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How Productive Is Chinese Industry?

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ABSTRACT

In this still on-going exercise, we provide a fresh scrutiny of the productivity performance of Chinese industry for the period 1952-2000 using a newly constructed data set. We have relaxed most unrealistic neo-classical assumptions as used in other studies, such as profit maximisation, perfect competition and constant returns to scale and taken into account important issues such as industry heterogeneity, production function stability and heteroschedasticity and autocorrelation problems in panel regression analysis.

The data used in this paper are the result of series unprecedented efforts on measuring industry-level inputs and output in Chinese industry together further improvements in this study. For output, a physical output index approach is used to tackle the widely criticised overestimation due to underdeflation and underreporting problems in the Chinese statistical system. For labour input, the Jorgenson approach is followed to capture quality changes in industry labour force. In constructing capital stock data, flaws in official investment data and problems in depreciation and deflation are seriously tackled.

Contradicting other studies, our preliminary findings show significant decreasing returns to scale for both the central planning and reform periods, which supports the market distortion argument for the Chinese economy. With a breakdown by factor intensity, we find that capital-intensive industries experienced a substantial rise in decreasing returns to scale over the two periods, whereas labour intensive industries had the opposite. Our measure of TFP gives higher results than the conventional income-share approach.

JEL Classification: O47, P27

Keywords: Growth accounting; returns to scale; total factor productivity; transition economies

1. INTRODUCTION

The growth of the post-reform Chinese economy over the past two decades has been phenomenal. Even based on so far the most critical reassessment by Maddison (1998), it is about 7.5 percent a year for the period 1978-95,¹ which is a fairly respectable rate for an economy that underwent significant policy and institutional changes. However, whether China's growth could be sustainable in the long run lies primarily in its productivity performance in manufacturing industries. This is mainly because many emerging market economies have the same nature of factor endowment as that of China, which is resource-scarce and labour-abundant, and they will compete fiercely with China along with the rising cost of input materials (e.g. minerals). This well justifies the need for a reliable measure of China's industrial productivity.

However, widely acknowledged data problems have been the biggest obstacle to this target. Firstly, the Chinese official statistics on industrial output is susceptible. This is because China's data reporting system together with the official methodology for measuring real output tend to underestimate inflation and overestimate output (Keidel, 1992; Rawski, 1993; Maddison, 1998; Woo, 1998; Wu, 2000). Some empirical evidences have strongly supported this argument (see Wu, 2002a; Adams and Chen, 1996). This suggests that even if input data have no problem, total factor productivity (TFP) estimates based on official output data could have been overstated.

Secondly, the official capital and labour statistics on Chinese industry could have also been flawed (Chen *et al.*, 1988a and 1988b; Wu and Shea, 2000). Problems such as the inappropriate inclusion of service employment in industrial employment and non-industrial or residential fixed assets in industrial capital stock and the inappropriate measure of depreciation and investment deflator have never been seriously tackled. These have added more doubts to the existing TFP estimates.

Thirdly, China's industrial classification is inconsistent over time. After China's implementation of the Soviet-style industrial classification standard to serve the administrative needs of central planning, which is reflected in the 1972 Standard of Industrial Classification, there have been major changes in 1985 and 1994. These

changes were to shift the standard of classification from one facilitating the planning controls over individual industries to one reflecting the technological nature of individual sectors in line with the international standard industrial classification (ISIC). However, there has been no official adjustment to the statistics of individual industries compiled under different standards. This is a big hurdle to a proper productivity analysis at industry or industry group level distinguishing industries with different factor intensity and nature of resources.

There is also some theoretical problem involved. Many studies on China have unconditionally accepted, explicitly or implicitly, the institutional and behavioural assumptions in the neoclassical growth accounting framework, that is, factors are paid their marginal product and firms are profit-maximising and operate in a distortion-free, perfectly competitive market system. While these strong and inappropriate assumptions make it convenient for researchers to substitute factor income shares in output for actual factor output elasticity to estimate TFP, they make TFP estimates difficult to interpret.

Using a newly constructed panel dataset that as we believe provides a more reliable measure of input and output data for 23 roughly two-digit level industries over the period 1952-2000,² we are able to tackle some significant theoretical and methodological problems prevailing in the literature. On the basis of that, we paint a overall picture about the productivity performance of Chinese industry over both the central planning and reform periods, as well as in different policy regimes.

This study is organised as follows. The next section reviews the literature by highlighting the problems in the previous studies and their implications for TFP estimates. Section 3 describes step by step how we construct the data set for this study. Section 4 explains how we tackle the theoretical and methodological problems. Section 5 reports and discusses our empirical findings. The last section concludes this study by highlighting unsolved problems and research priorities.

¹ Maddison's estimate refers to the period 1978-95, which could be compared with official annual growth rate of 10 percent (NBS, 2000) and the World Bank estimate of 8.2 percent (World Bank, 1998).

² It should be noted that of the total 23 industries in this dataset, there are 18 manufacturing industries, 4 mining industries and one for utilities. Strictly speaking, we should have separated mining industries and utilities from manufacturing. But we have not done so in this preliminary exercise.

2. PROBLEMS IN GROWTH ACCOUNTING FOR CHINA

2.1 Problems with the Neo-Classical Assumptions

Unconditional acceptance, either explicitly or implicitly, of the behavioural and institutional assumptions in the neoclassical growth accounting approach is the most important theoretical problem in many growth accounting studies on the Chinese economy (for examples, see Hu and Khan, 1997; World Bank, 1997).³ The neoclassical growth accounting approach introduced by Solow (1957) has some important institutional and behavioural assumptions. It assumes that firms are profit maximisers, operating in a distortion-free, perfectly competitive market system, under which prices reflect opportunity costs of resources and factors are paid their social marginal products (Barro, 1998). Together with the postulated linearly homogeneous Cobb-Douglas production function, these assumptions then make it logical to substitute output elasticity of factors (i.e. properly measured capital and labour inputs) by the respective shares of factor payment in national accounts. Importantly, such a substitution also makes it possible to bypass the drawbacks from estimating the output elasticity of inputs using regression method, which are largely due to data problems.

Clearly, only if all the above assumptions are held, technological changes are “Hicks neutral” and no major measurement problem will the growth of output not attributed to the growth of factors, known as the Solow residual, be qualified as the measure of the rate of technological progress. However, with all sorts of data problems in practice, even if the economy closely resembles the “neoclassical model”, the residual may be more appropriately described as a measure of “total factor productivity” growth, if not “the measure of our ignorance” (Abramovitz, 1956), rather than the “pure” measure of technological progress that shifts an economy’s production possibility frontier outward (Griliches, 1996).

