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HOW HAS CHINA'S MARKET-ORIENTED REFORM AFFECTED REGIONAL PRODUCTIVITY PERFORMANCE IN INDUSTRY?*

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Abstract

(To be revised after the completion of the paper)
For a large and dynamic economy like China, it is important to understand the role of individual regions in the national economy. Along with the reform-induced marketisation and integration with the international economy, there have been on-going changes in factor costs and hence comparative advantages across regions, and interregional resource reallocations. A proper assessment of regional economies and their potentials relies essentially on an accurate measure of regional productivity. However, data problems, especially the lack of properly measured capital input (stock and services), has been a major obstacle to such an assessment.

In this study, we begin with a critical discussion of the problems in the official investment data. Then following the Jorgenson approach, for each major industry across regions, we firstly construct an alternative investment series, secondly, calculate its net capital stocks, and lastly estimate its capital services. The newly constructed capital input data is used in production function analysis to assess the effect of the reform on regional productivity disparities.

Results of this study show that, first, shares of industrial sectors in most regions became more diversified after 1993. Second, economic growth of China's industry was mainly investment-driven. Third, in 1985, there were large gaps of labour productivity between rich regions and poor regions. Remarkable catch-up effect happened in those less-developed regions. Fourth, most regions experienced positive TFP growth during 1985-2005 and achieved significant productivity improvement since 1993.

Key Words:

JEL Codes:

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I. Introduction

For a large and dynamic economy like China, it is important to understand the role of individual regions in the national economy. Along with the reform-induced marketisation and integration with the international economy, there have been on-going changes in factor costs and hence changes in comparative advantages across regions, and interregional resource reallocations. A proper assessment of regional economies and their potentials relies essentially on an accurate measure of regional productivity.

However, data problems, especially the lack of properly measured capital input (stock and services), has been a major obstacle to such an assessment. First, investment series in China's official statistics do not satisfy the definition of SNA. Chow (1993) points out that "Investment in fixed assets" refers to the "workload" of fixed asset investment activities in value terms instead of contract-based purchase transfer of fixed capital that can be put into production. In fact, some of these projects may take years to become qualified fixed assets or completely wasted. This phenomenon is quite typical in central planning economies and still true for SOEs or government direct involved investment in transitional economies. Nature of this problem is commented by Xu (1999) that Chinese official statistics on "investment in fixed assets" does not follow the SNA capital formation criterion that defines such investment as sales contract-based, complete ownership transfer from producers or constructors to users of capital goods. Second, depreciation rates adopted in China's industrial sectors are decided by government orders, and are widely criticized to be too low compared with experience of western market economy. Third, there is no detailed official information of fixed assets deflator by asset type. The only official fixed assets deflator is the "price index of fixed assets investment", and was not available before 1992. Fourth, official statistics is lack of information on residential structure except three industrial censuses in 1985, 1995 and 2004. This problem could be more serious to SOEs since most of them provide schools, hospitals and houses to their employees.

However, in earlier studies, mistakes are often made on problems discussed above. In measuring China's net capital stock, an often made mistake is direct use of official investment series in PIM exercise, such as Huang et al., 2002; Ho and Jorgenson, 2001; Young, 2000a; Hu and Khan, 1997; Li at el, 1992. On the other hand, choices of improper depreciation rates or deflators could significantly affect the estimated growth rate of capital stock, such as Chow (1993), Hu and Khan (1997) and Wu Y. (1999 and 2000). Moreover, directly employ the official GDP deflator in deflation of fixed assets investment, which may under-estimate the inflation. Chen et al., 1988a; Chow, 1993; Hu and Khan, 1997 simply adopt official depreciation rate.

Chen et al (1988a, 1988b) make the first effort to reconstruct investment series from the official original value of fixed assets and remove residential buildings. They also deflate each asset type by newly constructed fixed assets deflator. Then, further improvement was mainly made by Chow (1993) and Wu (2002b, 2007). Chow (1993) constructs his investment series following SNA standard. Wu (2002b, 2007) attempts to estimate net capital stock for China's industries, employing newly constructed investment series, depreciation rate and deflator.

In this study, we begin with a critical discussion of the problems in the official investment data. Then following the Jorgenson approach, for each major industry across regions, we firstly construct an alternative investment series, secondly, calculate its net capital stocks, and lastly estimate its capital services. The newly constructed capital input data are used in production function analysis to assess the effect of the reform on regional productivity disparities.

II. Problems of Official Investment Statistics

2.1 The official investment series

Refer to the model of PIM, the first thing we need to do is to standardize the value of I , the investment series. In the official statistics, there are usually two series published for us to derive the I . In the next, we will describe the two series official definitions. One major industrial investment indicator adopted by the National Bureau of Statistics (NBS) is the investment in fixed assets. According to definition by the NBS in the official website, the amount of investment in fixed assets refers to the volume of activities in construction and purchases of fixed assets in monetary terms. It is a comprehensive indicator which shows the size, pace, proportional relations and use orientation of the investment in fixed assets. According to China's current management system, the investment in fixed assets in the whole country can be classified by various methods. The most common used is decomposed into the following four parts: investment in capital construction, investment in innovation, investment in real estates development and other investment in fixed assets. The investment in fixed assets can also be classified by type of construction into new construction in general, expansion and reconstruction. Another classification is by structure, and the investment series are decomposed into construction and installation, purchase of equipment and instruments and other expenses.

We can also find another related indicator named "newly increased fixed assets". It is defined as the newly increased value of fixed assets through investment, including the value of projects completed and put into production, the value of equipment, tools, and vessels considered as fixed assets, as well as the relevant expenses as investment in fixed assets. This is a comprehensive indicator of investment in fixed assets, reflecting the achievements of investment in fixed assets in different periods, different sectors, and different regions.

The final purpose of this part is to derive the net capital stock that put into production and capital input. So, official capital stock series could be helpful. However, this is no concept of capital stock in Chinese official statistics. The related indicator we can find is the gross value of fixed assets. It refers to the money value by firms to construct, purchase, install, rebuild, expand, and improve fixed assets. It normally includes purchase cost, package cost, transportation cost and installation cost etc.

To derive net capital stock and capital input, accurate deflators and depreciation rate of fixed assets are necessary. For industrial sectors, there is one price indicator defined as "price index of investment in fixed assets". This indicator is classified into structure, equipment and installation these three parts. For depreciation rate, we can find two sets of indices respectively for structure and equipment in the official statistics.

2.2 Problems of the Official Fixed Capital Statistics

2.2.1 Chinese practice versus SNA – why official investment data are problematic

Measurement of capital input is one of the most important procedures in productivity assessment. However, there are several obstacles in official statistics for rigid measurement, thus may bias our adjustment of productivity of China's industry. The biggest difficulty is that Chinese official statistical authorities do not make standard capital stock estimation according to internationally accepted concepts, and available official data on fixed assets suffer from improper treatments to aggregation and depreciation, inconsistencies in industrial classification, and lack of information on prices (Wu, 2002). For regional level, there is even no detailed study on it. Reasons behind this are mainly in scant data and related information to carry out a study. Publication of regional data seems optional to the authorities, there is no systematic, continuous and standard data available for every province-level region in China statistics. Even we have previous experiences to solve the national level problems in deflator, depreciation and others; we still have more difficulties to adjust the deflator and depreciation rate to be suitable for every region. Except regional effect, ownership effect is also significant in China at this moment. The different performance and behaviour of SOEs and non-SOEs are very critical issue in China at this moment. Only a few studies had taken ownership into their database, mainly because of scant data. After we cross-classifying region with ownership, there will be much more missed gaps to fill. On the other hand, the data coverage of SOEs took some times' change during the past. This also makes current official statistics not compatible for vertical comparisons.

In China, investment data are generally divided into three categories, they are "structure", "equipment" and "others". The Chinese classification of type of asset is compatible with the 1993 SNA requirement, which breakdown the fixed assets into three categories – machinery and equipment, buildings and structures and other assets. Of course, there are other kinds of breakdown method according to study objectives. A work done by Ho, Jorgenson and Stiroh (1999) provided a kind of assets breakdown, which distinguished 5 broad asset types: high-tech equipment, low-tech equipment, non-residential structures, residential structures and consumers' durable. For this kind of division, they find that for the most recent period (1990-1996), capital quality change was almost completely due to substitution between the 5 distinguished assets and in particular towards high-tech capital. Except these, we can extend our asset types by transportation equipment, land, and inventories. However, we cannot arrive at this target at this moment with scarce data.

Dealing with the Chinese case, we firstly need to solve the problem of "others" investment. The definition of "others" investment is the expense that are necessary to do the work with the relation to the structure and installation projects and to the purchase of equipment. If let "others" be a single type of assets, it will be difficult for calculate its deflator and depreciation because it is composed by many kinds of expenses. To be simple and workable, we can reallocate the investment in others into structure and equipment according to their ratio. Then, the assets types we consider in this study are structure and equipment. But to be compatible with the international standard and satisfy the competitive market assumption of user cost theory, both of these two types of assets should be productive. In China, nearly half of investment of SOEs is for residential housing, including workers' houses, schools, hospitals and other kinds of facilities for living. This is because that under central control period, enterprises assumed all kinds of responsibilities to their employees. The role of an enterprise is not simply a factory, but a society. However, such inputs like housing, education and medical treatment are not directly for production purpose. They should be treated as part of labour compensation instead of capital input. So, we will delete this part in SOEs. For the enterprises of other kinds of legal form, for example, FFEs, they seemed have no the incentive to invest such non-profitable projects. For COEs, we can look them as not profit-seeking as SOEs, but most COEs' size are small and they can not get finance support from the central government. So, most of them do not have the liability and incentive to invest on residential structures. Compared with SOEs, we will not consider the problem of non-productive assets of non-SOEs.

2.2.2 Problems of data quality

Besides of conceptual problem, obstacles are also available in quality of official statistics. There are three sets of industrial classifications (CSIC) in China. One is developed during the central planning period (known as the 1972 industrial classification system). In this system, there are 15 industry branches. Wu (2002) commented about this CSIC System that under central planning, industries with a close vertical linkage were grouped together and controlled by a specialized ministry to facilitate the implementation of production plans (because such a linkage was a key in co-coordinating input and output in quantity in the absence of market). For example, the Ministry of Metallurgical Industry administratively controlled metallic mining, basic metals, and fabricated metals production. In 1984 China made its first effort to establish a modern industrial classification system to replace the 1972 CSIC System. The current or the 1994 CSIC System is a further improvement of the 1984 one and is largely compatible with the international standard. In both of these two systems, there are 40 industry branches. However, at this moment, there is no official information to help us link these three systems. The inconsistency in the CSIC Systems has caused great difficulties in the analysis of long-run productivity performance at industry branch level. As a result, we will meet 1984 and 1993 CSIC Systems in this study. To make our database workable and for long-term productivity performance analysis, it is necessary for us to overcome this inconsistency. The most frequently used method to solve this problem is by regrouping one or more industries into a larger one, for example, Huang, Ren and Liu (2002). They regrouped the manufacturing part into 15 branches, from 30. So, they can link the different CSIC Systems directly without any other information. In some other studies, such as Wu (2002), unpublished information is used to regroup 1984 and 1972 industry branches into the new industry branches in the 1994 CSIC System. However, this can only be done at national level. There is not any information can help us regroup them at regional level. Moreover, to be consistent and systematic, we need more than one year's information on regrouping method for every region. This already makes it nearly impossible for us to do so even this method is very rough to use one year's ratio to apply to other years. Under current situation, we can only adopt the first method. Our principle in this adjustment is to combine as few industry branches as possible. So, we employ the 25 IC (detail refer to appendix one) in this study. Using this classification, the number of industry branches is 25 instead of the official 40. Lastly, since the 25th sector in 25 IC is lumbering industry, we will not consider it, which means we finally get 24 sectors in this paper.

Except above issues, we also have one problem of data coverage in China. From the publications by NBS, we can see that the coverage of industrial data changed for one time during 1985 and 2003. The coverage used before 1998 for ATI is "industrial enterprises with independent accounting systems", for SOEs, the coverage is "state-owned enterprises with independent accounting systems". Beginning in 1998, the coverage for ATI is "all state-owned industrial enterprises and non-state-owned industrial enterprises above designated size". The designated size here means that annual sales income of this enterprise should be over 5 million. For SOEs, the coverage used is "state-owned or controlling share hold industrial enterprises". There are two kinds of controlling share hold. One is the country hold not less than 50% of the company; second is that the country is the largest share holder. Under both circumstances, the country can control this company. Such enterprises are also treated as SOEs.

From the change of coverage in 1998, we can see the structure and policy changes to the Chinese enterprises. The central government tried to only maintain those important, large and medium sized SOEs and transfer the others to non-state-owned. For some of the maintained SOEs, part of their ownership is sold to the public by share-holding system reform, including being listed. Of course, this change cannot be achieved in one year. So, there must be a gap between 1997 and 1998 especially for SOEs. For ATI, the coverage seems changed not so significant, only add one requirement about annul sales volume. For SOEs, the state-controlled enterprises are added in from 1998, this may enlarge the coverage of this part. But we can say that the ratio of such state-controlled enterprises is very small, it will not make the gap between 1997 and 1998 very significant. Also from the data of 1997 and 1998, the annual growth is relatively smooth. On the other hand, to fill this gap, we need the progress at national level to provide us more information about state-controlled enterprises before 1998. So, in this study, we will just follow the coverage by NBS.

