dimension of the data. I assume that the term $(P_{nt}/\mathrm{MC}_{nt})\sum \nu_{nt}^x x_{nt}$ can be decomposed into three orthogonal parts, namely,

$$\frac{P_{nt}}{\mathrm{MC}_{nt}} \sum_{x=l,k,m} \nu_{nt}^x x_{nt} = \lambda_t' + \psi_n' + \phi_{nt}' \tag{19}$$

The combined residual term ξ_{nt} can then be rewritten as the sum of three orthogonal parts,

$$\xi_{nt} = (\lambda_t + \lambda_t') + (\psi_n + \psi_n') + (\phi_{nt} + \phi_{nt}') = \lambda_t'' + \psi_n'' + \phi_{nt}'' \tag{20}$$

where $E(\phi_{nt}'') = 0$. In order to approximate the complicated covariance structure of the parameter error terms, I allow $\mathrm{Var}(\psi_n'')$ to vary arbitrarily across enterprises, and ϕ_{nt}'' to have arbitrary serial correlation over time.

In the estimation, λ_t'' and ψ_n'' will be treated as fixed effects.

The time- and enterprise-specific shocks will likely be correlated with how changes in factor inputs are made, regardless of whether the changes are made by enterprise managers autonomously or by the local government, since these shocks are likely to be observed by the decision-makers. They are also likely to be correlated with how policy changes are made, since the implementation of the reform is typically left to the local government. By using the within estimation technique with panel data, I treat these specific shocks as "fixed effects" and can in fact eliminate them from the regression equation by transforming the data through differencing. To obtain consistent estimates of the parameters I need only to consider the endogeneity of the regressors with respect to the idiosyncratic shocks ϕ_{nt}''. The economics here suggests that ϕ_{nt}'' is also likely to be correlated with changes in factor inputs, changes in bonus, and changes in enterprise price markup, to the extent that enterprise managers observe ϕ_{nt}'' and can make autonomous decisions. However, the idiosyncratic shock ϕ_{nt}'', which is likely to be observable to enterprise managers, is usually unobserved by the government. The government's choice of factors, therefore, is usually not affected by the idiosyncratic shock. This proves to be an important identifying condition and is discussed below in the search for instrumental variables.

[19] It is, therefore, essentially a random coefficient specification, which may be estimated using some special generalized least squares (GLS) procedures (Swamy (1970) among others). But due to the possible correlation among its constituent parts, it is a tall order to derive a consistent estimator of the variance-covariance matrix of the residual term. More importantly, the residual term is likely to be correlated with the included variables in the regression, thus making GLS estimation techniques inappropriate.

5.1 Instrumental Variables

The instrumental variables for consistent estimation of the model should cause important changes in intermediate inputs (m_{nt}), labor (l_{nt}), capital (k_{nt}), growth of bonus per worker (B_{nt}) and product price inflation (C_{nt}). But they should be uncorrelated with the random fluctuations in productivity growth ϕ''_{nt}. Although finding such instrumental variables is in general a tall order, the particular economic structure in China makes it possible.

Between 1980-89, the Chinese government continued to allocate a substantial amount of capital, labor and materials to state enterprises. The state allocation may depend on enterprises' past performance as captured by enterprise-specific productivity variation, but it is generally orthogonal to the random shock ϕ''_{nt}, since the random shock is usually unobserved by the government. The government allocation of factors may also be influenced by purely political concerns. Labor, for example, may be allocated to an enterprise not because the enterprise needs to expand its work force for economic reasons, but because the government fears the instability that rising unemployment can bring.

State allocated inputs are part of the inputs that the enterprise uses in production. Changes in the state allocation of factors are naturally correlated with changes in factor inputs. Hence they are very persuasive instrumental variables for the purposes of this study. Let L^s_{nt}, K^s_{nt}, and M^s_{nt} denote, respectively, state allocated labor, capital and intermediate materials in enterprise n in year t. In estimation, I will use $\triangle L^s_{nt}/L^s_{nt}$, $\triangle M^s_{nt}/L^s_{nt}$, $\triangle K^s_{nt}/L^s_{nt}$ as instrumental variables.

To identify the model, I propose two additional instrumental variables.

Inflation rate in intermediate inputs, π^m_{nt}. It is reasonable to assume that price changes in the intermediate good markets are not caused in any important way by random fluctuations in a single enterprise's productivity. It is expected that π^m_{nt} is negatively correlated with $C_{nt} = \pi_{nt} - \pi^m_{nt}$ and negatively correlated with B_{nt}.

Growth rate in output quota, $\triangle \log(Q^p_{nt})$. Li (1994a) showed theoretically and tested empirically that an increase in output quota, under the "dual-track system," causes the market output price and enterprise profits to fall. Therefore the change in output quota should be negatively correlated with C_{nt} and B_{nt}. The government's choice of output quota for any enterprise, however, is unlikely to be correlated with the enterprise's random productivity shocks.[20] Again, these shocks are usually unobserved by the government.

