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EFFICIENCY AND PRODUCTIVITY PERFORMANCE OF CHINESE MANUFACTURING REVISITED

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ABSTRACT

Using a newly constructed data set for 24 manufacturing, mining and utility industries over the period 1952-2005, this study applies the Malmquist index approach to measure the productivity performance of China's individual industries over different periods when China had significant policy regime shifts in the central planning and the reform periods.

The adopted Malmquist index approach allows us to address several important industry level problems in measuring total factor productivity (TFP). Firstly, we measure the frontier shift and TFP change for each industry over the whole sample period and major sub-periods. Secondly, the calculated TFP growth for each industry is further decomposed into technical efficiency (TE) change (or catch up with the best-practiced industries which form the frontier) and technological progress (TP). Thirdly, TE is factored into two terms: one representing the pure efficiency change and the other representing scale efficiency change which is measured by comparing the CRS technical efficiency score with the VRS technical efficiency score. It should be emphasized that the investigation into the nature of returns to scale in Chinese industries can be particularly insightful given existing state interventions or market imperfections in China.

Our main (still preliminary) findings suggest that all Chinese manufacturing industries experienced the most rapid technological progress over the second reform period, but this was not accompanied by significant efficiency improvement! The only compatible period was found in the first planning period only for the "producer goods" industries, though to a much less extent. For both the "consumer" and "producer" goods industries, the second planning period saw relative efficiency improvement but technological regress. Interestingly, the earlier stage of reform seemed to give a boost to technological advance in the "consumer goods" industries, but at the same time the "producer goods" industries experienced ever-fast efficiency gain. Important policy implications are also discussed.

Key works: Malmquist index, pure and scale efficiency, technological change, TFP

JEL classification: L60, O47, P27

1. INTRODUCTION

China's rapid growth since the economic reform has stimulated studies assessing efficiency and productivity performance of the aggregate economy or its major sectors, typically the industrial sector as a whole, over the pre- and post-reform periods. Various methodologies have been used in these studies to address different policy and measurement problems, ranging from the conventional growth accounting, production function, to frontier approach, parametric or non-parametric. However, data problems have been a major obstacle to industry level investigation that may explain how reform policies have affected different industries with different initial conditions, levels of state interventions – hence different incentives of managers, and degrees of exposure to foreign trade and direct investment.

Since state intervention is selective, studies on aggregate economy cannot easily shed light on industry-specific policy problems, hence cannot deepen our understanding of the mechanism and process of industrial development under different policy regimes that nurture different incentives of managers, investors and government agencies. For example, if firms or industries are subject to soft budget constraints, competition would tend to drive investment in new technologies rather than improve efficiency. From the government point of view, facing foreign competition, acquiring new technology is a more politically feasible target than institutional reforms that may improve the efficiency of production.

Ideally, properly sampled firm level survey data can facilitate such an analysis. However, most survey data are too small or biased samples in nature, and often not available in the form of time series. In China, industrial census is only conducted every ten years and there have been no census data available for the pre-reform period.

Using a newly constructed data set for 24 manufacturing, mining and utility industries over the period 1952-2005, this study applies the Malmquist index approach to measure the productivity performance of China's individual industries over different periods when China had significant policy regime shifts in the central planning and the reform periods.

The adopted Malmquist index approach allows us to address several important industry level problems in measuring total factor productivity (TFP). Firstly, we measure the frontier shift and TFP change for each industry over the whole sample period and major sub-periods. Secondly, the calculated TFP growth for each industry is further decomposed into technical efficiency (TE) change (or catch up with the best-practiced industries which form the frontier) and technological progress (TP) (or shifting of the frontier). Thirdly, TE is factored into two terms: one representing the pure efficiency change and the other representing scale efficiency change (STE) which is measured by comparing the CRS technical efficiency score with the VRS technical efficiency score. It should be emphasized that the investigation into the nature of returns to scale in Chinese industries can be particularly insightful given existing state interventions or market imperfections in China.

In what follows, we first discuss some methodological issues involving the use of the Malmquist index approach in comparison with other approaches in measuring TFP as well as decomposing TFP into efficiency and technological changes. This will be followed by a data section to explain our data work and any likely bias that may arise due to the imperfection of the data. Lastly, we report and discuss the results in Section 4 and give concluding remarks in Section 5.

2. Methodological Issues

We have used the Malmquist index approach to measure the Chinese industrial performance in this study. With its ability to decompose TFP change into changes of efficiency and technology, and further decompose efficiency change into changes of pure efficiency and scale efficiency, the Malmquist index can help investigate the effect of resource constraints and costs of pursuing heavy industrialization under central planning, and the effect of market competition and opening to foreign trade and direct investment in economies like China.

Total factor productivity (TFP) can be measured using various methods, including the least squares econometric methods, Tornqvist/Fisher index numbers and the frontier approach (i.e. Malmquist index). In this paper, we are using the frontier approach (i.e. Malmquist index) to measure the TFP of the Chinese industries given that the Malmquist index has some advantages relative to the other two methods which make it valuable for our study.

The former two approaches assume that the decision making units (i.e. industries in this study) are technically efficient, which are definitely not the case for the Chinese industries in reality. Making wrong assumption would lead to incorrect measurement of productivity. (More about the China's case…) The use of Malmquist index helps to relax this assumption for our productivity measurement of Chinese industries.