Apparently, relaxation of these assumptions, which is fundamental to the improvement in growth accounting analysis of the transition economies, requires postulating and estimating parametric functions that should carefully take into account all important problems that cannot be tackled in the non-parametric approach. These problems are returns to scale, embodiment or disembodiment of technical change,

³ Also see McGuckin *et al.* (1992), Perkins (1988), Dernberger (1988), Tidrick (1986), and several Chinese authors (as cited by Jefferson, Rawski and Zheng, 1992, footnote 11).

capital utilisation over business cycles, industry heterogeneity, and function stability over different periods when policies and institutions undergo significant reforms. However, the first impediment to a sophisticated regression analysis is the limited data available to researchers. For example, in the previous studies on Chinese industry there are only two data sets available, one constructed by Chow (1993) and the other by Chen *et al* (1988a), both based on official statistics. Both series are aggregate data for the Chinese industrial sector as a whole and cover the period 1952-85. Such a limited number of observations make it methodologically impossible to take into account most of the problems mentioned above. Besides, these data series could tell little about the real impact of the nation-wide industrial reform that began in 1984.

2.2 Problems in Measuring Output

Problems in measuring output of Chinese industry are well known. China's persistent statistical practice originating from the Marxist material product system has not been able to provide adequate and accurate information that is required for the estimation of production function. Besides, the Government's high growth targets and various interventions in business decision making give local officials and state enterprise managers strong political incentives to report falsified statistics.

Most of the previous studies unconditionally accept Chinese official GDP deflators despite many believe that these output data contain upward biases due to both underdeflation and institutional effects (Wu, 2000; Maddison, 1998; Woo, 1998; Rawski, 1993; Keidel, 1992). For example, while official figures show that China's industrial GDP grew at 12 percent a year in 1978-97, empirical studies using different approaches have suggested that the actual annual growth may be somewhere between 8.7 percent (Wu, 2002a) and 4.6 percent (Adam and Chen, 1996). Besides, other official price indices also suggest different growth rates. For example, the industrial producer price index implies the rate should be 9.6 percent, also significantly lower than what suggested by official GDP deflators (Wu, 2000; Woo, 1998). Other things being equal, such an overstatement of output growth could invalidate any TFP estimate based on the official data.

The deflation problem becomes more complicated when the production function analyses of Chinese industry involve intermediate inputs. Woo (1998) criticises Jefferson, Rawski and Zheng (1992) for improperly using a higher deflator for input

materials, which yields a positive TFP growth of 2.4 percent compared with a zero TFP growth found in Woo *et al.* (1994). Using official price survey data as evidence, Jefferson *et al.* (1999) and Jefferson and Xu (1994) defend their deflation approach by arguing that price liberalisation in China resulted in a more rapid rise in prices of raw materials than in prices of output due to a long period of price control under central planning. However, if this is true, it implies that Chinese state firms have been able to either improve their input efficiency (which is not quite realistic) or receive subsidies (or something equivalent) to the extent as input prices rise. Here it should be noted that the deflators for gross output value and input materials in Jefferson *et al.* (1999) imply an annual GDP growth of 12.6 percent in 1984-92, even higher than the already dubious official rate (12.4 for this period, see NBS, 1998).

2.3 Problems in Measuring Capital Input

Difficulties in measuring real capital stock are another impediment to a proper production function analysis of Chinese industry. The Chinese official statistics provide no standard estimation of capital stock at any industry level or by any category. Their convention of calculating the current year's capital stock is to sum up the previous year's total value of fixed assets and the value of the new fixed assets added in the current year, without separating types of assets for production and non-production (residential) use. In many studies such a total value of fixed assets is adopted and inappropriately deflated using the official output deflator.

Even if the official fixed assets data are acceptable, researchers have to work out how to decompose the total value of fixed assets into different types, how to determine the depreciation rates for assets with different acquisition prices (historical costs), and how to reconstruct the capital stock so that all vintages of capital are priced on a constant basis. Obviously, the level and growth rate of capital stock can be sensitive to different ways of tackling all these problems.

Chen *et al.* (1988a and 1988b) makes the first important effort to estimate capital stocks for China's state industrial sector for the period 1952-85.⁴ The main contribution of their two widely cited studies is the reconstruction of the value of industrial fixed assets by removing residential fixed assets and then deflating it by

⁴ The earlier attempts by Rawski (1980) and Field (1980) relied on much less and unreliable information compared with Chen *et al.*

some “more carefully constructed deflators”. By contrast, a later study by Chow (1993) adopts official output (i.e. the Soviet-type net material product) deflators and makes no price or coverage adjustments to the available official data. Another big deficiency in both studies is the simple adoption of official depreciation rates without any empirical justification. The Chinese official depreciation rates are unusually low compared to international standard, ranging from 4.1 to 4.6 percent for total fixed assets (Chen et al., 1988a), which reflects the tradition of overstretching service lives of fixed assets under central planning. The official depreciation rates are irregularly adjusted without explicit justification.

There are two studies in Chinese advancing towards the use of the standard perpetual inventory method (PIM) to estimate capital stock. Zheng *et al.* (1993) attempt to use the Jorgenson approach to estimate capital stock for all 34 industries of the Chinese economy for a short period 1981-87. However, they explain neither what assumptions are made for the service lives of equipment and structures nor how the initial capital stock in 1980 is estimated. Huang *et al.* (1998) attempt to construct a net capital stock of structures and equipment for 15 state-owned manufacturing branches in 1978-95. By adopting Maddison’s assumption of the service life for structures (40 years) and equipment (16 years) for national industrial assets as a whole, they obtain a geometric depreciation rate of 8 percent for structures and 17 percent for equipment, which have been applied identically to all branches of Chinese manufacturing.

However, an often made mistake in these PIM exercises on China is the direct use of the official statistics on “investment in fixed assets” as the investment variable in the capital stock equation (Ho and Jorgenson, 2001; Young, 2000a; Huang et al., 2002; Hu and Khan, 1997; Li et al, 1992), which is conceptually inappropriate. By the official definition, this “investment in fixed assets” indicator refers to the “workload” of activities in construction and purchases of fixed assets in money terms (NBS, 2001, p.220). As correctly noted in Chow (1993, p.816), the work performed in the “investment in fixed assets” may not produce results that meet standards for fixed assets in the current period. In fact, some of the work (investment projects) may take many years to become qualified for fixed assets and some may never meet the standards, hence completely wasted, which is a typical phenomenon in all centrally planned economies, and still true for state firm or government directly involved projects in the transition of these economies.

