School of Economics and Finance

Evolution of Structural Indicators. China and Regions: 1981-2010

Jose Miguel Albala-Bertrand

Working Paper No. 701 April 2013 ISSN 1473-0278

Queen Mary
University of London

Evolution of Structural Indicators

China and Regions: 1981-2010

J.M. Albala-Bertrand

Abstract

This paper deals with some structural indicators and their evolution, in China and regions, over the period 1981-2010. We first produce estimates of the optimal productivities of incremental capital and the optimal incremental income elasticity of capital by means of a linear programming exercise. We then produce an accounting growth decomposition to assess the changes in the contribution of capital productivity, capital intensity and labour participation to the growth rate of output *per capita*. Finally, we combine an accounting growth decomposition with a standard production function, growth accounting, decomposition to assess both the contribution of both capital productivity and capital intensity to total factor productivity (*TFP*). We also show in an appendix the difference in the *TFP* growth contribution when marginal elasticities are assumed variable over time and when scale returns are assumed increasing rather than constant. Our main conclusion is that capital intensity, rather than capital productivity or labour participation, has been the main growth contributor. But this does not mean that quantity in itself, rather than quality, is behind such growth, as total factor productivity, which is significantly more than engineering technical change, has been relatively important over the period.

Key words: Structural indicators, incremental capital productivity, growth decomposition, optimal consistency method (OCM), total factor productivity (TFP).

JEL Classification: **O4, B4, E2**

Contact Address: Dr. J.M. Albala-Bertrand, School of Economics and Finance, Queen Mary, Univ. of London, Mile End Road, London E1 4NS, UK; E-Mail: J.M.Albala-Bertrand@qmul.ac.uk, Tel: +44(0)20 7882 8820, Fax: +44(0)20 8983 3580.

1. Introduction

There has been a good deal of macroeconomic studies about China's productivity and related issues. These are normally framed in standard production functions, especially the Cobb-Douglas, under the assumption of constant returns to scale (CRS) and often implicitly or otherwise perfect competition, with their theoretically convenient marginal conditions. CRS is often imposed in econometrics studies or directly used to calculate the elasticities via the actual capital and labour shares in GDP from official statistics (e.g. Jefferson et al. 2008, Wang & Yao 2002, Young 2000, Chow 1993a, Hu & Khan 1997). In turn, the income elasticities of capital and labour are assumed constant over all the target period, which may be unlikely, as shown by Holtz (2006). This means that the results necessarily carry a baggage of assumptions that may not tally with the reality of especially a latecomer and fast growing country undergoing significant structural change (Thirlwall 2011, De Long 2008, Zheng et al. 2008, Holtz 2006).

Associated with it, a good number of papers deal with the generation of capital stock series for China, normally via a perpetual inventory model (PIM) that starts from a benchmark capital stock, which is estimated in various, more or less elaborated, ways (e.g. Albala-Bertrand & Hao 2007, Chow 1993, Wang & Yao 2002, Li & Tang 2003), but also from more detailed estimations based upon the characteristics of the country and the meaning of variables, like Holtz (2006). The former has however become standard among practitioners and institutions because of its simplicity and comparability over time and across countries (e.g. OECD 2001, Hoffman 2000a). Again, these series incorporate additional assumptions about capital idleness, depreciation, quality, and the like. There is however little ways to improve such series, as idleness is extremely difficult to assess, so is normally either assumed away or some convenient overall rate is used to discount it. In turn, the resorted rate of capital depreciation is normally a conventional rate that you can live with (Woo 1998, Wang & Fan 2000, Young 2000). And lastly the productive quality of capital is too heterogeneous and variable to be assessed directly, so it is implicitly estimated via aggregate national and/or regional output results.

