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Abstract

This paper carries out for the first time an econometric investigation of the contribution of rural transformation to total factor productivity in China. We find that the efficiency gains resulting from rural transformation make a significant and non-trivial contribution to factor productivity in China. During the pre-reform period (1952-1977), the average growth rate of net factor productivity, which results from technical progress, was close to zero. But when rural transformation is introduced, average total factor productivity growth becomes positive. During the post-reform period (1978-2005), both total and net factor productivity exhibited increasing trends and high positive growth rates, except during 1989-90 (the period of the political troubles in Tiananmen Square). We find that the inclusion of rural transformation increases the average growth rate of factor productivity by nearly one percentage point during the post-reform period, thus making our estimates of total factor productivity growth higher than those reported by previous studies.

Keywords: Factor productivity; Rural transformation; Technical progress; China

JEL classification: O30, O47, O53

1. Introduction

Chow (1993), Borensztein and Ostry (1996), Hu and Khan (1997) and Maddison (1998) study China's economic growth for both pre-reform and post-reform periods[1]. They find a significant contribution of total factor productivity (TFP) to the economic growth in the post-reform period while in the pre-reform period economic growth is mainly attributed to capital accumulation. On the other hand, Sachs and Woo (1997) and Woo (1998) study the post-reform period and find that the high economic growth rate is mainly attributed to capital accumulation while technological progress made little contribution to economic growth.

Though it seems hard to define whether there is significant technological progress for the entire pre and post reform periods, it seems fair to say that there is little evidence of TFP growth for the pre-reform period according to the results of existing empirical studies. In particular, Chow (1993) employs extensive data of capital formation and labour and estimates the Cobb-Douglas production function for China's aggregate economy and five sub-sectors respectively from 1952 to 1988. He finds that there is no technological change in China from 1952 to 1980[2]. Chow and Li (2002) further extend Chow (1993) and re-estimate the Cobb-Douglas production for the period 1952-1998 by setting the time trend t, which captures the technological change, to zero for the period 1952-1977, to one in 1978 and increasing by one each year thereafter.

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[1] For earlier studies please refer to the surveys of Wu (1993) and Wu and Yang (1995).

[2] Chow (1993) further justifies this "zero technological change" by the implementation of the first Five-Year Plan in 1953 which tried to increases outputs in five sectors and in total through capital formation in these sectors. The estimations of both sectorial and aggregate production functions show there is no technological change. After 1960, the central-planned did not give any incentive to the private enterprises to innovate and therefore there was no technological progress. Chow (1993) argues that Solow's (1956) growth model is an important phenomenon to explain for a market economy like the US, one cannot presume its existence in a country like China during a period when private initiatives for innovations and adopting new technology from abroad appeared to be absent.

However the above studies ignored the role of rural transformation to productivity growth. Borensztein and Ostry (1996), World Bank (1996) and Woo (1998) have argued that total factor productivity in China reflects not only technical progress but also efficiency gains resulting from the reallocation of labour across sectors and ownership forms. Using data for the post-reform period, they show significant contribution of labour reallocation to productivity and GDP growth. But these estimates are based on national accounting data rather than on econometric investigations. Therefore, an important contribution of our paper is to incorporate rural transformation into the production function for China for both pre- and post-reform periods and carry out an econometric investigation of the contribution of rural transformation and technical progress to total factor productivity.

The paper is organised as follows: Section 2 specifies the production function with and without rural transformation and shows how we can obtain separate estimates for total and net factor productivity. Section 3 explains the measurement of variables and data sources. Section 4 discusses the econometric estimates of the production function, while 5 reports the estimates of total and net factor productivity, and discusses the contribution of rural transformation to total factor productivity. The final section concludes.

2. The Production Function

Following Chow and Li (2002), the Cobb-Douglas production function can be written as

$$Y = AK^{\alpha}L^{1-\alpha} \qquad (1)$$

where Y, K, L, A and α are real output, real capital stock, labour, level of technology and capital share of income respectively. Dividing both sides by L we obtain the form

$$y = Ak^{\alpha} = e^{\beta t} k^{\alpha} \tag{2}$$

where β measures the effect of technological progress. y and k denote real output per labour and real capital stock per labour respectively. Conventionally, A is also referred as TFP. In our study, we decompose TFP into net factor productivity (NFP) and rural transformation (RT). NFP captures the pure technology progress and RT captures the effect of inter-sectorial labour flows.

Unlike other emerging economies, China's transformation from central-planned to market oriented economy is characterized by "rural transformation". It refers to both rural-urban migration and rural industrialization. The former refers to the internal labour migration from countryside to cities. The latter refers to the establishment of rural enterprises (i.e. Town and Village Enterprises) which have been shifting farmers from working in the field to working in these labour intensive rural enterprises. Both result in shifts of labour from low productivity primary sector to more productive secondary and tertiary sectors[3]. Therefore, even if the levels of technology in different sectors remain unchanged (hence NFP is unchanged), labour flows from sectors with lower marginal productivity of labour to sectors with higher marginal productivity of labour will increase the TFP. In other words, for a country like China with enormous labour surplus, it is not only the total number of effective labour that matters for output growth; the distribution of effective labour also matters.

Therefore, the production function for China takes the following form:

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[3] Chow (1993) finds the marginal value product of labour 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

$$y = TFPk^{\alpha} = (NFP)(RT^{\gamma})k^{\alpha} \quad (3)$$

where γ measures the effect of RT on TFP. Put it in a numerical way, it measures how many units of increment in the level of TFP there will be if RT increases by one unit. We expect it to be within the range of zero and unity ($0 < \gamma < 1$). Hence equation (3) can be rewritten as:

$$y = (e^{\beta t})(RT^{\gamma})k^{\alpha} \quad (4)$$

3. Data

Two real capital stock series are employed for the period of 1952-2005. The first capital series, $K1$, is the extended series of Chow and Li (2002). The second capital series, $K2$, is collected from Bai, Hsieh and Qian (2006). The other series include real GDP, labour and rural transformation. All data are described in detail in the Data Appendix. $K1$, $K2$ and real GDP are divided by labour (number of employed persons). As mentioned above, following Chow (1993) and Chow and Li (2002), we set time trend, which captures the pure technological change, to zero for the period 1952-1977, to one in 1978 and increasing by one each year thereafter.