The nature of the problem is the same as that commented by Xu (1999) on the item of gross fixed capital formation in China's newly adopted SNA-type national accounts, which is based on the statistics of "investment in fixed assets". Xu (1999, pp.62-63) points out that the key difference between the Chinese system and the 1993 SNA is that the former 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 (investors) of capital goods. For example, in SNA (CEC et al., 1993, p.230) a plant construction is counted as *inventory* before it is sold to a buyer (investor), while in the Chinese national accounts it is included in the fixed capital formation.⁵ Such a practice exaggerates the amount of capital stock in actual productive service.

Obviously, one of the underlying key issues in the debate on China's TFP performance is how fast China's industrial capital stock has grown since the economic reform. It is because other thing being equal, a slower (faster) growth of capital stock will lead to a higher (lower) estimate of TFP. Available estimates for the growth of capital stock vary substantially due to differences in deflators, depreciation rates, initial capital stocks and coverage. For example, in Chen *et al.* (1988a) net industrial capital stock grew at 5.1 percent for 1978-85, compared with 7.6 percent in Chow (1993).⁶ For the period 1980-92, Jefferson *et al.* (1996) report a rate of 7 percent. However, for a slightly longer period 1978-95, Huang *et al.* (1998) report 6 percent for structures and 9.5 percent for equipment.⁷

2.4 Problems in Measuring Labour Input

The Chinese official data on employment also have severe flaws. The very first problem is that there is no any official employment indicator that could reflect

⁵ The general SNA principles governing the time of recording and valuation of gross fixed capital formation is "when the ownership of the fixed assets is transferred to the institutional unit that intends to use them in production" (CEC, 1993, p.223).

⁶ Chow's estimates include the non-state industrial sector while the others discussed here refer to the state industrial sector. The difference may be trivial as Chow used a (official) single output deflator for all types of "capital accumulation", and by 1985 the non-state industry was rather small.

⁷ As for the growth of national capital stock, the range of estimates for the reform period is even greater. For example, Hu and Khan (1997) estimate it at 7.7 percent (1979-94), Li, Gong and Zheng (1995) 9.1 percent (1978-90), Borensztein and Ostry (1996) 9.9 percent (1979-94), Woo (1998) about 10 percent, and Wu Yanrui (1999) 11.0 percent (1979-97). Both Borensztein-Ostry and Woo basically adopt the rate from Li (1992) with updating.

important changes in China's employment system while maintaining historical consistency. As identified in Wu (2002b), there is no unique published official source that has the ultimate authority, the definition of major employment indicators is often obscure and the coverage of these indicators is inconsistent over time. For example, for the indicator "staff and workers" an important inconsistency appears in two official sources, the Department of Industrial and Transportation Statistics (DITS) and the Department of Population and Employment Statistics (DPES). For the period 1978-1995, the DITS source reports that the number of industrial "staff and workers" increased from 48.4 to 85 million, or 3.4 percent per annum, while the DPES source shows that the number only rose from 43.3 to 67.5 million, or 2.7 percent per annum.

Secondly, China's statistical authorities have provided no working hour estimates by regular sample surveys. While almost all studies use the number of employed for labour input, the official standard of working hours was reduced from 48 to 44 hours per week effective from May 1, 1994, and a further cut to 40 hours since May 1, 1995. Even before the first reduction of working hours, the 48-hour standard was never identically applied to all industries. A recent study by Wu and Yue (2003) shows that after taking into account these changes and industry variations, the growth rate of hours worked in Chinese industry is 5.6 percent per annum in 1952-78 and 1.1 percent per annum in 1978-2000, much lower than 6.3 and 1.8 percent, respectively, if measured by the numbers employed in the official industrial statistics.

Thirdly, state firms in China traditionally recruited more staff and workers than what necessary for their production. These non-industrial employees worked in factory-run services such as educational and health care units, as well as in the communist party or its allied political organizations.⁸ As shown in Wu and Yue (2003), they account for 10 to over 20 percent of total employment across industries. In any case, these employees, whom are mostly categorised as persons engaged in "services and other activities", should not be counted as part of industrial work force. However, perhaps partially due to lack of systematic statistics for these employees, it has been out of concern in most studies.⁹

⁸ Such a practice made it socially and politically easy to control industrial workers, and was in line with China's unique *hukou* (residential registration) system that resulted in a virtually immobile society in terms of location choice of working and dwelling.

⁹ Check Chan at el??????

Lastly, many growth accounting exercises or productivity studies on the Chinese economy have simply used numbers employed as a proxy for labour input. Regardless the aforementioned problems in the official statistics on numbers employed, this implicitly assumes that workers embodied with different human capital stock are paid the same marginal product. Our established knowledge based on studies on the US economy suggests that the core issue in measuring labour input is how to hold the quality of hours worked constant when there are actually changes in the quality of workforce due to changes in the composition of the age, gender, education, occupation and industry of the workforce, or in other words, how to convert heterogeneous hours worked into homogenous volume of labour input.¹⁰ If failed to do so, for example, in the case of an increase of labour quality, the growth of total labour input will be understated and hence the growth of TFP will be exaggerated.

There have been very few studies attempting to measure the labour input in the Chinese economy according to the standard concept. Using population and industrial censuses data,¹¹ together with limited-sample surveys on households by NBS and CASS, Li et al (1993) made the first ever effort to construct labour input indices for 34 sectors of the economy in a short period 1981-87 following the Jorgenson approach (Jorgenson, 1990). However, they did not seriously tackle any conceptual and inconsistency problems in the official labour statistics. By contrast, using similar data Young (2003) devoted a significant part of his study on China's post-reform productivity growth to identifying and reconciling inconsistencies in measuring labour input. He has empirically shown that the census data on age-education profiles are seriously flawed and other NBS and CASS household surveys are heavily biased towards better-educated households (2000, pp.26-28). However, he did not work at any disaggregate level.

The only time series data source for measuring human capital contribution is the official statistics on the number of annual graduates with different levels of education attainment. But this time series is national aggregate only and comes without

¹⁰ This core issue has been made theoretically sound with clear empirical evidence because of the studies by, for example, Denison (1962, 1974), Griliches (1960), Jorgenson and Griliches (1967), Kendrick (1961, 1973), Chinloy (1980), and Jorgenson, Gollop and Fraumeni (1987).

¹¹ The five population censuses are 1953, 1964, 1982, 1990 and 2000, and the three industrial censuses are 1951, 1985 and 1995.

matching information on any characteristic of workforce. Following Barro and Lee (1997; 2000), some growth accounting studies (e.g. Wang and Yao, 2002) apply the perpetual inventory method (PIM) to such data to measure the stock of human capital in the Chinese economy. The so-estimated human capital stock cannot be a reliable proxy for the actual human capital service in the Chinese economy because education in China has been heavily controlled by the state regulations and national plans which have little concern about the (underlying) market needs. In such a context, it is also difficult to justify the (underlying) function of the depreciation of human capital.