III. Construction of net capital stock, working hours and output

3.1 Construction of net capital stock

The net capital stock data is constructed by following steps; first, the gross stock data is reclassified into 25 sectors. The data is cross-classified by region and ownership type. Second, gaps are filled and controlled by data published by DITS. Thirdly, calculate the gross flow of fixed assets which is the difference of connected two years' gross value of fixed assets. Fourthly, the gross flow of fixed assets is deflated by regional deflator. Fifthly, last years' net capital stock is depreciated by our sectoral depreciation rate and plus current year's deflated flow of fixed assets, employing the PIM.

For price index, we also try to differentiate regions for structure. Structure cannot be traded cross regions. So, it is affected by local price level much more significant than equipment. We can find two systematic related regional price indices from CSY, one is the provincial consumer price index of every year, and the second is the provincial investment price index of structure for year 1990-2005. The second one is exactly what we need. However, we have to estimate the index for year 1985-1989 with the help with regional CPI and Wu's national price index of structure. We regress the national CPI on Wu's index to find the relation between these two indices. Then, we apply this relation to every region's CPI to get the regional price index of structure.

For price index of equipment of Wu (2002), it is classified by 39 industry branches. We use geometric means to transfer it into 25 industry branches.

In this study, the national level depreciation rate is based on Wu's work in 2002. Wu's depreciation rate index is for 38 industry branches, and cross-classified by asset type. For different regions, the data from the CSY (1999) is employed for additional information. This series provide us the information of industrial depreciation of different regions. However, it is only for year 1991-1998, and not cross-classified by industry branch and asset type. Combing these two series, we can get a rough regional depreciation rate series. First, we reclassify Wu's depreciation rate into 25 industry branches. We use geometric mean for industry branch composition. Next, we calculate the weight of every region, denoted by j, to the country, which is the geometric mean of all the regions. Then we time this weight with the national depreciation of different asset types, k, and industry branches, j, we can get the regional depreciation rate by sector and asset types.

3.2 Construction of gross value added

The SNA was launched and followed by the regional statistical bureau since 1993. So, we can only get GVA series of the period from 1993 to 2005. To solve this problem, we first employed the data from "*Compilation of 50 Years Statistics of China*" to get the officially estimated regional total of GVA. However, the classification of this part of data is of all the industry instead of "industrial enterprises with independent accounting systems". We adjusted the official data with information of 1993 to satisfy our classification. Then, we decompose the regional GVA into industrial branches by the regional GVA/GVO ratio of 1993. This part of estimation is very rough but the best we can do with limitations of raw data.

As the second step, sectors are regrouped to make the whole time series consistent throughout the period of 1985-2005 since the CSIC was changed in 1993. The 40 pre-1993 and 40 post-1993 industrial sectors are composed into 25. Reclassification method is same as the approached used in dealing with capital and labour data, so it will not be discussed in detail.

The third step is to reconcile the output deflators. The GVO in comparable prices cannot be used as constant-prices GVO because that during the period of 1985-2005, there are two official benchmark years of the comparable price system, respectively 1980 price and 1990 price. To make the two intervals (1985-1989, 1990-2005) comparable, 1990 is chosen as the base year in this study since it covers longer period (1990-2005). There is also information on 1990 with both 1980 prices and 1990 prices, which can be used to change the 1985-1989 GVO in 1980 prices to 1990 prices. Denote 1990's GOV in 1990 prices as Y_{1990}^{1990}, 1990's GVO in 1980 prices as Y_{1990}^{1980}, year between 1985 and 1989's GVO in 1980 prices as Y_{1990-n}^{1980}, $n \leq 5$ in this study. Then the pre-1990' annual GVO in 1990 prices, Y_{1990-n}^{1990} will be,

(1) $$Y_{1990-n}^{1990} = Y_{1990-n}^{1980} \times \frac{Y_{1990}^{1990}}{Y_{1990}^{1980}}$$

There could be one problem that the products and each product's weight could be different between these two price systems. However, this approach is the best we can do with available information.

A set of output deflator is needed to construct GVA in constant prices. In the last step, GVO in 1990 prices of 1985-2005 has been constructed. Then the output deflator for year t, y_t is derived as,

(2) $$p_t = \frac{Y_t^c}{Y_t}$$

Fourthly, with the derived output deflator and GVA in current prices, GVA in constant prices, V_t^c can be estimated as,

(3) $$V_t^c = p_t \times V_t$$

It should be pointed out that by this approach, single deflator is employed. Related problems have been discussed above.

Fifthly, since this study is on sectoral level, gross output based productivity measurement is employed based on Jorgenson's argument. The intermediate input series in constant prices are necessary in this measurement. With GVO and estimated GDP in constant prices, the intermediate input, X_t can be derived as,

(4) $$X_t = Y_t^c - V_t^c$$

3.3 Construction of labour input

There are three major steps in constructing labour input. First is to transfer the quantity of labour into working hours. The yearly average working hour on nation level is employed. This index is cross-classified by sectors and ownership types. It is assumed that there is no regional difference here. The second step is to calculate the regional labour compensation ratio. This ratio is mainly based on the national data and adjusted by available regional information from the "China labour statistical yearbook". This study will only consider the working hours and sectoral average wage ratio to calculate the compensation ratio. The third step in constructing data on labour input for 24 sectors is to combine price and quantity data, into price and quantity indexes of labour input. To construct an index of labour input for each sector, we express sectoral labour input, say, L_i as a translog function of its components, say, L_{ji}. The corresponding index of sectoral labour input is a translog quantity index of individual labour inputs:

(5) $$d \ln L_t = \sum_l \bar{v}_{Llt} d \ln L_{lt}$$

IV. Methodology for Estimation of Regional Production Function

4.1 Production function

In 1957, Rober Solow publish a seminal paper on a production function describes how inputs such as bulldozers, semiconductors, engineers, and steel-workers combine to produce output. Inputs are grouped into two categories, capital, K and labour, L. If output is denoted as Y, the production function is assumed to have the Cobb-Douglas form and is given by

(6) $$Y = F(K, L) = K^{\alpha} L^{1-\alpha},$$

Where α is some number between 0 and 1 and it gives the output elasticity of capital.

(7) $$\varepsilon_{YK} = \frac{K}{Y}\frac{dY}{dK} = \alpha$$

Notice that this production function exhibits constant return to scale: if all of the inputs are doubled, output will exactly double.

If we consider technology improvement and not assume a constant return to scale, the formula will be:

(8) $$Y_t = AK_t^{\alpha} L_t^{\beta},$$

Taking logs of both sides, we get,

(9) $$\ln(Y_t) = \ln(A_t) + \alpha \ln(K_t) + \beta \ln(L_t)$$

Respectively, α and β are output elasticity of capital and labour. This is the production function in levels and can be estimated directly by regressing $\ln(Y_t)$ on $\ln(K_t)$ and $\ln(L_t)$.

Alternatively, with total (logarithmic) differentiation and then a little mathematical rearrangement of Equation (1), we could get the famous Solow residual:

(10) $$\frac{\dot{A}_t}{A_t} = \frac{\dot{Y}_t}{Y_t} - \frac{\partial Y}{\partial K}\frac{K_t}{Y_t}\frac{\dot{K}_t}{K_t} - \frac{\partial Y}{\partial L}\frac{L_t}{Y_t}\frac{\dot{L}_t}{L_t}.$$

$(\partial Y / \partial K)(K_t / Y_t)$ and $(\partial Y / \partial L)(L_t / Y_t)$ are the output elasticities of capital and labour, i.e. α and β as given in (1), respectively. By imposing perfect competition and constant returns to scale production technology, index number approach uses data on labour compensation from national accounts to get the factor share, which is equivalent to the output elasticity with respect to labour under the above assumptions.

4.2 Jorgenson's translog framework

Jorgenson (1973) provides a framework of measuring productivity with translog approach. The index of productivity is represented by A_{jt}. It is assumed that the function is separable in such a way that the various types of capital, labour and intermediate inputs may be aggregated into indices K_{jt}, L_{jt} and Z_{jt} respectively, so we may write the production function as:

(11) $$Y_{jt} = A_{jt} f(K_{jt}, L_{jt}, Z_{jt})$$

The index of capital input is aggregated from two types of assets, structures and equipment. The labour input is an aggregate of the number of workers cross classified by sex, age, and educational attainment.

We assume that (6) is described by a translog form so the index of technology may be derived from:

(12) $$d\ln Y_{jt} = \bar{v}_{Kjt} d\ln K_{jt} + \bar{v}_{Ljt} d\ln L_{jt} + \bar{v}_{Zjt} d\ln Z_{jt} + d\ln A_{jt}$$

Where $d\ln Y_{jt} = \ln Y_{jt} - \ln Y_{jt-1}$, and the $\bar{v}$'s is the two-period average share of the subscripted input in nominal gross output:

(13) $$\bar{v}_{Kjt} = \tfrac{1}{2}(v_{Kjt} + v_{Kjt-1})$$

$$v_{Kjt} = \frac{P_{Kjt} K_{jt}}{P_{Yjt} Y_{jt}}$$

$$v_{Ljt} = \frac{P_{Ljt} L_{jt}}{P_{Yjt} Y_{jt}}$$

$$V_{Zjt} = \frac{P_{Zjt} Z_{jt}}{P_{Yjt} Y_{jt}}$$

The P s denote the prices, P_{Yjt} is the output price to the producer (factory gate price less taxes), P_{Kjt} is the rental price of capital, and P_{Ljt} is the price of labour input. The value of capital input is calculated such that the value of inputs equals the value of output:

4.3 Estimation of capital input

In Jorgenson (1973), the rental price of one asset was expressed as,

(14) $$P_t^K = P_{t-1} r_t + \delta P_t - (P_t - P_{t-1})$$

where P_t^K is the rental price, P_t is the price of this asset at time t, r_t is rate of return at time t, δ is the geometric depreciation rate.

For the aggregation of capital services over different asset types, it is assumed that aggregate services K_t are a translog function of the services of individual assets K_k^t .

(15) $$\ln K_t - \ln K_{t-1} = \sum_k v_k (\ln K_k^t - \ln K_k^{t-1})$$

k = (equipment, structure)

where $v_k = \frac{1}{2}(v_k^t + v_k^{t-1})$, and $v_k^t = \frac{P_k^t K_k^t}{\sum_k P_k^t K_k^t}$. With this translog, the weight for each asset type V_k depends on the common rate of return and an asset specific rate of depreciation. This characteristic differ Jorgenson's model from those with simple linear aggregation.

The flow of capital service of each of the components of capital input $K_{ki}(T)$ is proportional to capital stock, say $A_{ki}(T-1)$:

(16) $$K_{ki}(T) = Q_{Kk}^i A_{ki}(T-1),$$

The constants of proportionality Q_{Kk}^i transform capital stock into a flow of capital services. The translog quantity indices of sectoral capital input K_i can be expressed in terms of their components K_{ki} or in terms of the components of sectoral capital stock A_{ki} :

(17) $$\ln K_i(T) - \ln K_i(T-1) = \sum \bar{v}_{Kk}^i \ \ln A_{ki}(T-1) - \ln A_{ki}(T-2)$$

We can define sectoral capital stock, say $A_i(T-1)$, as the unweighted sum of its components:

(18) $$A_i(T-1) = \sum A_{ki}(T-1)$$

Similarly, we can define sectoral indices of the quality of capital stock, say $Q_K^i(T)$, that transform sectoral measures of capital stock into the translog indices of capital input:

(19) $$K_k(T) = Q_K^i(T) \cdot A_k(T-1),$$

The sectoral indices of the quality of capital stock can be expressed in the form

(20) $$\ln Q_K^i(T) - \ln Q_K^i(T-1) = \sum \bar{v}_{Kk}^i \ \ln A_{ki}(T-1) - \ln A_{ki}(T-2) - \ln A_{ki}(T-1) - \ln A_{ki}(T-2)$$

These indices reflect changes in the composition of capital stock within each sector. Sectoral capital quality remains unchanged if all components of capital stock within a sector are growing at the same rate. Sectoral quality rises if components with higher flows of capital input per unit of capital stock growing more rapidly. Quality falls if components with lower flows per unit are growing more rapidly.

4.3.1 Sectoral capital property compensation for 1985-2005

IO tables are employed in the estimation process. Now, we have three comprehensive IO tables of 1987, 1992 and 1997; two less comprehensive IO tables of 1990 and 1995. For regional estimation, we have two incomplete IO tables of 1987 and 1997. IO tables of 1987, 1992 and 1997 are in detailed industrial classification, which can be reconciled with 25 IC properly. For the year of 1990 and 1995, we need assume that the growth pattern of capital input is stable. In the IO tables, there are value-added and labor compensation; we subtract the labor compensation from sectoral value-added to obtain the capital property compensation. Then, we link the five points using arithmetic means. The time series we get is from 1985 to 2005.

4.3.2 Sectoral capital input

For the calculation of rate of return, in the formula $P_t^K = P_{t-1}r_t + \delta P_t - (P_t - P_{t-1})$, we need sectoral depreciation rate δ and price P, we are following the relationship that

$$\delta = \frac{\sum \delta_k A_k}{A} \text{ and}$$

$$P = \frac{\sum P_k A_k}{A}$$

With capital compensation and net capital stock A, we can get the sectoral rental price P_K^t, $P_K^t = \frac{VK_i^t}{A_i^{t-1}}$,

where VK_i^t is the capital compensation. Then we put the sectoral rental price into the formula of rental price, we get the sectoral rate of return by equation

(21) $$r_t = \frac{P_t^K - \delta P_t + (P_t - P_{t-1})}{P_{t-1}}$$

With rate of return, depreciation rate, price of respective structure and equipment, we can get rental prices by asset type with equation (14). The assumption here is that the rate of return of each asset type is the same.