In particular, when comparing to the use of the Tornqvist/Fisher index numbers approach, the computation of the Malmquist index does not require input or output prices, which makes it extremely useful in situations where prices are misrepresented or data is not available. As some Chinese industries, especially state-owned, monopolistic industries, have long been under state control, the prices, labour wages and capital costs were not, or still not completely, based on market values and were heavily regulated by the government. Since Malmquist index can be constructed with input or output measured in its natural physical units, it excludes the need for an artificial weighting system that reduces those inputs and outputs into any single unit measure.

Besides, the use of the Malmquist index does not require the assumption of cost minimization and revenue maximization. This relaxation of behavioral assumptions makes it useful for situations where the objectives of producers under consideration are different, unknown or not achieved. (This is pretty relevant to the case of Chinese industries… More discussions here on the role of state, policy, planning and their effects on producers…)

Moreover, the use of the Malmquist index permits the TFP changes to be decomposed into two components, i.e. technological change and technical efficiency change (Färe et al., 1989). This helps to provide insight into the sources of productivity change for Chinese industries, taking into account state intervention and distorted incentives of firms.

Compared with the use of least squares econometric methods such as estimation of the Cobb-Douglas production function, the needs for specifying a distributional form for the inefficiency term and the functional form for the production function or cost function could be avoided. The use of a specific functional form that presumably approximates the underlying technology may impose unnecessary structure in our industry data. Given that we are considering various industries of different nature, it is not suitable to assign a general functional form to all industries.

In our paper, we apply the method of Data Envelopment Analysis (DEA) to compute the Malmquist index to measure Chinese industries' productivity. Data Envelopment Analysis (DEA) is a mathematical programming approach which is used to access relative efficiencies within a group of Decision Making Units (DMUs), i.e. industries in this study. DEA allows each DMU to select its most favorable weights which maximize its own efficiency. The advantage of weight flexibility in evaluating each DMU is that a best efficiency rating is associated to each DMU. Below we introduce the essence of the Malmquist Index.

The Malmquist productivity indexes were first suggested by Caves et al. (1982) and further developed by Färe et al. (1989). This index is defined using Shephard (1953)'s distance functions that describe multi-input and multi-output production technology without the requirement to specify a behavioural objective (such as cost minimization or profit maximization). We need to explain why this is an important development in general.

Caves et al. (1982) first defined an output-based Malmquist productivity index relative to a single technology as:

(1) $$M_0^t = \frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^t(y_t, x_t)}$$

(2) $$M_0^{t+1} = \frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_o^{t+1}(y_t, x_t)}$$

where $D_o^t(y_t, x_t)$ and $D_o^{t+1}(y_{t+1}, x_{t+1})$ are the output distance functions[1] by which production points are compared to frontier technologies from the same time periods, i.e. t and t+1, respectively. On the other hand, $D_o^t(y_{t+1}, x_{t+1})$ and $D_o^{t+1}(y_t, x_t)$ are mixed-period distance functions where production points are compared to frontier technologies at different periods.[2]

To avoid choosing an arbitrary referencing technology, Färe et al. (1989) employed the geometric mean of two Malmquist indexes defined above to calculate the output-oriented Malmquist index:

[1] An output distance function considers a maximal proportional expansion of the output vector, given an input vector.

[2] In both mixed period cases (i.e. period t observations being compared to period t+1 technology and vice versa), the distance functions could have values greater than unity. This could happen if the observation being evaluated is not feasible in the other period (i.e. the observations could be located outside the frontier).

(3) $$M_0(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_o^{t+1}(y_t, x_t)} \cdot \frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^t(y_t, x_t)} \right]^{1/2}$$

Following Färe et al. (1989, 1992), the above Malmquist productivity index can be written in an equivalent way which allows the decomposition of productivity change into changes in technical efficiency and shifting of the frontier:

(4) $$M_0(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_o^t(y_t, x_t)} \cdot \left[\frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^{t+1}(y_{t+1}, x_{t+1})} \cdot \frac{D_o^t(y_t, x_t)}{D_o^{t+1}(y_t, x_t)} \right]^{1/2}$$

The first term outside the bracket measures the change in the output-oriented[3] measure of technical efficiency between periods t and t+1 (catching up to the frontier), whereas the bracketed term provides a measure of technological change (innovation).

Following Färe et al. (1994), the technical efficiency change component of the Malmquist index in Equation (4) could be furthered decomposed into pure efficiency change and scale efficiency change:

(5)

$$M_0(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{S_o^t(y_t, x_t)}{S_o^{t+1}(y_{t+1}, x_{t+1})} \cdot \frac{D_o^{t+1}(y_{t+1}, x_{t+1}/VRS)}{D_o^t(y_t, x_t/VRS)} \cdot \left[\frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^{t+1}(y_{t+1}, x_{t+1})} \cdot \frac{D_o^t(y_t, x_t)}{D_o^{t+1}(y_t, x_t)} \right]^{1/2}$$

where the first term represents scale efficiency change,[4] the second term represents the pure efficiency change and the last term represents the technological change.[5]

The change in productivity, i.e. M_0, and its decomposition into technological change, pure efficiency change and scale efficiency change can have values of unity, greater than unity and less than unity, which are interpreted as no change, progress and regress, respectively. Figure A1 in Appendix A shows how the distance functions and the Malmquist index (defined in the context of a CRS technology) are constructed and Figure A2 in Appendix A shows the concept of scale efficiency with two technologies, i.e. CRS and VRS. In this study, Equation (5) has been applied to calculate TFP change.