The present paper attempts an aggregate contribution that is more founded on empirical patterns than theoretical assumptions and may complement alternative approaches. This is a quantitative paper that deals with structural indicators that are mostly based on definitional accounting, rather than functional, relationships. The point is to produce useful decompositions of growth rates by means of discrete first differences and from there observe compositional contributions to the national and regional actual growth rates. The paper structure is as follows. We first produce estimates of the optimal productivities of incremental capital for the post-economic reform, encapsulated in the 30-year period 1981-2010, for the country and key regions, by means of a linear programming exercise. This approach may reduce the difficulty of assessing idleness, as capital formation is related to optimal output directly (Albala-Bertrand 2010)[(1)]. In addition, a value for the optimal incremental income elasticity of capital can be derived from it, which can give an idea about the level and variability of the marginal elasticity used in standard production functions under CRS. We next produce a definitional accounting growth decompositions via first differences to assess the changes in the contributions of capital productivity, capital intensity and labour participation to the growth rate of output *per capita* over the said period. We then combine a definitional accounting decomposition with a standard production function growth accounting decomposition to assess both the growth contribution of total factor productivity (*TFP*) and the contribution of both capital productivity and capital intensity to it. Finally, in an appendix, we show how different can the *TFP* contribution be when using variable elasticities over time and when using increasing rather than constant returns to scale.

As a general conclusion, we show that the growth contribution of capital productivity has been becoming significantly negative, and that of labour participation meagre or negative, while capital intensity has taken the bulk of supporting both *GDP* growth and total factor productivity. This does not necessarily mean that *GDP* growth has relied on the quantity rather than the quality of resources and production, as capital intensity itself has also been the main contributor to total factor productivity, behind which are changes in human capital, organization, adaptations, technical efficiency and the like. So it has not just been the hardware of physical capital, but the important changes in economic and social software required to use it and absorb it, that are behind the high growth rates.

2. Estimation Procedures

We use two estimation methods for our presentation below. One for the optimal incremental productivity of capital and one for the capital stock benchmark and derived series.

2.1 Estimation of the Optimal Incremental Capital Productivity

Following a variation of our proposed method to calculate a reasonable benchmark capital stock with little data availability (see Albala-Bertrand 2010), for each year, output (Y) is defined as $Y_t = Y_{t-1} + \Delta Y$, which is a definition of a first difference. From here, we apply a simple functional mechanism via the productivity of capital to the two right-hand side terms, so that $Y_{t-1} = \delta_b K_{t-2}\mu$ and $\Delta Y = \delta_a I_{t-1}$, where δ_b and δ_a are respectively the average and incremental capital productivities, while $\mu = (1-\lambda)$, where λ is the depreciation rate, K is the capital stock and I is investment, and "t" is any given year. This functional form assumes that labour, required row materials and other productive requirements are available, which may not be too strong an assumption for China since its reform in 1978, although lately the growth in labour participation, as shown below, appears to be stagnant or slightly decreasing (Liu 2012, Golley & Meng 2011, Cai & Wang 2010). The latter two requirements by the way are almost always assumed as available in production function studies, whether that is the case or not.

We also assume the standard convention that new capital becomes productive with one year lag. Optimal output is then defined as $Y^*_t = \delta_b K_{t-2}\mu + \delta_a I_{t-1}$. Where $\delta_b = Y^*/K$ and $\delta_a = \Delta Y^*/\Delta K$ are the average and incremental capital productivities, corresponding to that optimal output, respectively, and "*" denotes "optimal". Let $K_{t-2} = K_{by}$ be the base-year capital stock. Then the iterative solution of the above equation for any year "t" is:

$$Y_t^* = \delta_b K_{by} \mu^t + \delta_a \sum_{i=1}^{t} I_{i-1} \mu^{(t-i)} \qquad (1)$$