3. DATA CONSTRUCTION

3.1 Data on Output

The output data are gross value added data for individual industries in 1952-2000. They are constructed based on volume indices and input-output table value added weights. This approach is used by Wu to tackle Chinese output data problems in a serious studies (1997, 1999, 2000, 2002a). It intends to bypass the problematic official output deflator that tends to understate inflation and likely data friction in output value report. In this study, while updating the Wu indices to 2000, we have improved the indices by adding new commodities, especially those produced by electrical and electronic industries and refining some existing series by cross checking the latest available different sources of information. The procedures of output data construction are briefly explained briefly as follows (see Wu 2002a for details).

Firstly, data on the physical output of 200 major industrial commodities, published annually by DITS (Department of Industrial and Transportation Statistics, NBS), are collected. Commodity group or sub-industry level aggregation is conducted for those commodities with 1987 ex-factory prices available. For those commodities without proper prices, they are incorporated into relevant groups using geometric means.

Secondly, further aggregation of the output indices of commodity groups or sub-industries is conducted in order to match the industries (roughly two-digit level) in the Chinese 1987 Input-Output Table (the SNA type).

Lastly, gross value added series at constant 1987 prices for individual industries are derived with the 1987 Input-Output Table weights. At this stage, we assume that

the output value that is *unidentified* by the commodities follows the same trend that is *identified* by the commodities. For the 1987 benchmark, the identified value accounts for about 70 percent of the total gross value added (Wu, 2002a).

3.2 Data on Capital Stock

The estimation of capital stock for Chinese industry industries described here primarily follows the perpetual inventory method (PIM) that has been intensively practised in studies on asset measurement by BEA (Bureau of Economic Analysis, US Department of Commerce). The PIM has been developed since Goldsmith (1951). With this method, both the net stock and depreciation of any given type of asset is a weighted average of past investment in that asset. The calculations of net stocks and depreciation are based on real investment data at the type-of-asset level of details. For each type of asset, depreciation is cumulated over all vintages, and net stocks are estimated by subtracting the cumulative value of past depreciation from the cumulative value of past gross investment.

To explain the PIM, let us start with the following equation:

$$K_t = I_t - D_t + K_{t-1} \quad (1)$$

where D_t is total physical depreciation (or loss of efficiency) occurring on all assets in year t , I_t is total gross investment, and K_t is the net stock of capital. Defining the one-period rate of physical depreciation to be $\delta = D_t / K_{t-1}$ equation (1) can be re-written as

$$K_t = I_t + (1 - \delta_t)K_{t-1}. \quad (2)$$

The parameter δ_t is the rate of physical depreciation of the capital stock which combines the effects of retirement from service and the in-place loss of efficiency. The special case of geometric depreciation occurs when $\delta_t = \delta$, that is, when the rate of depreciation is constant over time. The constant depreciation rates for specific types of assets are determined by dividing the appropriate declining-balance rate R for each asset by the asset's service life L , that is, $\delta = R / L$. The pattern of depreciation charges for a given asset is determined by its "depreciation profile" which for most assets can be assumed to be strictly geometric, and the appropriate rate of declining

balance are usually taken from empirical studies of similar classes of assets (Hulten and Wykoff, 1981a and 1981b).¹²

Our fundamental problems are how to construct gross investment series by asset type for individual industries, determine the depreciation rate for assets, and deflate the net capital stock so that all vintages of capital are priced on a constant basis.

Constructing the required investment series (I) is the first challenge. The steps described here basically follow Wu (2002c). Firstly, the gaps in the official year-end total fixed assets by industry at historical costs are filled by linear interpolations. Secondly, the assets series are corrected for any classification inconsistencies. Thirdly, the results are decomposed into equipment, production and residential structures using scattered information available in Ministry of Finance, and then residential structures are removed. Lastly, the first difference of the reconstructed equipment and structures series is taken for each industry, further corrected for scrapings (see Wu, 2002c). The results extend Wu's investment estimates to 2000 and are available for 23 mining and manufacturing industries.

To calculate net capital stock we need the initial level of capital stock that is set as 1952. Thanks to the recent disclosure of the information on the 1951 national census of industrial fixed assets and inventories, which verified industrial fixed assets and provided gross fixed assets and their cumulative depreciation in the 1952 replacement value. The information is available by industries under the administration of various industrial ministries. This allows us to work out the net initial stock in equipment and structure for 1952.

To deflate the gross investment flows at historical costs, two sets of investment price indices are required for equipment and structures, respectively. Investment price index for structures is derived from the official gross value of output of construction works at both current and constant prices. It is applied identically to structures of all industries. For investment price index for equipment, it is derived from the official capital formation data at both current and constant prices for the period prior to 1980 and applied to all industries. As for the period 1980-2000, we are able to construct

¹² Also see Coen (1975) and Koumanakos and Hwang (1988) for empirical support to the geometric-depreciation pattern assumption.

industry-specific indices with recently available price data on individual machinery and equipment that are officially compiled for assets evaluation (Ref???)

Finally, we have to depreciate the so-estimated gross capital stock series by a proper δ for equipment and structures of each industry. We adopt the BEA declining-balance rates for industrial equipment and structures that are based on empirical evidence on used asset prices (BEA, 1997, pp.70-71). We use two sources of information for gauging the service life of assets in Chinese industry. One is the (internally published) depreciation rates used by the Ministry of Finance in 1963 that refer to the fixed assets of industries under responsible ministries, and the other one is the officially adopted service life of equipment and structures assets of individual industries in 1993. Assuming a geometric depreciation profile, the service life of assets for 1963 can be derived. The estimated service lives for 1963 are used for the period 1953-78, the official standard of service life for 1993 are used for the period 1988-2000, and the average of these 1963 and 1993 figures are used for the period in between, that is, 1979-87. Therefore, the estimated depreciation rates are different for the three periods. Such a treatment should be justified given significant differences in industrial policies and institutional arrangements over these periods. Finally, following equation (2) the depreciation rates are employed to derive the net capital stock used in this study.

