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Measuring Mark-up Ratios for China's Manufacturing Industries*

By

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Abstract

'Perfect competition' is a necessary condition for measuring TFP growth that can also be called Solow residual when using the approach of growth accounting, contributed by R. Solow in 1950's. The question is that in the real world, there are various interventions in product market and factor market, especially in a developing country like China. As an attempt, this study has tried to estimate the mark-up ratio for Chinese manufacturing industry, an index representing the difference between price and marginal cost, and has recalculated the TFP growth by removing such influence of mark-up, that followed the thinkings about Solow residual contributed by Hall and Roeger. This estimation covers 31 sectors and focuses on the period 1993–2010. The following are findings obtained from my measure. (1) Prices of outputs were averagely as high as three times as marginal costs across manufacturing industries in China over the period. (2) The considerably high mark power can be observed in assembly industries and material processing industries. (3) Capital intensive industries were likely to be not competitive, which may come from the large initial investments that makes more obstacles to enter the industries. (4) It was not able to be found that mark-up ratios were clearly higher in industries dominated by the SOEs, although some product markets and factor markets heavily dominated by SOEs as a matter of fact. (5) The recalculated average TFP growth by removing such influence of mark-up shows lower than primal TFP growth rate, and the recalculated average TFP growth since around the year of 2000 is suggested to begin slowdown. (6) The recalculated TFP growth provides the evidence of lower productivities in most energy industries and parts processing industries, and the evidence of high level of productivities in most machinary, equipmet industries and parts of consumer processing goods industries.

Key word

mark-up, TFP, Chinese economy, manufacturing industry, imperfect competition

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1. Introduction

Whether or not total factor productivity (TFP) growth has played a significant role in China's economic growth is important because people concern whether China can maintain a sustainable growth after the outstanding economic growth over the past three decades. With the long-term development, the conditions of supply side had largely changed and the economy had also lost some advantages. However, as indicated in a report of OECD, China's growth model seems to be no longer sustainable. One of the reasons is that the fixed asset investment, the key factor for supporting China's growth, began to cause inefficiencies in resource allocation. According to the report of OECD, the returns of such investment have decreased after the financial crises in 2008, the excessive capacity has plagued several sectors and the negative externality such as pollution has been very onerous (OECD, 2016).

The working age population had declined since 2013 (*China Statistical Yearbook*), meanwhile, the country's household registration system (Hukou) and the undeveloped land market still constrain migrant workers (Marukawa and Kajitani, 2015). A report shows that the average pay for migrant workers has nearly doubled in the past six years (Harada, 2017). Shrinking labor pool is driving up labor costs and weakening the comparative advantage that had boosted China's manufacturing and export sectors for decades. Foreign direct investment into manufacturing sector of China had a continuously slip at an annual average rate of three percent from 2011–2015 (*China Statistical Yearbook*) as the profit margin of companies shrank. A survey last year by China's customs administration shows that 60% of exporters consider soaring labor and land costs a burden (Harada, 2017).

Under such situations, more researches have focused interests on considering which factor primarily drove China's economic growth in order to get correct knowledge about Chinese economy and government's policy, especially regarding the economic reform and the open door policy. General opinions based on these researches perceived that TFP had clearly improved in China after market-oriented economy started in 1979. Meanwhile, most of studies also indicated that the contribution from TFP growth is very limited, while the key driving force behind the rapid economic growth is from input uses, particularly from the increase of capital stock. Several main studies on Chinese industrial TFP growth will be reviewed in Section 2.

The problem is that there is one significant mistake in most of previous analyses on China's TFP growth rate that depends on a conventional growth accounting approach, which is that most of analyses assume there is a perfect competition in Chinese product market. In reality, in many cases, it is difficult to apply this assumption to the real world, especially to a developing country like China. Perfect competition assumption based on neoclassical economics, believes that firms make a maximum of profits by selling their products and are paid to their marginal product. Under this assumption, the output elasticities of factors equal to their respective shares. Some scholars have indicated this problem resulted from the growth accounting approach may lead to an incorrect result on TFP measurement. Off cause, it is true that since 1979, China had introduced market economy and tried a fair competitive mechanism by relaxing government involvement and carrying out enterprise reform to give them expanded discretion in business management. As a result to implement such policies in the period of 1980's and 1990's, the share of China's industrial output accounted for by state owned enterprises (SOEs) had fallen from somewhere between more than 70% to lower 30%. In contrast, the non-state sector including foreign invested firms without ties with government had made a remarkable development. However, even now the government still involves in resource allocation and protects specific industries by direct or indirect ways. Such include administrative orders, resource controls, regulars and policies. All of these can block sufficient competitions.

A joint report released by World Bank and one of China's leading government think-tanks in 2012, indicated that a mix of market and nonmarket measures in China still lacks clarity in distinguishing the individual roles of government, state enterprises, and the private sector. On one hand, in some "strategic" sectors for China including petroleum and petrochemicals, telecommunications, coal, SOEs are protected by barriers that discourage new entrants. In addition, some industries such as machinery, automobiles, electronics and information technology, steel, chemicals, as "basic" and "pillar" industries, have been designated by Chinese authorities, where the government retains a strong influence. Compared to the private sector, SOEs input a large proportion of capital, raw materials, and other intermediate inputs to produce relatively small shares of gross output and value added. On the other hand, factor markets, including markets for capital, land and labor still has some structural barriers, which often puts private businesses at disadvantages (World Bank and DRC, 2013).

This paper is based on hypothesis that there are various interventions in product or factor market given by the government, like analysis above from World Bank and DRC, and the object is to test the degree of market distortion of Chinese manufacturing industry, and recalculate the growth of TFP in these sectors following the methodologies to measure Solow residual contributed by Hall and Roeger. Different from the conventional TFP growth rate, this paper applies the Roeger's method (Roeger, 1995) to estimate mark-ups of prices over marginal cost and update the previous TFP growth rate calculated by the conventional approach. This study restricts the investigation to the manufacturing sector of Chinese economy on the two-digit level. The data cover the period from 1992–2010. The result of this estimation shows that in China in the period 1993–2010, the average prices of outputs exceed marginal costs by 66% averagely cross manufacturing industries. From the view point of industry structure, capital intensive industries is likely to be uncompetitive, which may come from the large initial investment that make more hurdles to enter capital intensive industries. For TFP growth, the recalculated TFP growth rate on average by removing the influence of mark-ups shows less than conventional TFP growth rate that is based on the assumption of marginal productivity theory. Moreover, the result suggests that recalculated TFP growth rates over the period of 2000–2010 in most of industries had a slowdown from the high level of TFP in the previous term.

The remainder of this paper is organized as the following. Section 2 offers a brief literature review on estimating industrial TFP growth for China. Section 3 describes Hall's opinion (Hall, 1988) concerning the decomposition of the conventional TFP growth rate into a pure technology component and a mark-up component, looking at the implication of a mark-up for the calculation of the Solow residual, and Roeger's alternative approach, which has been used as a major method in my study. Section 4 provides the data for measuring, and Section 5 shows the estimation results of industrial mark-ups, the conventional TFP growth rate, the recalculated TFP growth rates, and examines the results.

2. Preceding studies

Obviously, researches on sectoral productivity growth are very important for everyone to acquire correct perception about industrial development, especially for policy makers. The TFP study, as one of the very important economic index, not only need to investigate the real sources of economic growth in macro level, but also to investigate real sources for each industry. However, in fact, the studies on Chinese sectoral TFP are really rare up to day. This is probably because in China, it is still very hard to obtain satisfied industrial data including the data for time series analysis or industry comparison. Since the official statistics in China had undergone fundamental changes through reform so that these statistics are often discontinued in series and not well understood, which includes the establishment of New National Account System, the four times changes of sectoral classification system, the data grouping by ownership. The most important thing is that the economic growth and institutional reform were so fast that the government had to always revise its statistics system.

Under this conditions, a number of preceding studies had laid very precious groundwork in this field. Table 1 and Table 2 describe parts of the contents and the results of some preceding studies. Huang and Ren (2002) provides a preliminary estimation on total factor productivity growth at the 2-digit level for Chinese manufacturing industries. The study adopted the approach using data of value-added, labor input, capital service input and measured by trans-log model of production. They gave a result that a third of sectors show negative TFP growth in the 1985–94 period, such as tobacco, textile, wood products, paper, chemical products, metal products, and electrical machinery. For total manufacturing, they found, TFP showed negative growth rates, and evidenced the bigger negative growth rates in 1989 and 1990 that recovered quickly since 1991. They found that during the whole period of time, labor input grew relatively slow while capital input increased by a much quicker pace. They made a substantial contribution to building the data set of industrial value-added, because until 1993 the government had not constructed that data.

Mun and Jorgenson (2001) estimated sectoral productivity change by introducing the approach to use gross output data rather than value-added, and constructing a time series of input-output tables for the first time for China in order to estimate intermediate inputs, except for the final inputs including labor force and capital service. The estimation covers 29 sectors including agriculture, industrial sectors and service sectors, and suggests that in the period 1981–95, the agriculture sector showed good productivity gains, as did many manufacturing sectors, such as textiles, apparel, lumber/furniture, paper, petrol refining, and building materials. However, many miscellaneous manufacturing industries, like primary metals, machinery, electronic equipment, food processing, mining, showed negative productivity growth in the period. For measuring capital input and labor input, the study classifies inputs by types, say, to classify capital into structure and equipment, and to classify labor into sex, age, educational attainment, and then calculates the share of each factor in capital input and labor input respectively, which reflects the quality change of capital or labor inputs. Most of these estimation came from their partner: The Institute of Quantitative and Technical Economics, Chinese Academy of Social Sciences (IQTE). Undoubtedly, this study is a groundwork for a systematic and clear framework for sectoral productivity analysis of China.