Finally, we can calculate the rate of growth of sectoral capital input ($\frac{K_t}{K_{t-1}} - 1$) with Jorgenson's translog function

(22) $$\ln K_t - \ln K_{t-1} = \sum_k v_k (\ln K_k^t - \ln K_k^{t-1})$$

For the detailed calculation of v_k and rate of growth of sectoral capital input, we take $K_k^t = A_k^{t-1}$, and $\sum_k P_k^t K_k^t = VK_t$ for the calculation of V_k.

V. Regional TFP performance of industry in China

6.1 Regional industries in the national economy

Before any discussion, it is necessary to show the position of the regions covered this study in the national industrial economy. As shown in Figure 1, the industrial sector played the most important role in the economy during the post-reform period. The sectoral shares in GDP are measured at current prices. It is clear that over this period, the industrial share remained largest and grew steadily. Annual statistics by NBS do not provide sufficient information on the whole industrial economy. In this study, raw data comes from the DITS department of NBS. Statistics of DITS cannot fully cover the whole industrial economy, but the majority part. Taking year 2005 as example, statistics by DITS on “at or above the designated size enterprises” accounted for 93.86% of the whole industrial economy of GVA.

Due to data problem, we have dropped five small provinces in this study, namely Hainan, Gansu, Qinghai, Ningxia and Tibet. Except Hainan, they all located in the west of China. As shown in Table 1, their share in the national industrial economy is insignificant. Based on the statistics from NBS and using the DITS definition, the 25 regions covered in this study always accounted for 95% of gross value of output (GVO), original value of fixed assets and employment in the national industrial economy over the two decades since 1985.

TABLE 1: WEIGHT OF STUDIED REGIONS IN THE NATIONAL INDUSTRIAL ECONOMY

Weight of studied regions in the national industrial economy (%)			
	1985	1995	2005
Gross value-added in current prices	n.a	97.7	98.4
Gross value of output in current prices	98.1	98.5	98.6
Original value of fixed assets	95.4	96.9	98.6
Number of workers and employees	94.7	97.8	98.2

Source: NBS, Industry chapter of “China statistical yearbook various years”.

To quantify the coverage of our study, we can take 2005’s current-price GVA as the benchmark. Coverage by this study accounts for 92.39% of Chinese industry, or 38.8% of national GDP. So, coverage of this research is able to basically meet the requirement to reflect the performance of Chinese industry and the whole economy.

Within the selected regions, their shares of GVA in current prices in the cross-regional total are shown by Table 2. From the results, east regions often have larger shares than those in the middle and west of China. Regional structure changed over the time period, because of kinds of reasons. In the next section, we are going to discuss the industrial structure changes in detail.

6.2 Changes of industrial structures in economic development

To discuss productivity growth of Chinese industry, it is better to understand the industrial reform and its influence first. There are two major stages during the period of 1985-2005. The first stage should be traced to 1978’s economic reform. During 1978-1985, SOEs are granted more autonomy and profit retention. Moreover, prices were released at the margin though introduction of double-track price system. Besides these major policy changes, there are also related establishment such as special economic zones. However, without whole set of market mechanism, factor prices were still under control by government instructions. Flow of capital and labour across regions was very difficult. Market cannot take the role of resource allocation. On firm level, with soft-budget constrain, SOEs got no incentive to improve productivity. The second stage of reform during 1994-2005 was mainly market oriented. At the end of 1993, "socialist market economy" was adopted by the Third Plenary Meeting of the Fourteenth Central Committee of the Communist Party of China. This meeting for the first time removed the ideological barrier to develop market system in China. Following the promotion of the "socialist market economy", small and medium-sized SOEs, collective enterprises and rural enterprises were gradually privatized. Factor prices were also released step by step. Flows of capital and labour became possible. Without control of business banks by local government, unsuccessful firms were exiting the market. Enterprises were incented to improve productivity to survive in the market. After China's entering WTO, more FDI was attracted by favourable conditions of government. Brought by FDI, quality of capital input and labour input were improved. These caused China's industrial economy expanded substantially during the second stage of economic reform.

If treated as individual economy, one region's industrial structure can reflect this region's characteristics in economic growth and its resources endowment. However, during central planning era, capital and labour flows across regions were under control by the government. Markets are protected and segmented by local government with fiscal and employment consideration. Comparative advantage cannot be utilized since production was planned by the government. Under free market situation, a sector is expected to grow faster in the regions that can enjoy comparative advantages than in other regions. On the other hand, competitive sectors can attract more investment and labour flow-in to continuously support its quick growth.

Based on above discussions, it can be expected that after the 1993 industrial reform, sectoral performance of difference regions should be more diversified. With less price distortions and local protectionism, sectors with comparative advantages are expected to perform better.

6.2.1 Regional structure during pre-reform period

Before the 1993's industrial reform, there are several major distortions in the market. These distortions are going to be discussed one by one in the following. First is tight control on prices by the governments. Though double-track price system was introduced, prices were only released at the margin. Under this situation, products' prices were still seriously distorted. This pricing barrier was set by the government through policy instruction of pricing, taxing of export and import, local market protection and also due to incomplete market mechanism. SOEs were major producer in the market, so, with close connection between SOEs and governments, this price barrier was workable during pre-reform period. For production factor, resources allocation aimed at national plans to serve political agenda ignoring market conditions, hence distorting factor costs.

Second, local markets were segmented by local government with fiscal and employment considerations. Under market barrier, free flow of capital and labour were difficult. Successful firms cannot grow up quick though expansion their market; on the other hand, unsuccessful firms can keep surviving with market protection. There was little competition among one sector's firms in different regions. Shown by calculation results in Table 2, structures of local economies were very close to the nation for most regions. Except some regions that need to take the role of resources provider, like Xinjiang, Shanxi, Guizhou and Yunnan, most regions' variation of sectoral shares were very small to the cross-regional mean.

Third, bank loans need to follow local governments' instruction. So, unsuccessful enterprises were kept surviving, without incentive for improvement. This made productivity growth very slow during pre-reform period, as shown in Table 3. With quickly growth of labour productivity, TFP growth was very slow within 1985-1993, which means economic development during this period was mainly driven by capital input and intermediate input.

6.2.2 Expectations of sectoral restructuring during post-reform period

Industrial reform in 1993 aimed to remove barriers in the market, including prices distortion and local protection, and release enterprises from government control through changing share-holding or form of ownership, except some strategic sectors. With "piecemeal" approach of reform, performance of industrial firms was significantly diversified due to different policies and how they were implemented. On the other hand, initial conditions were different for different sectors because of the heritages of state policies during the central planning ear. Moreover, the "piecemeal" approach implies that different policy treatments could be introduced to different sectors at various stages, which also mean that exposuring to foreign trade, investment and competition were different across sectors, time periods and regions. This made situation in post-reform period very complex. To clearly understand influence of the reform, it is necessary to discuss on sectoral level and regional level. To make discussion simple, manufacturing sectors can be composed into capital goods which is capital-intensive heavy industry, consumer goods which is labour-intensive light industry and material sectors which is energy and resources intensive.

First, after the 1993's industrial reform, performance of different sectors in different regions should be more diversified. With different resources endowment, sectors that have comparative advantages are expected to perform better than the others. Local governments were loosing control over industrial firms and banks. Sectoral structure of regions would depend more on the market instead of political consideration. As discussed in section 7.21, sectoral structure during pre-reform period was designed by the government. Except a few sectors in some regions that had the responsibility to cooperate with strategies of the nation, others' industrial structures were very close to national structure. Target of this policy was autarky of each region. After the reform, policy instructions on industrial development continuously decreased. Under different resources endowment, deviation of sectoral shares is expected to increase.

Second, sectors with comparative advantages should be able to perform better in one region, which means shares of these sectors are expected to increase. In contrast, sectors that depended on policy loans to survive were difficult to make quick growth during post-reform period. Their shares in the whole industry were expected to decrease.

Third, with released control of capital and labour shift, sectors are expected to attract more investment and employment in the regions that can enjoy comparative advantage.

6.2.3 Regional restructuring during post-reform period

One result of industrial reform is that sectoral structure of regions is expected to be deviated from the nation. According to the results, nearly all the standard deviations of R/N ratio continuously rise, especially after 1993. Compared to output and net capital stock, labour's change is not so significant.

Xinjiang's deviation is the largest in all the regions since its special characteristics. Xinjiang is in the north-west of China and endowed with plentiful oil and gas resources. So, Xinjiang is expected to be very competitive in extraction of oil and gas industry and petroleum industry. However, as shown by the result, Xinjiang's R/N ratio of petroleum industry dropped from 2.34 to 2.02 during 1985-1992 and nearly no change of extraction of oil and gas industry's R/N ratio. Comparative advantage was not utilized before the industrial reform. Since 1993, Xinjiang's advantage in oil and gas extraction, petroleum industry began to be realized quickly. In 2005, its R/N ratio was respectively 51.3 and 12.08 of these two sectors. Moreover, due to Xinjiang's geographic position that is too far from the market, it is very difficult for Xinjiang to develop light industries as those east regions. Those two reasons make Xinjiang's R/N ratio continuous to be very high. It can be found from the results that most middle and west regions that with natural resources have the same situation with Xinjiang, like Yunnan, Guizhou, Shanxi and Shaanxi. These regions acted the role of material and energy suppliers to factories located in the east regions in the central planning era. After the industrial reform, they began to utilize their advantage of mineral resources and develop related resources processing industries quickly.

Stories are different to those more-developed regions in the east or middle of China. These regions normally developed as a complete economy during the central planning era. As shown by the results, these regions' R/N ratios were very close to 1 during 1985-1992. Since 1993, nearly all regions' R/N ratios raised, however, the growth is not so significant. This can be explained that, first, characteristics of these regions are very close. Second, local markets were still segmented due to protectionism and local governments' fiscal and employment consideration. Third, there is only 12 years during the 1993-2005, that is not long enough for enterprises to fully utilize local comparative advantage.

From the discussion above, production distribution of different sectors before the industrial reform was mainly planned by the central and local governments. Some regions took the role of resources suppliers to serve the country's strategy. The others that without such tasks normally had very close industrial structures. Comparative advantages cannot be utilized under this condition due to local markets were segmented by governments to protect local employment and fiscal income. Since the 1993's industrial reform, local governments gradually lost the control of enterprises and cannot continue to instruct policy loans to unsuccessful firms. Without help from local government, some firms or sectors that have no comparative advantages in the market became difficult to survive. Moreover, local government also gradually lost the power of market protection. This made products from other regions easier to enter into the market. So, both reasons caused the deviation of regional industrial structure bigger from the national.

6.2.4 Structural change of capital goods sectors

For capital intensive sectors, they are heavily dependent on capital, technology and skilled labour. During reform period, they are expected to grow faster of in post-reform period, with more investment embodied with technology, more FDI since China's entering into WTO and more skilled labour. For machinery, the indices of value-added in constant prices (Y), net capital stock (K) and working hours (L) are shown in Figure 2. With slow capital and negative labour growth, machinery's output grew quickly during 1985-2005. There are two periods that machinery experienced quick growth, respectively 1990-1997, and 2002-2005. The slope of growth rate became even sharper since 2003. Just as expected, efficiency of machinery grew very fast. Apparently, growth of Y/L is much quicker than K/L. In the next assessment of TFP, it is expected that machinery can achieve fast growth.

At regional perspective, released capital and labour flow across regions and sectors will lead to better performance in regions with comparative advantage. Table 4 is the share of machinery & equipment in local economies. Taking machinery as example of capital and energy intensive heavy industry, we can see that in 1985, Shaanxi, Shanghai, Henan, Liaoning and Inner Mongolia are the top five of compared with cross-regional mean (R/N ratio). In these five regions, Shanghai and Liaoning are the most important traditional industry bases in China. Shaanxi, Henna and Inner Mongolia are safer places for heavy industry with strategic consideration. In 1993, the top five are Inner Mongolia, Liaoning, Jiangsu, Henan and Tianjin. In 2005, the top five are Shaanxi, Shanghai, Liaoning, Shandong and Jiangsu. From the results, there is no big change of Shaanxi, Shanghai and Liaoning's performance of machinery industry. Better infrastructure of heavy industry had made them more competitive. Jiangsu and Shandong, with more capital resource, grew faster than the others. Because of higher entrance requirement of capital, most large-scale investments are from SOEs or the government, different from private investment, they have more political and fiscal consideration. So, distribution change of machinery industry is slower than light industries. One more interesting point is Shaanxi's case. In 1994, Shaanxi's R/N ratio continuously dropped to the lowest 1.02, and then gradually increased to 2005's 1.75. This means that Shaanxi does have comparative advantage in developing machinery industry. However, before the industrial reform, the advantage was not well utilized. Higher growth rate means this sector in the studied region grows faster than cross-regional mean. So, better performance is expected since the policy break in 1993 especially industrial conglomeration to the region that with comparative advantages.

However, looking at the level of shares of machinery in the whole industrial economy, it continuously dropped during 1985-2005. It is the same with every local economy. Benefit from growing ability of domestic investment and more FDI, growth of this sector was still slower than the cross-sector mean. It is necessary to question whether these advantages had been well utilized. Due to high entrance cost, this sector was dominated by SOEs for a long time during post-reform period. On the other hand, some sub-sectors of machinery are treated as strategic industries, so, FDI and private capital are prohibited. Moreover, machinery is the traditional heavy industry in China with military consideration. Major firms encountered kinds of difficulties in the reform process. Historical burdens such as redundant employees, heavy social responsibility, too close relationship with local government were all obstacles to further growth of this sector. At the same time, to unsuccessful firms, they need longer time and higher cost to exit. But, since Chinese economy has entered into the stage of heavy industry, with quick market orientation and productivity growth, machinery is expected to expand faster than before. Shown by the Figure 6, since 2000, rebound has happened after China's entering WTO. It is certainly that this rebound does not depend on policy favour, but the comparative advantage of this sector than the others in contemporary Chinese economy.