3.3 Data on Labour Input

To tackle the problems in the official employment statistics discussed previously, we adopt approach used by Wu and Yue (2003) and extended their labour input indices to individual industries.¹³ The steps are described as follows. Our first task is to construct a quantity series for each industry. Firstly, the DPES “persons engaged” in industries series are corrected for classification inconsistencies. Secondly, the share of SOEs in each industry is estimated using census and survey information so that the state and non-state components of the series could be treated differently whenever necessary. Thirdly, staff and workers engaged in non-industrial “services and other activities” are removed from the state component of each industry. Note that the non-state component is not adjusted because this is typically a SOE phenomenon. Lastly,

¹³ Here we express our great appreciation to Yue Ximing for extending the benchmark-based estimates in Wu and Yue (2003) to time series estimates.

the results on numbers employed are converted to hours worked using information on working hour standard across industries and over time (Wu and Yue, 2003). As these standards are only applied to state firms and it is reasonable to assume that non-state firms generally have longer working hours than state ones, the weekly working standard for the non-state component is then stick to 48 hours throughout the entire period.

The second task is to construct employment matrices for benchmark years. There are seven benchmarks that are chosen, namely, 1955, 1963, 1982, 1987, 1990, 1995 and 2000. They are chosen primarily because of data availability, but they make good sense for capturing important policy shifts over time: 1955 represents the first Soviet style five-year plan focusing on heavy industrialisation; 1963 just follows the failure of the Great Leap Forward and the government's rethinking of the previous industrial policy; 1982 is about two year before the nation-wide industrial reform and should be representative for the late planning period; as for 1987 and 1990, they are two points in the middle of the first stage of industrial reform mainly aiming to decentralise SOEs but confined to the planning framework; finally 1995 and 2000 represent a new era began in the early 1990s when the authorities substantially deregulated market-oriented activities in industrial production.

Next, for each of these benchmarks, our data on hours worked have to be cross classified by 2 genders, 7 age groups, 5 education levels, 4 occupations and 25 industries. Gaps in the matrices, which are inevitable by nature, are filled by the iterative proportional filling (IPF) approach developed by Bishop, Fienberg and Holland (1975).

The final task is to construct labour compensation matrices for all benchmarks to exactly match the employment matrices, so that all aspects of employment as shown in the employment matrices could be converted to homogenous unit via their prices. Before China's first SNA-type Input-Output Table in 1987, no direct measure of total labour compensation is available. Following Wu and Yue (2003), for the period prior to 1987, we collect total wage bill and welfare payment data for state industrial workers, and then adjust the results for other subsidies and for the non-state workers. For the period 1987-2000, data are obtained directly from the IO tables for the years when input-output surveys are conducted. As for other years, labour compensation is estimated by interpolations.

Eventually, time series labour input indices for individual industries are constructed by linking these benchmark matrices and taking into account the information in the time series of quantity data.

This dataset finally contains matching output, capital stock and labour input data for 23 industries for 1952-2000. There are 1127 observations in total.

4. ISSUES ON ESTIMATION METHODOLOGY

4.1 Parametric or non-parametric

Production function parameters are central to the decomposition of output growth into contributions from physical capital, labour, and productivity. Assume an aggregate value added production function

$$Y = F(A, K, L) \quad (3)$$

where value added Y is expressed as a function of primary inputs such as physical capital K , labour L and the level of technology A . Differentiation of equation (3) with respect to time, after division by Y of both sides of the equation and rearrangement of terms, results in the following expression relating growth in output, to growth in inputs, and growth that is due to technological change:

$$\frac{\dot{Y}}{Y} = \left(\frac{F_A A}{Y}\right) \cdot \frac{\dot{A}}{A} + \left(\frac{F_K K}{Y}\right) \cdot \frac{\dot{K}}{K} + \left(\frac{F_L L}{Y}\right) \cdot \frac{\dot{L}}{L} \quad (4)$$

where F_K and F_L are the social marginal product of capital and labor. $(F_K K)/Y$ and $(F_L L)/Y$ are ‘parameters’ known as output elasticities of capital and labour, respectively. If the technology is in a Hicks-neutral way, then $\left(\frac{F_A A}{Y}\right) \cdot \frac{\dot{A}}{A} = \frac{\dot{A}}{A}$.

In the literature, there are two approaches, i.e., non-parametric and parametric, in estimating these parameters. By imposing perfect competition and constant returns to scale production technology, the non-parametric approach uses data on labour compensation from national accounts statistics to gauge the factor share, which is equivalent to the output elasticity with respect to labour under the above assumptions. In a market economy, the risk of imposing perfect competition may be safely ignored so that workers are paid their marginal revenue product of labour and capital marginal revenue product of capital.

However, in the context of a centrally planned economy or transitional economy, assumptions of no distortion and perfect competition and that factors are paid their marginal revenue product are difficult to justify. This may lead to biases in the estimation of the parameters, i.e., output elasticities of capital and labour, no matter how comprehensive the coverage of labour compensation data is.¹⁴ As long as wage is not equal to marginal social revenue product of labour, labour compensation data may over- or under-estimate the output elasticity of labour (and therefore that of capital). To the extent that labour compensation data may be equal to the ‘true’ output elasticity of labour, it is by no means coincidental.¹⁵ We therefore argue that in estimating aggregate production function parameters, non-parametric approach is unreliable in the context of a centrally planned or transitional economy. Parametric approach is used in this study.

4.2 Estimation in levels or in growth rates

The second issue in the estimation of production function parameters is whether to estimate the production function at levels or in growth rates. Assume a simple Cobb-Douglas production function:

$$Y_t = A_t K_t^\alpha L_t^\beta, \quad (5)$$

Taking logs of both sides of equation (5) yields

$$\log(Y_t) = \log(A_t) + \alpha \log(K_t) + \beta \log(L_t), \quad (6)$$

This is the production function in levels and can be estimated directly by regressing $\log(Y_t)$ on $\log(K_t)$ and $\log(L_t)$.

Alternatively one can take the first difference of equation (6) which yields

$$\dot{Y}_t = \dot{A}_t + \alpha \dot{K}_t + \beta \dot{L}_t \quad (7)$$

This is the production function in growth rates and can be estimated directly by regressing \dot{Y}_t on \dot{K}_t and \dot{L}_t .

¹⁴ For example, to estimate labour share in China, Hu and Khan (1997) sum up total wage payment, labour insurance and welfare payments to obtain total labour compensation while Li and others (1993) further include implicit housing subsidies.

¹⁵ Chow (1993) assigned arbitrarily a value of 0.4 for labour share.

There are reasons that estimation in levels should be preferred. First, if the true data generating process is a production function in levels, as suggested by the production function theory, taking first difference would remove all the information about the long-run relationship between factor inputs and output. Second, if estimation in first difference is used, it is difficult to argue against the estimation in higher order differences.