Wu (2007) employs the growth accounting approach to assess the productivity

Table 1 Previous estimations on TFP growths by industries in China

Scholars	Target period	Inputs	Capital inputs	Labor inputs	Industrial sectors	Assumption on market
Huang, Yongfeng and Ruoen Ren (2002)	1985～1994	Capital service, Labor inputs	Structures, Equipments	Estimates man-hours by industry and removes non-industrial employees	Manufacture, 2-diget level	Perfect competition
Mun, Ho and Dale W. Jorgenson (2001)	1981～1995	Capital services, Labor inputs, Intermediate inputs	Structures, Equipments	Crossed by gender, age, educational attainment	29 sectors including agriculture, industrial sectors and service	Perfect competition
Cao, Jing, Mun S. Ho, Dale W. Jorgenson, Ruoen Ren, Lin Lin Sun, and Ximing Yue (2009)	1982～2000	Capital services, Labor inputs, Energies, Materials and other intermediate inputs	Structures, Equipments, Auto vehicles	Crossed by gender, age, educational attainment	33 sectors including agriculture, industrial sectors and service	Perfect competition
Wu, Harry X. (2007)	1980～2005	Labor inputs, Net capital stock	Capital stock without evaluating quality	Estimates man-hours by industry and removes non-industrial employees	19 manufactruing sectors, 4 mining sectors, 1 utility sector	Perfect competition
Wu, Harry X. (2015)	1980～2010	Capital services, Labor inputs	Capital service with evaluating quality	Crossed by gender, age, educational attainment	8 industry groups including agriculture, construction, energy, semi-finished and finished goods, commodities and primary materials, services	Perfect competition

Table 2 Comparision of aggregate annual growths of output, inputs and TFP

Scholars	Target period	Industry	Aggregate annual growth of output	Aggregate annual growth of capital inputs	Aggregate annual growth of labor inputs	Aggregate annual growth of TFP
Huang, Yongfeng and Ruoen Ren (2002)	1985～1994	Manufacturing industries	6.67%	10.73%	2.9%	−0.67%
Mun, Ho and Dale W. Jorgenson (2001)	1981～1995	All industries	8.0%	13.2%	3.72%	2.16%
Cao, Jing, Mun S. Ho, Dale W. Jorgenson, Ruoen Ren, Lin Lin Sun, and Ximing Yue (2009)	1982～2000	All industries	1982–2000: 8.29% 1994–2000: 8.74%	1982–2000: 8.75% 1994–2000: 12.58%	1982–2000: 3.89% 1994–2000: 3.91%	1982–2000: 2.70% 1994–2000: 0.83%
Wu, Harry X. (2007)	1980～2005	Manufacturing, Mining industries	1980–1993: 7.4% 1993–2005: 12.2%	1980–1993: 10.2% 1993–2005: 10.2%	1980–1993: 4.0% 1993–2005: −0.5%	1980–1993: −0.9% 1993–2005: 6.2%
Wu, Harry X. (2015)	1980～2010	Agriculture, Construction, Energy, Commodities and Primary materials, Finished goods, Services I II III	9.4%	12.5%	2%	1.24%

performance of China's 19 manufacturing industries, 4 mining industries and utilities from 1980 to 2005. As for the data construction, this study represents efforts to reconcile official industrial statistics; to remove non-industrial data that were mixed with industrial statistics; and to reconstruct capital stock estimates with a new approach, that sidesteps measurement problems inherent in the official data. Based on the estimation, the author indicates that China's industrial reform has been largely investment-driven, energy and mining industries are particularly inefficient largely because of heavy state controls and soft-budget-constrained investment, traditional labor intensive industries may not be as efficient as the theory of comparative advantage would imply. The paper also shows that machinery, electrical and electronic industries appear to have experienced the most rapid TFP growth over a period of this time.

Cao et al. (2009) reported their new estimation on sectoral output growth, sectoral productivity growth, and also, presented three alternative methodologies used to construct economy-wide estimates, which included Domar-weighted aggregation, aggregate production function, and aggregate production possibility frontier based on the pioneering previous studies. The research implies that aggregate production possibility frontier is more favorable than two other approaches, because this method can relax some of assumptions that are necessary in two other approaches. Their estimate for aggregate TFP growth is in the 1.9–2.5% range for the period 1982–2000. They also decomposed aggregate TFP growth into sectoral TFP growth and reallocation effects, and the estimates from the aggregate production function approach shows that the 1.9% TFP growth is made up of 2.70% sectoral TFP growth, −0.62% reallocation of value added, −0.17% reallocation of capital, and −0.02% reallocation of labor.

Wu et al.(2014) summarized most research findings of analysis on China's total factor productivity growth and argued that growth accounting is highly data-driven and its results are highly sensitive to what data are used and how variables are measured. This study constructed a new set of data for China's five major sectors in 1949–2012 by making alternative adjustments for the problems with both output and input. The estimates show that China's annual TFP growth is −0.5% for the planning period and 1.1% for the post-reform period, much slower than the results based on unadjusted official data which is 0.1 and 3.2% respectively. However, China's best TFP growth post-reform is found for 2001–07 by 4.1% per annum and the poorest TFP performance is found for 2008–12 by −0.8% due to this estimation.

Wu provided a further study (2015) that constructed newly economy-wide industry-level data set for the period 1980–2010 following the KLEMS principles and adopted the production possibility frontier framework that incorporates Domar weights to account for contributions of individual industries to the growth of aggregate inputs and output as well as the growth of aggregate total factor productivity (TFP). The research shows that 7.14 percentage points of China's gross domestic product (GDP) growth of 9.16% per annum can be attributed to the increase in labor productivity and 2.02 percentage points to the number of hours worked. The labor productivity growth can be further decomposed into 5.55 percentage points of capital deepening, 0.35 percentage points of labor quality improvement, and 1.24 percentage points of total factor productivity growth. Across industries, those less prone to government intervention, such as agriculture and "semi-finished & finished" manufacturing industries, appear to be more productive than those subject to more government intervention, typically the "energy" industry group. The Domar aggregation scheme also reveals that only two-thirds of the 1.24 percentage points are from annual TFP growth, or

0.84 percentage points, are directly from industries and the remaining 0.40 percentage points are from a net factor reallocation effect in which labor played a positive role of 0.56 percentage points whereas capital played a negative role of −0.16 percentage points.

As mentioned above, as a practical matter, the challenge to conduct a sectoral productivity investigation for China are very difficult, because a sectoral investigation originally needs a large quantity of data in every country. Especially in China, the rapid economic growth, institutional reform and internationalization gave the rise of fundamental change in its statistics institution system to conform standards of the world and to reflect the continuous reform in the transition to the market economy.

A large number of researches on the role of productivity in China's economic growth had gotten a lot of important result that definitely deepened people's perceptions of real driving force in Chinese economy. On the other hand, as mentioned in Section 1, there also has been a problem among these researches. The problem is that the methodology of most measurements relies on the theory of marginal productivity, which assumes that the each input's unobservable marginal product requested in TFP measurement equals to its observable income shares[1]. This assumption may cause measurement errors just as indicated at the beginning of this paper, the assumption of marginal productivity is probably not suitable for those imperfectly competitive markets like the situation in current China and in other most of developing countries, even though in some developed countries.

Some of the TFP studies are inclined to adopt parametric approach in applying production function into China in order to relax some restrictive hypothesis. In parametric approach, the productivity growth as a time trend with other variations of all inputs over time is determined only by the generalized least squares estimation using production function. On the other hand, in non-parametric approach, the growth rate of productivity is calculated based on the total differential of the production function, and can be calculated by doing subtraction between the growth rate of output and the growth rate of inputs, all should be weighted by their output elasticities. However, as repeatedly mentioned, the output elasticities are not directly observable, so the conventional TFP growth accounting method assumes that each input is paid the value of its marginal product, and in turn, converts the unobserved output elasticities into observable income shares, although this is condition only suitable for those perfect competition markets. Surely, using parametric approach could relax this restriction, but there is still a pity: even though adopting a parametric approach based on production function, we also could not quantify how much the prices of factors are greater than marginal costs. Therefore, this research tried to examine (a) the existence of gaps between the price of output and marginal cost in manufacturing industries in China, (b) the degree of gaps to which price exceeds marginal cost for every manufacturing sector, and (c) the change of TFP when removing the mark-up ratios' impacts.

3. Methodology

Two methods will be introduced in this section. One method was proposed by Hall (1988), which estimates the difference, say mark-up ratio between the price and the marginal

[1] But on the cases to assume the income shares in advance, mark-up ratios will not give impact to the measurement of TFP growth rate.

cost under monopoly, oligopoly and imperfect competition. The basic calculation of the measurement of productivity in Hall's method had used Solow's approach (1957), based on the comparison of changes of inputs with the changes in output. Another method was contributed by Roeger (1995), which carries Hall's approach concerning the deposition of the Solow residual into a pure technology component and a mark-up ratio, and gets one step further by adopting the mark-up ratio for the calculation of the dual productivity. This two methods has been applied as a base in a lot of studies on the measurement of mark-up ratio or TFP in industries (see, Martins et al., 1996; Polemis and Fotis, 2015; Rezitis and Kalantzi 2016).