4. Empirical Results

We estimate the production functions using Ordinary Least Squares (OLS). However, if the error term is autocorrelated, then OLS estimators are unbiased but inefficient. Therefore in our study we use the heteroskedasticity-and autocorrelation-consistent variance estimator (HAC) (Newey and West, 1987), which derives the correct formula for the standard errors of the OLS estimates with autocorrelated errors.

Taking natural logarithm of equations (2) and (4) yields equations (5) and (6) respectively. Therefore, in our study we use both time trend to capture NFP, the pure technological change, and RT to capture the effect of rural transformation on TFP. The level of TFP is the sum of levels of NFP and RT.

$$\ln y_t = c + \alpha \ln k_t + \beta t + u_t \tag{5}$$

$$\ln y_t = c + \alpha \ln k_t + \beta t + \gamma \ln(RT)_t + u_t \tag{6}$$

We estimated the two production functions (equations (5) and (6)) for the period 1952-2005 using the two alternative measures of capital stock, $\ln k1$ and $\ln k2$. The results are reported in Table 1.

All coefficients are correctly signed and statistically significant before and after RT is incorporated into the production function. However, there are four noticeable changes after the rural transformation is incorporated. First, capital shares are reduced from 0.648 to 0.573 for $k1$ and from 0.408 to 0.362 for $k2$. That implies that the inclusion of RT in the production function reduces capital shares since RT captures the originally ignored part of change of TFP if only time trend is included. Second, the intercepts and coefficients of t in the second set (regressions 3 and 4) are slightly lower than in the first set (regressions 1 and 2) after controlling for RT. It implies that the missing of RT from the production function magnifies not only the original level of NFP, which is represented by the intercept, but also the growth rate of NFP, which is captured by the coefficient of t. In other words, if RT is not controlled for, the contribution of NFP to TFP is over valued. Third, RT is positive and significant for both cases using $k1$ and $k2$ and the coefficients are within the range of zero and unity. Fourth, both adjusted-R squared and log likelihood are higher in the second set, implying a better fit of the model after the integration of RT.

We compare capital shares estimated in our study with previous studies and the results are shown in Table 2. Capital share estimated using $k1$ (0.573) is lower than those reported by Chow (1993) and Chow and Li (2002), which reflects the effect of incorporating RT into the production function. However the differences are rather small, as the capital shares in our study, Chow (1993) and Chow and Li (2002) are fairly close to 0.6. Capital share estimated using $k2$ is lower than Hu and Khan (1997) and higher than Maddison (1998). Nevertheless, the discrepancies are small as capital shares in our study, Hu and Khan (1997) and Maddison (1998) vary around 0.4.

5. Productivity

Table 3 shows the levels of total factor productivity (TFP), net factor productivity (NFP) and productivity due to rural transformation (CRT). The corresponding growth rates of TFP, NFP and CRT are shown in Table 4. The levels of TFP, NFP and CRT (in natural logarithm) are calculated based on coefficients in regressions 3 and 4 in Table 1 and actual values of variables (in natural logarithm)[4]. We denote the levels as TFP1, NFP1, CRT1, TFP2, NFP2, and CRT2, and the growth rates as GTFP1, GNFP1, GCRT1, GTFP2, GNFP2 and GCRT2, with 1 and 2 indicating they are calculated using $\ln k1$ and $\ln k2$. These series are exhibited in Figures 1-4.

In Figure 1, NFP and TFP have overall similar shapes. NFP1 and TFP1 are lower in levels compared with NFP2 and TFP2. This is due to series $K1$ being larger than $K2$ and therefore capital shares of $K1$ are greater than those with $K2$ (Table 1). With higher capital shares of $K1$, the levels of NFP1 and TFP1 are in general lower than the levels of NFP2 and TFP2. Figure 1 shows that rural transformation accounts for a

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[4] The levels of NFP and TFP are calculated as $NFP1_t = \ln y_t - 0.573 \ln k1_t - 0.314 \ln(RT)_t$, $NFP2_t = \ln y_t - 0.362 \ln k2_t - 0.208 \ln(RT)_t$, $TFP1_t = \ln y_t - 0.573 \ln k1_t$, and $TFP2_t = \ln y_t - 0.362 \ln k2_t$ respectively.

considerable proportion of the level of total factor productivity, though the results are sensitive to the capital stock employed. When we use K1, RT accounts (on average) for 46%-48% of the level of TFP throughout the sample period. This drops to 16% when we use K2 instead. What is remarkable is that the contribution of RT to the level of TFP remains fairly stable throughout the sample period.

As we can see from Figures 2 and 3, GNFP1 and GNFP2 follow each other quite closely, as do GTFP1 and GTFP2. The four series all present local minimal (most negative) growth rates in 1961, 1967, 1976 and 1990. For the year 1958, GNFP1 and GNFP2 are not consistent with (much lower than) GTFP1 and GTFP2 due to the high growth rate of RT in that year. It is worth noticing that both NFP and TFP display their highest growth rates during the periods 1963-1966, 1982-1985 and 1991-1995, irrespective of the capital stock employed.

