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Abstract

This paper carries out an empirical investigation of the contribution of labour reallocation, which can produce efficiency gains over and above those associated with technical progress, to total factor productivity in China during the pre-reform and post-reform periods. We consider two forms of labour reallocation, rural and ownership transformation, and exam their contribution within the frameworks of VES, CES and Cobb Douglas production functions. The empirical evidence rejects VES and CES and supports the Cobb Douglas production function. We find that rural transformation has made a highly significant contribution to total factor productivity and output growth in China irrespective of the production function and capital series employed. In contrast, ownership transformation has not had a significant impact on output and total factor productivity.

Keywords: Rural transformation; Ownership transformation; Total factor productivity; VES; CES; Cobb-Douglas; China

JEL classification: O30, O47, O53

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1. Introduction

A number of studies have investigated China's productivity growth. Most of them employ the Cobb-Douglas production function (e.g. Chow, 1993; Hu and Khan, 1997; Maddison, 1998; Young, 2003; Li, 2003, 2007). However, it is well known that the Cobb-Douglas production function assumes unity elasticity of substitution and constant returns to scale. Given these restrictions, to what extend is the Cobb-Douglas production function appropriate for modelling China's economic growth? To answer this question, we use two alternative production functions, i.e. Constant Elasticity of Substitution (CES) and Variable Elasticity of Substitution (VES) functions, which allow these two restrictions to be relaxed[1]. We then compare the results of CES and VES with the Cobb-Douglas production function and the best estimates are used to calculate total factor productivity. As a further robustness check, we employ two alternative capital series to evaluate whether the results are sensitive to the choice of capital.

A few studies of China have highlighted the efficiency gains that may result from the reallocation of labour across sectors and ownerships. For instance, Borenstein and Ostry (1996) argue that growth in total factor productivity (TFP) in China may not reflect technical progress at all, but only efficiency gains from surplus labour moving from the countryside to other sectors and employment in the non-state sector growing faster than the state owned sector. World Bank (1996) finds that during 1985-1994, the movement of labour from agriculture to industry and to a lesser extent services

[1] To our knowledge, existing studies examining alternative forms of production functions for China are not at aggregate level. For instance, Jia (1991) estimates Cobb-Douglas and CES production functions for China's industrial sector during 1952-1985; Bairam (1999) estimates Cobb-Douglas and CES production functions using provincial data for the year 1988. Both studies find supportive evidence for the Cobb-Douglas production function. On the other hand, Xu (1999) calculates the elasticity of substitution in a CES production function to be 1.4 for China's agriculture sector during 1952-1996. Duffy and Papaggeorgiou (2000) and Karagiannis *et al* (2004) employed data for a large panel of 82 countries (including China) but for a short period, 1960-1987, and find supportive evidence for CES and VES production functions respectively.

contributed about one percentage point to aggregate GDP growth and another 0.4 of a percentage point was the result of resource reallocation between state and non-state enterprises; together they account for one-third of growth. Woo (1998) argues that the intersectoral shift of labour (away from agriculture to other sectors) increases aggregate output when the marginal product of labour (MPL) in the primary sector is lower than the respective MPLs in the secondary and service sectors. More recently, Brandt *et al* (2008) study the contribution of reallocation of labour from agriculture to non-agriculture and from state to non-state sector to growth using growth accounting based on counterfactual simulation. They find the contributions of the first and second labour reallocation are 1.02% and 1.22% respectively and thus together they account for 2.24% of total productivity growth during 1978-2004.

However, most of these studies are based on growth accounting and focus on post-reform period; and none of them has examined the contribution of labour reallocation to total factor productivity using production functions other than the Cobb-Douglas specification. Using data for both pre- and post- reform periods (1952-2008), we estimate three alternative forms of production functions mentioned earlier. This allows us to evaluate whether the role of labour reallocation is robust across various forms of production function.

Furthermore, following the above mentioned studies, we evaluate the impact of two different forms of labour reallocation on economic growth and total factor productivity; rural transformation and ownership transformation. Rural transformation refers to both rural-urban migration and rural industrialisation. The former refers to the internal labour migration from countryside to cities (Zhao, 1999a, 1999b, 2000, Seeborg *et al*. 2000, Zhang and Song, 2003). The latter refers to the establishment of rural enterprises (i.e. tower and village enterprises) that have been shifting farmers from working in the field to working in these labour intensive rural enterprises (Wang 1999, Zhu, 2000). In contrast to rural-urban migration, rural urbanization provides an important solution to China's rural surplus labour problem by allowing people to leave their farmland but without leaving their villages. Both result in a shift of labour from low productivity primary sector to more productive secondary and tertiary sectors[2]. Ownership transformation has been accomplished via State Owned Enterprises (SOEs) restructuring and privatisation, which have laid off millions of workers[3] who later joined other more productive ownership enterprises such as joint venture, collective-owned enterprises, township and village enterprises, and private enterprises (Garnaut *et al.* 2005, Geng *et al*., 2009). With rural transformation and ownership transformation, even if the levels of technology in different sectors or ownerships remain unchanged, labour reallocation out from lower productive sectors or ownerships to higher productive ones will increase total factor productivity. In other words, for a country like China with enormous labour surplus, it is not only the total number of employees that matters for output; the distribution of labour also plays an important role.

The rest of the paper is organised as follows: Section 2 outlines the specification of the Cobb-Douglas, CES and VES production functions. Section 3 introduces two forms of labour reallocation - i.e. rural transformation and ownership transformation - into the production functions. Section 4 describes data sources and measurement of variables. Section 5 reports the estimation results. Section 6 calculates total factor productivity. Section 7 presents a comparative analysis, while section 8 summarises the empirical results and discusses some policy implications.

[2] Chow (1993) finds the marginal value product of labor in 1978 to be 63 yuan in agriculture, 1027 yuan in industry, 452 yuan in construction, 739 yuan in transportation and 1809 yuan in commerce

[3] According to Garnaut *et al*. (2005), the number of SOEs declined from 114,000 in 1996 to 34,000 in 2003 and about 30 million SOEs workers have been laid off since 1998.

2. Specification of the Production Functions

2.1. Cobb-Douglas Production Function

The Cobb-Douglas production function assumes unit elasticity of substitution and constant returns to scale:

$$Y = AK^{\alpha} L^{1-\alpha}; \tag{1}$$

where Y, K and L denote real output, real capital stock and labour respectively; A measures the effect of technical change on output; α is the capital share of income.

2.2. CES Production Function

The CES production function assumes varied returns to scale and an elasticity of substitution different from unity[4]:

$$Y = A\left[\delta K^{-\rho} + (1-\delta)L^{-\rho}\right]^{-\varphi/\rho}; \tag{2}$$

where ρ is the substitution parameter that determines the elasticity of substitution σ. δ is the distribution parameter; for any given value of σ (or ρ), δ determines the functional distribution of income[5] (e.g. the capital share). φ is the returns to scale parameter; if $\varphi > 1$ ($\varphi < 1$), there is increasing (decreasing) returns to scale and if $\varphi = 1$ there is constant returns to scale.

If we assume constant returns to scale, equation (2) becomes:

$$Y = A\left[\delta K^{-\rho} + (1-\delta)L^{-\rho}\right]^{-1/\rho}; \tag{3}$$

The elasticity of substitution (σ) for both forms of CES production function (equations (2) and (3)) is equal to:

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[4] Equation (2) was introduced by Brown and De Cani (1963) and has been widely used in the literature. For a recent literature review on applications of CES production function, please refer to Klump *et al.* (2007).

[5] Capital share (S_K) and labour share (S_L): $S_K = \dfrac{\varphi\delta(K/L)^{-\rho}}{\delta(K/L)^{-\rho} + (1-\delta)}$, $S_L = \dfrac{\varphi(1-\delta)}{\delta(K/L)^{-\rho} + (1-\delta)}$.

$$\sigma = 1/(1+\rho); \qquad (4)$$

If $-1 < \rho < 0$, then $\sigma > 1$; if $\rho > 0$, then $0 < \sigma < 1$ ($\rho > -1$ to ensure positive elasticity of substitution). It is clear that as the parameter ρ approaches zero, σ equals unity. When $\varphi = 1$ and $\rho = 0$, equation (2) collapses to the Cobb-Douglas production function. Therefore, Cobb-Douglas is a special case of the CES production function.

2.3. VES Production Function

In contrast to CES production function, VES production function assumes that the elasticity of substitution is a linear function of capital over labour ratio. We consider the following VES production function[6]:

$$Y = AK^{\theta\varphi}\left[L + \eta\theta K\right]^{(1-\theta)\varphi}; \qquad (5)$$

where φ is the returns to scale parameter. Both θ and η determine the capital share and the labour share of income[7].