3.1 Hall's method

Hall's method to the estimation of mark-up ratio is based on ideas contained in the framework of accounting for growth, in which the production function can be expressed by a technical relation between the quantities of inputs used in productive activities (such as labor, capital) and the amount of the output obtained as below.

$$Y_i^t = A_i^t F(L_i^t, K_i^t) \tag{1}$$

In equation (1), Y, L, K, F, respectively, each represents value-added, labor, capital, technical parameter respectively, and t, i shows time and sector. And the rate of output growth for a sector should be the sum of the rates of inputs and the rate of technical progress:

$$\frac{\Delta Y_i^t}{Y_i^t} = \alpha_i^t \frac{\Delta L_i^t}{L_i^t} + (1 - \alpha_i^t) \frac{\Delta K_i^t}{K_i^t} + \theta_i^t \tag{2}$$

where $\theta = \frac{\Delta A_i^t}{A_i^t}$ has come to be known as the rate of technical progress, or say, total factor productivity (TFP) growth. Under the assumptions of constant returns to scale, $\alpha = \frac{WL}{PY}$ and $(1 - \alpha) = \frac{RK}{PY}$ are the labor's cost share and the capital's cost share of total value added, where W represents the wage rate, R represents rental price of capital, P represents the price of output. And then, equation (2) can be rearranged as equation (3) by assuming the output market is under imperfect competition.

$$\frac{\Delta Y_i^t}{Y_i^t} = \frac{P_i^t}{MC_i^t} \frac{W_i^t L_i^t}{P_i^t Y_i^t} \frac{\Delta L_i^t}{L_i^t} + \frac{P_i^t}{MC_i^t} \frac{R_i^t K_i^t}{P_i^t Y_i^t} \frac{\Delta K_i^t}{K_i^t} + \theta_i^t \tag{3}$$

Under constant returns technology with the additional assumption of perfect competition, the marginal cost of output should be equal to its price, that means $P_i^t / MC_i^t = 1$, but under the imperfect competition, P_i^t / MC_i^t may exceed 1, or be less than 1. By defining the mark-up ratio as $\mu = P/MC$, equation (3) can be rewritten as below, which is the basic idea of Hall's method.

$$\frac{\Delta Y_i^t}{Y_i^t} = \mu_i^t \alpha_i^t \frac{\Delta L_i^t}{L_i^t} + (1 - \mu_i^t \alpha_i^t) \frac{\Delta K_i^t}{K_i^t} + \theta_i^t \tag{4}$$

Equation (4) reflects that the relation between price and marginal cost can be found by comparing the actual growth in the output with the actual growth in the inputs[2]. Solow residual (SR), the difference between output growth and input growth weighted by their shares in total value added, can be obtained by subtracting $\alpha(\frac{\Delta L}{L} - \frac{\Delta K}{K})$ from both side of equation (4)[3]. Here the SR means the real productivity growth.

$$SR_i^t = (\mu_i^t - 1)\, \alpha_i^t \left(\frac{\Delta L_i^t}{L_i^t} - \frac{\Delta K_i^t}{K_i^t}\right) + \theta_i \tag{5}$$

[2] Hall explained Solow approach by comparing the actual growth in the output/capital ratio with the growth in the labor/capital ratio (1988). Thus, equation (4) was expressed as $\frac{\Delta q_i^t}{q_i^t} = \mu_i^t \alpha_i^t \frac{\Delta l_i^t}{l_i^t} + \theta_i^t$, where q, l are output/capital ratio and labor/capital ratio respectively.

[3] Martins et al.(1996).

In the case of perfect competition, μ will be one, marginal cost and price will be equal, but in the case of monopolization and imperfect competition it is possible for firms to make the price higher than marginal cost for gaining more profits or lower for getting rid of rivals. In order to know the difference between marginal cost and price, θ_i^t is necessary, but in practice the rate of productivity growth will not be known. Hall assumed that the rate of productivity growth can be described as a constant rate plus a random error term. Then θ_i^t will be expressed as follows:

$$\theta_i^t = \theta_i + \varepsilon_i^t \tag{6}$$

and SR can be rewritten following Hall's idea of μ.

$$SR_i^t = (\mu_i - 1)\ \alpha_i^t \left(\frac{\Delta L_i^t}{L_i^t} - \frac{\Delta K_i^t}{K_i^t}\right) + \theta_i + \varepsilon_i^t \tag{7}$$

The equation (7) means that Solow's residual equals to θ_i^t if $\mu = 1$; the Solow's residual is lower than θ_i^t if μ exceeds 1 and $\frac{\Delta K_i^t}{K_i^t} > \frac{\Delta L_i^t}{L_i^t}$. The problem is that the change of labor/capital ratio and the error term are correlated. In order to eliminate this problem Hall suggested to use an instrumental variable that must be correlated to output growth but nether a cause nor a result of productivity growth and used the military spending, the world oil price and the political party of the president to estimate μ_i for 26 industries.

3.2 Roeger's method

Roeger (1995) proposed a method that used both the production function and the cost function for estimating the mark-up ratio and the Solow Residual. He carries 'Hall's insight concerning the decomposition of the Solow residual into a pure technology component and a markup for the calculation of the dual productivity residual'. His important contribution to estimation of mark-up ratio is that the method suggested by him does not require the use of instruments as found in Hall's analysis. As Roeger discussed in his paper, it is very hard to select instrumental variables and choosing poor instruments can be a main reason for a bias with Hall's method. Following are Roeger's method. Roeger introduced Lerner index developed by Abba P. Lerner to explain the market power, which is defined as equation (8).

$$B = \frac{P - MC}{P} = 1 - \frac{1}{\mu} \tag{8}$$

Next, using the coefficient B that is directly related to the mark-up ratio, Roeger shows that Solow Residual can be expressed by a sum of two terms under an imperfect competition assumption: one is the capital productivity growth multiplied by Lerner index, another is θ_i multiplied by $(1 - B)$ as the equation below.

$$SR_i^t = B\left(\frac{\Delta Y_i^t}{Y_i^t} - \frac{\Delta K_i^t}{K_i^t}\right) + (1 - B)\theta_i \tag{9}$$

Under a perfect competition, $B = 0$, and the Solow Residual should equals to θ_i, the growth rate of total factor productivity under the assumption of perfect competition. And then, as a different way to determine mark-up ratio and a real technology progress term, Roeger suggested a dual residual that also be decomposed into two terms: one is the capital productivity growth in price base multiplied by negative Lerner index, another is θ_i multiplied by $(1 - B)$.

$$SRP_i^t = -B\left(\frac{\Delta P_i^t}{P_i^t} - \frac{\Delta R_i^t}{R_i^t}\right) + (1 - B)\theta_i^t \tag{10}$$

Based on Roeger's idea, by subtracting equation (10) from (9) the expression for estimation of B can be obtained, and u_i^t is error term reflecting the difference of measurement errors from the two productivity terms SR_i^t and SRP_i^t.

$$SR_i^t - SRP_i^t = B\frac{\Delta X_i^t}{X_i^t} + u_i^t \tag{11}$$

$$\text{with } \frac{\Delta X_i^t}{X_i^t} = \left(\frac{\Delta Y_i^t}{Y_i^t} - \frac{\Delta K_i^t}{K_i^t}\right) + \left(\frac{\Delta P_i^t}{P_i^t} - \frac{\Delta R_i^t}{R_i^t}\right) \tag{12}$$

Roeger argues that the regression using equation (11) can avoid measurement errors. Some data collecting process, such as man hours collecting and value-added collecting, are easy to cause measurement errors. In formula (11), these data should appear two times that makes the measurement errors do not constitute a problem from this calculation. For example, the calculation using formula (11) can cancel out the mismeasurement of man hour, because man hour appears two times: one the calculation of SR, the other the calculation of SRP. Similarly, the mismeasurement of value added also can be offset because it appears on both calculations of SR and $\frac{\Delta X_i^t}{X_i^t}$.

4. Data for the measurement of Chinese manufacturing industries' mark-up ratio

As I mentioned as above, Roeger's approach to measure mark-up ratio and a right total factor productivity can avoid the correlation problem between the explanatory variable and the error term, and also can avoid the detection of instrumental variables. Following Roeger's method, this study makes both quantity residual and price residual for deriving the mark-up ratios of Chinese manufacturing industries. In this section I will explain how to build databases of value-added, labor service, capital service, price on output and input for each manufacturing industry.

Data for this paper are basically taken from my previous studies, which include data of value-added, capital input, labor input, wage and deflator for 33 manufacturing industries. However, the adjustment of industry classification is necessary in this study because of a data deficiency in fixed-asset investment by class of asset for Apparels industry and Mining of other ores industry until 1992. In 1993 version of *China Fixed Asset Investment Statistical Yearbook*, fixed asset investment from non-SOEs sectors in Textile is broken down into two industries: Textile and Apparel, which causes problems in both Textile and Apparel. In this study, all of data for Textile are reconstructed by integrating these two industries into one, so there is no Apparel industry in this paper. Similarly, the industry of Mining of other ores is also a new sector divided from Mining of nonmetal ores in *China Fixed Asset Investment Statistical Yearbook 1993*. At this measurement, Mining of other ores and Non-metallic ore mining are combined into one sector. As the result of adjustment, analysis target will include 31 manufacturing industries.

4.1 Value-added

Industrial value-added data can be considered a weak point compared with labor or investment statistics at the beginning of reform period. This is because under MPS (Material Product System) standard adopted by China during the term of centrally planned economy published total output instead of value-added as a main index reflecting industrial production. Along with a gradual transformation of national account system from MPS to SNA, value-added data has been constructed and made public by National Bureau of Statistics

(NBS). NBS began to release industrial value-added data at 2-diget in 1992 in *Chinese Statistics Yearbook*, for industrial enterprises with independent accounting systerm but it excluded township and village enterprises (TVE). In 1997 Bureau of Ministry of Agriculture published TVE data in *China Township and Village Enterprise Yearbook*.