[20] It should be noted that this statement does not rule out the possibility that the government may set a higher quota for an enterprise that has a proven record of rapid productivity improvement (enterprise-specific effect ψ''_n).

5.2 Estimation Procedure

Because $\sum_h I_{nh} = 1$, the 1989 markup ratios for all four industry groups cannot be jointly identified. In estimation, I let the 1989 markup ratio for the light industries be one, that is, $\mu_1 = 1$. I have no good justification for having such a prior. If this turns out to be close to reality (which I doubt), then the estimated marginal products of factors will be consistent. Even if μ_1 is significantly different from 1, the relative marginal products of factors can be estimated consistently. More specifically, suppose that the true average marginal product of labor is w_t^* in year t. Then the estimator $\hat{w}_t$ will have a probability limit equal to $\mu_1 w_t^*$. Since a wrong prior in μ_1 will bias the estimates of marginal products of factors by the same proportion, estimates of the relative factor productivity should be consistent. For example, the ratio of the average marginal productivity of labor to the average marginal productivity of materials, or the ratio of the average marginal productivity of labor in 1983 to the average marginal productivity of labor in 1989, will be consistently estimated. As a result, the total factor productivity will also be consistently estimated, using Equation (15).

The estimation is carried out in two steps. First, the enterprise-specific effects are eliminated by applying the following transformation to the data:[21] $y_{nt} - y_{n,89}$. The resulting left-hand side variable is $\triangle Q_{nt}/Q_{n,t-1} - \triangle Q_{n,89}/Q_{n,88}$, $t = 81, \ldots, 88$. The usual "within" transformation, $y_{nt} - \bar{y}_n$, is not used here because it would result in regression equations that are very complicated in parameters, given that the model is non-linear in parameters and the parameters are time-variant.

Second, each regression equation in each year from 1981 to 1988 is treated as a regression equation in a group of eight "seeming-unrelated" equations. In order to make use of the information from the cross-equation correlation among regression residuals ($\phi''_{nt} - \phi''_{n,89}$) and cross-equation parameter restrictions, non-linear three stage least squares (NL-3SLS) is used to estimate the equations using the instrumental variables discussed earlier (Gallant and Jorgenson (1979)). The estimates obtained are consistent. As with the conventional panel data estimation, this procedure requires that the instrumental variables be uncorrelated with $\phi''_{nt} - \phi''_{n,89}$ in all equations.

6 Results

6.1 Estimation Results

Table 3 reports the non-linear three stage least squares (NL-3SLS) estimates of (14).[22] For

[21] This transformation is numerically equivalent to the first difference transformation: $y_{nt} - y_{n,t-1}$.

[22] The estimates of λ''_t are not reported here since λ_t, the effects of excluded reform variables not already captured by included reform variables, cannot be inferred from λ''_t, when λ'_t cannot be estimated; see (20).

Table 3: Regressions of Productivity Changes (N=272)

Coefficients	NL-3SLS		NL-SUR	
	Estimates	t-ratios	Estimates	t-ratios
γ_1^b	.089**	(3.384)	.067**	(4.680)
γ_2^b	.060**	(3.167)	.044**	(4.216)
γ_1^c	-.732**	(-7.811)	-.744**	(-10.475)
γ_2^c	-.456**	(-8.203)	-.532**	(-13.657)
w_1^l	8.749*	(2.176)	4.603	(1.897)
w_2^l	13.468**	(3.090)	7.909**	(3.505)
w_1^k	.025	(.205)	-.034	(-.548)
w_2^k	.411**	(3.922)	.249**	(4.023)
w_1^m	.999**	(8.534)	.856**	(13.147)
w_2^m	1.002**	(9.300)	.995**	(16.826)
β_1^l	1.893	(1.341)	1.572*	(2.573)
β_2^l	9.597**	(5.388)	3.321**	(3.822)
β_1^k	.006	(.133)	.003	(.173)
β_2^k	-.025	(-.680)	-.006	(-.271)
β_1^m	.553**	(6.131)	.493**	(10.534)
β_2^m	.355**	(3.905)	.297**	(7.141)
θ	.158**	(4.174)	.127**	(5.296)
μ_2	-.518**	(-8.323)	-.385**	(-7.349)
μ_3	-.654**	(-14.857)	-.551**	(-16.217)
μ_4	-.589**	(-9.712)	-.532**	(-12.728)

1. Estimation equation:

$$\frac{\triangle Q_{nt}}{Q_{n,t-1}} = \left(\sum_h^H \mu_h I_{nh} - \theta \sum_{s=t+1}^{89} C_{ns}\right) \sum_{x=l,k,m} \sum_{\tau=1}^{2} D_{\tau t}[w_\tau^x + \beta_\tau^x (x_{nt} - \bar{x}_t)] x_{nt} + \sum_{\tau=1}^{2} D_{\tau t}(\gamma_\tau^b B_{nt} + \gamma_\tau^c C_{nt}) + \lambda_t + \psi_n + \phi_{nt} + \frac{P_{nt}}{\mathrm{MC}_{nt}} \sum_{x=l,k,m} \nu_{nt}^x x_{nt}$$