If we assume that there is constant returns to scale, i.e. $\varphi = 1$, then equation (5) can be rewritten as:

$$Y = AK^{\theta}\left[L + \eta\theta K\right]^{(1-\theta)} \qquad (6)$$

The elasticity of substitution for both forms of VES production function (equations (5) and (6)) is derived as:

$$\sigma = 1 + \eta\frac{K}{L} \qquad (7)$$

[6] Equation (5) was introduced by Revankar (1971) and has been widely used in the literature. Please refer to Karagiannis *et al* (2004) for a list of recent studies considering the VES production function.

[7] Capital share (S_K) and labour share (S_L): $S_K = \dfrac{\varphi[\theta + \theta\eta(K/L)]}{1+\eta\theta(K/L)}$, $S_L = \dfrac{\varphi(1-\theta)}{1+\eta\theta(K/L)}$.

Hence σ varies linearly with the capital-labour ratio around unity. Clearly when $\varphi = 1$ and $\eta = 0$, equation (5) collapses to the Cobb-Douglas production function.

3. Labour Reallocation

As discussed in Section 1, China's transformation from centrally-planned to market-oriented economy is characterised by "rural transformation". The ratio of those working in the agricultural sector to total employed people was gradually reduced from 84% in 1952 to 40% in 2008. We expect the process of rural transformation to have a statistically significant positive impact on China's total factor productivity and economic growth.

The ratio of SOEs employees to total urban area employees remained fairly constant (between 64%-78%) during the pre-reform period, but it steadily declined to 21% by 2008. Similar to the rural transformation, labour shift out of inefficient SOEs to more efficient non-SOEs will increase TFP even if the pure technology level (i.e. NFP) in each ownership remains unchanged. Therefore, ownership transfer could also have a positive impact on total factor productivity and economic growth.

We incorporate labour reallocation resulted from rural transformation and ownership transformation into Cobb-Douglas (equation (1)), CES (equations (2) and (3)) and VES (equations (5) and (6)) production functions. The parameter that captures technical progress, A, can be expressed as:

$$A = ce^{\beta t}; \tag{8}$$

where c denotes the initial technology level, t denotes time trend and β is the rate at which technology grows (i.e. pure technical progress). Once the effect of labour reallocation is taken into account, we obtain:

$$A = ce^{\beta t} rt^{\pi} ot^{\tau}\ ; \tag{9}$$

where rt denotes labour reallocation resulted from rural transformation, ot denotes ownership transformation, and π and τ measure the effects of rt and ot on A respectively.

In equation (8), only pure technical progress (it is referred to as Net Factor Productivity (NFP) thereafter) is counted. On the other hand, equation (9) accounts not only for NFP, but also for the efficiency gains resulted from rural and ownership transformation, and hence captures Total Factor Productivity (TFP). As we have emphasized earlier, even if NFP remains unchanged, an increase in rt and ot will lead to a higher TFP.

For equations (1), (3) and (6) where constant returns to scale is assumed, we divide both sides by L and take logarithms to obtain equations (1a), (3a), and (6a). For equations (2) and (5) where constant returns to scale is not assumed, we take natural logarithm of both equations and obtain equations (2a) and (5a); when rural transformation and ownership transformation are introduced, we obtain the corresponding equations (1b), (2b), (3b), (5b) and (6b).

$$\ln y = c + \beta t + \alpha \ln k \tag{1a}$$

$$\ln y = c + \beta t + \pi \ln rt + \tau \ln ot + \alpha \ln k \tag{1b}$$

$$\ln Y = c + \beta t - (\varphi/\rho)\ln\left(\delta K^{-\rho} + (1-\delta)L^{-\rho}\right) \tag{2a}$$

$$\ln Y = c + \beta t + \pi \ln rt + \tau \ln ot - (\varphi/\rho)\ln\left(\delta K^{-\rho} + (1-\delta)L^{-\rho}\right) \tag{2b}$$

$$\ln y = c + \beta t - (1/\rho)\ln\left(\delta k^{-\rho} + (1-\delta)\right) \tag{3a}$$

$$\ln y = c + \beta t + \pi \ln rt + \tau \ln ot - (1/\rho)\ln\left(\delta k^{-\rho} + (1-\delta)\right) \tag{3b}$$

$$\ln Y = c + \beta t + \varphi\theta \ln K + \varphi(1-\theta)\ln(L + \eta\theta K) \tag{5a}$$

$$\ln Y = c + \beta t + \pi \ln rt + \tau \ln ot + \varphi\theta \ln K + \varphi(1-\theta)\ln(L + \eta\theta K) \tag{5b}$$

$$\ln y = c + \beta t + \theta \ln k + (1-\theta)\ln(1 + \eta\theta k) \tag{6a}$$

$$\ln y = c + \beta t + \pi \ln rt + \tau \ln ot + \theta \ln k + (1-\theta)\ln(1 + \eta\theta k) \tag{6b}$$

where y and k are output per labour and capital per labour respectively.

4. Data and Variable Measurement

Our sample period is 1952-2008. Main data sources are *50 Years of New China* (*50YNC*), various issues of *China Statistical Yearbook* (*CSY*) including *CSY 2009* of China National Statistical Bureau (NBS), and *World Development Indicators (WDI)* of World Bank. We employ two series of capital stock. The first capital stock series, $K1$, is obtained by extending the real capital stock series of Chow and Li (2002) from 1952-1998 to 1952-2008. The second capital stock series, $K2$, is obtained by extending the real capital stock series of Bai *et al* (2006a) from 1952-2005 to 1952-2008[8]. The first form of labour reallocation, rural transformation (rt), is defined as unity minus the ratio of employed persons by primary industry to total number of employed persons[9]. It is expressed as a percentage. A higher value of rt implies more labour are allocated out from the agricultural sector to other sectors and hence a higher level of rural transformation and *vice versa*. Following the Wold Bank (1996) and Brandt *et al* (2008), ownership transformation (ot) is measured as one minus the ratio of employees in SOEs to the total urban employees[10]. As SOEs

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[8] We are very thankful to Professor Bai and Qian for sending us their data for real capital stock 1952-2005.

[9] World Bank (1996), Woo (1998) and Brandt *et al* (2008) use the ratio of agriculture employees to total employees in all sectors. We employ a similar measure but use one minus this ratio as our measurement of rural transformation. This makes the interpretation of estimates easier because a *higher* value of rt indicates a *higher* level of rural transformation.

[10] World Bank (1996) and Brandt *et al* (2008) use the ratio of SOEs employees to total non-agricultural employees. We employ a similar measure but use one minus this ratio as the measurement of ownership transformation. This makes the interpretation of estimates easier because a *higher* value of ot indicates a *higher* level of ownership transformation.

reforms were not introduced until the introduction of the open up policy after 1978, ot takes a value of zero in the pre-reform period and the actual value of ot is used for the post-reform period. A higher value of ot implies lower proportion of employees in SOEs as labour shifts out of SOEs and hence is an indicator of deeper reform towards a market-oriented economy. Following Chow (1993) and Chow and Li (2002), we set time trend, t, which captures the pure technological change NFP, to zero for the period of 1952-1977, to one in 1978 and increasing by one each year thereafter and denote it as t. Data for Y, K, L, rt and ot are described in detail in the Appendix; note that $y = Y/L$ and $k = K/L$.

5. Estimation Results

The VES (equations (5a)-(6b)) and CES production functions (equations (3a)-(4b)) are estimated using the Nonlinear Least Square (NLS) method. The Cobb-Douglas production function (equations (1a) and (1b)) is estimated using the Ordinary Least Square (OLS) method. If the error term is autocorrelated, then NLS and OLS estimators are unbiased but inefficient. Therefore, we used the heteroskedasticity-and autocorrelation-consistent variance estimator (HAC) (Newey and West, 1987), which derives the correct formula for the standard errors of the least square estimates with autocorrelated errors[11].

In the initial estimates of all production functions, the Jarque-Bera test strongly rejected the null hypothesis of normally distributed residuals for both capital series.

[11] We also employed the Engle and Granger and Johansen cointegration methods for the linear Cobb-Douglas production function. We first found all series are I(1) based on unit root tests. The Engle and Granger test confirmed that all variables are cointegrated. Using the Johansen method, we found there is one cointegrating vector at 5% based on both trace and max-eigenvalue tests when rural transformation is included (equation (1b)). But there is no cointegration when rural transformation is excluded (equation (1a)). However, as we are cannot apply cointegration methods to non-linear VES and CES production functions, we use OLS (which was supported by the Engle and Granger cointegration test) and NLS methods in order to present comparable results.