The deficiency of value-added data also took place depending on different size of firms. From 1992 through 1997, *Chinese Statistics Yearbook* published annual value-added data by sector, but the data were actually restricted to those "enterprises with independent accounting system (Duli hesuan danwei) at the township level and above". After 1998, the coverage of value-added surveys for enterprises by NBS have been changed to "industrial state-owned enterprises with independent accounting systems and all industrial non-state owned enterprises with independent accounting systems and annual sales revenue in excess of 5 million yuan"[4]. Besides this, either in the period before 1998 or in the period after 1998, there are gaps between the aggregations of all manufacturing industrial value-added in manufacturing and the manufacturing GDP. The gaps are considered to come mostly from the deficiency of TVE data. With this, it is more difficult not only for conducting time series analysis, but also for ensuring consistency between output and inputs. In order to supplement the deficiency value-added data TVE, a calculation is conducted by collecting the industrial distribution for TVE, which can be taken from *China Township and Village Enterprise Yearbook* after 1993. Then, the estimation of the industrial distribution is made using Simple Moving Average. This calculation depends on a judgement that there should be an industrial proportion similarity in value-added between TVEs and other small-size enterprises.

Apart from that, there was also a statistical break on 2004 – there is no value-added data publish in 2004. Carsten A. Holz indicated that this problem was caused by a series of statistical revision on industrial enterprises data in the *Chinese Statistical Yearbook 2005*, following the 2004 economic census (Holz, 2014). With a similar method to calculation for small-sized firms, we got the value-added data of 31 sectors for 2004 throughout calculating the rate of change in 2005, 2006, 2007.

Real value added data of manufacturing industries are obtained by deflating value added at current prices with the Producer Price Indices (PPI) by sector. The problem is that the industry breakdown for the PPI had followed the industrial classification as defined in MPS (Material Products System) up to 2001. This classifications used from the period of central planning economy just covered 14 sectors and the discrepancies of classifications between PPI and value added may cause biases in deflating value added for the period 1993–2001. Therefore, how to avoid the usage of real value added is a problem for measuring TFP growth in this study.

4.2 Labor inputs

The measurement method follows the research for constructing the U.S. labor input, which was contributed by Jorgenson et al.(1987), and also makes the research for Japan's labor input, which was contributed by Kobayashi (1996) as reference. In the measurement, the quantity of labor input for each industry is cross-classified by the two enterprise ownership (state-owned, non-state-owned), two genders, five age groups (15–24, 25–34, 35–54, 55–59, 60+), four educational groups. The main data is from *Population Census* (1982, 1990, 2000, 2010), *1% Population Sample Survey* during the inter-censual years (1987, 1995, 2005), *China Labor Statistical Yearbook* and *China Township and Village Enterprise Yearbook*.

[4]The size criterion changed from 5 million yuan to 20 million yuan in 2011. (*China Statistical Yearbook*, 2012)

Three steps were taken for this measurement. The first step was to estimate the number of employee by sector and by enterprise ownership. The second step was to select several year as the benchmark year or control totals to complete labor input data cross-classified by industry, ownership, gender, age and education. A number of *Population Census* provide employee's characteristic information. With benchmark and control totals, the number of employment cross-classified by industry, ownership, gender, age and education for other years were estimated by utilizing RAS method developed by Stone (Shimpo, 1996). As a result, the full five-way cross-classification of employment was constructed for each year. I have given the detail measuring procedure in another paper, Estimating China's labor input (1) and (2) (Meng, 2013a, 2013b).

The next step was to fill the absence in number of employment at an aggregation level. The absence in number of employment is considered to be a result generated from the different statistical scopes between *China Statistical Yearbook* and *China Labor Statistical Yearbook*. As a result, the gaps of employment in aggregation level between two statistical yearbooks for each year after 1990 is approximately up in the range of almost to the tens of millions. Several statisticians have made detailed investigations on this issue and concluded that the gaps resulted from the different statistical approach between two systems (Yue, 2005; Li, 2006, Wu and Zhang, 2010). According to the analysis by scholars, the gaps in numbers of employment had been generated mostly by the different statistical systems adopted by two yearbooks. As a yearbook taking an stand on enterprise, *China Labor Statistical Yearbook* is basically supported by ①the system of directly reporting industrial enterprises (DRIEs), ②the system to take the employee statistics for private enterprises, ③the system to take the employee statistics for township and village enterprises, with the emphasis on firm side. On the other hand, *China Statistical Yearbook* is compiled depending on *Population Census* and sampling surveys of population, which takes stands on individual. Due to the difference in statistical policy, the statistical data for migrant workers seemed to be a weak point in labor input, and then, such "gap" occurred from the beginning of migration of worker force from rural area to big city. The data and information on migrant workers' industrial distribution and characteristics are very limited. Only some secondary information can provide discontinued data, for example, the series of *REEN Book of Population and Labor* issued by Chinese Academy of Social Sciences (CASS) have continuously published reports on migration after 2003. With the limited data and the total number of migrant workers calculated based on the "gap" between two main statistical yearbooks as the control total, and also refer to the worker distribution in township and village enterprises, an insufficient dataset of migrant was constructed (Meng, 2012a).

This study estimates working hours firstly by constructing a unit matrix for all dimensions. The data mostly comes from ①the statistical information on average working hour, ②some regulations regarding working hour. And secondly, working hours per person for each year are calculated, thirdly, multiply yearly working hours per person by the number of total workers.

4.3 Income

The income data used in this measurement is also cross-classified by industry, ownership, gender, age and education.

Three statistical surveys are used in this estimation, which include *China Labor Statistical Yearbook*, *China Input-output Table*, *China Township and Village Enterprise Yearbook*. In addition, academic investigations provides complementary information on income distribution in China, such as the researches of Zhao, et al. (2005), Ma (2007). As known, *China Labor Statistical Yearbook* is the most important data source of wage data by industry and by ownership, but it has some problems for estimation. It does not cover the non-state-owned enterprises, and township or village-owned enterprises. And, it does not provide social insurance, pension and other social security income that should be included into the compensation of employees in SNA (Kobayashi, 1996).

Therefore, these five statistical and academic investigations are used in this measure. Constructing the benchmark data on total income by industry based on *China's Input-output table* of 1987, 1990, 1992, 1995, 1997, 2000, 2002, 2005, 2007, 2010 is the first step, which are broken into 40 industries same to the classification of labor amount from 31 industries provided by IO table. Next, extending the income data for the years without released IO table using the proportion of industry distribution provided by *China Labor Statistical Yearbook*. The third step is to classify each industry's total income data for benchmark year into state-owned enterprise and non-state-owned enterprise. A 'social security to total income ratio' for state-owner enterprise is calculated, which includes social insurance and pension released in CLSY. However, there is no official data for industries, therefore, the 'social security to total income ratio' is supposed to be the same number for all sectors in the year and industrial total incomes that takes social security incomes into account are calculated by using each year's ratio. Constructing the cross-classified by industrial sectors, by 2 ownership groups, by 2 gender, by 5 age groups, by 4 educational attainment matrices is the last work, and the wage difference by gender, age or educational attainment are estimated using the research output on income distribution conducted by Zhao, et al. (2005). You can get details of this estimation from Meng (2013b).

4.4 Capital service and the price of capital service

This measurement followed the methodology of estimating capital service that was developed by Jorgenson (1963). The capital service as a discrete trans-log index can be defined as below referring to Kuroda (1984).

$$lnK_i^t - lnK_i^{t-1} = \sum V_{ik}(lnK_{ik}^t - lnK_{ik}^{t-1}) \tag{13}$$

Where K_{ik} is the capital service k, which can be assumed as proportional to the quantity of capital stock under the condition of homogeneous on capital goods (see Kuroda, 1984, p. 126). V_{ik}^t is the weighted average of the capital input k of all categories of capital input at the end of t, as showed with equation (14).

$$V_{ik}^t = p_{ik}^t\, k_{ik}^t \,/\, \sum p_{ik}^t\, k_{ik}^t \tag{14}$$

While k indicates structure and equipment, and p_{ik}^t is nothing but the price of k's capital service in sector i. V_{ik} is k's two-period average share in total capital input. Capital service price p_{ik}^t is computed with the equation (15).

$$p_{ik}^t = r_i^t\, q_k^{t-1} + \delta_{ik} q_k^t - (q_k^t - q_k^{t-1}) = q_k^t\, \{r_i^t q_k^{t-1}/q_k^t + \delta_{ik} - (q_k^t - q_k^{t-1})\,/\,q_k^t\} \tag{15}$$

In this equation, r_i^t is the rate of return on capital service, δ_{ik} is the rate of depreciation, q_{ik}^t is the asset price for inventories, and t, i, k indicate year, industry and the asset class respectively. If we assume C_i^t to be the capital service of sector i, the C_i^t can be expressed by equation (16).

$$C_i^t = \sum_{k=1}^{j} p_{ik}^t\, k_{ik} \tag{16}$$

Next, by substituting equation (15) for p_{ik}^t, equation (16) can be rewritten to equation (17).

$$C_i^t = \sum_{k=1}^{j} q_k^t \{r_i^t q_k^{t-1}/q_k^t + \delta_{ik} - (q_k^t - q_k^{t-1})/q_k^t\} K_{ik} \tag{17}$$

It is obvious that two important components need to be estimated to get the quantity of capital service and the price of capital service. One is the capital stock K_i, and the other is the rate or return on capital r_i. Capital stocks crossed-by sector and asset class for 40 sectors in China have been imputed following perpetual inventory method expressed by formula (18).

$$K_{ik}^t = I_{ik}^t + (1 + \delta_{ik}) K_{ik}^{t-1} \tag{18}$$

Data on corporate investment in fixed assets can be obtained officially from 1953, and the data by class of asset covering structure and equipment can be obtained from 1981, but the industrial data can only be obtained from 1996. Some steps are taken to create fixed asset investment data from 1992 to 2010 by class of asset for 40 sectors, including both manufacturing and non-manufacturing industries. Firstly, the benchmark of capital stock crossed-by class of asset and industry is estimated by PIM (Perpetual Inventory Method) using official inventory data from 1953 to 1991. Secondly, the ratio of depreciation for each industry is computed by equation (19).

$$d_\tau = (1 - \delta)^\tau \tag{19}$$

While, d_τ is the relative efficiencies of capital goods, τ is the age of the capital goods. The lifetimes of capital goods are taken from the measure for the OECD countries, in which the life of structure was assumed to be forty years, and the life of equipment was assumed to be 16 years[5]. The relative efficiencies at the end of lifetime taken from Sun and Ren (2002) are five percent. Thirdly, the sequence of fixed asset investments are cross-classified by industry, and class of asset, depending on the official data released by *China Fixed Asset Investment Statistical Yearbook,* in 1996, 1998, 2002, 2004, 2005, 2006, 2007, 2008, 2009, 2010. Then, the deficiency data are calculated by using RAS. Lastly, real value of capital stocks are calculated using formula (19), the inventorial data developed in step 1, 2, 3, and deflators of inventorial assets from 1992, which are also taken from *China Fixed Asset Investment Statistical Yearbook* . The process of measuring sectoral capital stocks by class of asset was reported with another paper in 2012 (Meng, 2012a).