Where the year "t" ranges from 1 to n, and K_{by} would correspond to the year before the 5-year time-series for gross capital formation *GFCF* and *GDP*, which we use to estimate the said parameters (e.g. 1980 when the *GFCF* series start in 1981). The initial or base-year product $\delta_b K_{by}$ and the incremental productivity coefficient δ_a are the two parameters which our estimation approach will throw. But in this paper we are only interested in the latter, as this would correspond to the incremental productivity of capital, i.e. the productivity of the accumulated investment over our 5-year periods. We then estimate the said parameters by means of standard Linear Programming(2), which takes the following form (Ibid.):

Minimise:

$$Z = \sum_{t=1}^{n} (Y_t^* - Y_t) = (\delta_b K_{by} \sum_{t=1}^{n} \mu^t + \delta_a \sum_{t=1}^{n} \sum_{i=1}^{t} I_{i-1} \mu^{(t-i)}) - (\sum_{t=1}^{n} Y_t) \qquad (2)$$

Subject to:

$Y^*_t \geq Y_t$

$\delta_b K_{by}$ and $\delta_a \geq 0$

Where $n = 5$ corresponds to the length of our series (e.g. when 1981 is the initial year for *GDP* and *GFCF*, then 1985 would be the last year, and the base-year capital stock would then be 1980). We estimate such parameters from a moving 5-year period from 1981 to 2010. This then generates our target parameter δ_a, i.e. the optimal incremental capital productivity, over such period. This is then averaged in 5-year periods from 1981 to 2010 to produce our Tables 1 and 2 in section 4 below.

2.2 Estimation of Capital Stock Benchmark and Series

To estimate an initial benchmark capital stock, for consistency with our method above, but for a 10-year moving calculation, as in Albala-Bertrand (2010), we averaged the optimal incremental capital productivity (δ_a) over 1952 to 1957, which gives a capital-output ratio of 2.47 for China in 1953. This compares well with other estimates of such capital-output ratio for such year, e.g. 2.58 from Chow (1993a, 1993b) or 3.00 from Perkins (1998) and values of the same order of magnitude from other authors (see Zhang 2008). We use the same procedure for the benchmark capital for our four regions. From there we estimate a capital stock series by means of a perpetual inventory method (PIM), from 1953. The starting year of our analysis is however 1981, so by that year we would have accumulated investment over 28 years, which means that any departure from an initial benchmark capital in 1953 would have greatly converged to a common path, assuming the use of similar depreciation rates(3) and data(4). The PIM take the usual form of:

$$K_t = K_{t-1}(1 - \lambda) + I_t \quad (3)$$

Where K is net capital stock, I is gross capital formation (i.e. gross fixed capital formation plus inventories), and λ is the depreciation rate with a geometrical pattern of erosion (OECD 1997, 2001). This series is then used for our section 5 below.

3. Context for Results

The context for our results can be seen via the 1980-2010 share of the main regions[(5)] in China for our key variables, as follows:

Table 1: Regional Shares in China

	CHINA	EAST		WEST		CENTRAL		N -EAST	
SHARES		1980	2010	1980	2010	1980	2010	1980	2010
Output (*GDP*)	100	47	53	20	19	18	20	15	9
Investment (*GCF*)	100	54	47	17	22	20	21	8	10
Capital *(K)*	100	46	40	24	26	21	19	9	15
Labour (*L*)	100	37	38	27	28	29	27	8	7
Population (*N*)	100	35	36	27	28	29	28	9	8

Table 1 shows that as recent as 2010, the East region took by far the largest shares on all counts above, especially output (*GDP*), investment or gross capital formation *(GCF*), and capital (*K*), this region comprising the most important provinces and cities, e.g. Beijing, Shanghai and Guangzhou. As regards *GDP*, the East region increased its share of *GDP*, although it has decreased a few percentage points since 2005 in favour of the West and Central regions (not shown in the table). As regards gross capital formation (*GCF*), it shows that the share of the East has decreased while all the other regions record an increase of it. This is similar with capital, but the Central region shows actually a share decrease. This may be an indication of the start of a more balanced growth. Labour and population shares, however, have not changed significantly, but there has still been some decline in both the Central and the Northeast regions. Some general explanations have been put forward about this in terms of regional markets fragmentation, which means that most of trade and labour movements are carried within regions rather than between them (World Bank 2005).