2. Instruments: $\triangle L_{nt}^s/L_{nt}^s$, $\triangle M_{nt}^s/L_{nt}^s$, $\triangle K_{nt}^s/L_{nt}^s$ (state allocation of factors); π_{nt}^m (inflation in intermediate input prices); $\triangle \log(Q_{nt}^p)$ (changes in in output quota); and I_{nh} (industry dummies), D_{1t} and D_{2t} (period dummies).
3. The markup ratio of the light industries $\mu_1 = 1$ by default. Markups for material, machine, and chemical industries, relative to the light industries, are $1 + \mu_2$, $1 + \mu_3$, and $1 + \mu_4$ respectively.
4. * denotes significance at the 5% level. ** denotes significance at the 1% level.

comparison, I also include in the table the estimates from the conventional seemingly unrelated nonlinear regression (NL-SUR). Comparing these estimates, a Hausman specification test strongly rejected the hypothesis that the regressors are exogenous.[23] The parameters of the model are in general quite precisely estimated. Almost all of the estimates are significant at the 1% level. This is striking in light of the fact that the sample enterprises are quite heterogeneous.

The estimated markup ratios and marginal products of factors should be interpreted with caution. As discussed in the methodology section, these estimates are inconsistent if the markup ratio of the light industries μ_1 does not equal 1. In particular, the estimates have the following probability limits:

$$\text{plim}\hat{\mu}_h = \mu_h/\mu_1, \quad \text{plim}\,\hat{w}^x_\tau = \mu_1 w^x_\tau, \quad \text{and} \quad \text{plim}\hat{\beta}^x_\tau = \mu_1 \beta^x_{ta\,u} \tag{21}$$

where $h = 2, 3, 4$ for other three industry groups, chemical products, intermediate materials, and machines. The estimated markup ratios and marginal products of factors are consistent up to a constant multiplier. The estimated standard errors are also consistent up to the same multiplier. The relative markup ratios and relative marginal products of factors are therefore estimated consistently. All test statistics, including the t-statistics, are also estimated consistently. With this caution in mind, I turn to the discussion of the parameter estimates.

Markup Ratio

Estimates of the markup ratios show wide variation in market power in China's industrial sector in 1989. The markup ratios of the three heavy industry groups in 1989 are markedly smaller than that of the light industries. The machine industries have the smallest markup—only slightly more than one-third of the markup in the light industries. The chemical and materials industries have somewhat larger markup ratios in 1989. They are respectively 48 percent and 41 percent of the markup ratio in the light industries. If the machine industries' markup ratio were 1 in 1989, then the markup ratio would be 2.89 in the light industries, 1.19 in the chemical industries, and 1.39 in the materials industries.

The markup ratios at the enterprise level in each year between 1980–88 can be constructed using (12). The key to this construction is θ, which is estimated at 0.158. A positive θ implies that the markup ratio declined between 1980–89, for in general the inflation rate of input prices exceeded the inflation rate of output prices. Figure 2 contains the path of the average markup ratio weighted by output valued at marginal cost. Between 1980–89, the markup ratio fell by 15 percent on average.

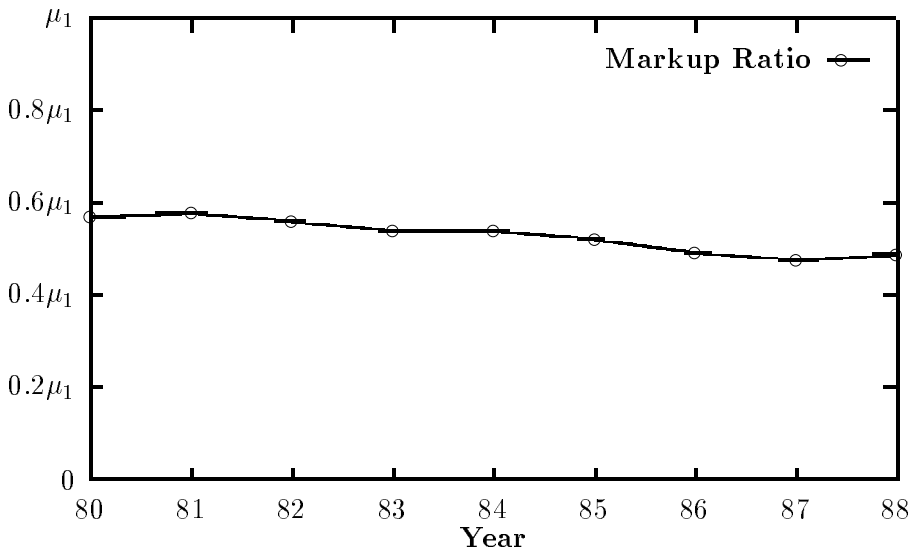

Figure 2: Movement of sample average markup ratio (market price over marginal cost) over time. The parameter μ_1 is the light industries' markup ratio in 1989.