We found the residuals for years 1961-1963 deviated considerably away from the -10% band and formed a spike for both $K1$ and $K2$. These could be due to the negative impact of historic events such as that Great Leap Forward campaign between 1958-1962 and the Three Years Natural Disaster between 1959-1961. In addition, for $K2$, residuals for the period 1952-1957 were persistently above the +10% band. Therefore, for $K1$, a dummy that equals one for 1961-1963 and zero for the rest of sample period ($D6163$) was introduced in all equations. The results are reported in Table 1. For $K2$, an additional dummy that equals one for years 1952-1957 and zero for the rest of sample period ($D5257$) was included in all equations. The results are reported in Table 2.

One could argue that the opening up policy in 1978 and/or the Tiananmen Square trouble in 1989 may have caused significant structural breaks. However, the Jargue-Bera statistics in Tables 1 and 2 show that the null hypothesis of normality in the residuals cannot be rejected for any regression with $K1$ and about half with $K2$. Interestingly, the residuals during the 1970s-1990s behaved well (without any spikes in 1978-1979 or 1989-1990) even before we introduced the d6163 dummy. As a further test, we introduced dummy variables for 1978 and 1989, but both were insignificant. The fact that the time trend takes the value of zero up to 1977 may capture any potential break between the pre-reform and post-reform periods.

There are some common features regarding the results of VES and CES production functions (Tables 1-2). First, we found that the returns to scale parameter φ, is highly significant and very close to one for all CES and VES production functions for $K1$ and $K2$. We carried out Wald tests and could not reject the null of $\varphi = 1$. This implies that there are constant returns to scale.

Second, η and ρ, the two parameters that determine the value of σ in VES and CES production functions, are highly insignificant in all equations (except in equations (3b) for $K2$). In addition, we test the null that $\rho = 0$ and $\eta = 0$ using the Wald test. The test could not reject neither of the null in all equations (except in equations (3b) for $K2$)[12]. These results strongly support the view that the elasticity of substitution, σ, is equal to unity.

Third, θ and δ are distribution parameters for VES and CES production functions respectively. Other factors such as η and K/L in VES and ρ and K/L in CES function also affect the capital share (and thus also affect labour share). However, as η and ρ approach zero, as in our case, capital share reduces to θ for VES and δ for CES production function. Only about half of the capital share parameters in the CES and VES equations are highly significant and the other half are marginally significant or insignificant, and their values vary considerably across regressions.

Given that ρ and η are highly insignificant, we wanted to investigate whether the other parameters alter when ρ and η are excluded. We found that all parameters become highly significant and take feasible values for both $K1$ and $K2$. Second, φ remains very close to one, a result also confirmed by the Wald test.

Based on the above findings, we conclude that there is clear evidence supporting constant returns to scale and unity elasticity of substitution in China's aggregate production functions. This indicates that the VES and CES production functions collapse to the Cobb-Douglas production function.

As we can see from Tables 1 and 2, all parameters in the Cobb-Douglas production function are highly significant and display the anticipated signs, except the one for

[12] Though ρ is significant at 5% and $\rho = 0$ is rejected at 5% in equation (3b) in Table 3, the distribution parameter δ is insignificant and is unfeasibly low. Therefore we do not regard this regression acceptable.

ownership transformation, irrespective of the capital series employed. This contracts with the VES and CES production functions where parameters (except β and π) do not remain significant and robust across regressions. The adjusted-R squared suggests a good fit and all residuals follow a normal distribution except for $K2$ in equation (1a) when labour reallocation is not incorporated. Overall we find strong supportive evidence for the Cobb-Douglas production function as the best model to describe China's aggregate output.

Turning to the rural transformation variable, we note that it is highly significant and has a positive effect across all production functions and capital series. Second, the value of π is very stable (varying around 0.25-0.26 for $K1$ and 0.17-0.22 for $K2$) irrespective of the production function used. Third, when rural transformation is introduced, the adjusted-R squared is higher in all cases, which suggests a better fit, and the Jarque-Bera statistics are lower in all cases, which reduces the rejection power of the null that the residuals follow a normal distribution. Fourthly, in all experiments, the time trend parameter β, though highly significant and consistent, takes a value that is 0.5%-1% lower when rural transformation is included. This is true for both $K1$ and $K2$. It suggests that if rural transformation is not accounted for, the contribution of NFP to TFP is magnified. Finally, in all equations where the capital series is significant, rural transformation tends to reduce the capital share. This suggests that the introduction of rural transformation in the production function reduces the capital share since it captures the originally ignored part of change in TFP if only time trend is included. Therefore, we conclude that the inclusion of rural transformation not only improves results statistically, but also, which is even more important, makes economic sense.

In contrast to rural transformation, it is interesting to note that the coefficient of ownership transformation is close to zero and highly insignificant for both $K1$ and $K2$ in all equations. Furthermore, it displays the wrong (negative) sign when we employ the $K2$ capital series. For robustness purposes, we also used the ratio of SOEs employees to total number of employees, but the results for ownership transformation remained exactly the same.

Therefore we conclude that ownership transformation has no significant impact on China's productivity and output growth. This may be due to two reasons. First, reforms on SOEs often lead to the write-off of huge debts as banks in China, largely state owned, are unable to restructure the debt and sell it to the new owner. This is, as described by Bai *et al* (2006b), a negative external effect of SOEs reforms on the whole economy via a weak financial system. Second, Bai *et al* (2006b) find privatisation of SOEs affiliated with lower-level (county or city) governments improves their profitability, but the opposite is true for SOEs affiliated with higher-level (provincial or central) governments[13]. Thus, at an aggregated national level, SOE reforms may not have a significant impact on economic growth; and even if there is any positive impact, it may have been offset by the negative external effect mentioned above.

Our results contrast with Brandt *et al* (2008) who find that ownership transformation accounts for 1.22% of the total productivity growth during 1978-2004. However, their conclusion is based on counterfactual simulation rather than on econometric estimation. Counterfactual simulation is based on growth accounting and calculates the aggregate labour productivity whilst maintaining the level of labour location in each sector unchanged as in 1978. Then this productivity data is compared with the

[13] Please refer to Bai *et al* (2006b) for detailed explanation and estimation on which this conclusion is based.

one calculated using actual labour location in each sector and the gap indicates the contribution of labour location. As our results are based on econometric estimation of the production function, we believe that they are more reliable.

Having confirmed the necessity of including rural transformation but not ownership transformation in the production function and established that Cobb-Douglas production function is the best model, we focus on equation (1b) but without ot for both $K1$ and $K2$, referred to as final equation (1c). The effect of pure technical progress is similar irrespective of whether we use $K1$ or $K2$ (i.e. 0.026 and 0.028). The capital shares are 57% and 49% respectively, depending on the use of $K1$ or $K2$. The negative impact of $D6163$ is almost equal (-0.27) for both $K1$ and $K2$. The positive contribution of rural transformation on China's aggregate output is 0.26 when $K1$ is used, but is reduced to 0.17 when we employ $K2$ instead.

6. Total Factor Productivity

Based on the empirical findings reported in Section 5, we calculate Total Factor Productivity (TFP), Net Factor Productivity (NFP) and contribution of Rural Transformation (CRT) using the estimates of equation (1c) in Tables 1 and 2. The results are presented in Table 3[14]. We denote the levels as TFP1, NFP1, CRT1, TFP2, NFP2, and CRT2, with 1 and 2 indicating they are calculated using $K1$ and $K2$. These series are exhibited in Figure 1. The corresponding growth rates of TFP, NFP and CRT are shown in Table 4. The growth rates are denoted as GTFP1, GNFP1, GCRT1, GTFP2, GNFP2 and GCRT2. These series are plotted in Figures 2-4.

[14] The levels of NFP and TFP are calculated as follows:

$NFP1_t = \ln y_t - 0.5710 \ln k1_t - 0.2604 \ln(rt)_t + 0.2668 D6163$,

$NFP2_t = \ln y_t - 0.4867 \ln k2_t - 0.1705 \ln(RT)_t + 0.2732 D6163 - 0.1927 D5257$,

$TFP1_t = \ln y_t - 0.5710 \ln k1_t + 0.2668 D6163$, $TFP2_t = \ln y_t - 0.4867 \ln k2_t + 0.2732 D6163 - 0.1927 D5257$.

In Figure 1, NFP and TFP have overall similar shapes. Figure 1 shows that rural transformation accounts for a considerable proportion of the level of total factor productivity, though the results are sensitive to the capital stock employed. As indicated in Table 3, when we use $K1$, rt accounts (on average) for 39 % and 37% of the level of TFP for pre- and post reform periods respectively. These drop to 16% and 17% when we use $K2$. What is remarkable is that the contribution of RT to the level of TFP remains fairly stable throughout the sample period.