This is the general background for our analysis below. The above methods then are applied to all china and these four regions.

4. Optimal Incremental Capital Productivity for China and Regions

We can now apply the above methodology, using the data for investment (*GFCF*) and output (*GDP*) coming from official statistics. To prevent a single rogue year from having undue influence on the optimal point, we apply a three-year moving average to both series over the sample period. Finally, all series have been made constant to 1952 prices via available deflators [(6)].

Table 2: Optimal Incremental Capital Productivity

	CHINA	EAST	WEST	CENTRAL	N-EAST
Period	$Op_{\Delta Y/\Delta K}$	$Op_{\Delta Y/\Delta K}$	$Op_{\Delta Y/\Delta K}$	$Op_{\Delta Y/\Delta K}$	$Op_{\Delta Y/\Delta K}$
1981-1985	0.44	0.36	0.51	0.38	0.70
1986-1990	0.47	0.37	0.67	0.38	0.80
1991-1995	0.47	0.38	0.65	0.38	0.66
1996-2000	0.40	0.32	0.57	0.37	0.67
2001-2005	0.36	0.30	0.42	0.42	0.57
2006-2010	0.35	0.35	0.32	0.32	0.37
Average 1981-2010	0.41	0.33	0.55	0.39	0.64
Average 1996-2010	0.37	0.32	0.44	0.37	0.54

Table 2 shows the incremental capital productivities from 1981 to 2010, for China and regions, split in 5-year periods. These figures then represent the optimal productivity of net investment over such 5-year periods, hence incremental capital. It generally shows that incremental capital productivity has fallen towards 2010, after an increase in especially 1991-2000. This period corresponds to an important bout of especially financial reforms (Chow 2004, Prasad & Wei 2005). But since mid 1990s capital productivity has systematically decreased on average, still the East appears to have increased it in the last period. This pattern is about the same for all regions, but the levels are different. As late as 2006-2010, all regions appear to have settled at about similar incremental productivities, around 0.35. The fast decline in incremental productivities in the West and Northeast regions, but also in the Central region, between 2001 and 2010, might be another indication of a start of a more balanced growth across regions. As late as the early 2000s there were indications of both poor capital mobility between regions and that some regions represented riskier latecomers into the China drive for growth, which made them lag behind. This may have many standard explanations in terms of main city and region centralism, poor infrastructures, poor working and financial conditions, policy preferences, international capital flowing to less risky regions, and the like (De Long 2008, Luo & Zhu 2006, Luo 2004, Fu 2004, Yao & Zhang 2001). It has been shown that as a consequence China was exhibiting market fragmentation, somehow confining most trade within rather than between regions (Zhang & Tan 2007, Fu 2004, World Bank 2005). This constrain may have now started to relax.

Table 3: Optimal Incremental Capital Elasticity of Income

	CHINA	EAST	WEST	CENTRAL	N-EAST
Period	$\varepsilon_{Y\text{-}K}$	$\varepsilon_{Y\text{-}K}$	$\varepsilon_{Y\text{-}K}$	$\varepsilon_{Y\text{-}K}$	$\varepsilon_{Y\text{-}K}$
1981-1985	1.0	0.8	1.4	0.9	0.9
1986-1990	1.1	0.9	1.5	1.1	1.0
1991-1995	1.1	1.0	1.3	1.1	0.9
1996-2000	0.9	0.9	1.0	1.0	1.0
2001-2005	0.8	0.9	0.7	1.2	0.8
2006-2010	0.9	1.0	0.6	0.9	0.6
Average 1981-2010	1.0	0.9	1.1	1.0	0.9
Average 1996-2010	0.9	0.9	0.8	1.0	0.8