In term of the measurement of rate of return by sectors r_i, we need to know C_i^t, q_{ik}^t, δ_{ik}, and K_{ik} in formula (17). The capital income, C_i^t is computed based on added-value of output and the share of capital in added-value, which is decided by aggregating the total income of labor and computing the share of labor compensation in added-value. The asset prices q_{ik}^t are the index of market prices, acquired directly from *China Statistical Yearbook*. The indexes of market prices whose base year is 1992 are different from the indexes in my previous work, whose base is the preceding year. This method was adopted by Christensen et al. (1996), Ezaki and Jorgenson (1996). Therefore in this computation, K_{ik} is the quantities expressed in terms of 1992 market prices.

Another effect on the capital service in the investment theory of Jorgenson is taxation in the corporate business sectors. The rental price of investment goods is not only dependent on the price of capital goods, rate of investment, the ratio of depreciation, but also dependent on taxes and reductions or exemptions in the taxation for investments (Takagawa, 1979).

[5]According to Sun and Ren (2002), the average lifetime of structure and equipment in Japan, Germany, France, The United States, British is 43, 10; 41, 15; 37, 17; 33, 17; 60, 24, respectively.

Three corporate taxes are considered in my measurement. Value added tax (Zengzhi shui); Fixed asset investment direction adjusting tax (guding zichan touzifangxiang tiaofie shui); and Corporate tax (Faren shui). However, Fixed asset investment direction adjusting tax was lifted down to be a policy of investment promotion from 2002. Then the capital service price that include taxes is

$$p_{ik}^{t*} = \{1 + (1 - u^t)\ \omega^t - u^t z^t\} / (1 - u^t)(r_i^t - \pi_{ik}^t)\ q_k^{t-1} + \delta_{ik} q_k^t + v q_k^t \qquad (20)$$

where $\pi = (q^t - q^{t-1}) / q^{t-1}$; u is the corporate tax; ω is the fixed asset investment direction adjusting tax. In term of value added tax, I introduce vq^t that reflects the relation between the tax and manufacturers prices. The rate of taxes are taken from the official data.

5. Findings

5.1 Mark-up ratios, conventional TFP and recalculated TFP

Table 3 summarizes several respects in 2010 to show sector characteristics. It is suggested that among Chinese manufacturing sectors, top five ones in value-added came from heavy industry, which were Machinery, Transport equipment, Communication equipment, Steel manufacturing, Chemicals materials and products. The smallest sector was non-metallic ore mining. Four of tops in value-added, say, Machinery, Chemicals, Transport equipment, Steel manufacturing plus Building materials were also at the top in capital stock. In terms of total compensation, the top five sectors were Transport equipment, Machinery, Textile, Communication equipment. However, this does not necessarily mean that the sectors were the ones with highest average wage. The sectors with highest average wage were Oil and gas mining, Petro refining, Coal mining, Steel manufacturing and Transportation equipment in the fact. With the exception of Coal mining, most of the enterprises in these sectors are state-owned companies.

Table 4 provides the estimation results for the growth rates of output and input by separating input growth in capital service, labor service and conventional TFP[6], based on equation (2). It should be noticed that the equation $\alpha = \frac{WL}{PY}$ and $(1 - \alpha) = \frac{RK}{PY}$ implies a hypothetical market situation where competition is at its greatest possible level. This table gives the average annual growth rate of output and input over 1992–2010. The deflators are taken from the producer price index made by NBS. Most of sectors of manufacture increased a double digit annual growth in value added except for mining and tobacco manufacturing. The period of 1992–2010 covers two important stages in economic policy: speeding up economic reform and opening-up in 1992; deepening SOEs reform after the later period of 1990's. Double-digit increase reflects an all-around improvement in Chinese economy with the major policies implemented in most of product manufacturing since the end of 1970's. The result shows that the annual growth rate of capital services was higher than value-added growth in fourteen industries. The labor services in most of industries had grown in one-digit, which covers the growth in labor input of rural migrant workers. Several industries related to IT, including Electronic machinery, Communication equipment, or related to consuming activities, including the Other manufacturing, Medicine, Food processing,

[6] I will use two terms to express the estimating results on growth rate of TFP. 'Primal TFP' expresses the estimate by using growth accounting approach, and 'recalculated TFP growth' expresses the estimate by using Roeger's method, which tries to remove the influence of mark-up. The recalculated TFP growth rate are also expressed as Solow residual in Section 3 (Methodology).

Table 3 Estimates on sectoral characteristics of Chinese manufacture in 2010

	Sector	Value added	Capital stock	Employment	Compensation	Average wages
		bil. Yuan	bil. Yuan	million	bil. Yuan	Yuan
1	Coal mining	642.97	1,058.63	10.60	273.96	44,119
2	Oil and gas mining	652.47	1,308.03	1.06	67.59	55,099
3	Iron ore mining	138.02	259.47	2.11	33.02	34,067
4	Non-ferrous mining	87.41	258.33	1.77	30.40	28,757
5	Non-metallic ore mining	71.89	194.30	2.75	44.78	24,702
6	Food processing	1,064.72	1,447.86	20.09	291.29	26,565
7	Beverage manufacturing	210.57	394.50	3.34	57.92	28,776
8	Tobacco	390.52	96.52	0.30	19.60	78,675
9	Textile	1,009.63	1,240.48	43.16	632.10	22,328
10	Leather products	181.69	186.62	7.81	104.48	22,490
11	Lumber and wood products	170.09	330.00	5.73	77.31	20,538
12	Furniture	101.57	204.97	3.82	53.76	25,125
13	Paper and paper products	240.05	465.08	5.43	79.88	25,326
14	Printing	81.97	215.17	2.45	38.41	28,513
15	Culture and sports products	72.14	82.65	3.52	48.19	23,095
16	Petro refining	672.69	714.55	2.27	48.80	45,754
17	Chemical materials and products	1,102.48	2,034.33	12.20	195.32	31,418
18	Medicine	270.13	550.82	4.26	74.80	33,004
19	Chemical fiber manufacturing	113.97	150.51	1.53	23.97	27,896
20	Rubber products	135.89	237.61	3.26	49.48	27,806
21	Plastic manufacturing	319.15	509.74	9.05	124.71	26,136
22	Building materials	737.53	1,826.76	16.35	227.83	24,297
23	Steel manufacturing	1,192.52	1,546.77	9.28	180.68	41,220
24	Non-ferrous manufacturing	646.92	779.15	5.27	88.01	30,560
25	Metal products	463.23	904.71	14.58	215.69	27,945
26	Machinery	1,304.35	2,316.56	23.96	385.01	33,897
27	Transport equipment	1,275.78	1,610.79	12.75	483.33	40,493
28	Electronic machinery	997.21	1,069.10	14.55	210.04	30,088
29	Communication equipment	1,264.69	1,084.96	17.69	292.33	36,156
30	Instruments	147.22	180.46	2.74	48.20	32,993
31	Other manufacturing	183.34	374.08	11.98	187.62	24,265

*All of data are normal value.

Transport equipment, showed higher increase in labor input. TFP had grown in most manufacturing industries with an average annual growth rate of 4.22%, while in several sectors, such as Oil and gas mining, Petro refining, Tobacco and Non-metallic ore mining, TFP had negative growths. Sectors with growth rate above 7% in TFP are Iron ore mining, Furniture, Transport equipment, Electronic machinery, and Communication equipment.