In Figures 2 and 3, GNFP1 and GNFP2 follow each other quite closely, as do GTFP1 and GTFP2. They present local minimal (most negative) growth rates in 1964 (shortly after the "Great Leap Forward"), 1967 and 1976 (beginning and end of Cultural Revolution) and in 1990 (shortly after the Tiananmen Square Event). Their highest growth rates occurred during the periods 1969-1970, 1982-1985, 1991-1995, and 2006-2007, irrespective of the capital stock employed. The pre-reform growth rates for all series have been volatile due to the "Great Leap Forward" (1958-1962) and Culture Revolution (1967-1976). The post-reform period has been relative stable. The only drop was observed during 1989-1990 due to the Tiananmen Square Event in 1989. We also observe a decline in the growth rates of NFP and TFP in 2008 due to the global financial crisis. In Figure 4 we observe a peak in 1958 and a trough in 1961 in the growth rate in rural transformation. These reflect the mass industrialisation in 1958 and massive reverse of rural-urban migration led by the rustication (*xia fang*) campaign[15]. Rural transformation has been much more stable during the post-reform period.

In Table 4 we also calculate the averages of all productivity series for pre- and post-reform periods. The average growth rate of NFP during the pre-reform period (1952-

[15] According to Prybyla (1975), total industrial employment in 1958 rose by 16.6 million in China; from 1961 through 1963, led by the rustication (*xia fang*) campaign, about 20 million urban dwellers in China were sent down to the countryside in a mass movement of reverse migration.

1977) is near zero (0.16% for $K1$ and -0.09% for $K2$), which implies lack of technological progress during the pre-reform period as suggested by Chow (1993). On the other hand, the contribution of rural transformation is positive (0.46% for $K1$ and 0.30% for $K2$). When the contribution of rural transformation is taken into account, total factor productivity growth increases to 0.61% for $K1$ and 0.20% for $K2$, with rural transformation accounting for over 74% of the increase in the case of $K1$ and for all the increase for $K2$.

Irrespective of the capital series employed, there is a drop of nearly 15% in TFP and NFP in 1964. This may due to the lagged negative effect of the Great Leap Forward. If we exclude 1964, the average growth rates of NFP1 and NFP2 increase by about 0.6%, and so do those for TFP1 and TFP2, whilst the growth rates of RTC1 and RTC2 remain unchanged.

For the post-reform period (1978-2008), we observe much more stable patterns for all productivity growth rates. The average growth rates for NFP1 and NFP2 are quite high, 2.79% for $K1$ and 2.81% for $K2$. The rural transformation continues to make significant contribution. When it is introduced, the growth rate of total factor productivity increases by 0.73% with K1 and 0.47% with K2. This leads to growth rates of TFP1 and TFP2 equal to 3.51% and 3.29% respectively for the post-reform period. The contribution of RT to the growth of total factor productivity varies between 21% (for TFP1) and 14% (for TFP2). This is obviously smaller than that for the pre-reform period, but it is important to point out that, as Figure 1 illustrates, the contribution of RT to the level of TFP remained fairly stable during the whole sample period, while the contribution of technical progress (captured by NFP) only increased significantly during the post-reform period. TFP is positive throughout the whole post-reform period apart from a large drop to negative during 1989-1990 due to the negative effect of the Tiananmen Square Event. Results based on $K1$ and $K2$ are much closer in the post-reform period.

7. Comparative Analysis

We compare capital shares estimated in our study with previous studies and the results are shown in Table 5[16]. Capital share estimated using $K1$ (0.5710) is lower than that reported by Chow (1993) but similar to the one found by Chow and Li (2002). On the other hand, the capital share estimated using $K2$ is 0.4867, which is considerably higher than those found by Hu and Khan (1997) and Maddison (1998) and much lower than Chow (1993) and Chow and Li (2002), but close to World Bank (1996) and Brandt *et al* (2008).

We compare the growth rate of productivity with previous studies and show the results in Table 6. For the pre-reform period, some studies show zero productivity growth (i.e. Chow, 1993, Chow and Li, 2002), some show negative growth (i.e. Maddison, 1998, Borensztein and Ostry, 1996) and some show positive growth (i.e. Hu and Khan, 1997). None of these studies have considered the contribution of rural transformation. Our study finds near zero growth rates of NFP for both cases of $K1$ and $K2$, which is consistent with Chow (1993) and Chow and Li (2002), but positive (though small) growth rates of TFP that is mainly attributed to rural transformation.

For the post-reform period, the average growth rates of NFP and TFP are 2.79% and 3.51% respectively based on $K1$, and 2.81% and 3.29% when $K2$ is used. These results are surprisingly consistent between $K1$ and $K2$. Growth rates for TFP are lower than those reported by Hu and Khan (1997), World Bank (1996), Borensztein

[16] Note that none of the previous studies reported in Table 5 have used the Bai *et al* (2006) capital stock series.

and Ostry (1996) and Brandt *et al* (2008), but higher than those found by Chow and Li (2002) and Maddison (1998).

The contribution of rural transformation for the post-reform period in our study (21% for TFP1 and 14% for TFP2) is smaller than that reported by Woo (1998) who finds half of the productivity growth is due to rural transformation. Our results are closer to World Bank (1996) who found that 28% of the 3.6% annual growth of total factor productivity growth is due to labour reallocation out of agricultural sector. Similar contribution of rural transformation (15%) is reported in Brandt *et al* (2008). Though both the World Bank (1996) and Brandt *et al* (2008) found that ownership transformation makes a contribution to TFP growth in China**,** our findings suggest its impact is insignificant that is in line with Bai *et al* (2006b).

8. Conclusions and Some Policy Implications

This paper carries out for the first time an econometric investigation of the contribution of rural transformation and ownership transformation to total factor productivity in China during the pre-reform and post-reform periods. Previous studies attribute the large productivity gains in China entirely to technical progress. But it has been argued that reallocation of labour across sectors and ownership forms has been a major feature of the Chinese economy and that this produces efficiency gains over and above those associated with technical progress. To assess the robustness of the empirical results, we use three production functions, i.e. Cobb-Douglas, Constant Elasticity of Substitution (CES) and Variable Elasticity of Substitution (VES) functions, as well as two alternative capital stock series.

The following empirical results warrant special mention. First, we find strong evidence for constant returns to scale and unit elasticity of substitution, which suggests that the Cobb-Douglass production function is the most appropriate form for modelling aggregate output in China. Second, rural transformation (labour reallocation from agricultural to non-agricultural sectors) is highly significant across all production functions and irrespective of the capital series used. On the other hand, ownership transformation (labour reallocation from SOEs to non-SOEs sector) is entirely insignificant irrespective of the production function and capital series employed. Third, the inclusion of rural transformation in the production function reduces the share of capital. This implies that omission of rural transformation from the production function, which has been the case in previous studies, overestimates the contribution of net factor productivity to the level and growth of total factor productivity.

With regards to factor productivity, a number of interesting findings have emerged. First, the average growth rate of net factor productivity was close to zero during the pre-reform period, a result that is consistent with a number of previous studies. However, when rural transformation is introduced, the average growth rate of total factor productivity rises to 0.61% for K1 and 0.20% for K2, with rural transformation accounting for over 70% of these increases. This result contradicts previous studies which report zero or negative average productivity growth for the pre-reform period. Second, total factor productivity grew at an average rate of 3.51% for K1 and 3.29% for K2 during the post-reform period, with rural transformation accounting for 21% and 14% respectively of these growth rates. This implies that technical progress was the major source of total factor productivity growth during the post-reform period, though rural transformation continued to make a significant and non-trivial contribution to factor productivity in China.

Our results have shown that rural transformation has made important contribution to China's economic growth over the past fifty years (1952-2008). However, as suggested by the World Bank (1996), despite the fact that China still has large labour surplus in agriculture sector, the continuous process of rural transformation will eventually absorb this surplus. The ratio of farmers to total employees was reduced from 84% in 1952 to 40% in 2008 and it will in time cease declining and will stabilise. Therefore, although rural transformation will continue contributing to China's economic growth, the level of contribution is unlikely to be sustained. Nevertheless, given the large number of surplus labour, until the tap of rural transformation is closed, China's economic growth will still benefit hugely from it. To take full advantage of the contribution of rural transformation to economic growth, central and local governments should put in place policies facilitating and promoting rural transformation.