Table 3 shows the optimal incremental elasticities of income with respect to capital, from 1981 to 2010, in 5-year averages, for China and regions. This takes advantage of

Table 1 data so as to produce incremental elasticities[7]. This shows that for China the average since 1981 is around 1.0, decreasing to 0.9 towards the most recent period. The regional pattern towards 2010 is similar, but the West and Northeast region show a more pronounced decline in the last 2001-10 period. The importance of this is simply that it seems unlikely that the actual economy, as distinct from a theoretical production function, exhibits constant marginal elasticities. But also that marginal capital productivities may be larger than the ones normally used (i.e. 0.6) and/or that constant returns to scale may be too strong an assumption. Increasing returns may be an acceptable proposition, i.e. output grows at a higher proportion than the growth of capital and labour, as this may be likely in developing countries that grow fast, especially via manufacturing, while exploiting scale economies and gains from trade coupled with industry agglomeration, top-of-range imported technology and know-how, and so on, which seems to be the case of China (Holtz 2006, Zheng et al. 2008, Kendrick 1993, Denison 1993, Hulten 1992). We come back to this in section 6 below.

5. Discrete Growth Decomposition Analysis

A definition of output *per capita*, Y/N can be decomposed as:

$$Y/N = (Y/K)(K/L)(L/N) \tag{4}$$

Where Y: output, N: population, K: net capital stock, and L: Labour. That is, output *per capita* is equal to the product of capital productivity (Y/K), capital intensity (K/L) and labour participation (L/N). Calculating the first difference of (4), dividing by

$(Y/N)_0$ and manipulating to transform all terms into growth rates, we get:

$$G_{Y/N} = G_{Y/K} + G_{K/L} + G_{L/N} + G_{Y/K}G_{K/L} + G_{Y/K}G_{L/N} + G_{K/L}G_{L/N} + G_{Y/K}G_{K/L}G_{L/N} \quad (5)$$

This shows that the discrete growth rate of income per capita is equal to the addition of the growth rates of its three components plus their interactive terms. If we proportionally distribute the interactive terms into the three growth rates, as we do in the calculation later, we preserve the accounting identity and get:

$$G_{Y/N} = G'_{Y/K} + G'_{K/L} + G'_{L/N} \quad (6)$$

Where G' indicates that the interactive terms have been incorporated to the growth rates, as mentioned above.

Table 4: Contributions to the Growth of Income *per capita*

	CHINA				EAST				WEST				CENTRAL				NORTH-EAST			
Period	$G'_{Y/K}$	$G'_{K/L}$	$G'_{L/N}$	$G_{Y/N}$	$G'_{Y/K}$	$G'_{K/L}$	$G'_{L/N}$	$G_{Y/N}$	$G'_{Y/K}$	$G'_{K/L}$	$G'_{L/N}$	$G_{Y/N}$	$G'_{Y/K}$	$G'_{K/L}$	$G'_{L/N}$	$G_{Y/N}$	$G'_{Y/K}$	$G'_{K/L}$	$G'_{L/N}$	$G_{Y/N}$
1981-1985	2.1	5.1	1.9	9.1	-0.4	7.9	1.7	9.2	6.7	0.4	2.1	9.3	2.1	5.7	1.7	9.5	1.6	3.7	2.9	8.2
1986-1990	-0.6	4.2	3.3	6.9	-1.6	6.2	3.0	7.6	2.8	0.1	3.5	6.4	-0.9	3.3	3.2	5.6	0.2	3.1	3.6	6.9
1991-1995	0.9	9.2	0.5	10.6	0.8	12.0	0.2	13.0	2.2	4.9	1.1	8.2	1.5	7.3	0.3	9.1	0.0	6.5	0.3	6.8
1996-2000	-2.3	9.8	0.2	7.7	-2.6	11.2	0.4	9.0	-1.4	7.3	-0.6	5.3	-2.3	8.8	1.2	7.7	0.1	8.0	-1.1	7.0
2001-2005	-0.7	9.7	0.1	9.1	0.8	7.2	0.6	8.6	-5.0	15.4	-0.2	10.2	0.4	8.7	-0.3	8.8	-6.1	15.5	-0.2	9.2
2006-2010	-0.9	11.6	-0.1	10.7	0.5	9.6	-0.1	10.1	-5.5	16.1	-0.1	10.6	-1.9	13.2	-0.2	11.1	-6.9	17.7	-0.1	10.7
Av 1981-2010	-0.3	8.3	1.0	9.0	-0.4	9.0	1.0	9.6	0.0	7.4	1.0	8.3	-0.2	7.8	1.0	8.7	-1.9	9.1	0.9	8.1
Av 1996-2010	-1.3	10.4	0.1	9.2	-0.4	9.3	0.3	9.2	-4.0	12.9	-0.3	8.7	-1.3	10.2	0.2	9.2	-4.3	13.8	-0.5	9.0