4.3 Restrictions on CRS and Hicks-neutral technological change

The estimation of the production function also raises the issues of whether to impose constant returns to scale (CRS) and/or Hicks-neutral technological change. The imposition of CRS is almost the norm in any study that applies non-parametric approach. In an aggregate national economy, the condition of CRS must hold if all of the income associated with the gross domestic product is attributed to one of the factors, capital or labour here (Barro 1998). However, in the context of the industrial sector, some net factor income may accrue to factors that are in other sectors, and value added output in the industrial sector would include this net factor income.¹⁶ The imposition of CRS would certainly introduce biases in the estimate of TFP.

Consider again equation (5). If the production function exhibits non-CRS, i.e., $\alpha + \beta \neq 1$, then

$$\log(Y_t) = \log(A_t) + \alpha \log(K_t) + (1 - \alpha) \log(L_t) + (\alpha + \beta - 1) \log(L_t), \quad (8)$$

which implies that the imposition of CRS will introduce a bias of $(\alpha + \beta - 1) \log(L_t)$ in the estimation of TFP. The direction of the bias is determined by the sign of $(\alpha + \beta - 1) \log(L_t)$.

In this study, restriction of Hicks-neutral technological change is also relaxed in the econometric estimation of the production function in levels. The constant term in the regression would capture any form of technological change, Hicks-neutral and labour-augmenting or capital-augmenting or both.

¹⁶ Even in the case of a national economy, Barro (1998) argues that the condition of CRS may not hold since some net factor income may accrue to foreign owned factors.

5. DISCUSSION OF RESULTS

We estimate a simple Cobb-Douglas production function¹⁷ at levels, but without imposing many a priori restrictions, such as constant returns to scale and Hicks-neutral technology that are common in the previous studies. The regression function is specified as follows:

$$y_{it} = \varpi_{it} + \alpha k_{it} + \beta l_{it} + e_{it} \quad (9)$$

where y , k and l are in logarithms and represent quantity of real value-added output, net capital stock and employment, respectively. The subscript i denotes industry while t represents year. The constant term ϖ measures technological progress that captures Hicks-neutral, labor-augmenting or capital-augmenting technological progress or both. Finally, the error term e is a stochastic variable that is assumed to be white noise. As explained in Section 3, our panel dataset includes 23 industries for the period 1952-2000, which gives us 1127 observations that are sufficient for more sophisticated econometric tests, as discussed below.

5.1 Estimates of output elasticity of capital and labour

To take advantage of our newly created dataset, we pool them together in our regression exercises to make efficient use of the information. The first step in our exercise is to check for any panel level heteroskedasticity (HC) and autocorrelation, as the presence of them may make our estimates less efficient although the estimates may still be unbiased. The panel level HC test (LR test) produce a χ^2 (22) of 641.13 which is statistically significant at less than 1% level and thus the null hypothesis of panel-level homoskedasticity may be rejected. We then follow a likelihood ratio test procedure suggested by Wooldridge (2002, 282-283) to test the presence of autocorrelation in panel-data models. The F test, $F(2, 22)$, is 128.97 and is also statistically significant at less than 1% level, which suggests the presence of

¹⁷ An estimation of a flexible function form is sometimes preferred, but it does not come without a price. For example, estimation of translog (or other flexible) function can lead to parameter estimates that imply oddly shaped isoquants, requiring the imposition of various restrictions on the value of these parameters (Hulten 2000). As this paper is the first of a series of research to explore this newly constructed data set, we start with a simple functional form and reserve other extensions for future research.

autocorrelation. Feasible generalized least square regression method is thus chosen to take care of HC and panel-specific autocorrelation in all models.

As we have three different measures of labour input (i.e. compensation-weighted, numbers employed, hours worked), we report the estimates for all of the three measures but focus our report on results from labour input index, in which the efficiency of labour input has been accounted for. Many studies on the sources of growth in the Chinese economy assume the stability of the production function parameters for the entire period observed including both the central planning and reform periods. To start with, we estimate the production function for the period 1952-2000 with no time break, along with different time break-down.

Table 1 reports regression results for three different labour input cases for each of the specified time period. All results are from feasible generalized least square (FGLS) regression method with corrections for HC and panel-specific autocorrelation in all models. In all models, we include branch dummies to take into account branch heterogeneity. The results show that they produce better results than common intercept, as suggested by the likelihood ratio tests.¹⁸

The coefficients estimated by the regression are reported in Table 1. The Wald χ^2 (24) test is significant in all models as reported in Table 1, suggesting a good fit overall. Furthermore, regression coefficients for capital and labour are all significant at one percent level. Interestingly, there is a robust pattern of decreasing return to scale for the production function over the entire period 1952-2000 and in all different time periods. For 1952-2000, the output elasticity with respect to capital is 0.50 while that with labour is 0.39. To the extent that the coefficient for labour is similar to the arbitrarily assigned value of 0.4 by many authors, for example, Chow (1993), it is by accident. However, as shown with different time periods, the results are rather different from the one with no time break: for the pre-reform period, the capital and labour elasticities are 0.43 and 0.42, respectively, and for the post-reform period, 0.63 and 0.17, respectively.¹⁹

¹⁸ The likelihood ratio tests for different scenarios are not reported here but are available from the authors on request.

¹⁹ To the extent that the coefficient for labour is similar to the arbitrarily assigned value of 0.4 by many authors, for example, Chow (1993), it is by accident. However, as shown with different time periods, the results are rather different from the one with no time break (Table 1).

As shown in Tables 2 and 3, we have also estimated the capital-intensive and labour-intensive cases separately. The division of the two cases is based on capital-labour ratio of industries. Since we have to draw the line arbitrarily, we do not want to emphasise too much on the findings here, although all tests have been passed with high significance, except for the period 1992-2000 in the capital-intensive case (it may help us detect some data problem later). There is, however, one interesting point that is worth mentioning. While labour-intensive industries seem to have moved from decreasing returns to scale to nearly constant return to scale status, capital-intensive industries have experienced just the opposite. This is certainly a worthwhile point for further investigation, especially on the role of the government industrial policy that affects market power of industries or imposes distortions.²⁰

²⁰ Another possible improvement is to have three groups, i.e introducing an “in-between” group to separate two more apparent cases of biased factor intensity. Besides, we need to separate mining industries from manufacturing industries.