Table 5 demonstrates the estimated results followed equation (10) on mark-up ratios (μ) regarding Chinese manufacturing industries over the period of 1993–2010. The result of regression reveals that mark-up ratio for each industry is statistically significant, although two industries, Oil and gas mining and Tobacco, show very high interdependence between the independent variable and the dependent variable. The results of the two industries may contain the problem of spurious relationship that may be caused by some lurking variables. For examining if there are spurious relationship problem, I will conduct a multiple regression later, which includes an additional variable, ΔGDP, a demand indicator. Apart from these two

Table 4 Estimates on the sources of sectoral growth of Chinese manufacture (1992–2010)

(%)

	Sector	Value added	Capital services	Labor services	TFP	Share of labor cost
1	Coal mining	7.15	11.20	1.54	2.97	0.69
2	Oil and gas mining	3.65	7.72	2.38	–3.73	0.07
3	Iron ore mining	17.42	16.27	6.63	7.40	0.62
4	Non-ferrous mining	9.53	12.21	1.61	2.72	0.68
5	Non-metallic ore mining	8.30	10.73	6.34	–1.24	0.23
6	Food processing	18.83	16.71	8.25	5.22	0.35
7	Beverage manufacturing	10.92	13.15	3.34	0.11	0.23
8	Tobacco	6.78	8.87	0.66	–1.78	0.04
9	Textile	12.34	13.82	6.18	1.40	0.42
10	Leather products	16.14	11.56	7.00	6.45	0.41
11	Lumber and wood products	14.48	17.21	6.12	3.72	0.43
12	Furniture	18.05	16.73	6.98	8.71	0.88
13	Paper and paper products	14.11	14.07	3.92	4.09	0.47
14	Printing	11.75	15.42	4.00	5.73	0.68
15	Culture and sports products	15.61	14.14	7.31	4.66	0.68
16	Petro refining	6.10	15.37	4.21	–6.60	0.22
17	Chemical materials and products	14.30	14.43	4.55	2.89	0.33
18	Medicine	15.34	15.71	9.49	1.15	0.25
19	Chemical fiber manufacturing	11.09	8.79	5.25	2.93	0.20
20	Rubber products	11.94	13.90	4.23	1.60	0.44
21	Plastic manufacturing	16.06	12.64	6.40	6.41	0.49
22	Building materials	11.95	14.74	0.78	4.05	0.49
23	Steel manufacturing	13.54	11.61	4.54	5.05	0.49
24	Non-ferrous manufacturing	16.82	15.61	7.89	3.12	0.26
25	Metal products	14.51	15.91	5.82	3.57	0.52
26	Machinery	14.74	14.76	3.49	5.42	0.56
27	Transport equipment	22.79	16.62	8.57	7.75	0.25
28	Electronic machinery	21.92	15.20	11.22	7.55	0.28
29	Communication equipment	22.82	16.00	12.86	7.42	0.28
30	Instruments	17.52	13.92	6.67	6.29	0.39
31	Other manufacturing	17.87	10.17	16.73	2.96	0.76
	Weighted average	15.71	14.29	6.60	4.22	0.39

industries, the result of this estimation finds that the mark-up rations range from 1.13 (Culture and sports products, Furniture) to 8.53 (Beverage manufacturing). This suggests a possible presence of imperfect completion in most of manufacturing industries in China during the said period. The industries with the biggest gaps between product prices and input costs are Petro refining, Medicine, Chemical fiber manufacturing, Transport equipment and Building materials, besides Beverage manufacturing, while the industries that have limited differences are Culture and sports products, Furniture, Other manufacturing, Non-ferrous mining. It seems that most of process manufacturing industries have very high mark-up ratios, and petroleum-based industries have higher mark-up values. This study for China manufacturing industries shows a greater degree of imperfect competition, compared to those previous studies that also employ Roeger's method to estimate the mark-up ratio for other countries. The main difference between the preceding estimation and mine, with exception for some details, is that these preceding estimations

Table 5 Estimated mark-up ratios in Chinese manufacturing industries (1)

		B	μ	R-squared
1	Coal mining	0.4197 (12.41)	1.7231	0.91
2	Oil and gas mining	0.9534 (108.73)	21.4772	0.99
3	Iron ore mining	0.3508 (6.57)	1.5404	0.73
4	Non-ferrous mining	0.1704 (1.85)	1.2054	0.18
5	Non-metallic ore mining	0.6220 (24.85)	2.6453	0.97
6	Food product	0.6584 (5.93)	2.9278	0.69
7	Beverage manufacturing	0.8828 (23.33)	8.5311	0.97
8	Tobacco	1.0011 (187.18)	−872.1696	0.99
9	Textiles	0.6833 (9.69)	3.1577	0.85
10	Leather and leather products	0.3319 (2.52)	1.4967	0.28
11	Lumber and wood products	0.3546 (4.09)	1.5495	0.51
12	Furniture	0.1155 (3.38)	1.1306	0.42
13	Paper and paper product	0.6225 (8.03)	2.6489	0.80
14	Printing	0.3532 (5.67)	1.5461	0.67
15	Culture and sports products	0.1153 (3.31)	1.1303	0.41
16	Petro refining	0.8727 (23.31)	7.8578	0.97
17	Chemical materials and products	0.7122 (19.18)	3.4751	0.96
18	Medicine	0.8693 (10.97)	7.6493	0.88
19	Chemical fiber manufacturing	0.8105 (17.85)	5.2760	0.95
20	Rubber products	0.5717 (8.93)	2.3350	0.83
21	Plastic manufacturing	0.5246 (7.93)	2.1034	0.80
22	Building materials	0.7201 (9.49)	3.5732	0.85
23	Steel manufacturing	0.1862 (2.48)	1.2288	0.28
24	Non-ferrous manufacturing	0.6928 (12.76)	3.2548	0.91
25	Metal products	0.5333 (5.79)	2.1426	0.68
26	Machinery	0.2627 (2.55)	1.3562	0.29
27	Transport equipment	0.7980 (6.48)	4.9495	0.72
28	Electronic machinery	0.5831 (14.90)	2.3989	0.93
29	Communication equipment	0.7678 (11.64)	4.3064	0.89
30	Instruments and related products	0.5935 (5.60)	2.4601	0.66
31	Other manufacturing	0.1568 (2.86)	1.1859	0.34

mostly put developed countries, for example, OECD countries on their target[7].

As indicated earlier there may be spurious correlation for some of regression results in Table 5, which means for some industries the independent variable and dependent variable appear to be related, but actually not to be related. Therefore, Roeger added the growth rate of total gross national products as a proxy for changes of demand to regression. Here, I add the growth rate of GDP and rewrite equation (11) as following specification.

$$SR_i^t - SRP_i^t = B_1 \frac{\Delta X_i^t}{X_i^t} + B_2 \Delta GDP^t + u_i^t \qquad (21)$$

[7] In the result reported by Roeger (1995), althought the estimated mark-up ratios in United States in the period of 1953–84 range from 1.15 (Apparel and other textiles) to 2.75 (Tobacco), but only three sectors' mark-up ratios exceed two out of twenty-two manufacturing industries. In the result for Japan in the period of 1970–98 reported by Inui and Kwon (2004), the estimates of mark-up ratios in manufacturing sectors range from 0.93 (Oil and coal industry) to 1.13 (Primary metal industry). Also, Martins et al.(1996) suggest that the mark-up ratios of thirty manufacturing industries in United States, Japan, Germany, France, Italy, United Kingdom, Canada, in the period of 1970–92 are almost below two, except for a few incidents. And, the group's estimates for Australia, Belgium, Denmark, Finland, Netherlands, Norway, and Sweden, are reported not to exceed two.

Table 6 Estimated mark-up ratios in Chinese manufacturing industries (2)

		B	B_1	B_2	μ^*	R-squared
1	Coal mining	0.4197	0.4210 (11.95)	−0.0347 (−0.25)	1.7271	0.91
2	Oil and gas mining	0.9534	0.9539 (−105.04)	−0.0025 (−0.42)	21.7061	0.99
3	Iron ore mining	0.3508	0.3520 (6.34)	−0.0317 (−0.17)	1.5432	0.73
4	Non-ferrous mining	0.1704	0.1726 (1.87)	0.2999 (1.04)	1.2086	0.18
5	Non-metallic ore mining	0.6220	0.6103 (20.67)	−0.0410 (−0.76)	2.5664	0.97
6	Food processing	0.6584	0.6085 (5.69)	−0.0736 (−1.85)	2.5540	0.69
7	Beverage manufacturing	0.8828	0.8643 (26.70)	−0.0307 (−2.79)	7.3673	0.97
8	Tobacco	1.0011	0.5138 (4.03)	−0.0464 (−0.87)	2.0568	0.56
9	Textile	0.6833	0.6310 (9.32)	−0.0949 (−2.19)	2.7098	0.89
10	Leather products	0.3319	0.3758 (2.87)	−0.0860 (−1.48)	1.6020	0.37
11	Lumber and wood products	0.3546	0.3224 (3.39)	−0.0540 (−0.86)	1.4759	0.53
12	Furniture	0.1155	0.1201 (3.58)	−0.1795 (−1.31)	1.1365	0.48
13	Paper and paper products	0.6225	0.4794 (5.51)	−0.1071 (−2.56)	1.9209	0.86
14	Printing	0.3532	0.2795 (4.25)	−0.1203 (−2.16)	1.3880	0.75
15	Culture and sports products	0.1153	0.1167 (3.15)	−0.0176 (−0.16)	1.1321	0.41
16	Petro refining	0.8727	0.8753 (22.05)	0.0072 (0.27)	8.0209	0.97
17	Chemical materials and products	0.7122	0.6979 (22.01)	−0.0507 (−2.74)	3.3102	0.97
18	Medicine	0.8693	0.8519 (10.48)	−0.0265 (−0.97)	6.7510	0.88
19	Chemical fiber manufacturing	0.8105	0.8104 (17.20)	−0.0004 (−0.01)	5.2736	0.95
20	Rubber products	0.5717	0.5273 (8.83)	−0.0701 (−2.32)	2.1154	0.88
21	Plastic manufacturing	0.5246	0.5099 (7.92)	−0.0792 (−1.51)	2.0404	0.82
22	Building materials	0.7201	0.6677 (8.06)	−0.0605 (−1.33)	3.0095	0.86
23	Steel manufacturing	0.1862	0.1582 (2.05)	−0.0811 (−1.26)	1.1880	0.35
24	Non-ferrous manufacturing	0.6928	0.6871 (12.66)	−0.0299 (−1.07)	3.1960	0.91
25	Metal products	0.5333	0.4669 (5.21)	−0.0998 (−2.08)	1.8757	0.75
26	Machinery	0.2627	0.2215 (2.40)	−0.1948 (−2.63)	1.2845	0.52
27	Transport equipment	0.7980	0.8702 (8.36)	−0.0923 (−2.69)	7.7022	0.82
28	Electronic machinery	0.5831	0.5956 (16.60)	−0.0702 (−1.92)	2.4728	0.95
29	Communication equipment	0.7678	0.7497 (11.97)	−0.0508 (−1.78)	3.9959	0.91
30	Instruments	0.5935	0.5327 (5.45)	−0.0766 (−2.29)	2.1399	0.75
31	Other manufacturing	0.1568	0.1814 (3.52)	0.5369 (−2.03)	1.2216	0.48

Table 6 presents the alternative regression results. B represents Lerner index in single regression model, while B_1 represents Lerner index in multiple regression, B_2 represents the growth of GDP and μ^* represents mark-up ratios under the alternative estimation. The multiple regression results show GDP growth produces almost nothing to the explanatory power of the equation and is insignificant for 19 sectors out of 31 sectors. as the mark-up ratio calculated by multiple regression model, suggests lower However, the results of 12 sectors show that GDP growth is a significant explanatory variable, such as Beverage manufacturing, Textile, Paper and paper products, Printing, Chemical fiber manufacturing, Metal products, Machinery, Instruments and others. Besides, B_1 of Tobacco industry demonstrates higher explanatory power compared to the case in the single regression model.