3. Data Construction

[3] In this study, we use an output-orientation for measuring the technical efficiency and productivity for Chinese industries, i.e. we aim at maximizing output with given inputs.

[4] Scale efficiencies measure the inefficiencies due to failure to operate at constant returns to scale (i.e. appropriate firm size). Increasing returns to scale is the predominant form of scale inefficiency observed. If there is a difference between the CRS and VRS in TE scores for a particular DMU (decision making unit), then this indicates that the DMU has scale inefficiency and that the scale inefficiency can be calculated from the difference between the CRS and CRTS TE scores, i.e. $SE = TE^{CRS} / TE^{VRS}$.

[5] Note that Equation (5) is an extension of the Malmquist index defined in the context of constant returns to scale (CRS) technology, i.e. Equation (4). The scale efficiency change is constructed with the implementation of additional linear constraints to the linear programming problems for the case of CRS.

Although China in principle fully switched to the System of National Accounts (SNA) in 1992 and has since continuously improved its national accounts through surveys and censuses, some of the concepts and national accounting practices used by the National Bureau of Statistics (NBS) are to some extent still influenced by the old material product system (MPS) (see Xu, 1999, for a full account of the differences). In this study, we use and update the data constructed by Wu in some of his earlier studies (Wu, 2002a, 2002b and 2007; Wu and Yue, 2007). Further efforts have been made to re-construct the official output data, to standardize the employment data, and to revise the net capital stock, as given below.

Output

A major concern from this data construction process lies in the accuracy of the constructed gross value added (GVA) series. In his comprehensive review, Wu (2000, pp. 479-484) discusses how methodological and institutional factors that might have exaggerated industrial output. Methodologically, China's long practice of the Soviet-style "comparable price" approach underestimates inflation because it requires enterprises to report their output at some "constant prices" that were set ten years ago and tended to ignore new products which have appeared after the base year. Institutionally, heavy government involvement in business and administratively managed data reporting system induce distorted incentives for firms and local officials to exaggerate performance.

There have been a number of important empirical studies attempting to make alternative estimates using various approaches, such as physical output index (Wu, 2002a), alternative price indices (Wu, 2000; Woo, 1998; Ren, 1997; Jefferson et al., 1996), and energy consumption approximation (Adams and Chen, 1996). Despite different results,[6] all appear to support the upward bias hypothesis for the official data. Wu's index based on physical output data is perhaps the most independent of official growth estimates.[7] However, since Chinese industrial statistics are based on enterprises rather than establishments of activities, product-based output estimates may not closely match the statistics on labour and capital stock for all industries. In this study, we still base our output data construction on the official data but choose alternative price indices to moderate the over-reporting effect on the output.

We obtain the nominal GVA of individual industries from the industrial statistics published in *China Industrial Economic Statistics Yearbook* by the Department of Industrial and Transportation Statistics (DITS), NBS. However, there are no GVA data for the period before 1993 or before China shifted to SNA, but data on the net value of output (NVO) complied following the MPS concept (for details see Wu, 2000). We adjust NVO to GVA by adding back estimated capital consumption (see discussion in estimation of capital stock below). After comparing official PPIs with the implicit "comparable price indices" (CPPIs) for individual industries, derived

[6] (Be more specific here – where did the differences come from – different samples or different units of measurements??)

[7] Wu (2002a) construct a Laspeyres quantity index for major industrial branches in 1949-97 using time series data on 200 major industrial products and value added weights from China's 1987 Input-Output Table. His estimates suggest an annual industrial GDP growth of 8.7% in 1978-97, compared with the official rate of 12%. Using the same approach, Maddison and Wu (2006) update Wu's earlier estimates showing an annual industrial GDP growth of 9.8% in 1978-97, compared with the official rate of 11.5%.

from nominal GVO and GVO at different constant prices by industry, we choose PPIs as deflators to deflate GVA because they suggest higher price levels than CPPIs.

Labour

Chinese official data on industrial employment have severe flaws. Before 1998, unemployed workers still remained on the payroll in all SOEs mainly due to political reason. Non-industrial staffs working in education, medical care, commercial outlets, and social and political organizations are inherent in the official industrial statistics. There have never been regular, systematic surveys on hours worked, even though institutional working hours per week have been changed several times. Direct usage of the officially reported numbers of workers employed would be very misleading. Adopting the approach used in Wu and Yue (2007), we first convert numbers of workers employed, published in *China Industrial Economic Statistics Yearbook* by DITS and the 1995 Industrial Census and the 2004 National Economic Census, to hours worked based on institutional working hours, standard working hours due to different shift arrangements across industries, and assumptions for possible extra or overtime hours. We then remove non-industrial employees based on occupational structure of industries provided by censuses. Note that this treatment is only applied to SOEs and collective enterprises, not foreign invested enterprises. The results on “hours worked” are further converted to standardized “man-days worked”.