Table 1. Estimates of output elasticity of Capital and Labour:
FGLS with HC and panel-specific AR(1) correction

Dependant variable	1952-1965			1966-1979			1980-1991			1992-2000		
	lab. Input	workers	hours	lab. Input	workers	hours	lab. Input	workers	hours	lab. Input	workers	hours
Ln K	0.4136	0.4290	0.4325	0.4403	0.4360	0.4526	0.6076	0.5858	0.5862	0.5569	0.5446	0.5602
	0.0286	0.0274	0.0282	0.0424	0.0423	0.0420	0.0420	0.0392	0.0386	0.0346	0.0357	0.0347
Ln L	0.4835	0.5087	0.4773	0.3992	0.4202	0.3921	0.2729	0.3756	0.3681	0.1698	0.1823	0.1870
	0.0367	0.0354	0.0374	0.0492	0.0508	0.0497	0.0731	0.0840	0.0801	0.0693	0.0741	0.0714
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi sq (24)	2303.94	2792.89	2204.07	7372.56	7089.00	7212.77	6650.70	6868.97	7017.25	3686.27	5525.56	5242.73
Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs.	322	322	322	322	322	322	276	276	276	207	207	207
No. of groups	23	23	23	23	23	23	23	23	23	23	23	23
No. of time period	14	14	14	14	14	14	12	12	12	9	9	9
Log Likelihood	-13.28	-11.34	-16.35	240.31	241.35	239.86	318.23	311.3	311.29	173.25	172.04	172.52

	1952-1979			1980-2000			1952-2000		
	lab. Input	workers	hours	lab. Input	workers	hours	lab. Input	workers	hours
Ln K	0.4306	0.4467	0.4597	0.6347	0.6441	0.6284	0.5013	0.5144	0.528
	0.02	0.0194	0.0196	0.0284	0.0277	0.026	0.0159	0.015	0.015
Ln L	0.4202	0.4424	0.4208	0.1729	0.1843	0.1742	0.3852	0.4079	0.3805
	0.0273	0.028	0.0282	0.0525	0.0603	0.0556	0.0227	0.0234	0.0232
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi sq (24)	3207.17	3313.71	3207.28	3611.3	3818.7	3801.91	5800.3	6107.9	5779.02
Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs.	644	644	644	483	483	483	1127	1127	1127
No. of groups	23	23	23	23	23	23	23	23	23
No. of time period	28	28	28	21	21	21	49	49	49
Log Likelihood	110.12	109.34	101.26	425.79	424.36	414.48	339.02	339.89	328.36

Sources: Authors' estimates. Figures below the coefficients are standard errors.

Table 2. Estimates of output elasticity of Capital and Labour for Capital-Intensive Industries
FGLS with HC and panel-specific AR(1) correction.

	1952-1965			1966-1979			1980-1991			1992-2000		
	lab. Input	workers	hours	lab. Input	workers	hours	lab. Inpu	workers	hours	lab. Inpu	workers	hours
Ln K	0.4965	0.5196	0.5135	0.1356	0.2349	0.1624	0.5046	0.5357	0.4477	0.4948	0.4265	0.4503
	0.0418	0.0307	0.0381	0.0438	0.0520	0.0459	0.0698	0.0345	0.0386	0.0371	0.0366	0.0375
Ln L	0.5381	0.5385	0.5606	0.7624	0.6605	0.7656	0.4944	0.5536	0.6839	0.0377	0.2266	0.2589
	0.0531	0.0369	0.0494	0.0744	0.0694	0.0650	0.1128	0.0510	0.0634	0.0679	0.0547	0.0616
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not sig. at 10%		
Wald Chi sq (11)	2157.44	3295.80	2016.54	1694.55	1688.17	1813.08	1409.75	1997.93	2173.83	632.92	840.68	943.31
Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs.	140	140	140	140	140	140	120	120	120	90	90	90
No. of groups	10	10	10	10	10	10	10	10	10	10	10	10
No. of time period	14	14	14	14	14	14	12	12	12	9	9	9
Log Likelihood	-9.63	1.1	-8.22	102.99	103.27	104.98	143.28	144.43	136.76	101.84	94.92	93.29

	1952-1979			1980-2000			1952-2000		
	lab. Input	workers	hours	lab. Input	workers	hours	lab. Inpu	workers	hours
Ln K	0.4734	0.5264	0.5191	0.5715	0.522	0.5145	0.5455	0.567	0.5654
	0.0345	0.032	0.0332	0.0414	0.0389	0.0358	0.0273	0.0239	0.024
Ln L	0.4541	0.4838	0.4934	0.1042	0.1517	0.2024	0.3773	0.4127	0.4358
	0.0507	0.0452	0.0492	0.0662	0.0694	0.0662	0.0395	0.0361	0.0369
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi sq (11)	1130.82	1380.73	1345.12	365.54	383.11	404.88	262.3	3002.48	3289.3
Significance									
Obs.	280	280	280	210	210	210	490	490	490
No. of groups	10	10	10	210	210	210	49	49	49
No. of time period	28	28	28	210	210	210	10	10	10
Log Likelihood	33.67	38.34	28.86	217.86	208.25	202.15	142.01	153.47	136.3

Table 3. Estimates of output elasticity of Capital and Labour for Labour-Intensive Industries
FGLS with HC and panel-specific AR(1) correction

	1952-1965			1966-1979			1980-1991			1992-2000		
	lab. Input	workers	hours	lab. Input	workers	hours	lab. Input	workers	hours	lab. Input	workers	hours
Ln K	0.2960	0.2957	0.3149	0.6233	0.6175	0.6305	0.6197	0.5956	0.6116	0.7021	0.6439	0.7071
	0.0337	0.0329	0.0331	0.0430	0.0435	0.0420	0.0663	0.0537	0.0534	0.0668	0.0729	0.0680
Ln L	0.3974	0.4234	0.4056	0.1781	0.1930	0.1712	0.1389	0.2702	0.2117	0.3154	0.5950	0.3780
	0.0444	0.0447	0.0450	0.0462	0.0485	0.0456	0.1441	0.1434	0.1379	0.1177	0.1558	0.1210
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi sq (14)	965.54	1052.54	1023.99	5112.63	5023.18	5009.23	3712.21	3454.42	3445.61	2455.30	2509.96	3084.97
Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs.	182	182	182	182	182	182	156	156	156	117	117	117
No. of groups	13	13	13	13	13	13	13	13	13	13	13	13
No. of time period	14	14	14	14	14	14	12	12	12	9	9	9
Log Likelihood	4.59	6.34	3.31	146.76	147.37	146.66	163.65	165.96	165.34	80.05	77.31	79.59

	1952-1979			1980-2000			1952-2000		
	lab. Input	workers	hours	lab. Input	workers	hours	lab. Input	workers	hours
Ln K	0.3700	0.3784	0.3908	0.6646	0.6172	0.6667	0.4446	0.4580	0.4698
	0.0242	0.0232	0.0233	0.0448	0.0430	0.0395	0.0204	0.0191	0.0192
Ln L	0.3608	0.3884	0.3696	0.2675	0.3965	0.2968	0.3578	0.3847	0.3592
	0.0311	0.0323	0.0320	0.0963	0.1084	0.0955	0.0276	0.0287	0.0280
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi sq (14)	1850.88	1954.34	1889.67	1856.12	1677.55	1836.86	2363.91	2576.09	2447.27
Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs.	364	364	364	273	273	273	637	637	637
No. of groups	13	13	13	13	13	13	13	13	13
No. of time period	28	28	28	21	21	21	49	49	49
Log Likelihood	82.52	83.2	80.26	208.28	211.46	209.49	198.71	199.19	195.63

5.2 TFP performance

With the new estimates of input parameters, we are now in a position to conduct the familiar growth accounting exercises. In Table 4, we compare TFP estimates using the traditional income share approach with those based on our estimated parameters. For the traditional approach, following many studies we set the share of capital as 0.6 and the share of labour 0.4 throughout.