Table 7 classifies mark-up ratios into three levels of noncompetitive product markets: 'low level' means $\mu^* \leq 1.5$, 'middle level' means $1.5 > \mu^* \leq 2.0$, 'high level' means $\mu^* > 2.0$. Meanwhile, this table divides the 31 industries to material processing (16 sectors), consumer goods processing (10 sectors) and assembly industry (5 sectors) following a classification

Table 7 Estimated mark-up ratios and degree of competition

	Sector	Mark-up ratio	Low level of noncom-petitive	Middle level of noncom-petitive	High level of noncom-petitive	Classified by production process and use
26	Machinery	1.2845	✔			ASI
27	Transport equipment	7.7022			✔	ASI
28	Electronic machinery	2.4728			✔	ASI
29	Communication equipment	3.9959			✔	ASI
30	Instruments	2.1399			✔	ASI
6	Food processing	2.5540			✔	CGP
7	Beverage manufacturing	7.3673			✔	CGP
8	Tobacco	2.0568			✔	CGP
9	Textile	2.7098			✔	CGP
10	Leather products	1.6020		✔		CGP
12	Furniture	1.1365	✔			CGP
14	Printing	1.3880	✔			CGP
15	Culture and sports products	1.1321	✔			CGP
18	Medicine	6.7510			✔	CGP
31	Other manufacturing	1.2216	✔			CGP
1	Coal mining	1.7271		✔		MAP
2	Oil and gas mining	21.7061			✔	MAP
3	Iron ore mining	1.5432		✔		MAP
4	Non-ferrous mining	1.2086	✔			MAP
5	Non-metallic ore mining	2.5664			✔	MAP
11	Lumber and wood products	1.4759	✔			MAP
13	Paper and paper products	1.9209		✔		MAP
16	Petro refining	8.0209			✔	MAP
17	Chemical materials and products	3.3102			✔	MAP
19	Chemical fiber manufacturing	5.2736			✔	MAP
20	Rubber manufacturing	2.1154			✔	MAP
21	Plastic manufacturing	2.0404			✔	MAP
22	Building materials	3.0095			✔	MAP
23	Steel manufacturing	1.1880	✔			MAP
24	Non-ferrous manufcturing	3.1960			✔	MAP
25	Metal products	1.8757		✔		MAP

Note: 31 sectors are classified into 3 groups by the manufacturing process and use of products: material processing industry (MAP), consumer goods processing industry (CGP), and assembly industry (ASI).

standard in Japan (see the homepage of Minister of Economy, Trade and Industry). According to the estimation of multiple regression, 4 consumer goods processing industries, 3 material processing industries, 1 assembly industry are recognized as low level noncompetitive markets, including Furniture, Printing, Culture and sports products, Other manufacturing, Non-ferrous mining, Lumber and wood products, Steel manufacturing and Machinery. On the other hands, most of assembly industries and material industries, several consumer goods processing industries are classified into the market with a high level of noncompetitive market structure. This means that the producers in most assembly as well as material processing industries have much stronger pricing power than those belonging to the consumer goods processing industries.

From the microeconomics perspective, competition generally can be influenced by the number of production firms (monopolize, duopoly, oligopoly), industrial concentration, barriers to entry, and differentiation of product. Some of the barriers of entry are caused by regulations or policies from government, technological monopoly or huge initial investment. Table 8 presents a classification of industries based on three indicators: total output per firm, the capital stock per employee, capital stock share of SOEs. These three indicators represent the scale of economy, the degree of capital intensive and the degree of state dominated. The border lines are their average value respectively and follow next method. Firstly, all industries are classified into segmented and fragmented depending on their average total output per firm. Sectors with large average firm's size are called 'segmented', and others are called 'fragmented' (see Martins, et al., 1996). Secondly, within each of the groups industries are divided by the capital stock per employee. Thirdly, the industries in each of groups are classified into state dominated and non-state dominated[8]. In principle, eight groups can be divided throughout this method: (1) segmented, capital intensive, state dominated; (2) segmented, capital intensive, non-state dominated; (3) segmented, labor intensive, state dominated; (4) segmented, labor intensive, non-state dominated; (5) fragmented, capital intensive, state dominated; (6) fragmented, capital intensive, non-state dominated; (7) fragmented, labor intensive, state dominated; (8) fragmented, labor intensive, non-state dominated. Actually, the case suitable for (3) and (6), cannot be founded in this study, which probably implies that SOE shares in labor-intensive industries can be very small.

Figure 1 – 6 describe the mark-up ratios by market structure characteristics. The figures show that the group of 'Segmented, capital intensive, state dominated', the group of 'Segmented, capital intensive, non-state dominated', and the group of 'Fragmented, capital intensive, non-state dominated' have higher mark-up ratios. It suggests that in Chinese manufacturing industries, the larger of the capital stock compared to the number of employees was, the greater the market power can be formed and exhibited, indicating that mark-up ratios generally tend to be higher in capital intensive industries, no matter whether the industry was dominated by government or not, or whether it has a more production or not. The cost share of capital may become a key factor to evaluate market power for Chinese manufacturing industries, although it cannot directly reflect initial investments. The fact is that most of capital intensive industries need more fixed assets, such as machineries, structures when starting up business. Next reason is that it can be easier to achieve economies of scale for capital intensive industry in accordance with a relative large share of fixed asset in all expenditures in this kind of industry. However, although comparing to the regulations entering industry set by government, the ability to invest seems to be a significant factor from a point of market competition, it is possible for government to confine the investment by regulations if the government really intends to strengthen the power of SOEs, even if this means a sacrificing of the reform in market system.

By using equation (2), table 9 gives the industrial estimates of average annual growth rate in primal TFP measurement and the recalculated TFP. The primal TFP measurement followed the approach of growth accounting model, and the recalculation of TFP removed the influences of mark-up. In this case, I adopt the estimating results in which the independent variables include Lerner index and ΔGDP. By table 9, it has been confirmed that the recalculated TFP growth rates in most sectors are less than primal TFP growth

[8] Chinese statistical authority defines 'State-owned enterprise' based on the share of capital. That includes two cases, the one state ownership accounted 100% and the other one state as a top shareholder. This study adopts the share in whole capital stock as standard to divide state dominated and non-state dominated.

Table 8 Breakdown of industries based on market structure characteristics

Industries	Mark-up ratio (%)	Total output per firm million yuan	Capital stock per employee thousand yuan	SOEs share (%)
Weighted average	**3.39**	243.78	257.40	18.89
Segmented, capital intensive and state dominated				
Tobacco	2.06	3869.21	854.86	99.35
Oil and gas mining	21.71	3199.30	1602.21	94.70
Petro refining	8.02	1258.12	1215.12	70.92
Steel manufacturing	1.19	657.70	827.28	38.96
Non-ferrous manufcturing	3.20	342.91	532.50	28.32
Transport equipment	7.70	267.65	296.10	46.51
Coal mining	1.73	245.22	277.70	56.46
Average	**6.51**	1405.73	800.82	62.18
Segmented, capital intensive and non-state dominated				
Chemical fiber manufacturing	5.28	255.49	508.95	8.77
Segmented, labor intensive and non-state dominated				
Communication equipment	4.00	370.47	229.72	7.89
Fragmented, capital intensive and state dominated				
Non-ferrous mining	1.21	155.52	269.60	27.35
Chemical materials and products	3.31	162.42	485.01	19.30
Average	**2.26**	158.97	377.31	23.32
Fragmented, capital intensive and non-state dominated				
Iron ore mining	1.54	140.76	325.10	14.04
Paper and paper products	1.92	101.60	357.92	7.93
Medicine	6.75	166.80	281.41	12.86
Beverage manufacturing	7.37	143.66	307.84	16.05
Building materials	3.01	92.14	275.73	9.93
Average	**4.12**	128.99	309.60	12.16
Fragmented, labor intensive and non-state dominated				
Electronic machinery	2.47	157.40	170.68	8.90
Food processing	2.55	124.02	219.18	7.20
Rubber products	2.12	121.64	231.77	12.83
Instruments	2.14	109.80	148.66	10.07
Machinery	1.28	97.93	205.77	16.53
Leather products	1.60	89.20	54.52	0.30
Textile	2.71	79.72	153.95	2.41
Metal products	1.88	78.34	168.31	5.49
Furniture	1.14	74.40	101.40	2.55
Other manufacturing	1.22	71.35	90.82	7.02
Non-metallic ore mining	2.57	66.77	182.37	11.16
Plastic manufacturing	2.04	65.95	164.89	2.68
Lumber and wood products	1.48	65.05	147.92	2.31
Culture and sports products	1.13	64.96	64.67	1.16
Printing	1.39	52.01	232.92	12.34
Average	**1.85**	87.90	155.86	6.86

Data source: The share of capital stock is taken from Meng (2012a), output per establishment and capital stock per employee are taken from *Chinese Statitical Yearbook*.