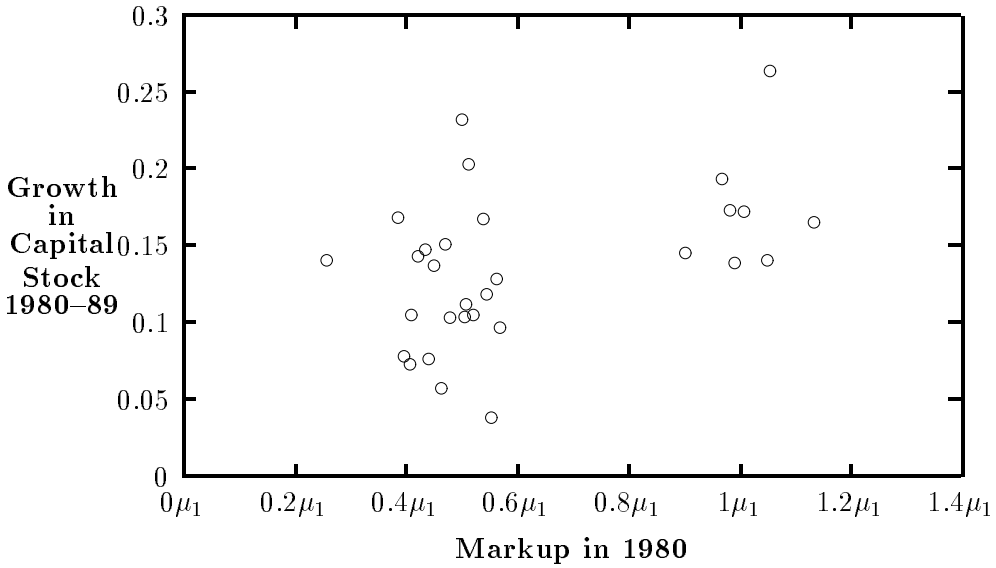

Figure 3: A positive correlation exists between the 1980 markup ratio and the aggregate growth in productive capital assets between 1980–89 at the 2-digit industry level.

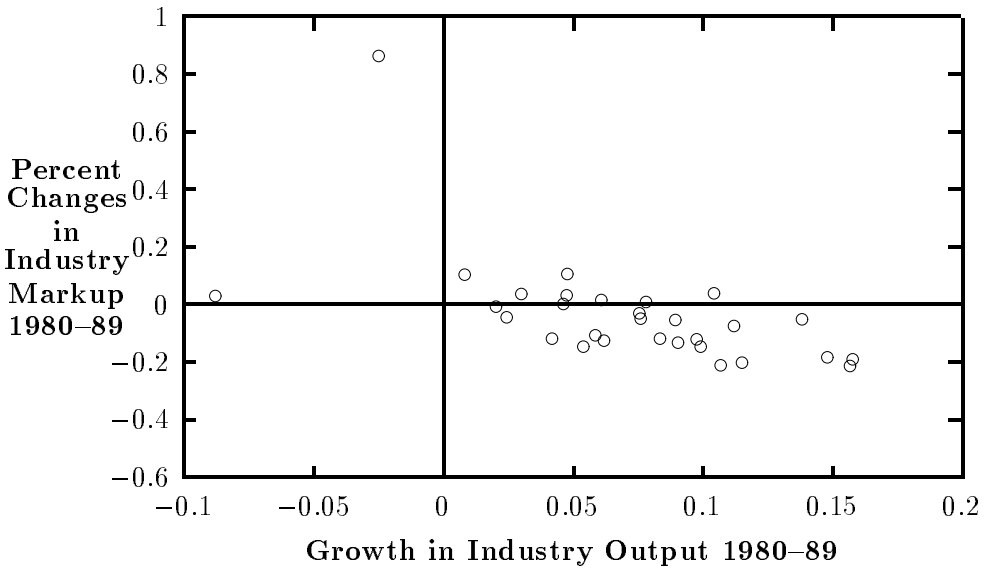

Figure 4: A negative correlation exists between the percentage change in markup ratio and the aggregate growth in output between 1980–89 at the 2-digit industry level.

What could have caused state industry's markup ratio to fall? The sectoral shifts in resources during China's economic liberalization offer a logical explanation as discussed in Section 2. To test this hypothesis, I investigate whether higher markup in 1980 as measured here is positively correlated with higher aggregate investment between 1980–89 at the 2-digit industry level, and whether sectoral changes in output are negatively correlated with sectoral changes in markup ratios between 1980–89. Data on the growth of aggregate productive capital assets and the growth of aggregate output at the 2-digit industry level between 1980–89 are from the *Statistical Yearbook of Industrial Economy 1991* published by the State Statistical Bureau in Beijing. In Figure 3, I plot the aggregate growth in capital stock between 1980–89 (vertical axis) against the sample average of the markup ratio in 1980 at the 2-digit industry level. The plot reveals a positive correlation; without controlling for any other influences there might be on investment, a simple regression using these data confirms that a one unit increase in the 1980 markup by an industry would elicit a statistically significant 0.09 percentage point increase in capital growth. In Figure 4, I plot the aggregate output growth between 1980–89 against the sample average of the percentage change in markup ratio between 1980–89 at the 2-digit industry level. This plot reveals a strong negative correlation; a one percentage point increase in the aggregate output in an industry would elicit on

[23]The (χ^2) test statistic was 2200.9 with 20 degrees of freedom.