6.2.5 Structural change of consumer goods sectors

Consumer goods sectors often appear to be labour-intensive. With cheap labour cost, China is very competitive in these sectors, such as textile. However, from Figure 2, it can be found that growth of textile was almost investment-driven, especially before 1999. If one firm can enjoy profit just from exploiting cheap labour resources, it will loose incentive to improve efficiency, just like what happened during the 1980s and 1990s of China. Since year 2000, China was loosing her comparative advantage of cheap labour cost, investment growth become much slower. However, output experienced fastest growth during 2000-2005. This means that growth pattern in the 2000s of textile had been mainly driven by productivity growth instead of capital input. Then, it is interesting to discuss the reasons of the growth pattern change. The change can be caused by several reasons. First, with increasing labour cost, firms were pushed to survive through productivity improvement. Second, with years of wealth accumulation, firms were able to replace equipment embodied with higher technology, thus increase output by higher quality of capital input. Third, under quickly growing scale of textile industry in China, keen competition drove firms to improve efficiency. Fourth, quality of FDI since China's entering into WTO was better than before. In the earlier stage of reform, production lines were moved to China from other east-Asia regions that with higher labour cost. These firms only aimed to exploiting China's low cost advantage, and their products were mainly for export. So, incentive was very low for these firms to keep improving efficiency. If labour cost rose or foreign market depress, they will just move to other regions of China or other countries, or just exit the sector. As shown in the Figure 2, growth of net capital stock during 1997-2000 appeared to be negative, which means FDI in the earlier stage of reform had been leaving from China. In contrast, FDI after 2000 aimed at domestic market of China instead of export. They cannot lower their cost just through moving around, but to continuously improve productivity and efficiency.

Compared with machinery, market of textile is more open and with less policy distortions. However, there is no evidence show that textile had achieved better performance in productivity improvement. Scale of production did expand for both sectors, but growth of machinery looks more health. Ignoring policy effects, different purposes of FDI and market condition can bring significant different results of productivity performance.

On regional level, shown by Table 5, the five regions with highest R/N ratio are Jiangsu, Zhejiang, Shandong, Hebei and Shaanxi in 1985, and Zhejiang, Jiangsu, Xinjiang, Shandong and Hubei in 1993, and Heilongjiang, Zhejiang, Henan, Jiangsu and Shandong in 2005. Jiangsu, Zhejiang and Shandong are traditional textile zones in China. However, though with better infrastructure, they have no advantage in labour cost, which is very important to textile industry. Since the industrial reform, we can see that the canter of textile production is moving from the east to middle regions, where have much more labour resources. In Heilongjiang, many workers were released by SOEs in the late 1990s, which caused a large number of labour resources. Henan is the province with largest population in middle China. Local labour cost is much lower than the east. Zhejiang still performs very well in the post-reform era since its active private investment and better export condition than the others. Jiangsu and Shandong's situation is close to Zhejiang. Their production of textile is also export-driven compared with middle regions.

It also needs to be pointed out that, shares of capital and labour significantly dropped during 1985-2005, especially after 1993 for nearly all the regions. This means that the importance of textile continuously decrease in Chinese economy. Compared with output, capital and labour's share are smaller. It means that productivity of textile is relatively higher than the industrial mean. However, keen competition due to low entrance cost had reduced profitability and attractiveness of this industry.

6.2.6 Structural change of material sectors

Another typical kind of industry in China is material, which is energy and resource intensive, often brings serious pollution. Taking chemicals & allied products as example, we can see its performance on the national level first. Shown by Figure 2, its growth was even faster than machinery. It can be found that output growth was mainly pulled by investment during 1990s, and productivity growth during 2000s. Compared with machinery and textile industry, chemicals' market is more open than machinery, and higher entrance cost than textile. These two characteristics made its performance better than the other two. However, it needs to be pointed out that, material sectors are often energy and resources intensive, with serious pollutions. Quick growth of these sectors does not mean improvement of welfare of the whole society. Under high labour productivity, it is necessary to improve efficiency of energy and resources consumption. Proper government policy guide seems not enough during the past twenty years.

On regional level, according to Table 6, shares of Y, K and L kept steady during 1985-2005. However, regional shares change was very significant. On regional level, Beijing, Jilin, Tianjin, Shanghai and Hunan are the top five of R/N ratio in 1985. Jilin, Jiangsu, Hunan, Hebei and Shanghai are the top five in 1993. Guizhou, Jilin, Zhejiang, Yunnan and Jiangxi became the top five in 2005. From the results, in 1985, chemistry industry distribute in the most industrialized regions, like the three municipalities. After 1993, some west and middle regions that with more natural resources grew much faster in chemistry, like Guizhou, Yunnan and Jiangxi. Jilin is close to oil resources and with better infrastructure, so its growth in chemistry industry continues to be faster than the national mean. Zhejiang also grew very fast from the industrial reform. Since 1993, China's net import of raw oil became positive in this year. With geographic advantage, Zhejiang improves quickly in oil processing and related sectors. It also needs to be pointed out that the cost of pollution in China is comparatively low, especially in the less-developed regions. So, these regions actually have more advantages in developing energy and resource intensive industry.

From above discussion, share of chemicals & allied products kept steady during 1985-2005 in the whole economy. However, it experienced regional transfer during this period, from more-developed regions to less-developed regions, and from the east to the west of China. This shift was driven by several reasons. First, firms moved to the places that close to resources. Most natural resources in China are distributed in the west. As an exception, though Shandong is in east China, it is close to oil resource.

Second, pollution cost is much lower in the west of China. As discussed above, energy and resources intensive sectors often bring serious pollution problems. So, after years of development, east regions began to resist such sectors for environmental and industrial structure upgrade consideration. Third, after the industrial reform, capital and labour flow across regions were much easier, but west regions can only attract investment to these energy and resources intensive sectors with incomplete infrastructure.

6.3 Levels of labour productivity and capital deepness

Before discussing regional TFP growth, it is essential to understand the actual level of one region's productivity and its status in the country. In this section, sectoral labour productivity and capital-labour ratio are employed to roughly represent the comparable level of productivity.

6.3.1 Regional labour productivity

As discussed in the research methodology, the ratio of output over labour input is one approach to measure partial productivity. In this measurement, both variables are in constant prices. We can take Shanghai as example of rich region and Inner Mongolia as example of poor region in China.

Referring to Figure 3, China's labour productivity of manufacturing improved significantly during 1985-2003, especially after 1990. The time period can be divided into three sub-periods, respectively 1985-1990, 1991-1996 and 1997-2005. During 1985-1990, Shanghai, Inner Mongolia and the cross-regional mean kept to be very steady and had little improvement. The ratio of Shanghai's Y/L over Inner Mongolia's was 2.95 in 1985. In 1991-1996, the gap between Shanghai and Inner Mongolia enlarged and reached maximum in 1996. Within 1997-2005, Inner Mongolia caught up and significantly reduced the gap to 60% of Shanghai's Y/L.

Since labour productivity can be measured by level, rough regional comparison of productivity become possible. Picking up the leading regions in selected year, we can get,

	1985	1990	1995	2000	2005
Total	Heilongjiang	Heilongjiang	Shanghai	Shanghai	Beijing
Mining	Heilongjiang	Heilongjiang	Xinjiang	Xinjiang	Heilongjiang
Manufacturing	Shanghai	Shanghai	Guangdong	Shanghai	Beijing
Utility	Shanghai	Hebei	Shanghai	Zhejiang	Shanghai

The results show that except Xinjiang, every leading region is in east China. As discussed above, Xinjiang and Heilongjiang are endowed with plentiful oil and gas resources. They are very competitive in the extraction of oil and gap industry, which has the largest weight in mining sectors. So, it is reasonable that Xinjiang and Heilongjiang's productivity in mining are on the "frontier" of China. Shanghai is the most important industrial city in China. Strong foundation of industry made Shanghai keeps to be the leader of labour productivity in manufacturing and utility. Guangdong and Zhejiang are quickly developing industrial zones of China. Together with Beijing, these four regions can be treated as the frontier of productivity in manufacturing and utility in China. In Wang and Szirmai's work (2007), they compared regional labor productivity during the period of 1978-2002. Their results show that Shanghai has the highest labor productivity in almost all years which is very close to ours.

6.3.2 Regional capital-labour ratio

It is expected that rich regions can produce more, and then invest more. This means regions with high Y/L ratio should also have high K/L ratio. Moreover, compared with labour-intensive light industries, heavy industries often appear to be capital-intensive. So, a region with high heavy industry weight should also have high capital-labour ratio.

Picking up the region with highest capital-labour ratio,

	1986	1990	1995	2000	2005
Total	Xinjiang	Xinjiang	Shanghai	Xinjiang	Beijing
Mining	Tianjin	Tianjin	Tianjin	Shaanxi	Tianjin
Manufacturing	Guizhou	Guangdong	Shanghai	Shanghai	Shanghai
Utility	Beijing	Tianjin	Shanghai	Beijing	Beijing

It can be found that during studied period, Shanghai's capital-labour ratio kept higher than the others in almost every year of manufacturing. Employing the same approach used in regional comparison of labour productivity, we can find that regions with lowest capital-labour ratio during 1985-2005 were not poor region as shown in Figure 4. Zhejiang is in the east of China, and one of the most developed regions. From the results, capital-labour ratio is more related to sectoral structure instead of economic development. Zhejiang focuses more on labour-intensive light industries, such as textile and apparelling. It also needs to be pointed out that there is quick growth period during 1993-1998, and significant slow-down during 1999-2003. After the Asian financial crisis, ability of investment was weakened. As we can see from Figure 3, labour productivity continuously increased during this period, which means economic growth was not mainly driven by investment.

6.4 TFP performance by region in major sectors

It has been discussed that labour productivity had been growing quickly during 1985-2005 and there are two explanations behind of this. One is increasing capital-labour ratio, second is growth of TFP. According results of this study, during the period of 1987-2005, every studied region has achieved positive average annual growth rate of TFP as shown in Table 3. The rates of growth are quite different across regions. The slowest growing region, Shanghai, only attained 0.22 percent per year in average, which is only one-nineteenth of Inner Mongolia. In average, mining has attained the highest growth rate among the three big industries, which is 2.47 percent per annum. Utilities are the slowest in average, which are 0.68 percent annually. In manufacturing, every region's TFP growth rates are positive and very close with the whole industry's performance because manufacturing's weight of output is the highest in every studied region.

In Table 7, these regions are ranked by their growth rates of TFP of all the industry, mining, manufacturing and utilities. From the results, it can be found that Inner Mongolia's performance is ranked the first in mining and utility, and the second in manufacturing. In contrast, Shanghai is ranked the last in manufacturing; Tianjin is the last in mining and utility. Interestingly, the most important industrial regions, including the three municipalities, and provinces, like Guangdong, Jiangsu and Zhejiang are obviously slower of TFP growth of manufacturing than other regions. Shanxi and Inner Mongolia attained remarkable improvement in productivity of manufacturing sectors, especially resources-intensive industry, like heavy chemical industry. These two provinces have sufficient natural resources and land supply. They have more advantage in developing heavy chemical industry.

There are three zones in China distinguished by their economic development status. They are the east, the middle and the west. It is known that the east regions' economy is the most developed. The middle regions are less developed but better than the west regions. However, from the results of this study, it can be found that during the period of 1987-2005, the middle regions' TFP growth is the fastest with average 2.79% per year in the three zones as shown by Figure 7. Following is the west regions with average growth rate of 2.34% per year. East regions' growth rates are averagely 1.4% per year.

The most developed regions in China, including Shanghai, Beijing and Tianjin these there municipalities and Jiangsu, Zhejiang and Shandong these east provinces are in the slowest ten of average annual TFP growth rate. Middle regions take seven of the ten places in the fastest ten of TFP growth. Performance of west regions is quite different. However, from our result, Shanghai's TFP growth is the slowest in China's provincial-level regions. This can be explained by two reasons. First, by Wang and Szirmai's work, Shanghai is in the frontier of China's productivity curve. It is difficult for Shanghai to shift the productivity curve quickly. But to less-developed regions, they can improve their TFP by learning from Shanghai and other more-developed regions. Second, since our capital input and labour input have considered the effect of quality improvement, some advantages of more-developed regions, like sufficient investment in high technology-embodied fixed assets and more educated labour will be decomposed from our results. These two reasons are the same in explaining Xinjiang and Yunnan's cases. Though Xinjiang and Yunnan are in the west of China, their productivity performances were the best two in the west regions (see Wang and Szirmai, 2007). Around regions can learn from them, but they are too far from the most-developed east regions. So, their TFP growth rates are also very slow. Comparatively, middle regions achieved fastest TFP growth in the period of 1987-2005.

6.5 TFP performance by region in selected manufacturing sectors

Since manufacturing is very important in China's industrial economy, it is necessary to discuss in detail. In this part, manufacturing sectors will be grouped into capital goods and consumer goods.