Figure 1 Segmented, capital intensive, state dominated

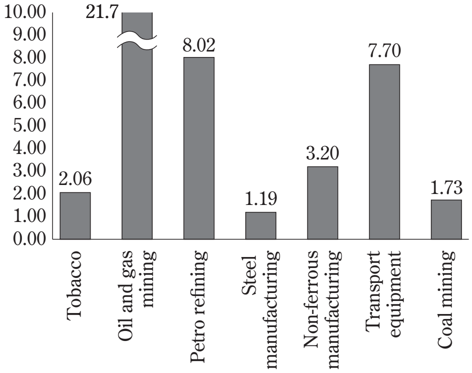

Figure 2 Segmented, capital intensive, non-state dominated

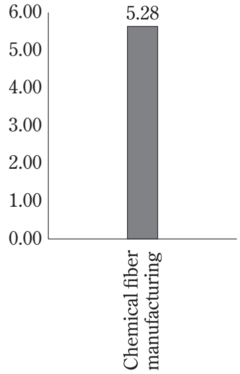

Figure 3 Segmented, labor intensive, non-state dominated

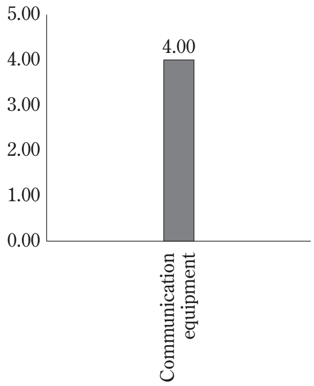

Figure 4 Fragmented, capital intensive, state dominated

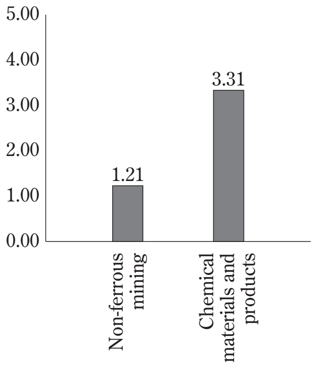

Figure 5 Fragmented, capital intensive, non-state dominated

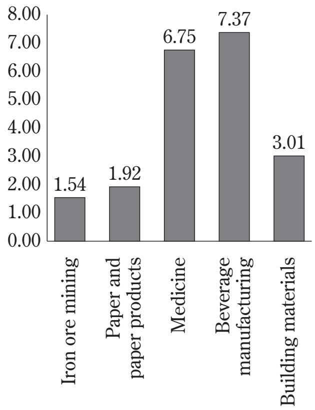

Figure 6 Fragmented, labor intensive, non-state dominated

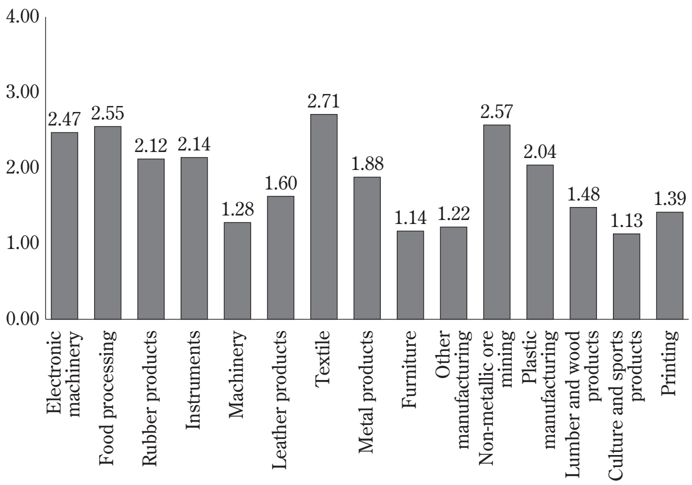

Table 9 The effect of mark-up ratios on TFP growth measurement (1993–2010)

(%)

Sector		Primal TFP growth			Re-calculated TFP growth		
		1993–2010	1993–2000	2000–2010	1993–2010	1993–2000	2000–2010
1	Coal mining	2.97	2.53	3.33	0.02	0.75	−0.57
2	Oil and gas mining	−3.73	−2.77	−4.49	−4.05	−2.97	−4.91
3	Iron ore mining	7.40	10.53	4.89	5.20	10.14	1.24
4	Non-ferrous mining	2.72	8.86	−2.19	1.79	8.71	−3.74
5	Non-metallic ore mining	−1.24	9.89	−10.14	−1.97	11.86	−13.03
6	Food processing	5.22	16.81	−4.04	3.33	16.89	−7.51
7	Beverage manufacturing	0.11	7.53	−5.82	−1.91	6.96	−9.00
8	Tobacco	−1.78	−3.25	−0.60	−1.94	−3.41	−0.76
9	Textile	1.40	11.47	−6.65	−0.41	9.55	−8.39
10	Leather products	6.45	17.69	−2.54	5.75	17.63	−3.76
11	Lumber and wood products	3.72	7.19	0.94	1.64	6.87	−2.54
12	Furniture	8.71	14.28	4.26	7.83	14.09	2.81
13	Paper and paper products	4.09	10.85	−1.32	2.15	10.04	−4.16
14	Printing	5.73	7.78	4.10	3.10	6.46	0.42
15	Culture and sports products	4.66	13.09	−2.08	4.29	13.43	−3.02
16	Petro refining	−6.60	−10.71	−3.31	−8.93	−12.15	−6.36
17	Chemical materials and products	2.89	8.67	−1.73	0.78	7.10	−4.27
18	Medicine	1.15	9.34	−5.40	−0.15	9.44	−7.82
19	Chemical fiber manufacturing	2.93	8.46	−1.49	2.41	8.38	−2.36
20	Rubber products	1.60	7.66	−3.25	−0.28	6.47	−5.67
21	Plastic manufacturing	6.41	15.64	−0.98	4.88	15.90	−3.93
22	Building materials	4.05	9.17	−0.05	−0.52	7.93	−7.28
23	Steel manufacturing	5.05	7.38	3.18	4.56	6.69	2.85
24	Non-ferrous manufcturing	3.12	9.96	−2.35	1.81	9.75	−4.54
25	Metal products	3.57	13.61	−4.46	1.25	12.90	−8.07
26	Machinery	5.42	12.92	−0.59	4.21	11.91	−1.94
27	Transport equipment	7.75	9.70	6.18	6.38	7.64	5.36
28	Electronic machinery	7.55	18.46	−1.17	7.06	17.98	−1.68
29	Communication equipment	7.42	22.76	−4.85	6.97	23.66	−6.39
30	Instruments	6.29	15.28	−0.90	4.85	14.47	−2.84
31	Other manufacturing	2.96	2.98	2.95	3.82	7.96	0.50
	Weighted average	4.22	10.62	−1.42	2.75	9.96	−3.50

Note: the rate reflects the average annual growth for the industry.

rates in the period of 1993–2010. In several industries, such as Building materials, Coal mining, Printing, Petro refining, Metal products, Chemical materials and products, Lumber and wood products, Beverage manufacturing, the percentage difference between primal TFP and recalculated TFP is over 2.0 percent point. It should be noticed that both of the primal TFP growth rate and the recalculated TFP growth rate suggest a slowdown in the period of 2000–2010, compared to previous period of 1993–2000.

5.2 Conclusions

This study's aim is to confirm if the market of Chinese manufacturing industry is perfect competitive, because 'perfect competitive' is a necessary condition for measuring TFP growth. The question is that in the real world, there are various interventions in product market or factor market given by governments, like the analysis on Chinese economy by World Bank and DRC (2013). Also, this study aims to test the degree of imperfect competition, say, mark-up ratio and recalculates the TFP with that index. As an attempt, based on the revised data on output and inputs, say, value-added, labor service, income and capital service, mark-up ratios for 31 sectors in manufacturing were estimated and several facts became clear. Before giving conclusions, it is important to emphasize that all examinations for my measurement of the gaps between price and marginal costs are based on the data constructed for output, inputs, wages and price index, which may cause bias of measure. The following is a summary of this measure.

(1) There is an evidence to suggest that the prices of outputs in general exceeded marginal costs across manufacturing industries in China, and the prices were almost as three times as marginal costs over the period of 1993–2010. This reflects two facts. One is that probably the rapid economic growth in the period created a good chance for firms to raise prices substantially more than what they pay. The other fact was that there were still too much barriers or hurdles to enter markets for most manufacturers.

(2) It is likely that the considerably high market power can be observed in assembly industries and material processing industries. This implies that there were too many obstacles for enterprises to join such industries engaged with processing products, such as Transport equipment, or the raw materials with much more machinery or equipment. In the contrast, consumer goods processing product market seemed to be in a condition to get closer with perfect competition. Meanwhile, the prices of energy products, such as the price of crude petroleum may be linked to the world market more easily.

(3) From a view point of industry structure, capital intensive industries in China's manufacturing was likely to be uncompetitive, may come from the large initial investment that make more hurdles to entry. Also, economies of scale may happen more easily in capital intensive industries due to the relatively big proportion of fixed asset.

(4) It is not to be found that mark-up ratios was clearly higher in SOEs dominated industries according to my estimation. This study found some of the non-state dominated markets show high degree of imperfect competition, such as some of consumer goods processing sectors.

(5) The recalculated TFP growth on average by removing the influence of mark-up ratios for each period shows 1.47 percet points higher than primal TFP growth rate that is based on the assumption of marginal productivity theory. More ever, the recalculated TFP growth rates over the period of 2000's in most of industries are suggested to decrease from the previous period. We can also reach this conclusion following the estimates of primal TFP growth rate.

(6) The results of recalculated TFP growth also provides the evidence of lower productivities in most energy industries and Tobacco, Beverage manufacturing, Medicine, Building materials and the evidence of higher productivities in most machinery and equipment manufacturing industries, and consumer goods processing industries.

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