In Tables 3 and 4 we also calculate the averages of all productivity series for each decade, pre- and post-reform periods and periods divided according to historical events. During the pre-reform period of 1952-1977, the growth rates of NFP and TFP have been volatile due to the "Great Leap Forward" (1958-1962) and Culture Revolution (1967-1976)[5] (Figure 2 and 3), especially for the period 1958-1970. If this period (1958-1970) is excluded, the volatility is reduced considerable[6]. The average growth rate of NFP during the pre-reform period is near zero, which suggests lack of technological progress during the pre-reform period[7] as suggested by Chow (1993). However, when rural transformation is introduced, factor productivity growth

[5] The period Cultural Revolution is conventionally defined as 1966-1976. However, due to the fact that it started in October 1966, we define the ten years Cultural Revolution as from 1967 to 1976.

[6] The average levels of NFP1 and NFP2 for the pre-reform period are 1.05 and 3.38, which are almost identical to constants in regressions 3 and 4 (Table 5.1). The average levels of NFP1 and NFP2 are also very close to the values in 1952, which are 1.04 and 3.44. So are the levels of TFP1 and TFP2.

[7] The growth rate of NFP1 and NFP2 are as low as 0.05% % and 0.03% for the pre-reform period.

increases to between 0.40% and 0.60%, with rural transformation accounting for about 90% of this increase.

Due to the historic event of the Great Leap Forward (1958-1962) and the start of ten years of cultural revolution in 1967, there are both high growth and large setbacks in productivity and rural transformation for the period of 1958-1970, among which 1961 sees the biggest downside fall in productivity. Therefore, we calculated the average of productivities for the pre-reform period by excluding the period of 1958-1970 and the year 1961 respectively. When 1958-1970 is excluded, the growth rates of NFP1 and NFP2 increase and decrease respectively, while the absolute values of them are still close to zero. However the growth rates of TFP1 and TFP2 rise to 1.36% and 0.61% respectively, due primarily to the contribution of RT. When 1961, the biggest outlier, is excluded, both growth rates of NFP1 and NFP2 increase by about one percentage point (to around 1%), while the growth rates of TFP1 and TFP2 increase by about 1.4 percentage point (becoming 2.03% and 1.73% respectively). About 54% of the latter increase is due to the contribution of rural transformation

For the post-reform period (1978-2005), NFP1, NFP2, TFP1 and TFP 2 have all exhibited similarly increasing trends except a drop during 1989-1990[8]. The volatility of their growth rates has been reduced significantly compared with the pre-reform period, especially for the last decade. The average growth rate for net factor productivity was quite high during the post-reform period irrespective of the capital

[8] During the transformation period of 1977-1981 and early 1980s, the economy was stimulated by the implementation of reform and opening up policy in 1978 and the Household Responsibility Contract System in rural area. The real GDP growth rate was reduced to 4.1% and 3.8% in 1989 and 1990 compared with an average of over 10% in early 1980s. This slow down of China's economy was caused by high inflation in the late 1980s and the other measures taken by the government pursuing economic growth. For details explanation for the economic slow down in late 1980s, please refer to Li (2001). For the period 1990-1995, Austerity programmes in early 1990s, tightened monetary policy, Deng Xiaoping's southern tour in 1992 and reform on State Owned Enterprises (SOEs) have revived the economy from the slowdown in late 1980s. Following the steps of reforms, the NFP and TFP had high growth rates for the period 1991-1995 and for the last decade they grow with reasonable and very stable rates.

stock employed. It is interesting to note that when rural transformation is introduced, the growth rate of total factor productivity increases by nearly one percentage point with K1 and 0.6 of a percentage point with K2. The contribution of RT to the growth of TFP varies between 14% and 27%. This is obviously smaller than that for the pre-reform period; as Figure 1 illustrates, the contribution of RT to the level of TFP remained fairly stable during the sample period, while the contribution of technical progress (captured by NFP) increased significantly during the post-reform period.

We compare the growth rate of productivity with previous studies and show the results in Table 5. 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). Out study finds near zero growth rates of NFP for both cases of $\ln k1$ and $\ln k2$, which is consistent with Chow (1993) and Chow and Li (2002), but positive (though small) growth rates of TFP that is mainly attributed to RT. However, if we were to exclude 1961, the big outlier associated with the "Great Leap Forward", the growth rate of NFP increases by 1 percentage point and that of TFP by about 1.4 percentage point (the latter is due RT). These findings contradict those obtained by previous studies for the pre-reform period. For the post-reform period, the average growth rates of NFP and TFP are 2.36% and 3.23% respectively based on $k1$. Such growth rates are higher than those reported by Woo (1998) but are overall in line with most of other studies in Table 2. But when we use $k2$, the average growth rates of NFP and TFP are 3.60% and 4.18% respectively, which higher that those reported by previous studies.

6. Conclusions

This paper carries out for the first time an econometric investigation of the contribution of rural transformation to total factor productivity in China. 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. The introduction of rural transformation into the production function allows us to identify the separate contributions of net factor productivity, which results from technical progress, and of rural transformation to total factor productivity. Using the latest available national accounts, we construct consistent time series for aggregate output, two series for capital stock, labour and rural transformation for 1952-2005, thus covering both the pre-reform and post-reform periods.

The estimated coefficients of the production function are significant and display the anticipated signs, irrespective of the capital series employed. We found that 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.

A number of interesting results have been obtained with regards to factor productivity. During the pre-reform period (1952-1977), the growth rates of productivity were very volatile, due primarily to the “Great Leap Forward” (1958-1962) and the Cultural Revolution (1967-1970). The average growth rate of net factor productivity was close to zero, 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 0.60%. If we remove the 'Great Leap Forward year' of 1961 which represents a major outlier, the average growth rate of total factor productivity increases considerably (to 2.03%), a result due primarily to the contribution of rural transformation (54%). This result contradicts previous studies which report zero or negative average productivity growth for the pre-reform period.