6.5.1 TFP performance of capital goods sectors

For capital goods, comparative advantages include endowment of natural resources, sufficient skilled labour, and better infrastructure for heavy industry. Taking machinery as example, we can choose three regions with highest share of machinery respectively in the east, middle and west of China, their indices of TFP are presented in Figure 5. From the figure, Shanghai experienced stable TFP growth during the period and significant growth during 1997-2000. For Henan, it is in the middle of China, with high share of machinery. However, even with very low level of labour productivity in 1985, Henan's TFP growth was still slow, which means that the reform was not helpful for Henan in developing machinery. In contrast, Shaanxi is one important industrial province in the west of China, also with low level of labour productivity in 1985, only accounted for 50% of Shanghai. Since 1996, TFP growth of Shaanxi became very quick. With almost the same labour productivity with Henan in 1985, Shaanxi's performance was much better after 1995. Comparison on growth rate of all studied regions during two sub-periods after 1985 is presented in Figure 6. From the result, it can be found that since the 1993's industrial reform, most regions' performance in TFP became better than pre-reform period, except Guangdong, Guangxi and Yunnan. Sichuan's performance was the best during 1993-2005. In contrast, Yunnan's TFP growth was the slowest. Most east rich regions with more FDI inflow achieved quick TFP growth in machinery, except Jiangsu and Zhejiang. These two provinces' labour productivity was very close with Shanghai, which means that they are very close to the frontier of China's productivity in machinery. So, it is difficult for them to achieve quick TFP growth continuously. For middle and west regions, their level of productivity was comparatively low and catch-up effect is expected. However, from the result, it can be found that only those regions enjoying comparative advantages can achieve fast growth of TFP, such as Sichuan, Jiangxi and Shaanxi.

6.5.2 TFP performance of consumer goods sectors

For consumer goods sectors, they depend more on cheap labour cost and efficient market situation. Different with capital goods sectors, FDI is not expected to bring significant TFP growth. Instead, remove of price distortion and establishment of market-supporting institutions are more helpful to efficiency improvement.

Taking textile as example, we can select Jiangsu, Hubei and Shaanxi to represent the east, middle and west zones of China, since their shares of textile are highest in the three zones. Shown by Figure 5, TPF performance of textile was clearly not as good as machinery. There was even no significant improvement for Jiangsu province during the period of 1986-2005. Situation of Hubei and Shaanxi were very close, both experienced quick growth since 1997. Being close to the east, Hubei and Shaanxi can benefit more from market orientation by learning. For all studied regions, their TFP performance during the two sub-periods is shown in Figure 6. From the result, it is obvious that TFP performance was better-off after the 1993's industrial reform. Performance of regions in the middle and northeast were better than the others. With more complete market establishment and sufficient labour supply, the three provinces in northeast China were designed as base of heavy industry during central planning period. Light industries in these three provinces were left behind by other east regions. After the reform, they experienced strong catch-up of TFP in textile. For middle regions and some west regions, like Sichuan and Shaanxi, their market situation was also significantly improved during the post-reform period. Together by learning effect from the east, these regions achieved fast growth in TFP. In contrast, regions with highest level of labour productivity in textile, like Shanghai, Jiangsu and Zhejiang got little growth in TFP. This means that productivity frontier of China in textile did not expand during the twenty years. Improvement was only through catch-up effect of those less-developed regions.

6.5.3 TFP performance of material sectors

As the third type of manufacturing, material sectors experienced fast growth in China. As requirement by both capital goods and consumer goods sectors, demand of material was kept strong. For comparative advantage, material sectors require abundant supply of energy and resources, and low pollution cost.

Taking chemicals as example of material sectors, we can pick up three regions which have highest share of chemicals in the three zones of China. Their indices of TFP of chemicals are presented in Figure 5. Shown by the figure, TFP growth of these three regions in chemicals is comparatively stable. Only Sichuan experienced quick growth during 2003-2005. However, refer to their level of labour productivity in 1985, Sichuan and Hunan were much lower than Beijing, which means that catch-up effect was not significant for lagged regions. Comparing the two sub-periods during 1985-2005, regional annual compound growth rates of TFP is shown in Figure 6. From the figure, every region was better-off after the 1993's industrial reform in TFP growth. Inner Mongolia, Sichuan and Shanxi achieved fastest growth. These three regions are all endowed with abundant natural resources, like oil and coal. Another important reason is that they are in lower level of economic development status than east region, which means that pollution costs are lower in these regions. In contrast, Shanghai, Jiangsu and Zhejiang are slowest in TFP growth of chemicals. There are two reasons behind of this. First, the same as situation in other sectors, these three regions are in the productivity frontier of China, which means that it is more difficulty for them to achieve quick growth. Second, with high level of economic development, pollution cost became higher in these regions.

As conclusion of this part, major sectors experienced faster improvement of TFP after 1993's industrial reform in most regions. With released control of the factor prices and SOEs, market was taking the role of resources allocation. Results have shown that with different resources endowment, regional performance became more diversified in different sectors. On the other hand, sectors can perform better in the regions that they can enjoy comparative advantage. Furthermore, we can find significant catch-up effect across regions. Middle and west regions obviously improved more through learning from the east. On the other hand, representing production frontier of Chinese industry, Shanghai and other east regions' TFP growth was much slower and more stable.

VI. Concluding Remarks

Based on official statistics, we have for the first time constructed input and output data for 23 industries in mining, manufacturing and utilities in 25 Chinese provinces for the period 1985-2005. We have made tremendous efforts to fill data gaps and solve many other data problems to ensure that our data work basically satisfies the modern theory of production function. We then apply Jorgenson's translog production function to this newly constructed dataset to examine industry-level productivity performance across regions. In this section, we first conclude our data work for major indicators and discuss remaining data problems, and we then conclude the TFP results estimated using the data and likely biases because of existing data deficiencies.

7.1 Conclusions on data work

Construction of capital input is the most important step in measuring TFP growth. However, it is often mistakenly made by previous studies due to improper use of official statistics. Investment series in China's official statistics do not satisfy the definition of SNA. "Investment in fixed assets" refers to the "workload" of fixed asset investment activities in value terms instead of contract-based purchase transfer of fixed capital that can be put into production. In this work, investment was reestimated based on official statistical series of "gross value of fixed assets". Our investment series are the differences between two years gross value of fixed assets, less investment in residential structures. Then, effort is made to estimate regional deflator of fixed assets investment and depreciation rate adopting Wu (2002)'s work with regional adjustment. After construction of these series, perpetual inventory method is employed to derive net capital stock. Next, in estimating capital input, IO tables are employed, following Ho & Jorgenson (2001)'s framework, we are able to derive nominal rate of return first, then, with this rate to aggregate asset types with translog weight. Using capital input series, quality of capital input can be considered. In contrast, taking net capital stock as input, contribution of capital will be under-estimated, thus over-estimate TFP growth.

In the measurement of output, major problem is the deflator to use. Following Jorgenson's framework, gross value of output (GVO) is used instead of gross value-added (GVA). With this approach, intermediate input is derived as difference between GVO and GVA in constant prices and employment of double deflation are a proper way. However, due to limitation of raw data, especially on regional level, we have no choice but using single deflator. In official statistics, there are sets of deflators can be used. The first choice is PPI, however, official data is not complete to support this research. Data availability was even poorer on regional level. The second choice is implicit deflator derived from nominal GVO and GVO in comparable prices. Such raw data is available for most years on regional level. But due to some shortcomings of the comparable price system, the so-derived deflator may underestimate the real output. In this work, we tried to derive regional PPI based on regional comparable prices, then make adjustment with national PPI to reconcile the 1980 prices and 1990 prices.

For labour input estimation, there have never been regular and systematic surveys on total working hours and weekly hours worked. In addition, lack of information on detailed statistics on employment may bring difficulties in estimation of quality improvement of labour. In this study, measurement of labour input is in two steps. First is the estimation of working hours. Following Wu and Yue (2007)'s framework, number of workers and employees was decomposed to four career types on sectoral level, and then recomposed by different weekly working hours. Second is the derivation of labour input adopting Wu & Yue (2007)'s quality indices of labour. After two decades of market-oriented reform, quality of labour has been substantially improved and made significant contribution to growth of output. As comparison, simply using number of workers and employees or working hours may under-estimate labour input, thus over-estimate TFP.

After preparation of output and input data, share of labour input is calculated with total working hours and hourly wages which are adopted from Wu and Yue (2007) of different sectors. Share of intermediate input is calculated by its weight in nominal GVO. With constant return to scale assumption, share of capital input is derived. Finally, sectoral TFP growth by regions is estimated.

7.2 Regional TFP performance by industry

Since the economic reform started in 1978, China has experienced thirty years' of continuous high growth rate. With highest weight in economy, industry acted the most important role in the society. Purpose of this study is to investigate the effect of economic reform on China's industrial productivity performance on regional level. Assessment is based data work of labour productivity, capital intensity and total factor productivity across individual industries and over different reform periods. Looking at regional level, different regions are endowed with different resources thus comparative advantages. Speed and degree of reform in different regions are also different. So, performance of regions diversified with different background.

To investigate China's industrial performance during the reform period, we must make sure about data coverage of our research. Taking output as example, data employed in this study accounts for around 92% of China, which means that there will not be any problem to infer the results to China's total industrial sector's performance. For research methodology, Jorgenson's translog framework is employed by this study. This framework is well developed with sound theoretical foundation and widely applied by important empirical studies, such as KLEMS project in Europe.

Major findings by this study are as following. First, shares of different sectors in most regions became more diversified after 1993. This means that under market situation, sectors can expand more quickly if they have comparative advantages in one region, and vice versa. Before market orientation, structures of most local economies were very close to the nation as designed by the government. This kind of structure could be stable at that time since local market was protected and segmented. Loosing money SOEs will not break since it can banking loans instructed by local government.

Second, economic growth of China's industry was mainly investment-driven. Capital intensity was greatly increased, which can explain major part of labour productivity growth. Welfare was quickly improved but cannot sustainable. Evidence is from slowing-down of labour productivity growth caused by stagnant net capital stock growth after the Asian financial crisis. Since 2000s, China's entering into WTO has played an important role in attracting FDI, and partly caused remarkable growth in recent years. However, to keep the effects of WTO accession and current fast growth, pace of domestic reform should not be slowed.

Third, in 1985, labour productivity was diversified across regions. Gaps between east rich regions and west poor regions were very large. During 1985-2005, labour productivity substantially increased for all the regions. From results, there is significant catch-up effect in less-developed regions. East more-developed regions were much slower in improving TFP since they are in the frontier of China's productivity.

Fourth, most regions experienced significant TFP growth within 1985-2005. Before 1993, TFP performance was very mixed across industries. Without establishment of whole set of market mechanism, efficiency improvement only happened in those more competitive sectors. During 1993-2005, most sectors achieve quick growth in TFP except oil extraction and petroleum industry which are monopolized by SOEs. If decompose manufacturing into capital goods, consumer goods and materials, performance of capital goods was the best, then materials. Output growth of consumer goods depended more on increase of capital intensity. Enjoying China's comparative advantage of cheap labour cost, firms got less incentive to improve productivity.

References

Bai, Chong-En, lu, Jiangyong, Tao, Zhigang, "The Multitask Theory of State Enterprise Reform: Empirical Evidence from China", American Economic Review, May 2006, v. 96, iss. 2, pp. 353

Bai, Chong-En, Hsieh, Chang-Tai, Qian, Yingyi, "The Return to Capital in China", Brookings Papers on Economic Activity, 2006, iss. 2, pp. 61-88

Bai, Chong-En, Du, Yingjuan, Tao, Zhigang, Tong, Sarah Y., "Local Protectionism and Regional Specialization: Evidence from China's Industries", Journal of International Economics, July 2004, v. 63, iss. 2, pp. 397-417

Bai, Chong-en, Li, David, Wang, Yijiang, 1997, "Why Is the Productivity Analysis Misleading for Gauging State Enterprise Performance?", Boston College Department of Economics, Boston College Working Papers in Economics: 344

Barro, Robert J., 1998, "Note on Growth Accounting", Harvard University, mimeo

Chow, Gregory C, 2006, "New capital estimates for China: Comments", China Economic Review, v.17, iss. 2, pp. 186-92

Denison, Edward F. 1962. The Source of Economic Growth in the United States and the Alternatives before Us, Committee for Economic Development, New York.

Denison, Edward F. 1972. Classification of sources of growth, Review of Income and Wealth, 18(1): 1-25

Ezaki, Mitsuo & Sun, Lin (1999) Growth Accounting in China for National, Regional, and Provincial Economies: 1981-1995, Asian Economic Journal, 13(1), pp.39-71.

Measuring Capital – OCDE Manual, 2000. Organization for Economic Co-operation and Development

Measuring Productivity – OCDE Manual, 2001. Organization for Economic Co-operation and Development

Fraumeni, Barbara M. 1997, "The measurement of depreciation in the US National Income and Product Accounts", Survey of Current Business, July 1997

Ho, Mun S. and Dale W. Jorgenson, 2001, Productivity Growth in China, 1981-95, mimeo, Kennedy School of Government, Harvard University, Cambridge, MA

Huang, Yongfeng, Ren Ruoen and Liu Xiaosheng, 2002, "Capital Stock Estimates in Chinese Manufacturing by Perpetual Inventory Approach", China Economics quarterly, Vol. 1 (2), 377-396

Hulten, Charles R. 1990, The Measurement of Capital, Fifty Years of Economic Measurement: The Jubilee, NBER, Studies in income and Wealth, No. 54, University of Chicago Press, 1990

Hulten, Charles R. (2000), 'Total Factor Productivity: A Short Biography', NBER Working Paper #7471, Cambridge, MA.

Hulten, Charles R & Frank C. Wykoff, 1981, "The measurement of economic depreciation" The Urban Institute Press, Washington D. C.

Hulten, Charles R & Frank C. Wykoff, 1981, "The measurement of economic depreciation using vintage asset prices" The Urban Institute Press, Washington D. C.

Hsueh Tien-tung, Qiang Li and Shucheng Liu, eds, 1993, China's Provincial Statistics: 1949-1989, Boulder: Westview Press.

Jefferson, Gary H., Inderjit Singh, Junling Xing, and Shouqing Zhang, 1999, "China's industrial performance: a review of recent findings", Chapter 6 in Jefferson, Gary H. and Inderjit Singh (eds.), Enterprises Reform in China: Ownership, Transition, and Performance, New York: Oxford University Press.