Table 4: Wald Tests of Improving Allocative Efficiency

Null Hypothesis	Alternative Hypothesis	Wald Statistics	Reject Null (1%)
$\beta_1^l = 0$ & $\beta_2^l = 0$	$\beta_1^l > 0$ & $\beta_2^l > 0$	30.32 ($\chi^2(2)$)	Yes
$\beta_1^m = 0$ & $\beta_2^m = 0$	$\beta_1^m > 0$ & $\beta_2^m > 0$	40.27 ($\chi^2(2)$)	Yes
$\beta_1^k = 0$ & $\beta_2^k = 0$	$\beta_1^k > 0$ & $\beta_2^k > 0$	0.48 ($\chi^2(2)$)	No

average 2.1 percentage point reduction in the markup ratio. These simple statistical tests, while crude, do confirm the theoretical conjecture raised in Section 2 that the marginal liberalization in China was effective in improving resource allocation.

Marginal Products

The value marginal product of labor increased by over 54 percent from $8.749/\mu_1$ (measured in 1,000 constant 1989 RMB) in 1980–84 to $13.468/\mu_1$ in 1985–89. The mean marginal product of capital increased even more dramatically from a statistically insignificant $0.025/\mu_1$ to $0.411/\mu_1$. The mean marginal product of materials stayed at $1/\mu_1$ in both time periods. A Wald test rejected the joint hypothesis that there is no change in the marginal products of all three factors from 1980-84 to 1980-89 at the 5 percent significance level.[24] When tested individually, however, only $w_1^k = w_2^k$ was rejected.

The increase in the mean marginal products of factors reflects only part of the improvement brought about by the reform. There was also a gain from improved allocation of factors. The estimated β's for materials and labor are positive and statistically significant in both periods. The estimated β's for capital in both periods are small in magnitude and are statistically insignificant. These results indicate that the reform resulted in more efficient allocation of labor and materials, but not in capital. When tested formally (see Table 4), the null hypothesis that there was no change in efficiency of labor allocation, or $\beta_1^l = \beta_2^l = 0$, was rejected. A Wald test also rejected the null hypothesis $\beta_1^m = \beta_2^m = 0$. The test for capital, however, failed to reject the null hypothesis that there was no change in the efficiency of capital allocation.

The finding that there was a marked improvement in the allocation of materials is not surprising. Much of the improvement in materials allocation was perhaps attributable to the dual pricing system that created a market for materials on the margin. What is surprising is the finding that

[24]The test statistic (χ^2) is 8.11 with 3 degrees of freedom.

there was a significant improvement in the allocation of labor in both periods, even when there was no functional labor market in the state sector during the 1980's. Pinpointing what might have led to improved labor allocation is not so easy. Two explanations come to mind. The first, and perhaps the most important, is the consolidation of enterprise property rights. This change gave local governments the incentive to maximize the value of the enterprises they controlled. Given that the allocation of labor was primarily done by local governments, this should have motivated local governments to reallocate labor away from less productive enterprises to more productive ones. Second, the reform allowed some labor mobility. Although layoffs were virtually forbidden, enterprises were allowed to set up collectives where they place their redundant workers. Employees were also given more flexibility to quit their jobs, whether they wanted to move to other state enterprises or to start their own businesses.

The finding that there was no visible improvement or deterioration in the allocation of capital is not surprising. One could always point out that there was no capital market that directed funds to their most productive uses. Enterprises or local governments with funds did not necessarily have profitable investment projects. Since the regulated interest rate was artificially low, there was no effective mechanism through which the funds could be loaned to enterprises/local governments that had more profitable projects. In principle, however, the consolidation of enterprise property rights should have improved capital allocation among enterprises owned by the same government. But if so, this gain was apparently offset by a deterioration in the inter-governmental allocation of funds.

Impact of Reform on Productivity

The growth of bonus per worker had a significantly positive impact on the growth of total factor productivity. According to the estimates, an increase in bonus per worker by one percentage point caused TFP to grow by .089 percentage point between 1980–84 and .060 percentage point between 1985–89. The difference in the impact of bonuses on productivity between the two periods was statistically insignificant. Since bonuses in China were primarily linked to enterprise performance rather than individual performance, this finding, suggests that collective incentives did indeed work.