Table 4 shows the contribution of capital productivity ($G'_{Y/K}$), capital intensity ($G'_{K/L}$) and labour participation ($G'_{L/N}$) to the growth rate of income *per-capita* ($G_{Y/N}$). In other words, the former three represent the contribution in terms of percentage points to the latter, so they add up to the value of the latter. For China, as a whole, the capital productivity (*Y/K*) contribution has fallen towards the last three periods, becoming a negative contributor to the growth rate of income *per capita*. This is in accord with the declining optimal incremental capital productivity in the previous section. This pattern is similar for all regions, except the East, which shows positive but small contribution over 2006-2010. Capital intensity (*K/L*), however, represents the most important contributor to *GDP per-capita* growth, which has strongly increased over time, although significantly moderating in the East. In the case of China, as a whole, the contribution has gone from 56% of the growth rate of income per capita in 1981-85 (5.1) to 108% in 2005-10 (11.6), which means that capital intensity has also been compensating for the negative fall in capital productivity (i.e. -0.9) and that of labour participation (-0.1). This pattern is similar in all regions, although the levels differ.

In turn, labour participation (*L/N*) appears as significantly adding to the growth rate of income *per capita* in the first three periods and then decreasing in importance until being a small or negative contributor to it in the last three periods. This pattern is similar in all regions, although the timing of negative contribution differs. This also means that despite falls or losses in capital productivity, increases in labour participation appear as about compensating for it in many years, especially in the East region up until around 1995. Since then, labour participation appears as less than compensating for the losses in capital productivity, or adding to the losses, which is similar in all regions. At any rate, with the caution warned about the problem with the labour statistics, the growth rate of labour participation and its contribution has significantly slowed down in the last decade of our analysis, while capital intensity has become the main accounting contributor to the growth rate of GDP *per-capita*. Does this mean that it is the quantity rather than the quality of resources that appear to be largely the driving force behind the growth of output? To help sort out such question, we turn to a decomposition of total factor productivity.

6. A Decomposition of Total Factor Productivity (TFP)

If we combine an accounting decomposition of the growth rate of labour productivity (equation 7 below) with a standard production function growth accounting (equation 8 below), we can then derive a decomposition of TFP.

$$G_{Y/L} = G'_{Y/K} + G'_{K/L} \qquad (7)$$

$$G_{Y/L} = G_{TFP} + \alpha G'_{K/L} - \gamma G_L \qquad (8)$$

Where α and (implicitly) β are the income elasticities of capital (K) and labour (L), respectively, while γ takes the slack for $\alpha+\beta+\gamma= 1$. This means that if $\gamma= 0$, then the economy would be under of constant return to scale (CRS). If $\gamma < 1$, then the economy would be under increasing return to scale (IRS). And if $\gamma > 1$, then the economy would be under decreasing returns to scale (DRS). So if we equalize (1) and (2) and solve for G_{TFP}, after manipulating we obtain:

$$G_{TFP} = G'_{Y/K} + \beta G'_{K/L} + \gamma(G'_{K/L} + G_L) \qquad (9)$$

Where the term $\gamma(G'_{K/L} + G_L)$ is about $\gamma(G'_K)$ when the yearly G_L is small, which is normally the case. So given that G'_K has been positive and large over our target period, then if the economy exhibit increasing returns to scale, i.e. $\gamma< 0$, assuming an unchanged β, then G_{TFP} will be smaller than under constant returns to scale (CRS). So unless the economy exhibits decreasing returns to scale, which is highly unlikely, this means that *TFP* under CRS should be considered as an upper limit, ceteris paribus. We show this in our appendix. In the table below we assume CRS, under the above considerations. Following Chow (2008, 1993) and others (e.g. Mankiw et al. 1992, Li 2003)[8], we then assume $\alpha = 0.6$ and so $\beta = 0.4$.

Table 5: TFP Growth Contribution under CRS

(α = 0.6, β = 0.4)	CHINA			EAST			WEST			CENTRAL			NORTH-EAST		
Period	$G'_{Y/K}$	$\beta G'_{K/L}$	G_{TFP}	$G'_{Y/K}$	$\beta G'_{K/L}$	G_{TFP}	$G'_{Y/K}$	$\beta G'_{K/L}$	G_{TFP}	$G'_{Y/K}$	$\beta G'_{K/L}$	G_{TFP}	$G'_{Y/K}$	$\beta G'_{K/L}$	G_{TFP}
1981-1985	2.1	2.0	4.1	-0.4	3.2	2.8	6.7	0.2	6.9	2.1	2.3	4.4	1.6	1.5	3.1
1986-1990	-0.6	1.7	1.1	-1.6	2.5	0.9	2.8	0.0	2.9	-0.9	1.3	0.4	0.2	1.2	1.4
1991-1995	0.9	3.7	4.6	0.8	4.8	5.6	2.2	2.0	4.2	1.5	2.9	4.4	0.0	2.6	2.6
1996-2000	-2.3	3.9	1.6	-2.6	4.5	1.9	-1.4	2.9	1.5	-2.3	3.5	1.2	0.1	3.2	3.3
2001-2005	-0.7	3.9	3.2	0.8	2.9	3.7	-5.0	6.1	1.2	0.4	3.5	3.9	-6.1	6.2	0.1
2006-2010	-0.9	4.7	3.8	0.5	3.8	4.3	-5.5	6.5	1.0	-1.9	5.3	3.4	-6.9	7.1	0.2
Av 1981-2010	-0.3	3.3	3.1	-0.4	3.6	3.2	0.0	2.9	2.9	-0.2	3.1	2.9	-1.9	3.6	1.8
Av 1996-2010	-1.3	4.1	2.9	-0.4	3.7	3.3	-4.0	5.2	1.2	-1.3	4.1	2.8	-4.3	5.5	1.2

Table 5 shows the value of the growth of *TFP* (G_{TFP}), decomposed into the growth of capital productivity ($G'_{Y/K}$) and that of a fraction of capital intensity ($G'_{K/L}$), for China and the four regions, over our target periods. The decomposition shows that *TPF* growth has mostly relied upon the strong values for capital intensity, rather than capital productivity. Recall that *TFP* theoretically represents anything that cannot be attributed to the growth of physical capital and labour of the same proportional productive quality or capacity[9]. So we call *TFP* any effect on income that goes beyond such proportion. This then means that the growth of capital productivity above represents the rate of change in the embodied quality of physical capital and the disembodied architecture and organization to deploy it (including scale economies, technical efficiency, etc), while the growth of capital intensity represents changes in human capital (education, training, nutrition, health, motivation, etc) and their conditions and adaptations to work efficiently with both more capital and new technology. Both contributions are interrelated, but changes in capital levels and technology, whether motivated by competition, catching up, sectoral shifts, learning by doing and so on, are likely to drag and pull a good deal of the way labour is enhanced and deployed[(10)]. If this is so, then a good deal of fast capital accumulation represents actually important social and economic qualitative changes, which are here encapsulated under the heading of total factor productivity.