Jefferson, Gary H., Rawski, Thomas G., Wang Li and Zheng Yuxin, 2000, "Ownership, Productivity Change, and Financial Performance in Chinese Industry", Journal of Comparative Economics 28, 786–813 (2000)

Jorgenson, Dale W.; Productivity. Volume 1. Postwar U.S. economic growth, 1995, Cambridge and London: MIT Press

Jorgenson, Dale W. 1990 Productivity and Economic Growth, Fifty Years of Economic Measurement: The Jubilee, NBER, Studies in income and Wealth, No. 54, University of Chicago Press, 1990

Jorgenson, Dale W. and Zvi Griliches, 1967, "The Explanation of Productivity Change," Review of Economic Studies, 34, July 1967, 349-83

Jun Zhang, Wu Guiying and Zhang Jipeng, 2007, "Compilation of China's Provincial Capital Stock Series Using Perpetual Inventory Method", paper prepared for the the International Workshop on Productivity in China held at Tsinghua University in Beijing on 13-14 January, 2007.

Li, Jingwen, Dale W. Jorgenson, Zheng Youjing and Masahiro Kuroda, 1993, Productivity and Economic Growth in China, USA and Japan, China Social Science Publishing House, Beijing

Li, Jingwen, et al., 1992, "Productivity and China's Economic Growth", The Economic studies Quarterly, 43 (4): 337-350

Maddison, Angus, 1998, Chinese Economic Performance in the Long Run, OECD Development Centre, Paris

Meng, Xin, 2004, "Economic Restructuring and Income Inequality in Urban China", Review of Income and Wealth, Series 50, Number 3, September, 2004.

National Bureau of Statistics of China, Official Website: http://www.stats.gov.cn/

Rawski, Thomas, 1993, "How fast has the Chinese industry grown?", Policy Research Working Paper, WPS 1194, Policy Research Department, World Bank, Washington D.C.

Ren, Rouen, 1997 China's Economic Performance in an International Perspective, OECD Development Centre Studies.

Sachs, Jeffrey D.; Woo, Wing Thye, "China's Economic Growth after WTO Membership", Journal of Chinese Economic and Business Studies, January 2003, v. 1, iss. 1, pp. 1-31

Sachs, Jeffrey D.; Woo, Wing Thye, "Understanding China's Economic Performance", Journal of Policy Reform, 2000, v. 4, iss. 1, pp. 1-50

State Statistical Bureau (Annual), (Zhongguo Tongji Nianjian) China Statistical Yearbook, China Statistical Publishing House, Beijing.

Sylvie, Démurger; Jeffrey, D. Sachs; Woo, Wing Thye; Bao, Shuming; Chang, Gene and Andrew Mellinger, 2002, “Geography, economic policy, and regional development in China”, NBER Working Paper #8897, Cambridge, MA.

Woo, Wing Thye (1998) "Chinese Economic Growth: Sources and Prospects", in M. Fouquin and F. Lemoine (eds.) The Chinese Economy, Economica, London.

Wu, Harry X., 2000, China’s GDP level and growth performance: Alternate estimates and the implications, Review of Income and Wealth, 46 (4): 475-499

Wu, Harry X. and Esther Y. P. Shea 2002, what can we learn from productivity analysis of the Chinese economy, mimeo, The Hong Kong Polytechnic University

Wu, Harry X. 2002a, “How Fast Has Chinese Industry Grown? – Measuring the Real Output of Chinese Industry”, Review of Income and Wealth, 48 (2)

Wu, Harry X., 2002b, “Measuring the Capital Stock in Chinese Industry – Conceptual Issued and Preliminary Results”, mimeo, the Hong Kong Polytechnic University, Hong Kong

Wu, Harry X. and Ximing Yue, 2007, Source of quality change in the labour input of Chinese industry 1949-2005, unpublished paper, The Hong Kong Polytechnic University.

Xinhua Net, website: http://www.xinhuanet.com

Xu, Xianchun, 1999, On reform and Development of the Chinese System of National Economic Accounting, Economic Science Press (in Chinese).

Xu, Xianchun, 2004, “China’s gross domestic product estimation”, China Economic Review, v. 15 pp. 302-322

Young, Alwyn, 2003, “Gold into Base Metals: Productivity Growth in the People’s Republic of China during the Reform Period”, Journal of Political Economy, 2003, vol. 111, no. 6

Young, Alwyn, 2000b, “The Razor’s Edge: Distortions and Incremental Reform in the People’s Republic of China.” The Quarterly Journal of Economics CXV, no. 4 : 1091-1135

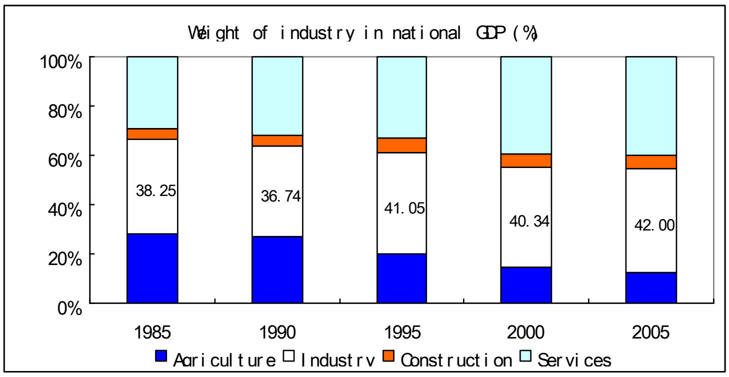
Lin, Justin Yifu, “Viability, Economic Transition and Reflection on Neoclassical Economics”, Kyklos, 2005, v. 58, iss. 2, pp. 239-64

Zheng, Jinghai and Hu, Angang, 2006, “An empirical analysis of provincial productivity in China, 1979-2001”, Journal of Chinese Economic and Business Studies, November 2006, v. 4, iss. 3, pp. 221-39

Zheng, Jinghai, Liu, Xiaoxuan, Bigsten, Arne, “Efficiency, Technical Progress, and Best Practice in Chinese State Enterprises (1980-1994)”, Journal of Comparative Economics, March 2003, v. 31, iss. 1, pp. 134-52

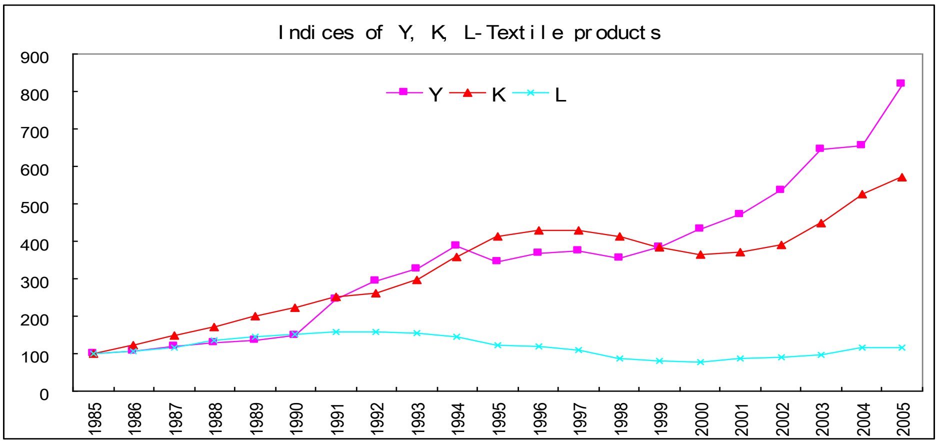
Zheng, Jinghai, “A Comparative Study of Employment Adjustment in Chinese Enterprises (1986-1990)”, Economics of Planning, 2001, v. 34, iss. 1-2, pp. 73-88

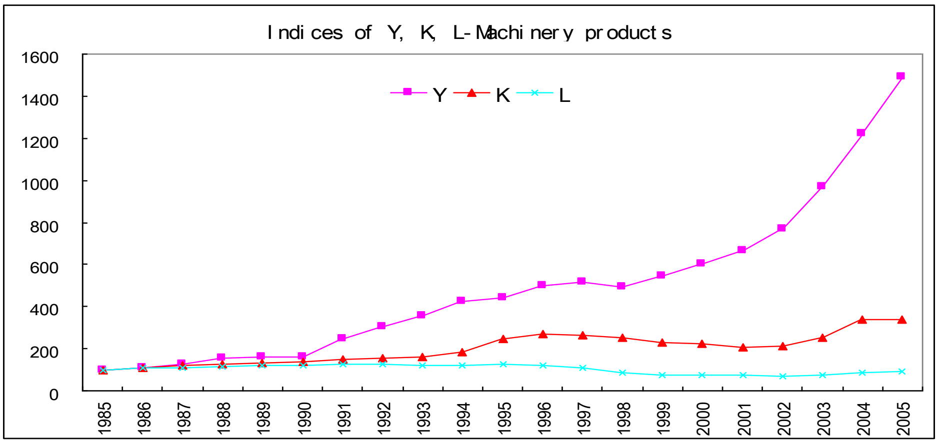
FIGURE 1: WEIGHT OF INDUSTRY IN NATIONAL GDP



Source: NBS, Chapter three of "China statistical yearbook, 2006"

FIGURE 2: INDICES OF Y, L, L (1985=100)





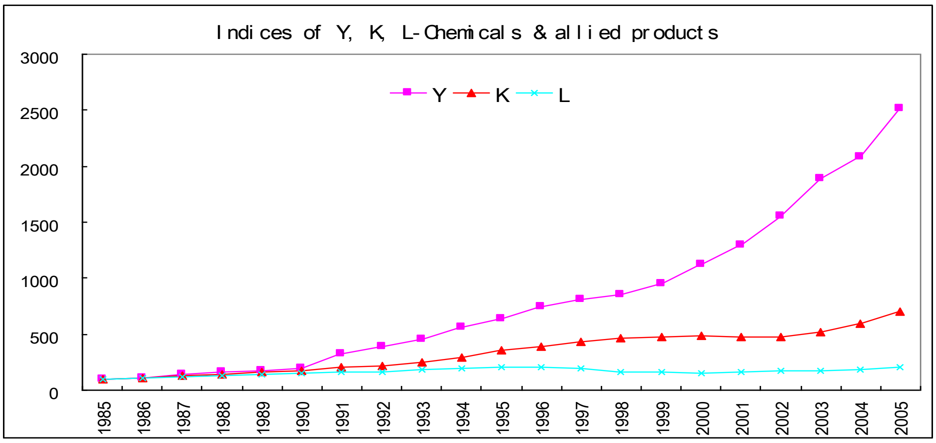
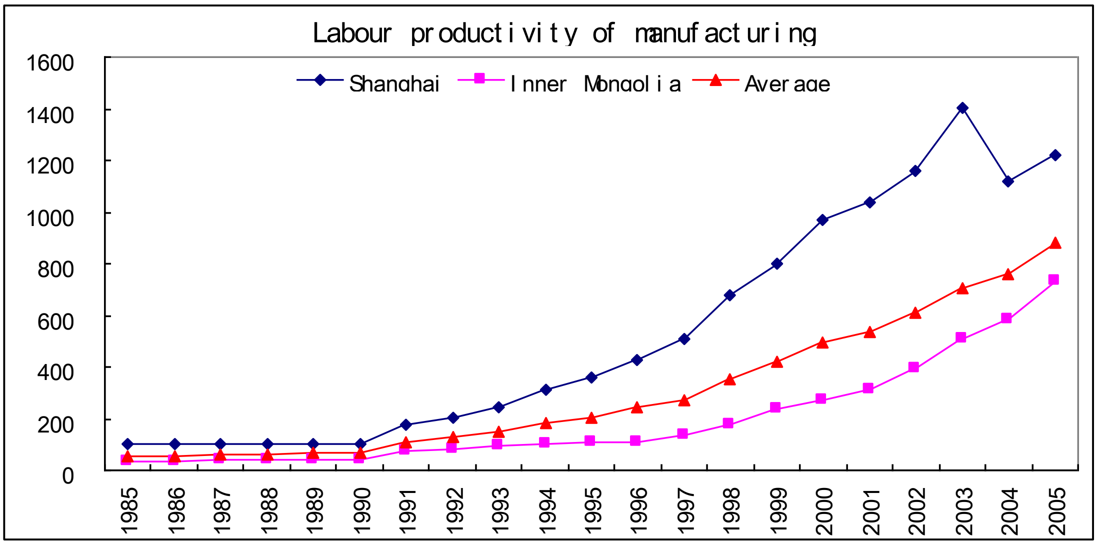
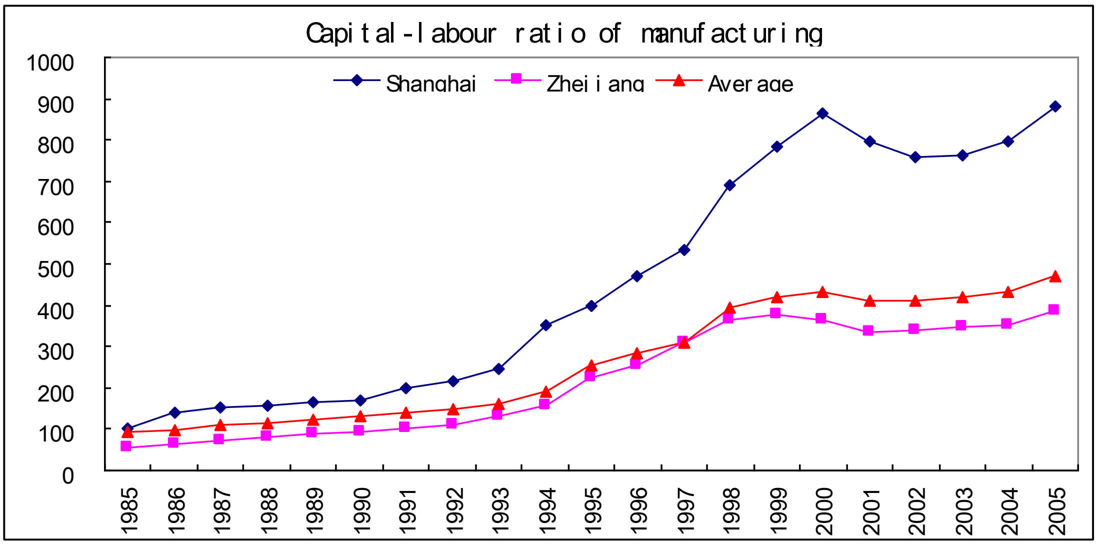


Figure 3: Labour productivity of Shanghai, Inner Mongolia and cross-regional mean of manufacturing



Note: taking labour productivity of Shanghai in 1985 as 100.