Net Capital Stock

As discussed in Wu (2002b and 2007), an often made and significant mistake in constructing capital stock is the direct use of official statistics on “investment in fixed assets” as the investment variable in estimating capital stock with the perpetual inventory method (PIM).[8] By the official definition, “investment in fixed assets” refers to the “workload” of fixed asset investment activities in value terms rather than the ownership transfer-based purchase of fixed capital as defined by SNA. This is regarded as the key difference between SNA and the Chinese system in measuring fixed asset investment (Xu, 1999, pp.62-63). Apparently, the official investment series represents a flow of activities that mix investment in fixed capital and in inventories (work-in-process). 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 in some state projects in the post-reform era in China.

Official statistics also include capital stock series as end-of-year “original value of fixed assets” based on accounting data reported by enterprises. It embodies a mixture of the newly invested buildings, equipment and machinery, with the value of the existing stock at acquisition prices. Two problems arise from directly adopting it as a proxy for capital stock: inaccurate valuation and improper coverage. Firstly, it is impossible to find a deflator that can correctly deflate a capital stock mixed with assets purchased in different periods. Secondly, like the official data on investment, the stock series also includes residential and non-industrial structures. Pioneer studies by Chen et al. (1988a, 1988b) derive annual investment flows from the official stock

[8] For example, see Young (2000), Huang et al. (2002), Hu and Khan (1997) and Li at el (1992).

to bypass the first problem, and remove residential buildings to solve the second problem. Yet, it has underestimated the annual flows by ignoring the effect of scrapings (equipment or structures that had been disposed during the year in question) and unconditionally accepted the official depreciation method (give more details…).

Following Wu's earlier work (2002b) and his recent update (Wu, 2007), we estimate net capital stock in 1995 constant yuan through the following procedures. First, we derive annual flow of investment by subtracting the last from the current end-of-year stock and adding back the value of scrapings by an assumed scraping function and timing (details to follow…). Second, based on the information on type of fixed assets in investment as surveyed by Ministry of Finance (MoF), we identify and remove non-industrial assets from the so-derived investment flow. Third, we construct deflators for individual industries using detailed (6-digit) annual asset evaluation data for the period 1984-2000, compiled by MoF et al. (2002), and construct PPI for building materials and machinery (taking a geometric mean) for the period 2001-05. Lastly, in the PIM exercise, we feel justified to assume a geometric function of depreciation that reflects changes in economic efficiency of different types of fixed assets. Thus, as depreciation (δ) of an asset equals to its declining-balance rate (R) divided by its service-live (T), we need to estimate proper R and T for equipment and structures of each industry. In this study, we adopt the BEA (Bureau of Economic Analysis, Washington DC) estimates of declining-balance rates for major industrial equipment and structures as given in Kaze and Herman (1997, pp.72-3) that are mainly based on the empirical work by Hulten and Wykoff (1981). To gauge the service lives of assets in Chinese manufacturing, we rely on three sources of information, including the depreciation rates (by the straight-line approach) used since 1963 by MoF, a detailed list of the standard service lives for fixed assets issued by the State Council in 1985 (No. 63 Circular), and a new regulation on service lives by MoF in 1992 (No. 574).

(Add a couple of summary tables here that give annual growth rate of output and input, or Y/L and K/L.)

4. RESULTS (PRELIMINARY)

Our main (still preliminary) findings suggest that all Chinese manufacturing industries experienced the most rapid technological progress over the second reform period, but this was not accompanied by significant efficiency improvement. The only compatible period was found for the "producer goods" industries in the first planning period, though to a much less extent. For both the "consumer" and "producer" goods industries, the second planning period saw relative efficiency improvement but technological regress. Interestingly, the earlier stage of reform seemed to give a boost to technological advance in the "consumer goods" industries, but at the same time the "producer goods" industries experienced ever-fast efficiency gain. Important policy implications are also discussed.