On the other hand, we found the contribution of pure technical progress was zero in the pre-reform period and gradually increasing during the post-reform period. This finding leads to the same conclusion as Borensztein and Ostry (1996); that is, although TFP has made a remarkable contribution to China's growth, the true underlying productivity growth, i.e. the pure technical progress, is substantially lower. Therefore, with the slowly decreasing contribution of rural transformation in the future, the contribution of technical progress must be raised in order to sustain China's continuous high economic growth. Apart from capital accumulation, which has always been the focus of central and local governments in order to raise output, more emphasis and investment must be dedicated to research and development to lift the growth rate of technical progress and hence TFP.

Appendix. Data Sources and Variable Measurement

The main data sources of this study include *50 Years of New China* (*50YNC*), various issues of *China Statistical Yearbook* (*CSY*) including *CSY 2009* of China National Statistical Bureau (NBS), and *World Development Indicators* (*WDI*) of World Bank. The Data span is 1952-2008. Data are in 1978 price.

CSY 2009 reports most of the data from 1978. For the years before 1978, most of the data are collected from *50YNC* (published in 2000), which covers data from 1952 to 1999. Therefore, we collect data for the period 1978-2008 from *CSY 2009*, and for the period 1952-1977 from *50YNC*. However, due to the National Economics Consensus in 2004, since *CSY 2005* some data series have been updated back to 1978. Therefore to obtain the consistency between *50YNC* and *CSY 2009*, we adjust the original data of *50YNC* for the period 1952-1977 as follows:

1. For the years of 1978-1980, data from *50YNC* are compared with *CSY 2009*;

2a. If the two data series are identical, we leave data of 1952-1977 from *50YNC* as they are and call them "original data" from 1952 to 1977;

2b. If the two data series are different, we adjust data of 1952-1977 from *50YNC* using an adjustment factor. The adjustment factor is calculated as the ratio of the 3 overlapping years' average of data from *CSY 2009* to the same 3 years' average of data from *50YNC*. The 3 overlapping years are 1978, 1979 and 1980.We name them "adjusted data" from 1952 to 1977.

1. Nominal GDP: Nominal GDP from 1952 to1977 is collected from Table A-03 "*Gross Domestic Product of China*", adjusted data of *50YNC*, and nominal GDP from 1978 to 2008 is collected from Table 3-1 "*Gross Domestic Product*", *CSY2009*[17]

[17] *WDI 2009* provides GDP (current Local Currency Unit) from 1960 to 2008, which is consistent with the combined data of *50YNC* and *CSY 2009.*

2. GDP Deflator: The GDP deflator is calculated using the same methodology as Jun (2003). GDP at constant prices (preceding year=100) from 1952 to 1977 is collected from original data of *50YNC* and data from 1978-2005 is collected from *CSY 2009*. Nominal GDP data from 1952 to 2008 is constructed as above. We construct GDP at current prices (previous year=100) by dividing nominal GDP of current year by nominal GDP of previous year. By dividing GDP at current prices by GDP at constant prices and times 100, we get the implicit GDP deflator (preceding year=100). By choosing 1978, we convert GDP deflator into 1978 prices (1978=100)[18]

3. Real GDP of China (Y): The series for real GDP in 1978 price is constructed by adjusting nominal GDP using GDP deflator.

4. Total Number of Employed Persons (L): The total number of employed persons from 1952 to 1977 is collected from Table A-02 "*Employment, Staff and Workers of China*", original data from *50YNC*. From 1978 to 2008, data are collected from Table 4-3 "*Number of Employed Persons at the Year-end by Three Industries*", *CSY 2009*.

5. Rural Transformation (RT) (%): Rural transformation is defined as one minus the ratio of employed persons by primary industry to total number of employed persons. It is in percentage form. According to the definition of *CSY 2009*, primary industry is equivalent to agriculture. Data of the employed persons by primary industry from 1952 to 1977 are collected from A-02 "*Employment, Staff and Workers of China*", original data from *50YNC* and data from 1978 to 2008 are collected from table 4-3 "*Number of Employed Persons at the Year-end by Three Industries*", *CSY 2009*.

6. Ownership Transformation (OT) (%): Ownership transformation is defined as one minus the ratio of SOE employee to total number of urban employed persons. It is in percentage form. Data of the SOE employee from 1952 to 1977 are collected from A-

[18] We also converted our GDP deflator with the base year 1990 and compared it with GDP deflator data from *WDI 2009*. For the overlapping years 1960-2008, these two series are consistent with each other.

02 "*Employment, Staff and Workers of China*", original data from *50YNC* and data from 1978 to 2008 are collected from table 4-2 "*Number of Employed Persons at Year-end in Urban and Rural Areas*", *CSY 2009*.

7. Real Capital Stock (K)

7.1. Real Capital Stock (K1) — An Extension of Chow and Li (2002): K1 is obtained by extending the real capital series of Chow and Li (2002) from 1952-1998 to 1952-2008 using same methods[19]. For the detail of the methods please refer to Chow and Li (2002). Here we present data sources of series used in our extension. Data needed for the computation of real capital formation include real GDP and GDP deflator, which are explained above, and real consumption and real net export, which are explained as follows. Nominal net exports of goods and service is collected from Table 3-11 "*Gross Domestic Product by Expenditure Approach*", *CSY 2009*. Real net exports are nominal value adjusted by GDP deflators. Final consumption expenditure is collected from Table 3-11 "*Gross Domestic Product by Expenditure Approach*", *CSY 2009*. Consumer Price Index (CPI) for the period is collected from Table 9-1 "*Fixed-base Price Indices*", *CSY 2009*. Real consumption is obtained by adjust the nominal final consumption by CPI. According to Chow and Li (2002) The depreciation rate is 0 for 1952 to 1978 and 0.054 for 1979 to 1992. For the period 1993 to 1998, Chow and Li (2002) use the sum of provisional depreciation. For 1999-2008, we obtain provincial data of depreciation from Table 3-10 "*Structure of Gross Domestic Product by Region*" of various issues *CSY*.

[19] Strictly speaking, we should also update capital series of Chow and Li (2002) for the period 1952-1978 to reflect updates of the National Economics Consensus in 2004. However we have decided not to for two reasons. First, we collected original data of nominal capital formation of 1952-1978 from Table A-6 *Gross Domestic Product by Expenditure Approach of China*, *50YNC* and data after 1978 is collected from Table 3-12 "*Components of Gross Domestic Product by Expenditure Approach*", *CSY 2009*. We compare the overlapping year of 1978, 1979 and 1980 and calculated the adjustment factor which is very close to unity: 1.003. Second, Chow (1993) analyses that for the period 1952-1978 there is no significant change in the price of capital and hence nominal capital formation is regarded as equivalent to the real capital formation. Therefore, to avoid confusion and complication, we decide to use data of capital stock from Chow and Li (2002) for the period 1952-1978.

7.2. Real Capital Stock (K2) — Bai et al (2006a): Data on K2 were collected from Bai *et al* (2006) for period 1952-2005. We extended the data from 2005 to 2008 using the same methods as Bai *et al* (2006a).

For detailed methods please refer to Bai *et al* (2006a). We explain our data sources for years 2006-2008. Data for investment in construction and installation and investment in equipment and instruments are obtained from Table 5-4 "*Sources of Funds for Investment and Structure of Investment in Fixed Assets in the Whole Country*" of *CSY 2009*. Gross fixed capital formation is obtained from Table 2-18 "*Components of Gross Domestic Product by Expenditure Approach*" of *CSY 2009*. Data for price indices for investment in construction and installation and investment in equipment and instruments are collected from *Table 8-16 "Price Indices for Investment in Fixed Assets by Region*" of *CSY 2009*.