Recall that our results suggest apparent decreasing returns to scale, statistically robust for almost all cases except for capital intensive case in 1992-2000. Obviously, if the estimated output elasticities, rather than the traditional income shares, are used to calculate input contributions, it will result in higher residuals or TFPs than the traditional approach. This is just as what are shown in Table 4.

A sensible question is how to explain the higher TFP estimates. First of all, we should be reminded that the residual is no longer the Solow residual. If there is no any type of market distortion and firms are efficient, operating with least-cost combination of inputs as in the theory, that is, they are in the decreasing-return-to-scale zone but still with their short-run cost curves tangent to the long-run cost curve, the residual then measures both Hicks-neutral and factor-augmenting technical progress.

However, our problem is what if firms, or some of them, are not efficient and market is distorted due to administrative monopoly as observed in China. While inefficient firms with market power may gain profits, they may over invest with cheap credits, which lower output elasticity of capital. In fact, this has been very phenomenal in China where local governments protect local markets, control land supply, and influence lending policy of local state banks, worse when corruptions are involved. Similarly, if the labour market is intervened, overstaffing can be inevitable, which may also lower output elasticity of labour.

Furthermore, when firms are not minimising their costs, they are not efficient. In such a case, the residuals will capture changes in efficiency mixed up with changes in technology. While overinvestment in equipment may shift the underlying frontier, one does not know if at the same time the situation of inefficiency is improved, worsened or unchanged. Certainly, any policy that aims to boost technological progress but ignores existing inefficiency should not be encouraged (Wu and Shea, 2000).

Table 4: Annual Growth Rate of Capital, Labour and Total Factor Productivity (in percent), and Their Contributions

	Growth of GVA	Growth of Capital	Growth of Labour	Income-Share Approach (K=.6; L=.4)			Parametric Approach		
				Contribution of Capital Growth	Contribution of Labour Growth	Total Factor Productivity Growth	Contribution of Capital Growth	Contribution of Labour Growth	Total Factor Productivity Growth
<i>Labour-intensive</i>									
1953-1965	16.7	25.7	24.3	15.4 (92)	9.7 (58)	-8.4 (-50)	10.6 (64)	11.7 (70)	-5.7 (-34)
1966-1979	9.9	10.6	10.6	6.4 (64)	4.2 (43)	-0.7 (-7)	4.7 (47)	4.2 (43)	1.0 (10)
1980-1991	8.5	11.1	5.5	6.6 (78)	2.2 (26)	-0.4 (-4)	6.8 (80)	1.5 (18)	0.2 (2)
1992-2000	9.3	8.4	0.5	5.0 (54)	0.2 (2)	4.0 (44)	4.7 (50)	0.1 (1)	4.5 (49)
<i>Capital-intensive</i>									
1953-1965	26.4	24.6	27.8	14.8 (56)	11.1 (42)	0.5 (2)	10.2 (39)	13.4 (51)	2.7 (10)
1966-1979	13.4	13.8	10.2	8.3 (61)	4.1 (30)	1.1 (8)	6.1 (45)	4.1 (30)	3.3 (25)
1980-1991	8.8	10.9	8.1	6.5 (74)	3.3 (37)	-1.0 (-11)	6.9 (79)	2.2 (25)	-0.3 (-4)
1992-2000	8.8	13.7	0.6	8.2 (93)	0.2 (3)	0.4 (5)	7.6 (86)	0.1 (1)	1.1 (13)
<i>All industries</i>									
1953-1965	20.9	25.8	25.4	15.5 (74)	10.2 (49)	-4.7 (-23)	10.7 (51)	12.3 (59)	-2.0 (-10)
1966-1979	11.6	11.9	10.4	7.2 (62)	4.2 (36)	0.2 (2)	5.3 (45)	4.2 (36)	2.2 (19)
1980-1991	8.8	10.7	6.5	6.4 (73)	2.6 (30)	-0.3 (-3)	6.7 (76)	1.8 (20)	0.3 (3)
1992-2000	9.3	10.6	0.6	6.4 (69)	0.2 (2)	2.7 (29)	5.9 (64)	0.1 (1)	3.2 (35)

Note: Figures in parentheses are contribution to GVA growth with GVA growth =100.

6. CONCLUDING REMARKS

(To be finalised.)

The most important issue in any empirical study is how the dataset is constructed. Despite some inevitable problems in measuring both inputs and output, it is reasonable to believe that the panel dataset we have constructed is the best available so far for Chinese industry. With this dataset some unrealistic restrictions have been relaxed and more sophisticated tests have been conducted, which have enabled us to tackle some significant theoretical and methodological problems in other studies. Despite existing problems, including unsolved data problems, which demand for further solution, we believe that we have painted a more reliable picture of the performance of Chinese industry over the past half century under different policy regimes.

As already pointed out, the puzzling problems in our results certainly deserve further investigation. Future research priorities with this dataset should be given to the areas below:

- The top priority is to develop proper explanation for decreasing return to scale and hence TFP performance in the Chinese context; if we follow Abramoviz and David's (1996) point about the importance of resource endowments and market size in determining TFP performance, it is likely that regional barriers to trade, driven by local governments' fiscal incentives, have seriously affected China's exploitation of return to scale, especially for heavy industries that mainly rely on domestic market and standarization.
- While improving the current panel model regression, we should try other models to explore the most efficient estimator for our problem;
- Test following Hall (1990) on whether the productivity performance is procyclical with meaningful instruments;
- Further investigation into industries with different factor intensity by better grouping approaches;

- Analysis at industry level to investigate the performance of individual industries in the long-run, which can test for the argument about China's comparative advantage;
- Further data work should aim to separate the state component from the non-state component of an industry so that empirical investigation by ownership and industry is possible.

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