To be presented by power points at the conference…

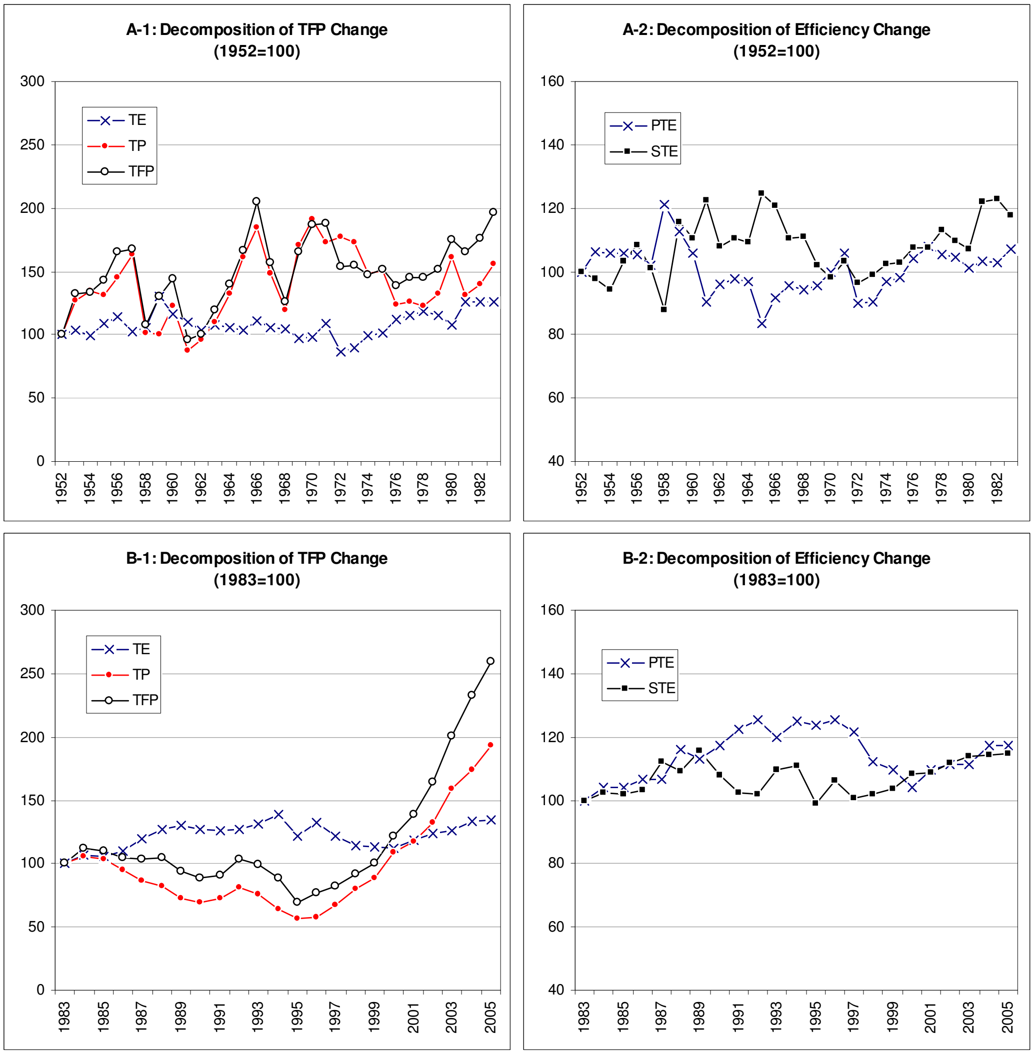
TABLE 1
CHANGES OF EFFICIENCY, TECHNOLOGY AND TFP IN CHINESE MANUFACTURING UNDER DIFFERENT "POLICY REGIMES":
"PRODUCER GOODS" INDUSTRIES
(Annual change, last year = 1)

Industries	TE	PTE	STE	TP	TFP	TE	PTE	STE	TP	TFP
	1952-71					1971-83				
Chemicals	0.984	1.000	0.984	1.036	1.019	0.988	0.976	1.012	1.009	0.996
Medicine manufacturers	1.065	1.000	1.065	1.026	1.093	1.000	1.000	1.000	0.966	0.966
Rubber products	1.018	1.000	1.018	1.020	1.038	1.000	1.000	1.000	0.981	0.981
Non-metallic mineral products	0.989	0.987	1.003	1.006	0.996	1.030	1.021	1.009	0.963	0.992
Ferrous metal smelting/rolling	0.987	1.000	0.987	1.043	1.030	1.021	1.000	1.021	1.022	1.043
Non-ferrous metal smelting	1.004	1.008	0.996	1.028	1.032	1.008	1.000	1.008	1.016	1.024
Metal products	1.033	1.045	0.988	1.002	1.035	0.979	0.984	0.995	0.963	0.942
General machinery	0.986	1.011	0.975	1.040	1.026	1.040	1.013	1.027	1.000	1.040
Specialized machinery	1.005	1.029	0.976	1.048	1.053	1.042	1.014	1.028	0.979	1.021
Transportation equipment	0.964	0.972	0.992	1.020	0.983	1.058	1.047	1.010	1.009	1.067
Electrical equipment	0.969	0.994	0.976	1.022	0.991	1.003	0.993	1.010	0.992	0.995
Information & com. equipment	1.049	0.980	1.070	1.050	1.102	1.005	0.998	1.007	0.998	1.003
Instruments & office machinery	1.012	1.014	0.998	1.040	1.052	0.987	0.968	1.020	0.995	0.982
Total "producer goods"*	***1.005***	***1.003***	***1.002***	***1.029***	***1.034***	***1.012***	***1.001***	***1.011***	***0.991***	***1.003***
	1983-92					1992-05				
Chemicals	1.002	1.022	0.981	0.998	1.001	1.013	0.988	1.025	1.113	1.128
Medicine manufacturers	1.000	1.000	1.000	0.988	0.988	0.980	0.996	0.984	1.071	1.049
Rubber products	1.000	1.000	1.000	0.964	0.964	0.954	1.000	0.954	1.043	0.995
Non-metallic mineral products	1.000	0.995	1.005	0.954	0.954	0.978	0.944	1.035	1.043	1.020
Ferrous metal smelting/rolling	1.000	1.000	1.000	0.996	0.996	1.000	1.000	1.000	1.119	1.119
Non-ferrous metal smelting	0.990	0.986	1.004	0.998	0.987	0.993	1.006	0.986	1.116	1.108
Metal products	1.025	1.008	1.017	0.954	0.978	1.011	1.001	1.010	1.046	1.057
General machinery	1.043	1.046	0.997	0.972	1.013	1.027	0.998	1.029	1.049	1.077
Specialized machinery	1.051	1.039	1.011	0.989	1.039	1.027	0.996	1.031	1.050	1.078
Transportation equipment	1.131	1.109	1.020	0.985	1.113	1.004	0.995	1.009	1.075	1.080
Electrical equipment	1.037	1.023	1.014	0.963	0.999	1.017	1.000	1.017	1.064	1.083
Information & com. equipment	1.043	1.029	1.014	0.983	1.026	1.024	1.011	1.013	1.064	1.090
Instruments & office machinery	1.041	1.081	0.963	0.963	1.003	1.027	1.000	1.027	1.047	1.075
Total "producer goods"*	***1.027***	***1.025***	***1.002***	***0.977***	***1.004***	***1.004***	***0.995***	***1.009***	***1.069***	***1.073***