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Table 1. Estimation Results with Rural Transformation and Ownership Transformation: Capital Series K1

VES production function					CES production function					Cobb-Douglas production function			Final Equation
	Eq. 5a	Eq. 5b	Eq. 6a	Eq. 6b		Eq. 2a	Eq. 2b	Eq. 3a	Eq. 3b		Eq. 1a	Eq.1b	Eq.1c
c	1.5724*** (0.3720)	1.4155*** (0.3098)	-1.8936 (4.2718)	0.1067 (3.5091)	c	0.1956 (0.6653)	1.8780* (1.0905)	-0.9861 (2.4337)	1.4723 (0.4790)	c	1.6458*** (0.3536)	1.3255*** (0.2921)	1.2667*** (0.2470)
β	0.0332*** (0.0034)	0.0244*** (0.0037)	0.0315*** (0.0039)	0.0234*** (0.0043)	β	0.0367*** (0.0044)	0.0243*** (0.0045)	0.0337*** (0.0081)	0.0226*** (0.0069)	β	0.0307*** (0.0033)	0.0261*** (0.0027)	0.0261*** (0.0026)
π		0.2537*** (0.0508)		0.2511*** (0.0512)	π		0.2533*** (0.0502)		0.2523*** (0.0505)	π		0.2498*** (0.0470)	0.2604*** (0.0532)
τ		0.0089 (0.0128)		0.0084 (0.0122)	τ		0.0078 (0.0126)		0.0079 (0.0123)	τ		0.0046 (0.0107)	
θ	0.6388*** (0.0475)	0.5527*** (0.0387)	0.3941 (0.2637)	0.4483*** (0.2518)	δ	0.9408*** (0.0815)	0.4231 (0.2766)	0.6304 (1.2714)	0.1962 (0.5442)	α	0.6285*** (0.0452)	0.5673*** (0.0336)	0.5710*** (0.0292)
η	-0.0000229* (0.0000133)	0.0000165 (0.0000232)	0.0000130 (0.0000580)	0.0000397 (0.0000640)	ρ	0.2966 (0.1849)	-0.0742 (0.1449)	0.0767 (0.5364)	-0.1765 (0.3275)	Dummy 6163	-0.3093*** (0.0253)	-0.2656*** (0.0218)	-0.2668*** (0.0219)
φ			1.2355*** (0.2960)	1.0914*** (0.2419)	φ			1.1322*** (0.3779)	1.0771*** (0.2689)				
Dummy 6163	-0.3040*** (0.0257)	-0.2648*** (0.0221)	-0.2723*** (0.0461)	-0.2535*** (0.0374)	Dummy 6163	-0.3040*** (0.0251)	-0.2642*** (0.0224)	-0.2855*** (0.0632)	-0.2535*** (0.0446)				
Adjstd $\bar{R}^2$	0.9936	0.9967	0.9971	0.9985	Adjstd $\bar{R}^2$	0.9938	0.9967	0.9971	0.9984	Adjstd $\bar{R}^2$	0.9934	0.9967	0.9968
Jarque-Bera	3.1666 (0.2053)	1.6183 (0.4452)	3.9917 (0.1359)	2.4445 (0.2946)	Jarque-Bera	4.4586 (0.1076)	1.3749 (0.5029)	3.8548 (0.1455)	1.4723 (0.4790)	Jarque-Bera	3.6685 (0.1597)	1.8931 (0.3881)	1.8545 (0.3959)
Wald Test η=0	2.9479 (0.0860)	0.5059 (0.4769)	0.0507 (0.8219)	0.3848 (0.5351)	Wald Test ρ=0	2.5721 (0.1088)	0.2624 (0.6085)	0.0205 (0.8863)	0.2925 (0.5886)				
Wald Test φ=1			0.6332 (0.4262)	0.1428 (0.7055)	Wald Test φ=1			0.1225 (0.7264)	0.0810 (0.7759)				

Note: NLS under regression coefficients─standard error in brackets; Jarque-Bera test─probability in brackets; Wald Test─Chi-square(1)-is used and probability in brackets. All regressions use heteroskedasticity-and autocorrelation-consistent standard errors (HAC) (Newey and West, 1987). *, **, and *** indicate 10%, 5% and 1% significance level respectively..

Table 2. Estimation Results with Rural Transformation and Ownership Transformation: Capital Series K2

VES production function					CES production function					Cobb-Douglas production function			Final Equation
	Eq. 5a	Eq. 5b	Eq. 6a	Eq. 6b		Eq. 2a	Eq. 2b	Eq. 3a	Eq. 3b		Eq. 1a	Eq.1b	Eq.1c
c	3.1235*** (0.5050)	2.3801*** (0.3835)	3.0793 (3.1166)	0.0068 (3.1688)	c	2.9138*** (0.8325)	2.5040*** (0.6854)	1.7403 (2.7001)	-0.6986 (2.4668)	c	3.1953*** (0.4425)	2.4798*** (0.3246)	2.6744*** (0.2527)
β	0.0344*** (0.0049)	0.0283*** (0.0030)	0.0343*** (0.0055)	0.0260*** (0.0028)	β	0.0347*** (0.0046)	0.0275*** (0.0033)	0.0324*** (0.0063)	0.0218*** (0.0034)	β	0.0335*** (0.0050)	0.0276*** (0.0031)	0.0284*** (0.0029)
π		0.1988*** (0.0396)		0.2120*** (0.0315)	π		0.1980*** (0.0416)		0.2215*** (0.0297)	π		0.1980*** (0.0411)	0.1705*** (0.0384)
τ		-0.0155 (0.0112)		-0.0182 (0.0108)	τ		-0.0107 (0.0112)		-0.0170 (0.0101)	τ		-0.0110 (0.0089)	
θ	0.5011*** (0.0723)	0.5188*** (0.0454)	0.4987*** (0.1621)	0.4108*** (0.1494)	δ	0.5720*** (0.1845)	0.4971*** (0.1586)	0.3770 (0.2750)	0.1742 (0.1368)	α	0.4904*** (0.0632)	0.5038*** (0.0358)	0.4867*** (0.0030)
η	-0.0000210 (0.0000166)	-0.0000156 (0.0000134)	-0.0000205 (0.0000301)	0.0000138 (0.0000401)	ρ	0.0481 (0.0853)	-0.0037 (0.0808)	-0.0282 (0.1103)	-0.1466* (0.0869)	Dummy 6163	-0.3143*** (0.0359)	-0.2720*** (0.0281)	-0.2732*** (0.0284)
φ			1.0026*** (0.1761)	1.1364*** (0.1896)	φ			1.0925*** (0.1723)	1.2220*** (0.1578)	Dummy 5257	0.1385 (0.0937)	0.2122*** (0.0538)	0.1927*** (0.0488)
Dummy 6163	-0.3086*** (0.0399)	-0.2699*** (0.0284)	-0.3082*** (0.0558)	-0.2454*** (0.0356)	Dummy 6163	-0.3117*** (0.0391)	-0.2721*** (0.0285)	-0.2954*** (0.0580)	-0.2293*** (0.0307)				
Dummy 5257	0.1518 (0.1059)	0.2264*** (0.0627)	0.1517 (0.1062)	0.2301*** (0.0555)	Dummy 5257	0.1497 (0.1094)	0.2111*** (0.0627)	0.1415 (0.1029)	0.2109*** (0.0462)				
Adjstd $\bar{R}^2$	0.9965	0.9977	0.9984	0.9989	Adjstd $\bar{R}^2$	0.9964	0.9977	0.9983	0.9990	Adjstd $\bar{R}^2$	0.9965	0.9977	0.9977
Jarque-Bera	18.4756 (0.0001)	4.0224 (0.1338)	18.4943 (0.0001)	7.8436 (0.0198)	Jarque-Bera	19.3648 (0.00001)	3.6043 (0.1649)	19.6652 (0.0001)	9.4963 (0.0087)	Jarque-Bera	19.9918 (0.0000)	3.6503 (0.1612)	4.4222 (0.1096)
Wald Test η=0	1.6029 (0.2055)	1.3556 (0.2443)	0.4622 (0.4966)	0.1190 (0.7301)	Wald Test ρ=0	0.3182 (0.5727)	0.0021 (0.9635)	0.0653 (0.7982)	2.8484 (0.0915)				
Wald Test φ=1			0.0002 (0.9882)	0.5179 (0.4717)	Wald Test φ=1			0.2884 (0.5912)	1.9801 (0.1594)				

Note: See note to Table 1 for an explanation

Table 3. Levels of NFP, TFP and RTC

Year	K1			K2		
	NFP1	TFP1	RTC1	NFP2	TFP2	RTC2
1952	1.21	1.94	0.73	2.70	3.18	0.48
1953	1.29	2.03	0.74	2.74	3.22	0.48
1954	1.28	2.02	0.74	2.68	3.16	0.48
1955	1.30	2.03	0.73	2.66	3.14	0.48
1956	1.34	2.12	0.77	2.65	3.15	0.51
1957	1.35	2.11	0.76	2.62	3.12	0.50
1958	1.22	2.19	0.97	2.50	3.14	0.64
1959	1.25	2.20	0.95	2.69	3.31	0.62
1960	1.22	2.14	0.92	2.63	3.23	0.60
1961	1.25	2.07	0.81	2.65	3.18	0.53
1962	1.24	1.99	0.75	2.64	3.13	0.49
1963	1.31	2.06	0.75	2.73	3.22	0.49
1964	1.16	1.91	0.75	2.58	3.07	0.49
1965	1.26	2.02	0.76	2.68	3.18	0.50
1966	1.30	2.06	0.76	2.72	3.22	0.50
1967	1.20	1.96	0.76	2.63	3.12	0.50
1968	1.12	1.87	0.76	2.55	3.05	0.50
1969	1.23	1.98	0.76	2.65	3.15	0.50
1970	1.33	2.10	0.77	2.75	3.25	0.50
1971	1.32	2.10	0.78	2.74	3.25	0.51
1972	1.30	2.10	0.79	2.72	3.24	0.52
1973	1.32	2.12	0.80	2.75	3.27	0.52
1974	1.29	2.09	0.80	2.71	3.24	0.52
1975	1.31	2.12	0.81	2.73	3.26	0.53
1976	1.23	2.06	0.83	2.65	3.20	0.54
1977	1.25	2.09	0.84	2.68	3.23	0.55
1978	1.27	2.15	0.88	2.71	3.29	0.58
1979	1.30	2.19	0.89	2.73	3.31	0.58
1980	1.33	2.22	0.90	2.74	3.33	0.59
1981	1.34	2.24	0.90	2.74	3.33	0.59
1982	1.39	2.29	0.90	2.77	3.36	0.59
1983	1.44	2.35	0.91	2.82	3.41	0.60
1984	1.51	2.44	0.93	2.87	3.48	0.61
1985	1.56	2.50	0.94	2.92	3.54	0.62
1986	1.57	2.52	0.95	2.93	3.56	0.62
1987	1.61	2.57	0.96	2.97	3.60	0.63
1988	1.64	2.60	0.96	3.01	3.64	0.63
1989	1.61	2.57	0.96	3.02	3.65	0.63
1990	1.53	2.49	0.96	2.95	3.58	0.63