During the post-reform period (1978-2005), both total and net factor productivity exhibited increasing trends and high positive growth rates, except during 1989-1990 (the year of the political troubles in Tiananmen Square) when there was a significant drop. The average growth rate of net factor productivity was high and similar to the estimates reported by previous studies. But when rural transformation is taken into account, the average growth rate of factor productivity increases by nearly one percentage point, thus making our estimates of total factor productivity growth higher than those found by previous studies.

On average, and depending on the capital stock employed, rural transformation seems to contribute between 20% and 46% to the level of total factor productivity, and between 14% and 27% to the growth rate of total factor productivity. This implies that technical progress remains a major source of total factor productivity growth, especially during the post-reform period, but the efficiency gains resulting from rural transformation also make a significant and non-trivial contribution to factor productivity in China.

Appendix A. Data Sources and Variable Measurement

The main data sources of this study include *50 Years of New China* (*50YNC*), and *China Statistical Yearbook* 2006 (*CSY 2006)* of China National Statistical Bureau (NBS), and *World Development Indicators* (*WDI*) of World Bank. The Data span is 1952-2005.

However, *CSY 2006* 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 1978-2005 from *CSY 2006,* and for the period 1952-1977 from *50YNC.* To obtain the consistency between these two data series (*50YNC* and *CSY 2006*) 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 2006*;

2a. If the two data series are identical, we leave data of 1952-1977 from *50YNC* as thy 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 2006* to the same 3 years' average of data from *50YNC*. The 3 overlapping years are 1978, 1979 and 1980 unless it si stated otherwise. We name them "adjusted data" from 1952 to 1977.

1. Nominal GDP

Nominal GDP from 1952 to1977 is collected from adjusted data of *50YNC* (Table A-03), and nominal GDP from 1978 to 2005 is collected from *CSY 2006*[9] (Table 3-1).

[9] *WDI 2006* provides GDP (current Local Currency Unit) from 1960 to 2005, which is consistent with the combined data of *50YNC* and *CSY 2006*.

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*[10] and data from 1978-2005 is collected from *CSY 2006*. Nominal GDP data from 1952 to 2005 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, 1990 and 2000 as base years, we convert GDP deflator into 1978 prices (1978=100), 2000 prices (2000=100) and 1990 prices (1990=100)[11] and we call them GDP deflator 1, 2 and 3 respectively. *WDI 2006* provides GDP deflator with the base year of 1990=100 between 1960 and 2005 and we call it GDP deflator 4. GDP deflator 4 and GDP deflator 3 are consistent with each other. After this confirmation, we use GDP deflators 1 (1978=100) and 2 (2000=100) in our study.

3. Real GDP of China (Y)

The series for real GDP in 1978 prices and 2000 prices are constructed by dividing nominal GDP by GDP deflators (1978=100 and 2000=100) and multiplying by 100.

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

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[10] Data of GDP at constant prices (preceding year=100) *50YNC* and data from *CSY 2006* are identical for period of 1978-1992.

[11] We construct implied GDP deflator with base year of 1978 due to the capital stock is constructed using base year 1978; with the base year 2000 is due to most data from *IFS* choose 2000 as base year; with base year of 1990 is because GDP deflator provided by *WDI* is with the base year 1990=100.

to 2005, data are collected from Table 5-2 "*Number of Employed Persons at the Year-end by Three Industries*", *CSY 2006*.

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 2005*, 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 2005 are collected from table 5-2 "*Number of Employed Persons at the Year-end by Three Industries*", *CSY 2006*.

6. Real Capital Stock (K)

We employ two series of capital stock (K1 and K2) which use different investment price indices as well as different initial capital stocks and depreciation rates. The reason we use two capital stock series is because the estimation of capital share in the production function is sensitive to the choice of capital series.

6.1. Real Capital Stock (K1) — An Extension of Chow and Li (2002)

K1 is calculated by employing the methodology of Chow and Li (2002) but using updated data after the National Economics Consensus in 2004 (published in *CSY* 2006). For the period 1952-1978, we use the original data of capital stock from Chow and Li (2002)[12]. For the period 1979-2005, data needed for the computation of real

[12] We use data from Chow and Li (2002) rather than collecting updated data of nominal capital formation for the period 1952-1978 because of 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 2006*. We compare the overlapping year of 1978, 1979 and

capital formation, i.e. real GDP, real consumption, nominal net export, and GDP deflator, were obtained from *CSY 2006* and *50YNC* (consistent time series were constructed as explained above). The depreciation rate is 0 for 1952 to 1978 and 0.054 for 1979 to 1992. For the period 1993 to 1998, sum of provisional depreciation from Chow and Li (2002) is used as this data is not affected by National Economics Consensus in 2004[13]. Provincial data of depreciation of 1999, 2000, 2001, 2003, and 2005 are collected from Table 3-10 "*Structure of Gross Domestic Product by Region", CSY 2000, 2001, 2002, 2004 and 2006.* While data for 2002 and 2004 are not available we use the average of 2001 and 2003 to approximate 2002 and average of 2003 and 2005 to approximate 2004. The sum of the provincial depreciation is used as the total depreciation.

6.2. Real Capital Stock 2 (K2) — Bai, Hsieh and Qian (2006)

Data on K2 were collected from Bai, Hsieh and Qian (2006)[14]. In their study, the data of "gross fixed capital formation" from 1952 to 1977 are collected from Heush and Li (1999) and data from 1978 to 2005 are collected from *CSY 2006*[15]. However, the gross fixed capital formation is not disaggregated into different types of investment while the series of total investment in fixed assets is disaggregated into two types of investment in fixed assets: investment in structures and building, investment in machinery and equipment. To get around with this problem, Bai, Hsieh and Qian

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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 1953-1978.