Note: * "Producer goods" industries are only loosely defined. See the text.

FIGURE 1

CHANGES OF EFFICIENCY, TECHNOLOGY AND TFP IN CHINESE MANUFACTURING: "PRODUCER GOODS" INDUSTRIES



To be completed…

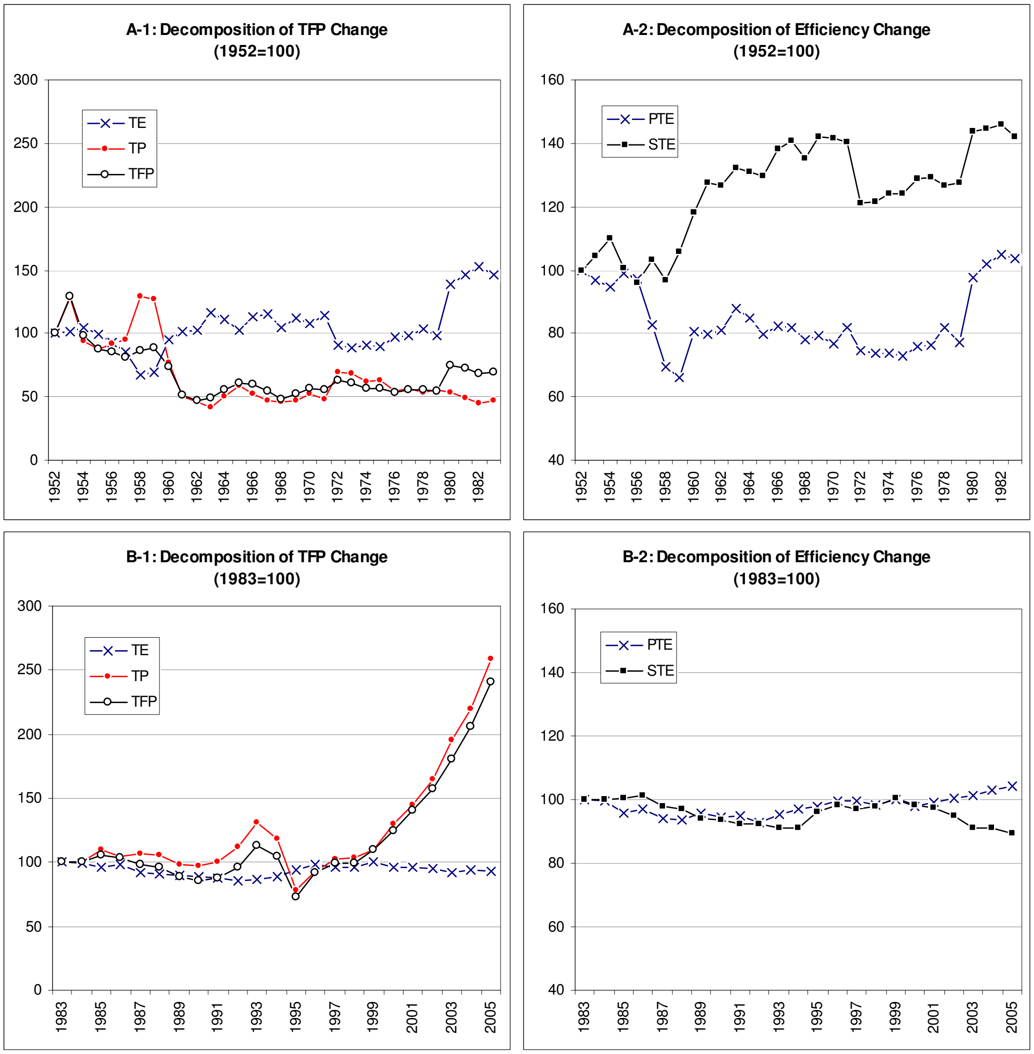
TABLE 2
CHANGES OF EFFICIENCY, TECHNOLOGY AND TFP IN CHINESE MANUFACTURING UNDER DIFFERENT "POLICY REGIMES": "CONSUMER GOODS" INDUSTRIES
(Annual change, last year = 1)