Year	K1			K2		
	NFP1	TFP1	NFP1	TFP1	NFP1	TFP1
1991	1.57	2.53	0.96	3.00	3.63	0.63
1992	1.63	2.60	0.97	3.08	3.71	0.64
1993	1.68	2.66	0.98	3.14	3.78	0.64
1994	1.72	2.71	1.00	3.19	3.84	0.65
1995	1.74	2.74	1.01	3.22	3.88	0.66
1996	1.75	2.77	1.02	3.25	3.91	0.67
1997	1.78	2.80	1.02	3.27	3.94	0.67
1998	1.79	2.81	1.02	3.29	3.96	0.67
1999	1.81	2.83	1.02	3.31	3.98	0.67
2000	1.84	2.86	1.02	3.34	4.00	0.67
2001	1.87	2.89	1.02	3.36	4.03	0.67
2002	1.90	2.92	1.02	3.39	4.06	0.67
2003	1.93	2.96	1.02	3.41	4.08	0.67
2004	1.96	2.99	1.03	3.43	4.11	0.68
2005	1.99	3.03	1.04	3.45	4.14	0.68
2006	2.03	3.09	1.05	3.49	4.18	0.69
2007	2.09	3.15	1.06	3.53	4.23	0.70
2008	2.11	3.18	1.07	3.55	4.25	0.70
Mean levels in pre- and post-reform periods						
1952-1977	1.27	2.06	0.79	2.67	3.19	0.52
1978-2008	1.69	2.67	0.98	3.13	3.77	0.64

Note:
NFP1= net factor productivity (natural log) estimated using capital stock K1
NFP2= net factor productivity (natural log) estimated using capital stock K2
TFP1=total factor productivity (natural log) estimated using capital stock K1
TFP2=total factor productivity (natural log) estimated using capital stock K2
RTC1= contribution of rural transformation to TFP1
RTC2= contribution of rural transformation to TFP2

Table 4. Growth Rates of NFP, TFP and RTC (%)

Year	K1			K2		
	GNFP1	GTFP1	GRTC1	GNFP2	GTFP2	GRTC2
1952						
1953	8.29	9.02	0.73	3.56	4.04	0.48
1954	-1.20	-1.31	-0.11	-6.04	-6.11	-0.07
1955	1.85	1.65	-0.20	-2.06	-2.19	-0.13
1956	4.45	8.35	3.90	-0.87	1.69	2.55
1957	0.20	-0.71	-0.91	-2.46	-3.06	-0.59
1958	-12.71	8.12	20.83	-12.15	1.49	13.63
1959	3.45	0.88	-2.58	19.26	17.58	-1.69
1960	-3.74	-6.33	-2.59	-6.94	-8.64	-1.70
1961	3.49	-7.07	-10.56	2.55	-4.36	-6.91
1962	-1.09	-7.45	-6.36	-0.88	-5.04	-4.16
1963	6.94	6.44	-0.50	8.82	8.49	-0.33
1964	-14.82	-14.46	0.37	-14.85	-14.61	0.24
1965	9.67	10.54	0.87	9.92	10.49	0.57
1966	3.90	4.02	0.12	3.73	3.81	0.08
1967	-9.81	-10.02	-0.21	-9.14	-9.27	-0.14
1968	-8.25	-8.24	0.01	-7.23	-7.23	0.00
1969	10.91	10.98	0.07	9.97	10.02	0.04
1970	10.32	11.49	1.17	9.57	10.33	0.77
1971	-0.87	0.51	1.38	-1.08	-0.17	0.91
1972	-1.81	-0.75	1.05	-1.60	-0.91	0.69
1973	2.02	2.20	0.19	2.28	2.40	0.12
1974	-3.03	-2.69	0.34	-3.29	-3.07	0.22
1975	1.63	3.14	1.50	1.36	2.34	0.98
1976	-7.47	-5.97	1.50	-7.17	-6.19	0.98
1977	1.59	2.96	1.37	2.37	3.27	0.90
1978	1.87	5.65	3.78	3.39	5.86	2.48
1979	3.41	4.05	0.64	1.93	2.35	0.42
1980	2.58	3.47	0.89	1.16	1.75	0.58
1981	0.97	1.51	0.53	-0.26	0.09	0.35
1982	4.91	4.88	-0.02	3.19	3.18	-0.02
1983	5.43	6.27	0.84	4.43	4.98	0.55
1984	6.50	8.80	2.30	5.66	7.17	1.50
1985	4.97	6.13	1.15	4.88	5.63	0.75
1986	1.30	2.30	1.00	1.24	1.90	0.66
1987	3.94	4.57	0.63	3.78	4.19	0.41
1988	2.97	3.38	0.41	3.81	4.08	0.27
1989	-2.69	-3.14	-0.45	0.79	0.50	-0.29
1990	-7.95	-7.98	-0.03	-6.72	-6.74	-0.02

Year	K1			K2		
	GNFP1	GTFP1	GRTC1	GNFP2	GTFP2	GRTC2
1991	3.41	3.67	0.26	4.79	4.96	0.17
1992	6.77	7.53	0.76	7.76	8.26	0.50
1993	4.43	5.72	1.29	6.18	7.02	0.84
1994	3.89	5.11	1.23	4.97	5.77	0.80
1995	2.03	3.20	1.17	3.18	3.94	0.77
1996	1.76	2.67	0.91	2.50	3.10	0.60
1997	2.38	2.70	0.31	2.66	2.86	0.21
1998	1.69	1.74	0.05	1.69	1.73	0.03
1999	1.90	1.75	-0.16	2.02	1.92	-0.10
2000	2.81	2.86	0.05	2.71	2.74	0.03
2001	2.54	2.54	0.00	2.36	2.36	0.00
2002	3.39	3.39	0.00	2.86	2.86	0.00
2003	3.23	3.70	0.46	2.54	2.85	0.30
2004	2.45	3.55	1.10	1.91	2.63	0.72
2005	3.20	4.21	1.01	2.01	2.67	0.66
2006	4.40	5.41	1.01	3.30	3.96	0.66
2007	5.71	6.50	0.79	4.85	5.37	0.52
2008	2.23	2.79	0.56	1.67	2.03	0.36
Mean growth rates in pre- and post-reform periods						
1952-1977	0.16	0.61	0.46	-0.09	0.20	0.30
1952-1977*	0.78	1.24	0.46	0.52	0.82	0.30
1978-2008	2.79	3.51	0.73	2.81	3.29	0.47

Note:
GNFP1=growth rate of NFP1
GNFP2= growth rate of NFP2
GTFP1=growth rate of TFP1
GTFP2= growth rate of TFP2
GRTC1= growth rate of RTC1
GRTC2= growth rate of RTC2
*1964 is excluded.