[13] Each year *CSY* report provisional depreciation of the previous year only. Therefore, the consensus in 2004 does not affect provisional of 1993 to 1998 or it is not possible to check if data of 1993 to 1998 have changed. Therefore we keep data from Chow and Li (2002) for the period 1993 to 1998

[14] I am very grateful for the generous help of Bai, C-E and Qian, Z. for sending me the data of real capital stock (1952-2005) used in their study of Bai, Hsieh and Qian (2006).

[15] Bai, Hsieh and Qian (2006) did not adjust data from 1952 to 1977 by any adjustment factor. However, to respect the originality of their estimation, we use the real capital stock data in their study.

(2006) assume that the shares of the two types of capital in fixed capital formation are the same as those for total investment in fixed assets.

Between 1953 and 1977, the investment price index from Heush and Li (1999) is used to deflate the nominal gross fixed capital formation. Between 1978 and 1989 price of structures and building is measured by the deflator of value added in the construction industry, while the price of machinery and equipment is measured by the output price deflator of the domestic machinery and equipment industry. After 1991 the NBS reports separately price indices for investment in structures and buildings and for investment in machinery and equipment. All price indices are in 1978 prices. Finally, the capital stock in 1952 is initialised as the ratio of investment in 1953 to the sum of the average growth rate of investment in 1953-1958. The depreciation rate is assumed to be 8% for structures and buildings and 24% for machinery and equipment.

The two series for real capital stock (K1 and K2) have the same trend. Before 1978, they are fairly close to each other. But after 1978, K1 becomes larger than K2; this could be due to the highest investment price deflator of K2 after 1978 and the lowest initial capital stock of K2 in 1952.

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Table1. Estimation of Production Function (1952-2005)

Variables	Regressions			
	1	2	3	4
Constant	1.4639	3.7334	1.0591	3.3873
	(0.4327)	(0.2705)	(0.4382)	(0.3378)
$\ln k1$	0.6484		0.5731	
	(0.0548)		(0.0480)	
$\ln k2$		0.4076		0.3617
		(0.0404)		(0.0465)
t	0.0288	0.0421	0.0231	0.0388
	(0.0040)	(0.0042)	(0.0042)	(0.0044)
$\ln RT$			0.3144	0.2079
			(0.0684)	(0.0901)
$\overline{R}^2$	0.9840	0.9849	0.9902	0.9881
Log likelihood	48.9599	50.4434	62.6204	55.2177

Note: $\overline{R}^2$ denotes adjusted R-squared. Standard errors are in parentheses. All regressions use heteroskedasticity-and autocorrelation-consistent standard errors (HAC) (Newey and West, 1987).

Table 2. Comparison with Previous Studies: Capital Share %

Sources	Periods	Capital Share %	
		Pre-reform	Post-reform
This Study	1952-2005	K1: 0.573055	
		K2: 0.361657	
Chow (1993)	1952-1988	0.6317	
Chow and Li (2002)	1952-1998	0.6284	
Hu and Khan (1997)	1953-1994	0.386	0.453
Maddison (1998)	1952-1995	0.3	
Borensztein and Ostry (1996)	1953-1994	na	
Woo (1998)	1979-1993		0.4, 0,5 and 0.6

Table 3. Levels of NFP, TFP and Contribution of RT to the Levels of TFP

Year	K1			K2		
	NFP1	TFP1	RTC1	NFP2	TFP2	RTC2
1952	1.04	1.93	0.88	3.44	4.03	0.58
1953	1.13	2.02	0.89	3.50	4.09	0.59
1954	1.11	2.00	0.89	3.46	4.05	0.59
1955	1.13	2.02	0.89	3.46	4.04	0.59
1956	1.17	2.10	0.93	3.46	4.08	0.62
1957	1.17	2.09	0.92	3.45	4.06	0.61
1958	1.00	2.18	1.17	3.32	4.10	0.78
1959	1.04	2.18	1.14	3.35	4.11	0.76
1960	1.01	2.12	1.11	3.31	4.05	0.73
1961	0.80	1.78	0.98	3.08	3.73	0.65
1962	0.80	1.71	0.91	3.08	3.68	0.60
1963	0.87	1.77	0.90	3.16	3.76	0.60
1964	0.99	1.90	0.90	3.29	3.88	0.60
1965	1.09	2.00	0.92	3.39	3.99	0.61
1966	1.12	2.04	0.92	3.43	4.04	0.61
1967	1.03	1.94	0.91	3.34	3.95	0.60
1968	0.94	1.86	0.91	3.27	3.87	0.60
1969	1.05	1.97	0.92	3.37	3.98	0.61
1970	1.15	2.08	0.93	3.48	4.09	0.61
1971	1.14	2.09	0.95	3.47	4.10	0.63
1972	1.12	2.08	0.96	3.46	4.10	0.63
1973	1.14	2.10	0.96	3.49	4.13	0.64
1974	1.11	2.07	0.97	3.47	4.11	0.64
1975	1.12	2.11	0.98	3.49	4.14	0.65
1976	1.04	2.05	1.00	3.43	4.09	0.66
1977	1.06	2.08	1.02	3.45	4.13	0.67
1978	1.07	2.13	1.06	3.49	4.19	0.70
1979	1.10	2.17	1.07	3.52	4.22	0.71
1980	1.12	2.20	1.08	3.53	4.25	0.72
1981	1.13	2.22	1.09	3.53	4.25	0.72
1982	1.17	2.26	1.09	3.57	4.29	0.72
1983	1.22	2.32	1.10	3.62	4.35	0.73
1984	1.28	2.40	1.13	3.68	4.43	0.74
1985	1.32	2.46	1.14	3.74	4.49	0.75
1986	1.33	2.49	1.15	3.76	4.52	0.76
1987	1.37	2.53	1.16	3.81	4.57	0.77
1988	1.40	2.56	1.16	3.85	4.62	0.77
1989	1.37	2.53	1.16	3.87	4.63	0.77
1990	1.29	2.45	1.16	3.79	4.55	0.77
1991	1.32	2.48	1.16	3.84	4.61	0.77
1992	1.39	2.56	1.17	3.93	4.70	0.77
1993	1.42	2.61	1.19	4.00	4.79	0.78
1994	1.46	2.66	1.20	4.06	4.86	0.79
1995	1.47	2.69	1.22	4.11	4.91	0.80
1996	1.48	2.71	1.23	4.14	4.96	0.81
1997	1.51	2.74	1.23	4.18	5.00	0.81
1998	1.52	2.75	1.23	4.21	5.03	0.81
1999	1.54	2.77	1.23	4.24	5.06	0.81
2000	1.57	2.80	1.23	4.28	5.09	0.81
2001	1.60	2.83	1.23	4.32	5.13	0.81