	TE	PTE	STE	TP	TFP	TE	PTE	STE	TP	TFP
	1952-71					1971-83				
Food processing	0.981	0.971	1.011	0.984	0.966	1.037	1.038	0.999	1.000	1.037
Food manufacturing	1.004	0.995	1.009	0.964	0.968	0.993	0.999	0.994	1.002	0.995
Beverage manufacturing	1.000	1.000	1.000	0.993	0.993	0.999	1.000	0.999	1.003	1.003
Textile industry	1.013	1.000	1.013	0.976	0.989	0.997	1.000	0.997	0.998	0.994
Wearing apparel	1.000	1.000	1.000	0.923	0.923	1.000	1.000	1.000	0.992	0.992
Leather & fur products	0.993	0.994	0.998	0.943	0.936	0.997	0.995	1.002	1.001	0.998
Sawmilling of wood	0.933	0.935	0.998	0.936	0.873	1.092	1.087	1.005	0.993	1.084
Furniture manufacturing	1.085	0.959	1.131	0.951	1.031	1.063	1.061	1.001	0.990	1.052
Paper & paper products	0.999	0.998	1.001	0.992	0.991	1.022	1.012	1.010	1.006	1.028
Printing & publishing	1.043	1.036	1.007	0.978	1.020	1.032	1.031	1.001	1.002	1.034
Cultural & sporting goods	1.037	1.000	1.037	0.945	0.980	1.000	1.000	1.000	0.995	0.995
Total "consumer goods"*	***1.007***	***0.989***	***1.018***	***0.962***	***0.969***	***1.021***	***1.020***	***1.001***	***0.998***	***1.019***
	1983-92					1992-05				
Food processing	0.978	0.986	0.991	1.030	1.007	1.030	1.019	1.011	1.076	1.109
Food manufacturing	0.985	0.969	1.016	1.014	0.998	1.011	1.017	0.993	1.079	1.090
Beverage manufacturing	1.001	1.000	1.001	1.053	1.054	1.000	1.000	1.000	1.092	1.092
Textile industry	0.975	1.000	0.975	1.018	0.993	0.992	1.000	0.992	1.067	1.058
Wearing apparel	1.000	1.000	1.000	0.973	0.973	0.992	0.998	0.994	1.050	1.042
Leather & fur products	1.010	1.016	0.994	0.996	1.005	1.008	1.002	1.006	1.051	1.059
Sawmilling of wood	0.956	0.963	0.992	1.002	0.958	1.038	1.044	0.995	1.060	1.101
Furniture manufacturing	0.972	1.010	0.962	1.003	0.974	1.014	1.000	1.014	1.057	1.072
Paper & paper products	0.984	0.981	1.003	1.034	1.017	1.004	1.005	0.998	1.071	1.074
Printing & publishing	0.978	0.984	0.994	1.027	1.005	0.974	1.011	0.963	1.079	1.050
Cultural & sporting goods	0.975	1.000	0.975	0.992	0.967	1.007	1.000	1.007	1.055	1.062
Total "consumer goods"*	***0.983***	***0.992***	***0.991***	***1.013***	***0.995***	***1.006***	***1.009***	***0.997***	***1.067***	***1.073***

Source: Authors' estimates. See the text for methodology.
Note: * "Consumer goods" industries are only loosely defined. See the text.