Table 5. Comparison with Previous Studies: Capital Share %

Sources	Periods	Capital Share %	
		Pre-reform	Post-reform
This Study	1952-2008	K1: 0.5710	
		K2: 0.4867	
Chow (1993)	1952-1988	0.6317	
Chow and Li (2002)	1952-1998	0.5577	
Hu and Khan (1997)	1953-1994	0.386	0.453
World Bank (1996)	1985-1994	0.5	
Maddison (1998)	1952-1995	0.3	
Borensztein and Ostry (1996)	1953-1994	na	
Woo (1998)	1979-1993		0.4, 0,5 and 0.6
Brandt et al (2008)	1978-2004		0.5

Table 6. Comparison with Previous Studies: Average Productivity Growth Rates (%)

Sources	Periods	Average Productivity Growth Rate (%)			
		Pre-reform (%)		Post-reform (%)	
This Study	1952-2008	GTFP1: 0.61	GNFP1: 0.16	GTFP1: 3.51	GNFP1: 2.79
			GRTC1: 0.46		GRTC1: 0.73
		GTFP2: 0.20	GNFP2: -0.09	GTFP2: 3.29	GNFP2: 2.81
			GRTC2: 0.30		GRTC2: 0.47
Chow (1993)	1952-1988	0		n.a.[20]	
Chow and Li (2002)	1952-1998	0		3	
Hu and Khan (1997)	1953-1994	1.1		3.9	
World Bank (1996)	1985-1994			GTFP: 3.6	GLR1: 1.00
					GLR2: 0.40
Maddison (1998)	1952-1995	-0.78		2.23	
Borensztein and Ostry (1996)	1953-1994	-0.7		3.8	
Woo (1998)	1979-1993			GNFP: 1.1 to 1.3	
				GRTC: 1.1	
Brandt et al (2008)	1978-2004			GTFP: 6.96	GLR1: 1.02
					GLR2: 1.22

Note: GLR1: labour reallocation from non-agricultural to agricultural sector
GLR2: labour reallocation from state to non-state owned sector

[20] Chow (1993) estimates productivity growth for each sector (e.g. .industry, transport, commerce) in China and hence the aggregate productivity is not available.

Figure 1. Levels of NFP and TFP and Contribution of RT (CRT)

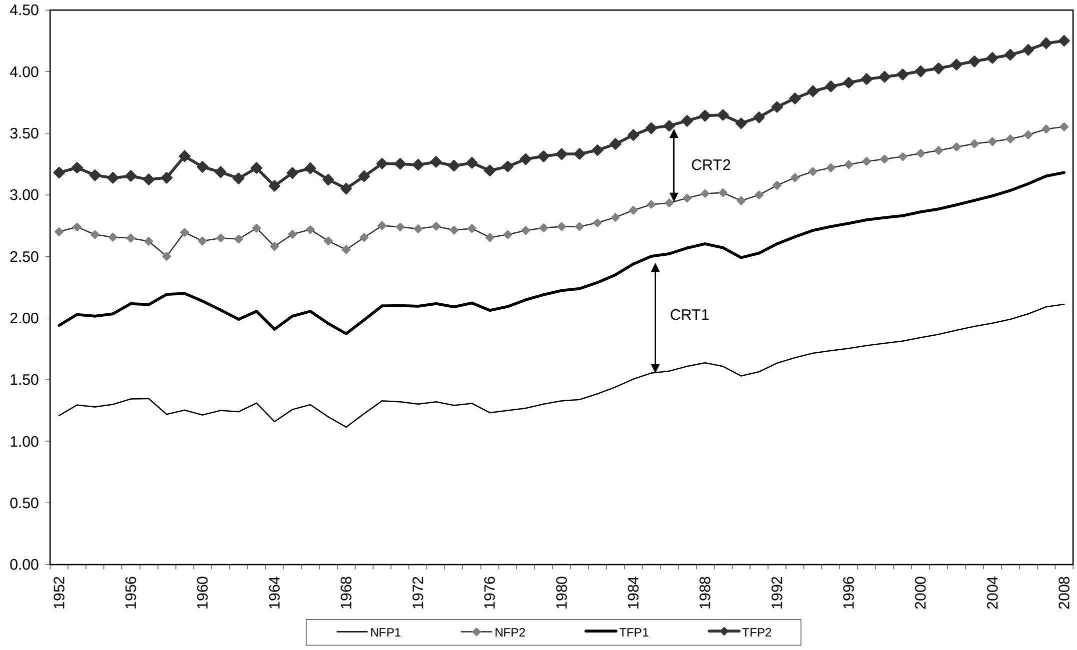

Figure 2. Growth rate of TFP

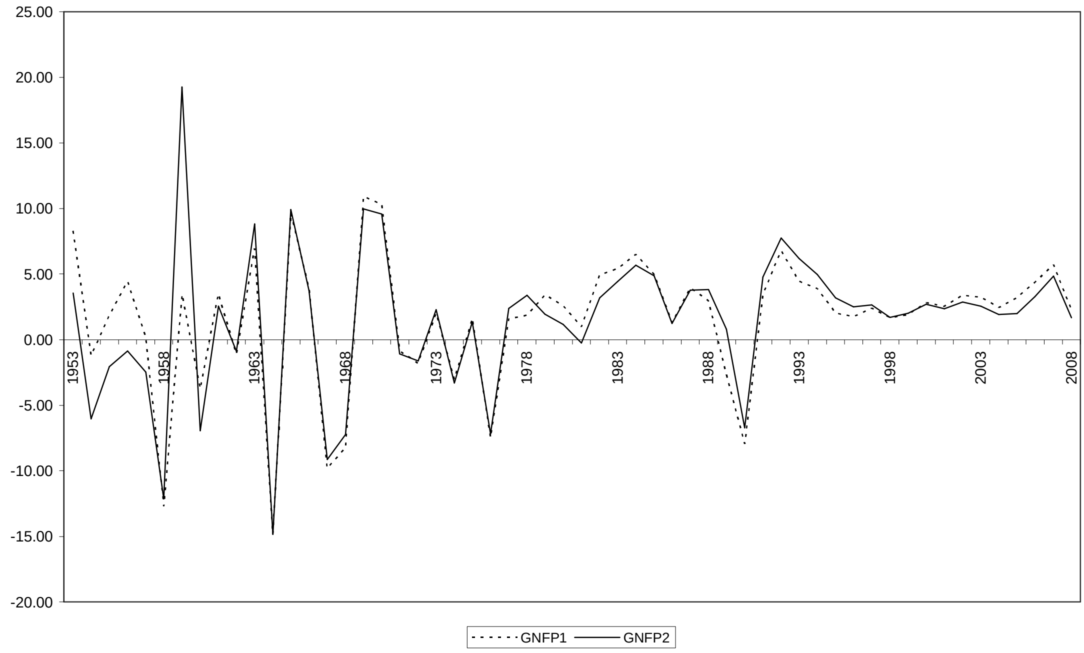

Figure 3. Growth rate of NFP

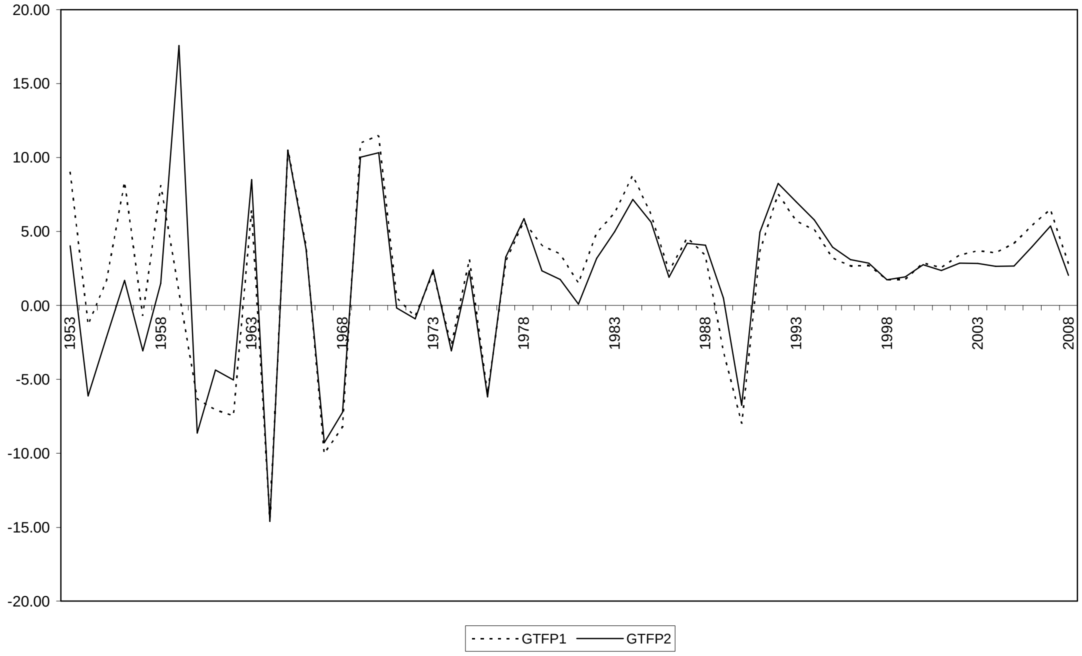

Figure 4. Growth of CRT