The increase in competition, or more precisely, the decrease in market power between 1980–89 also contributed to productivity. Between 1980–84, a one percentage point reduction in the inflation rate of output prices relative to that of material input prices elicited a .732 percent increase in productivity. Between 1985–89, the elasticity of productivity with respect to competition was 0.456. This finding thus provides empirical support for the theoretical conjecture that competition promotes productivity. The drop in the elasticity of productivity with respect to market power

Table 5: Annual Percentage Changes in Enterprise Performance

Year	TFP Growth	TFP Growth Attributable to Reform[a] (TFP-R)	TFP Growth Attributable to Reallocation (AE)
1980–1	-2.18	2.20	2.43
1981–2	6.18	1.36	2.64
1982–3	6.26	-0.58	1.75
1983–4	10.75	7.16	1.47
1984–5	2.15	-1.56	1.90
1985–6	4.08	3.71	1.66
1986–7	8.36	7.31	1.83
1987–8	7.35	4.63	1.41
1988–9	-.12	-3.14	.98
1980–9	4.68[b]	2.29[b]	1.79[b]

[a] Growth in bonus per worker B_{nt} and changes in market power C_{nt} are the only two reform variables included in the analysis.

[b] Average annual growth rate.

between the two periods is statistically significant.[25] This suggests that changes in enterprise productivity in response to changes in market power exhibit diminishing returns. As the market power winds down, an additional decline in market power brings less gain in productivity.

The impact of the consolidation of enterprise property rights and the change in the enterprise governance structure, λ_t, is not identifiable if λ_t' cannot be estimated; see20). However, their impact may have been implicitly measured by changes in the marginal productivity of factors, and perhaps are partly accountable for the improvements in productivity that are not attributable to the measured reform.

6.2 Changes in Enterprise Performance

Table 5 summarizes the weighted average annual growth rates of TFP, TFP attributable to incentives and to competition (TFP-R), and TFP attributable to improvements in factor allocation (AE). The weight used was each enterprise's real output measured at marginal cost. The growth in TFP between 1980–9 was about 4.68 percent per year on average, accounting for over 73 percent of output growth. The remaining 27 percent of output growth was presumably attributable to increases in factor inputs. Improvements in factor allocation (AE) contributed 1.79 percentage

[25] The Wald statistic (χ^2) for the Chow test was 6.62 with 1 degrees of freedom.

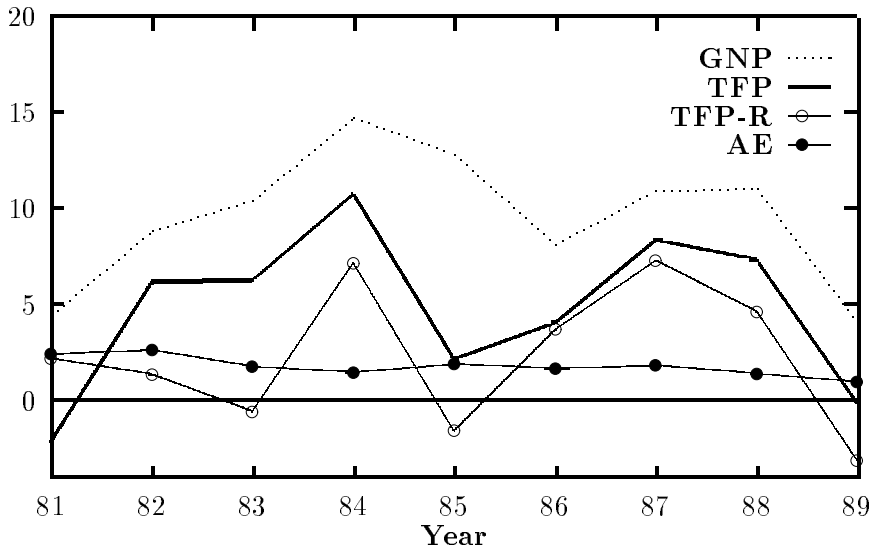

Figure 5: Growth in enterprise TFP, TFP-R, AE, and in Chinese GNP. GNP data come from *China Statistical Yearbook*, 1991.

points to TFP growth, accounting for 28 percent of output growth and 38 percent of TFP growth. Improved incentives and intensified competition in product markets, TFP-R, contributed 2.29 percentage point to TFP growth, accounting for 49 percent of TFP growth and 36 percent of output growth. The study, therefore, finds robust growth in productivity in China's state enterprises between 1980–89, and more importantly, that the growth can be attributed to the reform.

While productivity grew by 4.58 percent per year on average between 1980–89, this growth was far from steady. In Figure 5, I plot the movements of TFP, TFP-R and AE over time. For comparison, I also include in the figure the movement of Chinese GNP. The plots reveal that the aggregate TFP was highly cyclical and its fluctuations between 1980–89 were positively correlated with GNP fluctuations. Given that the state industry produced more than half of China's industrial output in the 1980's, this observation indicates that the TFP fluctuations in the state industrial sector were an important component of the macroeconomic fluctuations in China. The growth in TFP attributable to improvements in incentives and to market competition, or TFP-R, also exhibited cyclical fluctuations. The improvements in allocative efficiency, AE, on the other hand, were quite steady and followed a declining trend. This suggests that the gain from marginal liberalization might exhibit diminishing returns.