Figure 4: Capital-labour ratio of Shanghai, Zhejiang and cross-regional mean of manufacturing



Note: taking capital-labour ratio of Shanghai in 1985 as 100.

FIGURE 5: TFP INDICES OF SELECTED REGIONS

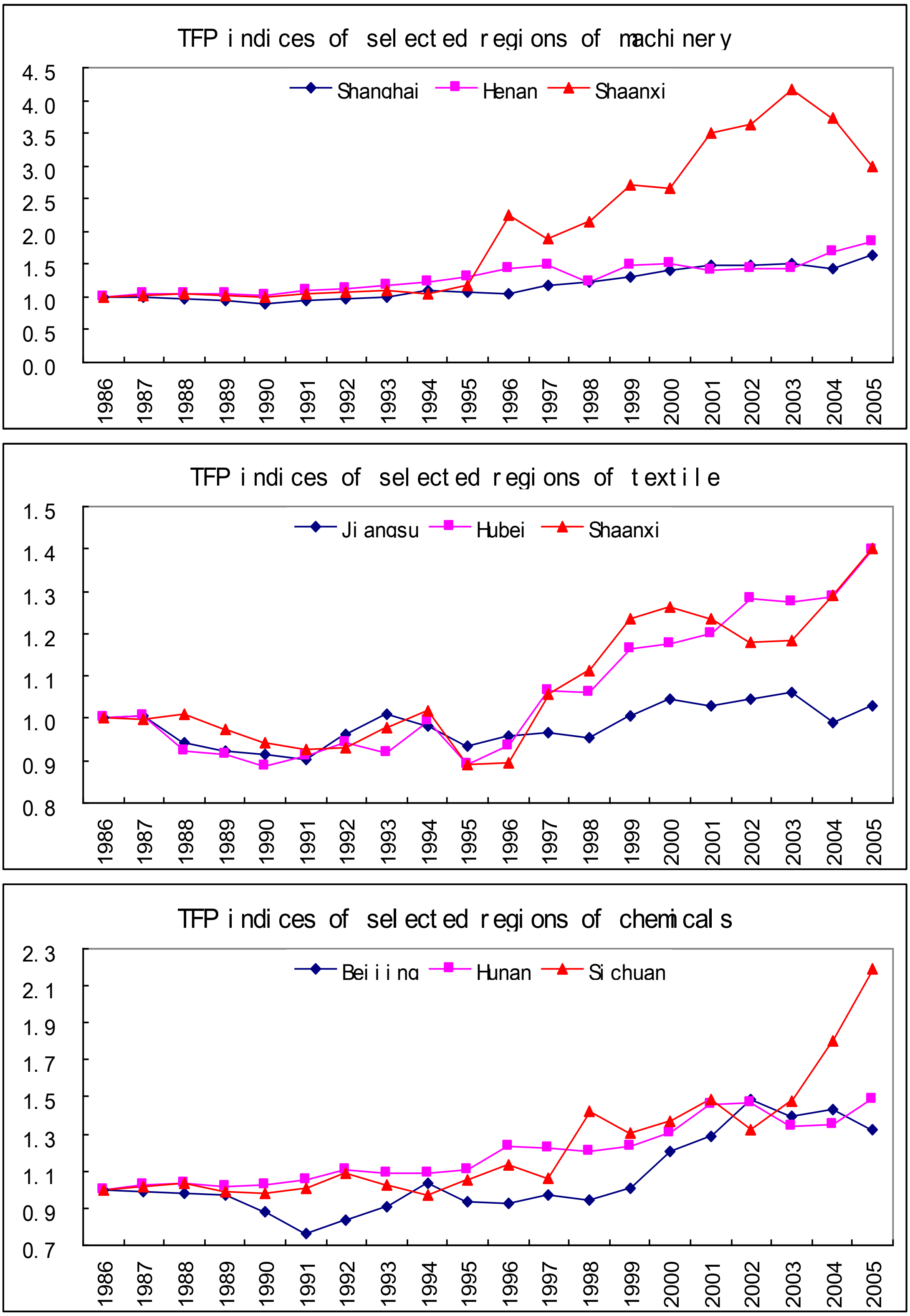


FIGURE 6: ANNUAL COMPOUND GROWTH RATE OF TFP

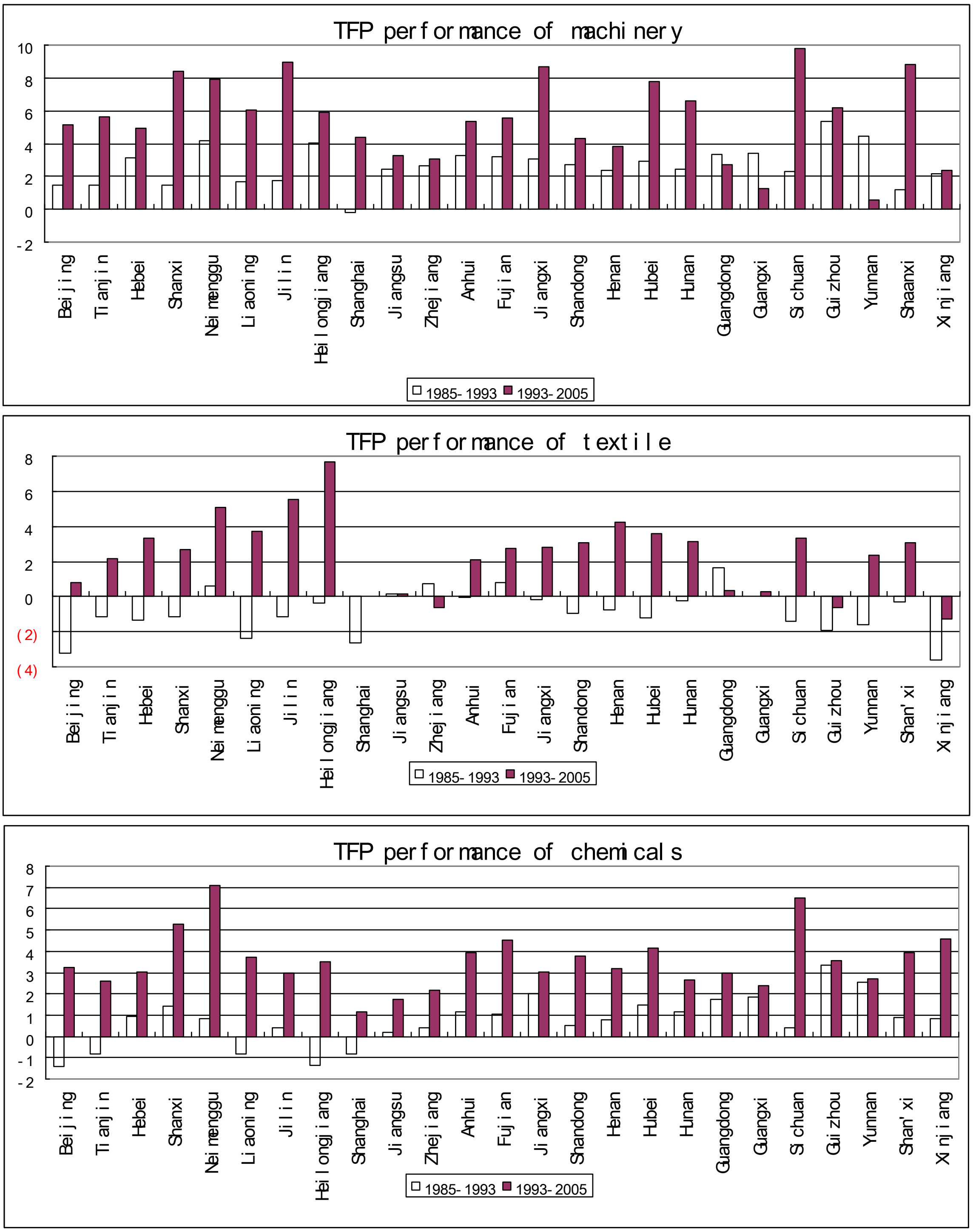


FIGURE 7: AVERAGE ANNUAL GROWTH RATE OF TFP IN PERCENTAGE

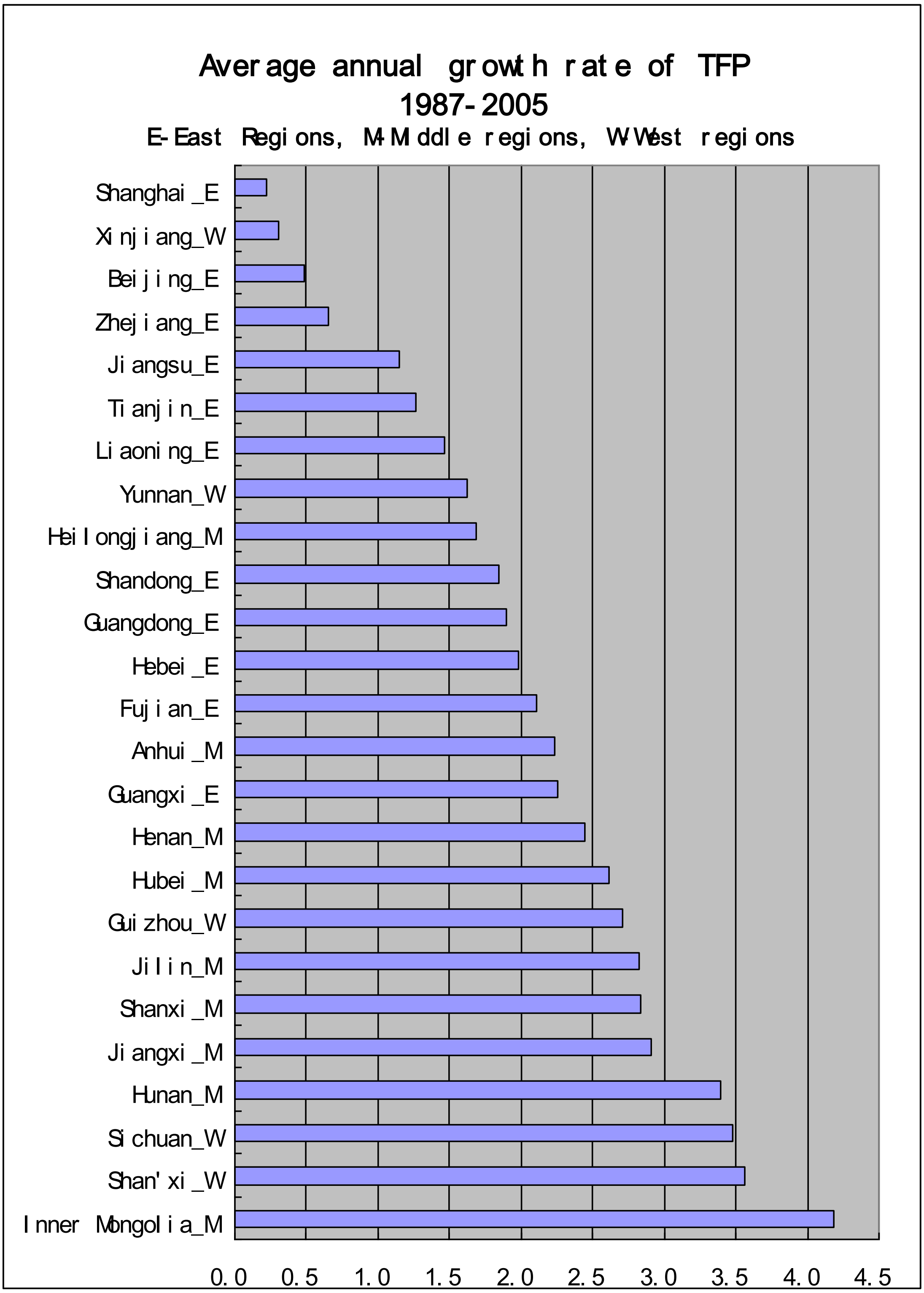


TABLE 2: SHARES OF REGIONAL INDUSTRIAL IN THE CROSS-REGIONAL TOTAL

Shares of regional industrial in the cross-regional total (%), measured by GVA in current prices					
	1985	1990	1995	2000	2005
Beijing	3.64	3.25	2.56	3.05	2.80
Tianjin	3.29	2.72	2.44	3.10	2.73
Hebei	3.93	3.92	3.95	4.07	4.44
Shanxi	2.24	2.20	1.72	1.45	1.96
Inner Mongolia	1.21	1.20	0.96	0.89	1.21
Liaoning	8.03	6.75	5.29	5.05	4.36
Jilin	2.67	2.48	1.85	2.00	1.53
Heilongjiang	4.25	4.04	2.93	2.92	1.90
Shanghai	9.32	7.66	6.84	7.37	6.36
Jiangsu	9.53	10.69	12.03	12.42	13.19
Zhejiang	5.01	5.44	6.22	7.84	9.32
Anhui	2.70	2.74	3.07	1.97	1.84
Fujian	1.63	2.04	2.75	3.11	3.28
Jiangxi	1.82	1.78	1.48	1.11	1.20
Shandong	6.78	7.87	8.44	9.87	12.31
Henan	3.75	3.70	4.13	4.15	4.23
Hubei	4.78	4.24	4.48	3.64	2.45
Hunan	3.19	3.04	2.42	1.93	1.92
Guangdong	10.32	12.25	15.65	14.83	14.49
Guangxi	1.42	1.55	1.70	1.19	1.03
Sichuan	5.26	5.09	4.50	3.61	3.51
Guizhou	1.04	0.98	0.73	0.75	0.68
Yunnan	1.38	1.60	1.55	1.26	1.05
Shaanxi	1.97	1.87	1.42	1.41	1.37
Xinjiang	0.84	0.90	0.90	1.01	0.85