2002	1.64	2.86	1.23	4.36	5.17	0.81
2003	1.67	2.90	1.24	4.40	5.21	0.82
2004	1.69	2.94	1.25	4.43	5.26	0.83
2005	1.72	2.98	1.26	4.46	5.30	0.83
Mean rates in selected periods						
1952-1955	1.10	1.99	0.89	3.46	4.05	0.59
1956-1965	0.99	1.98	0.99	3.29	3.94	0.65
1966-1975	1.09	2.03	0.94	3.43	4.05	0.62
1976-1985	1.15	2.23	1.08	3.56	4.27	0.71
1986-1995	1.38	2.56	1.17	3.90	4.68	0.78
1996-2005	1.59	2.83	1.24	4.30	5.12	0.82
1952-1977	1.05	2.01	0.96	3.38	4.01	0.63
1952-1977[16]	1.06	2.02	0.96	3.39	4.03	0.63
1952-1977[17]	1.12	2.06	0.94	3.47	4.09	0.62
1978-2005	1.40	2.57	1.17	3.95	4.73	0.78
Mean rates in selected periods according to historical events						
1952-1957	1.13	2.03	0.90	3.46	4.06	0.59
1958-1962	0.93	1.99	1.06	3.23	3.93	0.70
1963-1966	1.02	1.93	0.91	3.32	3.92	0.60
1967-1976	1.09	2.03	0.95	3.43	4.06	0.63
1977-1981	1.10	2.16	1.06	3.51	4.21	0.70
1982-1985	1.25	2.36	1.11	3.65	4.39	0.74
1986-1990	1.35	2.51	1.16	3.82	4.58	0.77
1991-1995	1.41	2.60	1.19	3.99	4.77	0.79
1996-2005	1.59	2.83	1.24	4.30	5.12	0.82

Note:
NFP1= net factor productivity (natural log) estimated using capital series 1
NFP2= net factor productivity (natural log) estimated using capital series 2
TFP1=total factor productivity (natural log) estimated using capital series 1
TFP2=total factor productivity (natural log) estimated using capital series 2
RTC1=contribution of level of rural transformation to the level of TFP1
RTC2=contribution of level of rural transformation to the level of TFP2

[16] Year 1961 is excluded.
[17] Years 1958-1970 are excluded.

Table 4. Growth Rates of NFP, TFP and Contribution of Growth Rate of RT to the Growth Rate of TFP (%)

Year	K1			K2		
	GNFP1	GTFP1	GRTC1	GNFP2	GTFP2	GRTC2
1953	8.13	9.02	0.89	5.36	5.95	0.59
1954	-1.19	-1.32	-0.13	-3.96	-4.04	-0.09
1955	1.89	1.65	-0.24	-0.36	-0.51	-0.16
1956	3.63	8.34	4.71	0.95	4.06	3.11
1957	0.38	-0.72	-1.10	-1.10	-1.82	-0.73
1958	-17.03	8.12	25.14	-13.45	3.18	16.63
1959	3.96	0.85	-3.11	3.38	1.33	-2.06
1960	-3.23	-6.35	-3.13	-4.14	-6.21	-2.07
1961	-21.01	-33.76	-12.75	-23.02	-31.45	-8.43
1962	0.23	-7.45	-7.68	-0.47	-5.54	-5.08
1963	7.05	6.44	-0.60	8.49	8.09	-0.40
1964	11.78	12.22	0.44	12.44	12.73	0.29
1965	9.48	10.53	1.05	10.28	10.98	0.69
1966	3.86	4.01	0.14	4.35	4.45	0.10
1967	-9.77	-10.02	-0.25	-9.09	-9.25	-0.17
1968	-8.25	-8.24	0.01	-7.35	-7.35	0.00
1969	10.89	10.98	0.08	10.37	10.42	0.05
1970	10.06	11.48	1.41	10.38	11.32	0.93
1971	-1.17	0.50	1.67	-0.37	0.74	1.10
1972	-2.04	-0.77	1.27	-0.73	0.11	0.84
1973	1.97	2.19	0.22	3.02	3.17	0.15
1974	-3.11	-2.70	0.41	-2.47	-2.20	0.27
1975	1.31	3.12	1.82	2.14	3.34	1.20
1976	-7.79	-5.98	1.82	-6.66	-5.46	1.20
1977	1.29	2.95	1.65	2.86	3.95	1.09
1978	1.07	5.64	4.56	3.68	6.70	3.02
1979	3.16	3.93	0.77	2.56	3.07	0.51
1980	2.24	3.32	1.08	1.69	2.40	0.71
1981	0.50	1.14	0.64	0.13	0.56	0.43
1982	4.17	4.14	-0.03	3.71	3.69	-0.02
1983	4.73	5.74	1.01	5.05	5.72	0.67
1984	5.91	8.68	2.78	6.17	8.01	1.84
1985	4.91	6.30	1.39	5.64	6.56	0.92
1986	0.88	2.09	1.21	2.06	2.86	0.80
1987	3.70	4.46	0.76	4.69	5.19	0.50
1988	2.72	3.22	0.49	4.71	5.03	0.33
1989	-2.61	-3.15	-0.54	1.30	0.94	-0.36
1990	-8.21	-8.25	-0.04	-8.06	-8.09	-0.03
1991	3.07	3.38	0.31	5.45	5.65	0.21
1992	6.56	7.48	0.92	8.68	9.29	0.61
1993	3.83	5.38	1.55	7.30	8.33	1.03
1994	3.38	4.86	1.48	6.23	7.20	0.98
1995	1.42	2.83	1.41	4.42	5.36	0.93
1996	1.25	2.34	1.10	3.69	4.42	0.73
1997	2.10	2.48	0.38	3.84	4.09	0.25
1998	1.59	1.65	0.06	2.87	2.92	0.04
1999	1.97	1.78	-0.19	3.16	3.03	-0.12
2000	3.05	3.11	0.06	3.82	3.86	0.04
2001	2.76	2.76	0.00	3.47	3.47	0.00