More interesting, however, is that the downturns of TFP-R between 1982-83 and between 1984-85 coincided with the timing of major changes in policies. In February 1983, the Chinese government began implementing a new tax system in which the marginal profit tax rate was to be determined in a progressive manner based on each enterprise's realized profits in 1983. Enterprises responded to this perverse tax by incurring additional costs and by holding off on production in 1983. In January 1985, the Chinese government called for linking workers' bonuses to their enterprises' performance and specified that the coefficient of linkage be determined by each enterprise's 1985 profitability in an effort to limit the inequality in bonus distribution across enterprises. According to this directive, more profitable enterprises would be allowed to share a smaller percentage of profits than less profitable enterprises. Enterprises once again responded by incurring additional costs and holding off on production in 1985. It is remarkable that such behavioral responses are registered in the measure of TFP-R. Future research that scrutinizes this coincidence to determine if there is in fact a causal relationship is certainly called for.

7 Qualifications and Conclusion

The basic empirical findings of this study are, (1) that there was substantial productivity growth during the reform, and (2) that much of the productivity growth can be attributed to the reform. This study does not assert that Chinese state enterprises have become efficient or as efficient as firms in a developed market economy. It only states that the gain in efficiency in Chinese state enterprises was significant enough to be measured. Chinese state enterprises may yet have a long way to go in order to reach an internationally comparable level of efficiency.

These findings are, of course, not without qualifications. It is possible that the results are affected by selectivity bias and measurement errors. There are reasons to believe that better managed enterprises might have been chosen to participate in the survey. For one, they were more "visible." The CASS researchers might have closer ties with these enterprises due to their previous case studies. There might also be political motivations to select more successful enterprises in order to showcase the reform. If the selection problem is real, then without additional data, the selectivity bias cannot be corrected. If one believes that less successful firms are excluded from the sample, then the estimated productivity growth and the estimated impact of the reform will be *higher* than their true values.

On the other hand, there are plausible reasons to believe that the estimated productivity and the estimated impact of the reform are *lower* than their true values. Enterprises may, with good

reason, distrust the anonymity and confidentiality pledged by CASS. They may understate their profitability, fearing that their response may be used by the tax bureau or by the local government. If this is the case, then enterprises will tend to understate their output and overstate their costs. Under the dual pricing system, enterprises have much flexibility in tinkering with accounting data. They may understate the proportion of output that is sold at market prices and overstate the proportion of inputs that is purchased at market prices. They may also engage in barter trade, which gives them the flexibility of understating or even not reporting their barter sales, but overstating their barter purchases. Since I measure output and inputs all at market prices, I may have been successful in eliminating the manipulation of accounts that is made easy by the dual track system. However, the estimation may still be affected by the account manipulation that is made easy by barter exchanges.

The estimation may also be affected by errors in measuring capital and labor. Since I do not have data on capital utilization and on actual man-hours, the dominant source of measurement errors is likely to be the difference between the actual capital and labor in use and the capital and labor that the enterprise has in place.[26] These measurement errors are usually counter-cyclical, that is, they are low during booms and high during slumps. If the government allocation of capital and labor, which forms part of the instruments, are based on long-term calculations, then the measurement errors are not much of a problem. If, however, the government allocation is correlated with the measurement errors either positively or negatively, the estimates of marginal products of labor and capital and the estimate of TFP will be inconsistent.

Subject to these qualifications, the empirical findings here suggest that enterprise restructuring that concentrates on improving the allocation of property rights and incentives can yield large benefits even without formal privatization, and that the controlled marginal economic liberalization can improve resource allocation when entry barriers to the state monopolized industries are lowered simultaneously to foster competition.

References

[1] Atkinson, S. E. and C. Cornwell (1994), "Parametric Estimation of Technical and Allocative Inefficiency with Panel Data," *International Economic Review*, 35:1, 231–43.

[26] In measuring labor, I excluded absentee workers. This should reduce the error in measuring labor but not eliminate it.

[2] Bergson, A. (1987), "Comparative Productivity: The USSR, Eastern Europe, and the West," *American Economic Review*, June, 77:342–57.

[3] Bresnahan, T. (1989), "Empirical Studies of Industries with Market Power," in *Handbook of Industrial Organization*, eds. R. Schmalensee and R. Willig. Amsterdam: North Holland.

[4] Byrd, W. (1989), "Plan and Market in the Chinese Economy: A Simple General Equilibrium Model," *Journal of Comparative Economics*, 13: 177–204.

[5] Caves, D. W., L. R. Christensen, and J. A. Swanson (1980), "Productivity in the U.S. Railroads, 1951–1974," *Bell Journal of Economics*, 11:166–81.

[6] Chen, K., H. Wang, Y. Zheng, G. H. Jefferson and T. G. Rawski (1988), "Productivity Change in Chinese Industry: 1953–1985," *Journal of Comparative Economics*, 12:570–591.

[7] Dollar, D. (1990), "Economic Reform and Allocative Efficiency in China's State-Owned Industry," *Economic Development and Cultural Change*, 39:89–105.

[8] Färe, R., S. Grosskopf, M. Norris, and Z. Y. Zhang (1994), "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries," *American Economic Review*, 84: 66–83.