TABLE 3: COMPOUND ANNUAL GROWTH RATE OF PRODUCTIVITY

Compound annual growth rate of productivity						
	1985-1993			1993-2005		
	Y/L	K/L	TFP	Y/L	K/L	TFP
Beijing	15.34	14.35	(1.55)	20.76	12.12	1.70
Tianjin	13.84	8.05	(0.97)	17.43	14.79	2.59
Hebei	15.06	7.93	(0.66)	16.23	10.62	3.56
Shanxi	13.49	4.36	(0.92)	12.34	10.68	5.10
Inner Mongolia	17.06	4.65	0.24	17.82	18.09	6.56
Liaoning	13.31	8.65	(1.55)	17.13	11.89	3.26
Jilin	13.47	7.29	0.12	20.59	14.37	4.44
Heilongjiang	11.98	5.42	(3.94)	13.59	13.52	5.11
Shanghai	15.43	9.63	(1.14)	15.18	13.09	1.02
Jiangsu	21.28	11.75	0.95	12.61	12.81	1.26
Zhejiang	21.35	11.44	1.18	10.03	11.27	0.35
Anhui	15.96	4.92	0.64	14.60	13.42	3.18
Fujian	21.71	9.00	1.67	13.51	8.62	2.36
Jiangxi	15.21	3.42	0.90	14.66	12.85	4.09
Shandong	19.01	9.64	(0.36)	14.25	7.79	3.15
Henan	15.25	5.59	0.55	15.75	9.03	3.57
Hubei	13.71	5.42	1.04	18.18	14.78	3.54
Hunan	12.06	3.09	0.33	16.41	12.98	5.22
Guangdong	24.06	13.97	2.44	15.29	4.04	1.59
Guangxi	18.25	6.00	1.69	13.07	11.74	2.74
Sichuan	13.06	3.68	(0.90)	21.53	15.34	6.13
Guizhou	16.26	3.71	1.31	17.12	11.84	3.54
Yunnan	21.32	6.56	1.75	11.63	11.52	1.55
Shaanxi	13.36	3.15	0.57	14.44	15.29	5.35
Xinjiang	13.01	11.55	(2.44)	12.52	12.30	1.93

TABLE 4: SHARES OF MACHINERY & EQUIPMENT IN LOCAL ECONOMIES

	Shares of machinery & equipment in local economies								
	Y			K			L		
Raw data	1985	1993	2005	1985	1993	2005	1985	1993	2005
All	0.11	0.09	0.06	0.11	0.07	0.04	0.15	0.12	0.08
Beijing	0.11	0.10	0.07	0.13	0.09	0.04	0.17	0.13	0.11
Tianjin	0.13	0.11	0.07	0.12	0.07	0.04	0.18	0.14	0.08
Hebei	0.11	0.09	0.07	0.11	0.06	0.03	0.15	0.12	0.08
Shanxi	0.12	0.08	0.09	0.12	0.06	0.03	0.15	0.13	0.06
Inner Mongolia	0.13	0.15	0.05	0.08	0.05	0.02	0.13	0.06	0.07
Liaoning	0.13	0.13	0.11	0.11	0.08	0.05	0.19	0.17	0.12
Jilin	0.10	0.07	0.02	0.09	0.04	0.01	0.12	0.10	0.05
Heilongjiang	0.03	0.05	0.03	0.14	0.09	0.03	0.16	0.13	0.09
Shanghai	0.14	0.10	0.11	0.15	0.08	0.06	0.21	0.16	0.13
Jiangsu	0.12	0.12	0.10	0.13	0.10	0.06	0.15	0.14	0.12
Zhejiang	0.11	0.10	0.06	0.11	0.08	0.06	0.14	0.13	0.12
Anhui	0.08	0.09	0.06	0.07	0.06	0.03	0.11	0.09	0.07
Fujian	0.09	0.06	0.04	0.07	0.04	0.02	0.11	0.08	0.03
Jiangxi	0.10	0.08	0.02	0.09	0.05	0.01	0.12	0.10	0.04
Shandong	0.11	0.10	0.10	0.10	0.06	0.05	0.15	0.11	0.10
Henan	0.14	0.12	0.07	0.14	0.08	0.04	0.17	0.15	0.09
Hubei	0.08	0.07	0.07	0.09	0.05	0.02	0.13	0.11	0.07
Hunan	0.10	0.10	0.06	0.11	0.08	0.05	0.14	0.12	0.08
Guangdong	0.08	0.04	0.02	0.07	0.03	0.03	0.12	0.06	0.04
Guangxi	0.10	0.10	0.07	0.08	0.06	0.01	0.12	0.10	0.05
Sichuan	0.13	0.09	0.08	0.14	0.08	0.03	0.15	0.10	0.08
Guizhou	0.11	0.07	0.04	0.10	0.04	0.01	0.13	0.09	0.04
Yunnan	0.08	0.05	0.03	0.09	0.04	0.01	0.13	0.08	0.04
Shaanxi	0.15	0.10	0.11	0.16	0.09	0.03	0.19	0.15	0.10
Xinjiang	0.06	0.04	0.01	0.06	0.01	0.00	0.09	0.05	0.02

TABLE 5: SHARES OF TEXTILE IN LOCAL ECONOMIES

	Shares of textile in local economies								
		Y			K			L	
Raw data	1985	1993	2005	1985	1993	2005	1985	1993	2005
All	0.15	0.12	0.05	0.07	0.07	0.04	0.10	0.10	0.07
Beijing	0.09	0.06	0.01	0.05	0.03	0.00	0.08	0.07	0.03
Tianjin	0.15	0.08	0.02	0.10	0.07	0.02	0.13	0.10	0.04
Hebei	0.20	0.11	0.05	0.07	0.08	0.03	0.11	0.10	0.07
Shanxi	0.07	0.04	0.01	0.03	0.02	0.00	0.06	0.05	0.02
Inner Mongolia	0.09	0.09	0.07	0.03	0.04	0.01	0.06	0.07	0.06
Liaoning	0.09	0.05	0.02	0.05	0.04	0.01	0.07	0.06	0.03
Jilin	0.06	0.03	0.01	0.04	0.03	0.00	0.05	0.05	0.02
Heilongjiang	0.13	0.11	0.14	0.05	0.05	0.01	0.06	0.06	0.03
Shanghai	0.18	0.10	0.01	0.10	0.07	0.01	0.16	0.14	0.05
Jiangsu	0.24	0.21	0.08	0.16	0.16	0.08	0.16	0.18	0.13
Zhejiang	0.23	0.26	0.13	0.14	0.19	0.13	0.18	0.20	0.14
Anhui	0.13	0.11	0.04	0.07	0.08	0.03	0.10	0.12	0.07
Fujian	0.09	0.05	0.06	0.05	0.05	0.07	0.07	0.06	0.06
Jiangxi	0.10	0.07	0.06	0.05	0.06	0.02	0.07	0.07	0.06
Shandong	0.22	0.12	0.08	0.10	0.10	0.07	0.14	0.14	0.11
Henan	0.14	0.10	0.10	0.06	0.07	0.03	0.11	0.10	0.06
Hubei	0.18	0.11	0.07	0.09	0.09	0.02	0.14	0.14	0.11
Hunan	0.10	0.06	0.03	0.07	0.06	0.02	0.07	0.07	0.05
Guangdong	0.10	0.08	0.02	0.07	0.08	0.04	0.10	0.08	0.05
Guangxi	0.12	0.06	0.02	0.05	0.05	0.01	0.08	0.07	0.04
Sichuan	0.09	0.09	0.03	0.05	0.06	0.01	0.08	0.10	0.04
Guizhou	0.04	0.02	0.01	0.02	0.02	0.00	0.04	0.04	0.01
Yunnan	0.06	0.03	0.01	0.02	0.02	0.00	0.04	0.05	0.02
Shaanxi	0.19	0.11	0.03	0.07	0.08	0.01	0.10	0.09	0.06
Xinjiang	0.16	0.14	0.06	0.07	0.07	0.02	0.11	0.14	0.10

TABLE 6: SHARES OF CHEMICALS & ALLIED PRODUCTS IN LOCAL ECONOMIES

Shares of chemicals & allied products in local economies									
		Y			K			L	
Raw data	1985	1993	2005	1985	1993	2005	1985	1993	2005
All	0.10	0.11	0.10	0.11	0.10	0.08	0.06	0.08	0.08
Beijing	0.17	0.10	0.05	0.18	0.05	0.03	0.07	0.08	0.07
Tianjin	0.14	0.11	0.07	0.21	0.11	0.06	0.09	0.10	0.10
Hebei	0.09	0.12	0.11	0.09	0.10	0.06	0.07	0.08	0.09
Shanxi	0.10	0.11	0.10	0.10	0.06	0.06	0.08	0.08	0.07
Inner Mongolia	0.06	0.07	0.08	0.04	0.04	0.04	0.05	0.06	0.08
Liaoning	0.10	0.11	0.08	0.13	0.10	0.07	0.06	0.08	0.07
Jilin	0.16	0.16	0.19	0.20	0.15	0.15	0.08	0.10	0.13
Heilongjiang	0.03	0.03	0.03	0.04	0.07	0.06	0.03	0.05	0.06
Shanghai	0.13	0.12	0.08	0.18	0.14	0.08	0.07	0.09	0.07
Jiangsu	0.11	0.13	0.13	0.12	0.17	0.12	0.07	0.09	0.09
Zhejiang	0.08	0.09	0.19	0.09	0.09	0.09	0.05	0.07	0.06
Anhui	0.08	0.09	0.11	0.09	0.09	0.06	0.06	0.07	0.08
Fujian	0.11	0.09	0.07	0.12	0.11	0.07	0.08	0.08	0.03
Jiangxi	0.08	0.12	0.14	0.08	0.12	0.08	0.06	0.08	0.11
Shandong	0.07	0.09	0.12	0.07	0.09	0.10	0.06	0.07	0.09
Henan	0.09	0.11	0.09	0.09	0.09	0.07	0.07	0.09	0.08
Hubei	0.07	0.09	0.12	0.07	0.06	0.06	0.06	0.08	0.11
Hunan	0.12	0.12	0.10	0.13	0.11	0.08	0.08	0.09	0.14
Guangdong	0.09	0.10	0.05	0.07	0.08	0.05	0.06	0.06	0.03
Guangxi	0.10	0.11	0.11	0.11	0.09	0.07	0.08	0.09	0.12
Sichuan	0.10	0.11	0.12	0.12	0.10	0.08	0.07	0.09	0.11
Guizhou	0.07	0.10	0.20	0.08	0.07	0.11	0.05	0.07	0.13
Yunnan	0.10	0.10	0.15	0.15	0.10	0.09	0.08	0.09	0.13
Shaanxi	0.07	0.09	0.10	0.08	0.07	0.05	0.06	0.07	0.09
Xinjiang	0.04	0.04	0.08	0.04	0.02	0.02	0.05	0.05	0.06

TABLE 7: RANKING OF AVERAGE ANNUAL GROWTH RATE OF TFP

Ranking of average annual growth rate of TFP				
Rank	All	Mining	Manufacturing	Utility
1	Inner Mongolia	Inner Mongolia	Shanxi	Inner Mongolia
2	Shaanxi	Guizhou	Inner Mongolia	Sichuan
3	Sichuan	Yunnan	Shaanxi	Hunan
4	Hunan	Hunan	Sichuan	Henan
5	Jiangxi	Sichuan	Hunan	Zhejiang
6	Shanxi	Beijing	Jilin	Xinjiang
7	Jilin	Jiangsu	Heilongjiang	Guangxi
8	Guizhou	Zhejiang	Hubei	Guangdong
9	Hubei	Jilin	Guizhou	Fujian
10	Henan	Shaanxi	Jiangxi	Shanxi
11	Guangxi	Fujian	Hebei	Hubei
12	Anhui	Henan	Henan	Jilin
13	Fujian	Guangdong	Anhui	Shandong
14	Hebei	Anhui	Shandong	Jiangxi
15	Guangdong	Jiangxi	Fujian	Guizhou
16	Shandong	Guangxi	Guangxi	Hebei
17	Heilongjiang	Shanxi	Guangdong	Yunnan
18	Yunnan	Heilongjiang	Yunnan	Liaoning
19	Liaoning	Hubei	Liaoning	Beijing
20	Tianjin	Hebei	Tianjin	Shaanxi
21	Jiangsu	Liaoning	Jiangsu	Heilongjiang
22	Zhejiang	Shandong	Xinjiang	Jiangsu
23	Beijing	Xinjiang	Beijing	Anhui
24	Xinjiang	Tianjin	Zhejiang	Shanghai
25	Shanghai		Shanghai	Tianjin