2002	3.58	3.58	0.00	4.12	4.12	0.00
2003	3.34	3.90	0.56	3.95	4.32	0.37
2004	2.37	3.70	1.33	3.29	4.17	0.88
2005	2.76	3.98	1.22	3.31	4.11	0.81
Mean rates in selected periods						
1952-1955	2.94	3.11	0.17	0.35	0.46	0.11
1956-1965	-0.48	-0.18	0.30	-0.66	-0.47	0.20
1966-1975	0.38	1.05	0.68	1.03	1.47	0.45
1976-1985	2.02	3.59	1.57	2.48	3.52	1.04
1986-1995	1.47	2.23	0.76	3.68	4.18	0.50
1996-2005	2.48	2.93	0.45	3.55	3.85	0.30
1952-1977	0.05	0.60	0.55	0.04	0.40	0.36
1952-1977[18]	0.93	2.03	1.10	1.00	1.73	0.73
1952-1977[19]	0.27	1.36	1.08	-0.11	0.61	0.72
1978-2005	2.36	3.23	0.87	3.60	4.18	0.57
Mean rates in selected periods according to historical events						
1952-1957	2.57	3.39	0.83	0.18	0.73	0.55
1958-1962	-7.42	-7.72	-0.30	-7.54	-7.74	-0.20
1963-1966	8.04	8.30	0.26	8.89	9.06	0.17
1967-1976	-0.79	0.06	0.85	-0.07	0.48	0.56
1977-1981	1.65	3.40	1.74	2.19	3.34	1.15
1982-1985	4.93	6.22	1.29	5.14	5.99	0.85
1986-1990	-0.70	-0.33	0.38	0.94	1.19	0.25
1991-1995	3.65	4.79	1.14	6.42	7.17	0.75
1996-2005	2.48	2.93	0.45	3.55	3.85	0.30

Note:
GNFP1=growth rate of net factor productivity estimated using capital stock K1.
GNFP2= growth rate of net factor productivity estimated using capital stock K2.
GTFP1=growth rate of total factor productivity estimated using capital stock K1.
GTFP2= growth rate of total factor productivity estimated using capital stock K2.
GRTC1=contribution of rural transformation to the growth of TFP1
GRTC2=contribution of rural transformation to the growth of TFP2

[18] Year 1961 is excluded.
[19] Years 1958-1970 are excluded.

Table 5. Comparison with Previous Studies: Average Productivity Growth Rates (%)

Sources	Periods	Average Productivity Growth Rate (%)			
		Pre-reform (%)		Post-reform (%)	
This Study	1952-2005	GTFP1: 0.60	GNFP1: 0.05	GTFP1: 3.23	GNFP1: 2.36
			GRTC1: 0.55		GRTC1: 0.87
		GTFP2: 0.40	GNFP2: 0.04	GTFP2: 4.18	GNFP2: 3.60
			GRTC2: 0.40		GRTC2: 0.57
Chow (1993)	1952-1988	0		Na	
Chow and Li (2002)	1952-1998	0		3	
Hu and Khan (1997)	1953-1994	1.1		3.9	
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	