FIGURE 2

CHANGES OF EFFICIENCY, TECHNOLOGY AND TFP IN CHINESE MANUFACTURING: "CONSUMER GOODS" INDUSTRIES



5. Concluding Remarks

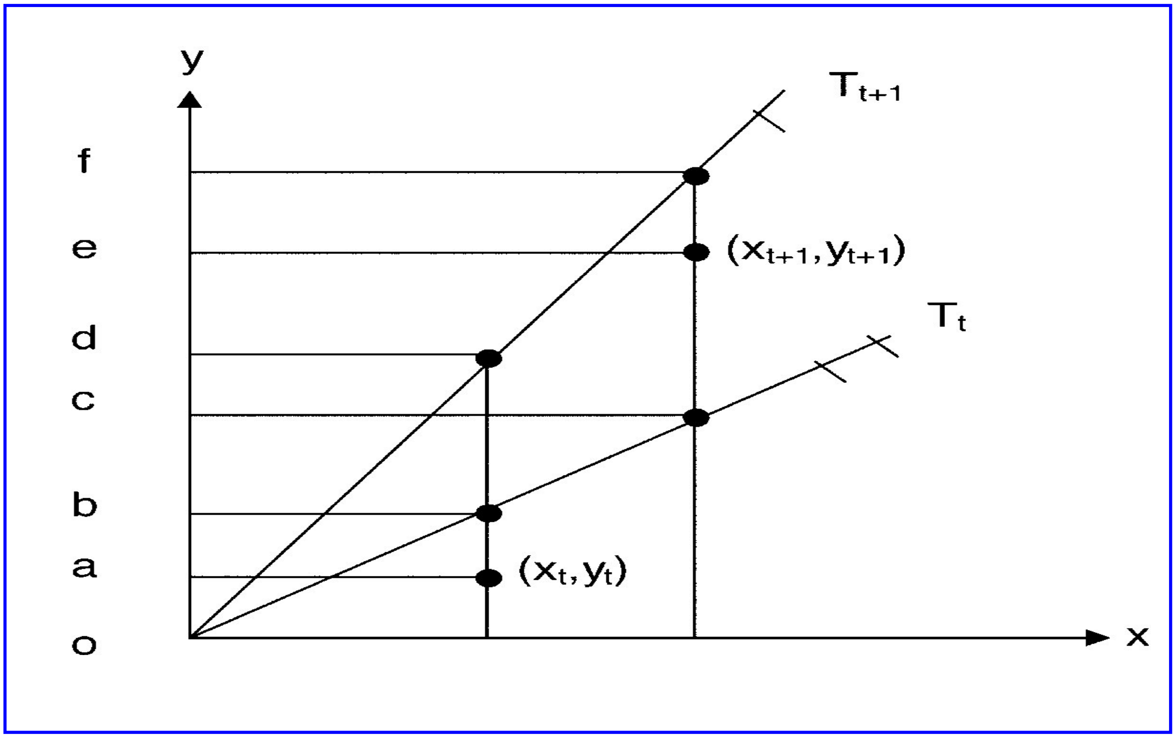
To be completed…

Appendix

To be completed…

Appendix *A*

Figure A1
Graphical illustration of distance functions and Malmquist index



T_t and T_{t+1} represent technology at period t and t+1, respectively.

$D_o^t(y_t, x_t) = oa/ob$

$D_o^{t+1}(y_{t+1}, x_{t+1}) = oe/of$

$D_o^t(y_{t+1}, x_{t+1}) = oe/oc$

$D_o^{t+1}(y_t, x_t) = oa/od$

Technical efficiency change: $\frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_o^t(y_t, x_t)} = \frac{oe/of}{oa/ob}$

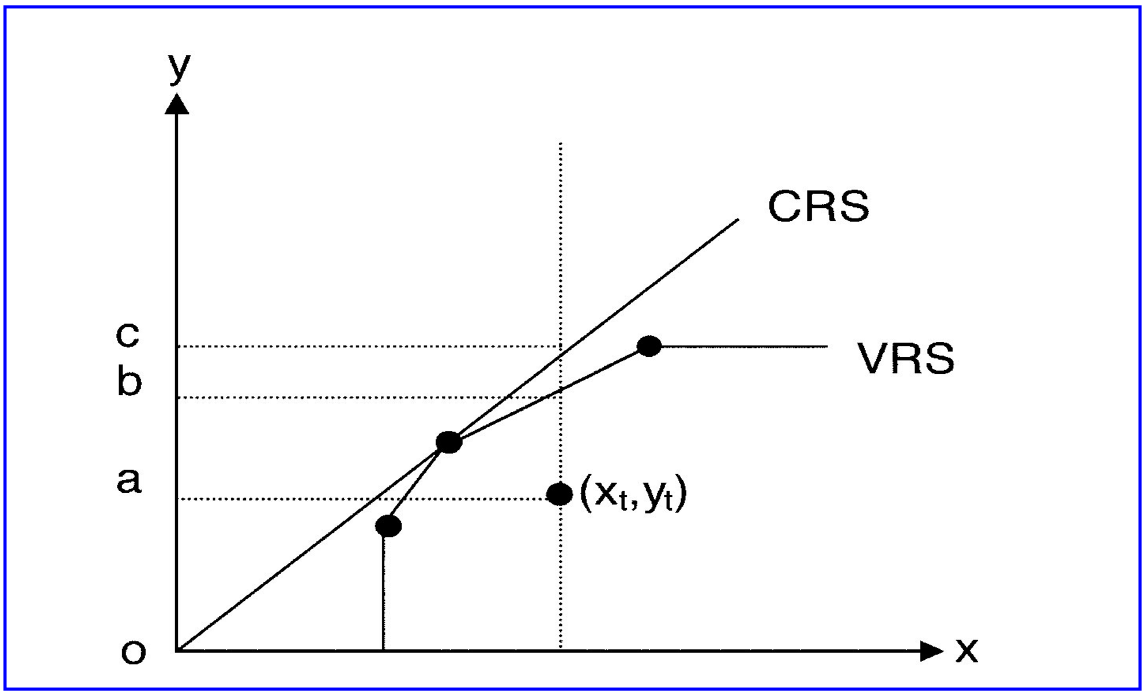
Technological change: $\left[\frac{D_o^t(y_{t+1},x_{t+1})}{D_o^{t+1}(y_{t+1},x_{t+1})}\cdot\frac{D_o^t(y_t,x_t)}{D_o^{t+1}(y_t,x_t)}\right]^{1/2}=\left[\frac{oe/oc}{oe/of}\cdot\frac{oa/ob}{oa/od}\right]^{1/2}$

Malmquist productivity index:

$$M_0=\frac{D_o^{t+1}(y_{t+1},x_{t+1})}{D_o^t(y_t,x_t)}\cdot\left[\frac{D_o^t(y_{t+1},x_{t+1})}{D_o^{t+1}(y_{t+1},x_{t+1})}\cdot\frac{D_o^t(y_t,x_t)}{D_o^{t+1}(y_t,x_t)}\right]^{1/2}=\frac{oe/of}{oa/ob}\cdot\left[\frac{oe/oc}{oe/of}\cdot\frac{oa/ob}{oa/od}\right]^{1/2}$$

FIGURE A2

GRAPHICAL ILLUSTRATION OF SCALE EFFICIENCY AT PERIOD T



Scale efficiency of $(x_t,y_t)=\frac{oa/ob}{oa/oc}=\frac{oc}{cb}$

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