[9] Førsund, M. J., C. A. K. Lovell, and P. Schmidt (1980), "A Survey of Frontier Production Functions and of Their Relationship to Efficiency Measurement." *Journal of Econometrics*, 13, 1:5–25.

[10] Gallant, A. R. and D. J. Jorgenson (1979), "Statistical Inference for a System of Simultaneous, Non-linear, Implicit Equations in the Context of Instrumental Variable Estimation," *Journal of Econometrics*, 11:275–302.

[11] Gordon, R. H. and W. Li (1994), "The Change in Productivity of Chinese State Enterprises, 1983–1987," forthcoming in *Journal of Productivity Analysis*.

[12] Gordon, R. H., and W. Li (1991), "Chinese Enterprise Behavior Under the Reform," *American Economic Review*, 82,2:202-206.

[13] Granick, D. (1990), *Chinese Regional Property Rights: Operation of Industrial Enterprises*, Chicago: University of Chicago Press.

[14] Griliches, Z. and J. Mairesse (1983), "Comparing Productivity Growth: An Explanation of French and U.S. Industrial Firm Data," *European Economic Review*, 21:89–119.

[15] Grossman, S. and O. Hart (1986), "The Costs and Benefits of Ownership: A Theory of Lateral and Vertical Integration," *Journal of Political Economy*, 94:691–719.

[16] Groves, T., Y. Hong, J. McMillan and B. Naughton (1994a), "Autonomy and Incentives in Chinese State Enterprises," *Quarterly Journal of Economics*, 109: 183–210.

[17] Groves, T., Y. Hong, J. McMillan and B. Naughton (1994b), "Productivity Growth in Chinese State-Run Industry," in F. Dong, C. Lin and B. Naughton, eds., *Reform of China's State-Owned Enterprises*, London: MacMillan, in press.

[18] Hart, O. and J. Moore (1990), "Property Rights and the Nature of the Firm," *Journal of Political Economy*, 98:1119–58.

[19] Hicks, J. (1935), "Annual Survey of Economic Theory: The Theory of Monopoly," *Econometrica*, 3:1–20.

[20] Jefferson, G. and W. Xu (1991), "The Impact of Reform on Socialist Enterprises in Transition: Structure, Conduct, and Performance in Chinese Industry," *Journal of Comparative Economics*, 15:45–64.

[21] Jorgenson, D. J. and Z. Griliches (1967), "The Explanation of Productivity Change," *Review of Economic Studies*, 34:249–82.

[22] Leibenstein, H. (1966), "Allocative Efficiency vs. X-Efficiency," *American Economic Review*, 72:816–824.

[23] Li, W. (1994a), "A Tale of Two Reforms: Why Is 'Big Bang' Implosive in Output and Explosive in Prices, While Controlled Marginal Reform Isn't," Fuqua School of Business, Duke University.

[24] Li, W. (1994b), "From Where to a Market Economy: A Positive Theory of the Soviet–Type Economy," Fuqua School of Business, Duke University.

[25] Li, W. (1994c), *Essays on the Economics of Transition*, University of Michigan Doctoral Dissertation.

[26] Lovell, C. A. K. and R. C. Sickles (1983), "Testing Efficiency Hypotheses in Joint Production: A Parametric Approach," *Review of Economics and Statistics*, LXV:1, 51–8.

[27] McMillan, P., J. Whalley, and L. Zhu (1989), "The Impact of China's Economics Reforms on Agricultural Productivity Growth," *Journal of Political Economy*, 97:781-807.

[28] Milgrom, P. and J. Roberts (1990), "Bargaining Costs, Influence Costs, and the Organization of Economic Activity," in *Perspectives on Positive Political Economy*, J. Alt and K. Shepsle, eds. Cambridge University Press.

[29] Morrison, C. J. and W. E. Diewert (1990), "Adjusting Output and Productivity indexes for Changes in the Terms of Trade," *The Economic Journal*, 96:659–79.

[30] Naughton, B. (1994), *Growing Out of the Plan: China's Economic Reform 1978–1992*, Cambridge, UK: Cambridge University Press, forthcoming.

[31] Oi, J. C. (1993), "Fiscal Flows and Institutional Incentives for Economic Growth in China," Harvard University.

[32] Shleifer, A. (1994), "Establishing Property Rights," Harvard University. (Paper presented at the Annual Bank Conference on Development Economics, World Bank, April 28-29).

[33] Solow, R. M. (1957), "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, 39, 3:312–20.

[34] State Statistical Bureau, *China Statistical Yearbook*, Beijing: Zhongguo Tongji, Annual.

[35] Swamy, P. A. V. B. (1970), "Efficient Inference in a Random Coefficient Regression Model," *Econometrica*, 38:311–23.

[36] Tidrick, G. and J. Y. Chen (1987), *China's Industrial Reform*, Oxford:Oxford University Press.

[37] Woo, T. W., W. Hai, Y. Jin, and G. Fan (1994), "How successful Has Chinese Enterprise Reform Been? Pitfalls in Opposite Biases and Focus," *Journal of Comparative Economics*, 18: 410–37.