Figure 1. Levels of NFP and TFP and Contributions of RT

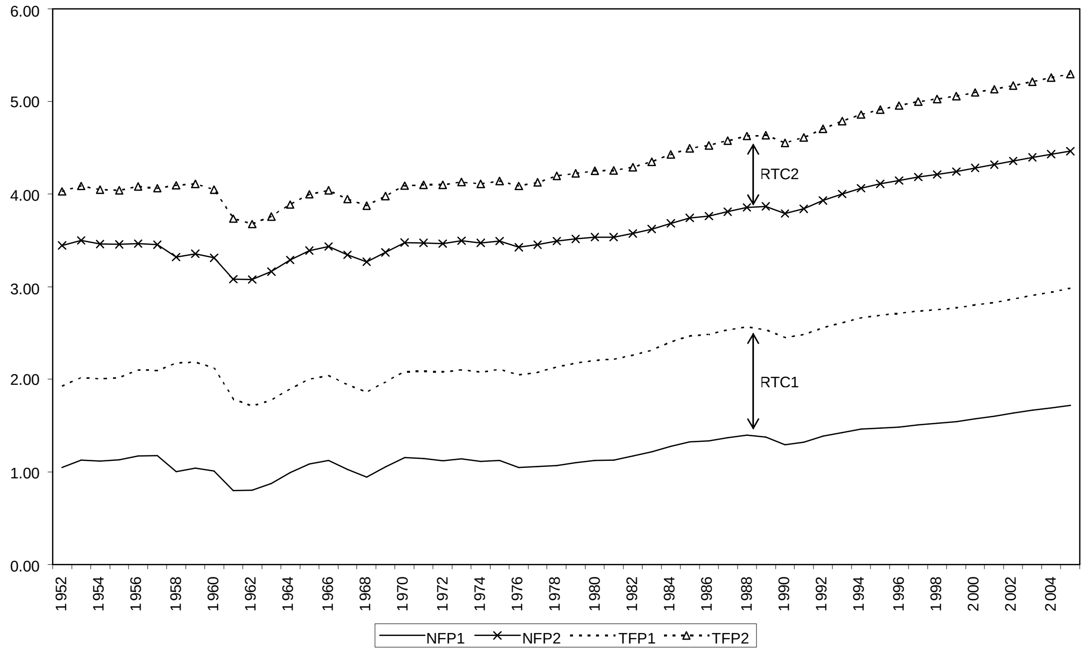

Figure 2. Growth rate of TFP

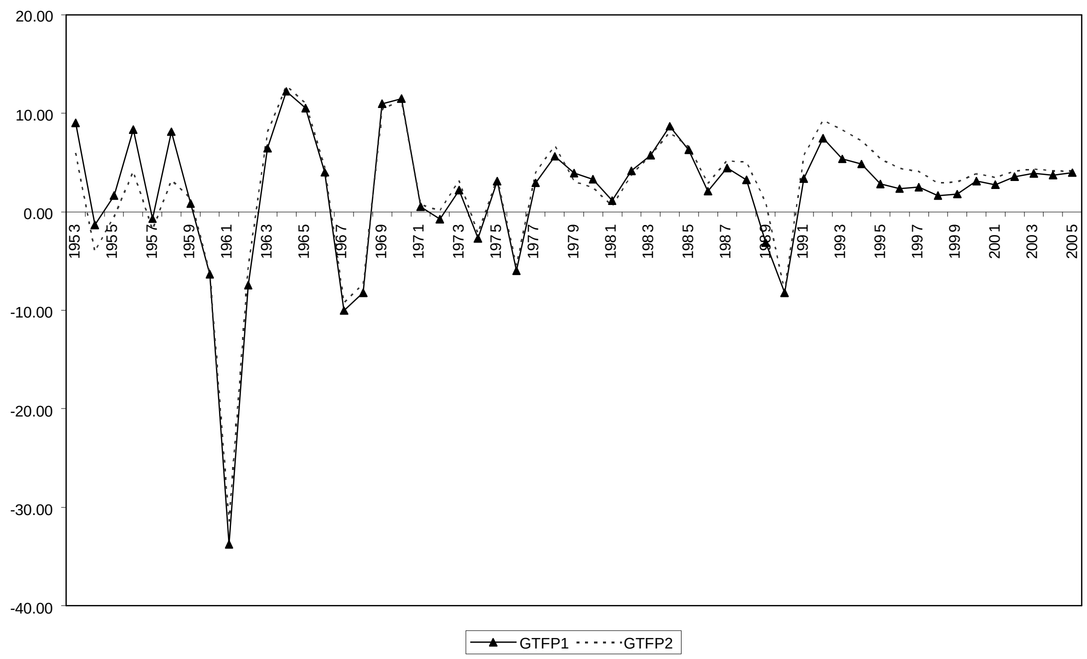

Figure 3. Growth rate of NFP

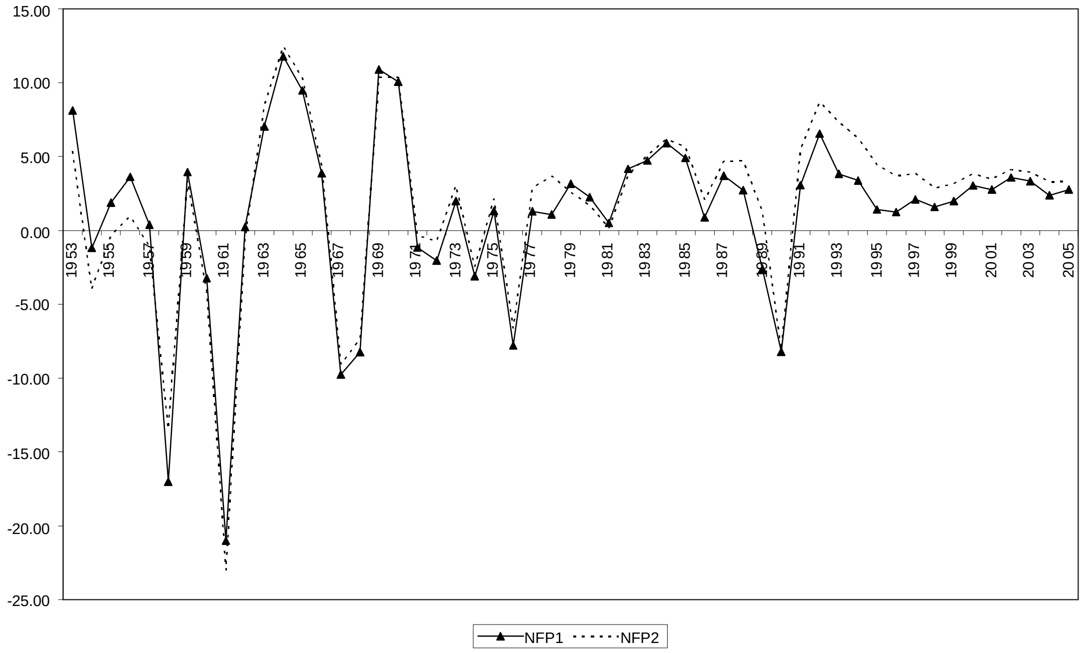

Figure 4. Growth of Total Factor Productivity due to RT