Under the above assumptions, in terms of averages since 1981, the *TFP* in China has grown at a 3.1% a year. This is around the results from other studies (e.g. Chow 2008, Wang & Yao 2003). As regards regions, the East shows the largest average growth, while the Northeast the lowest one. The East, contrary to the other regions, also shows a small contribution from capital productivity over the 2001-10 period. In terms of our periods, it shows that a large *TFP* growth was observed over 1991-95 in all regions, the Northeast picking up over 1996-2000. As said, this corresponds to a period of important, especially financial, reforms. It is apparent from the data that despite the assumption of a constant elasticity of capital, the *TFP* contribution to the growth rate of *GDP* has been quite variable over time, although more stable for China as whole in the last two periods. It is however likely that the elasticity of capital has been declining together with their productivity, following the optimal incremental elasticity of it. But it may also be that overall capital elasticity was higher than 0.6 on account of likely increasing returns to scale, especially in the periods of strong reforms. This may produce some significant differences for the *TFP* contribution to the growth rates (see Appendix).

The analysis above accounts for the evolution of some important structural contributors to the growth of the Chinese economy up until 2010. The international crisis, and its consequence on the demand for exports from the world, seems to start moving China towards the domestic market in a more determined way than before. This is an ongoing process, so it is too early to know how these and other structural variables will be affected in the long run, as this can happen in many alternative ways, so it is not clear at this junction how intensely the patterns presented in this paper will change (He & Zhang, 2010; Zhen, Hu & Bigsten, 2009).

7. Conclusion

Our linear programme relates the variation of output to accumulated investment at an optimal level. This implicitly reduces the problem of assessing idle capacity to estimate a series of the incremental productivity of capital, which we produce over the period 1981-2010 for China and its four regions, presenting it in 5-year periods. It shows that the optimal incremental capital productivity has significantly fallen towards 2010, from 0.44 in 1981-85 to 0.35 in 2006-10, systematically decreasing from mid 1990s towards a similar level for all regions. This pattern may be an indication that China's drive for growth is becoming more balanced.

We also derived from the above exercise the optimal incremental capital elasticities. It shows that capital elasticities have normally been variable over time, especially since mid 1990s, the West and the Northeast regions showing higher declines. From here it seems unlikely that the marginal capital elasticity is actually constant and that it is likely to be higher than the normally used in production function studies. It may also be the case that the economy operates under increasing rather than decreasing scale returns, at least in some periods. In our appendix we show some possible consequences of it.

We then decomposed the actual growth rate of *GDP per capita* into the growth rates of capital productivity, capital intensity and labour participation. It shows that the most important contribution has been that of capital intensity, which has represented between 56% and 108% of the *per-capita* GDP growth rate. A value over 100% simply means that capital intensity has also been compensating for the negative contribution of capital productivity and lately that of labour participation. The growth contribution of capital productivity has been falling, becoming increasingly negative, while that of labour participation has become meagre or negative, since mid 1990s, and especially in the period 2001-2010. The pattern is similar for all regions, especially in the last three periods, but the West, Central and Northeast appear as more extreme for both positive capital intensity and negative capital productivity and labour participation. Again this can be a consequence of regional fragmentation of markets and products.

Are the above results a confirmation that China's very high and sustained GDP growth rates are the result of the quantity, rather than the quality, of resources and production? To help sort out this popular proposition, we resorted to a decomposition of total factor productivity (*TFP*) by combining an accounting decomposition with a standard production function growth accounting. The result is that the contribution to *TFP* growth can be separated into the growth of capital productivity and a fraction of the growth of capital intensity. Assuming CRS and similar elasticities as some authors do, we show that the *TFP* has been relatively important and that capital intensity has significantly contributed to it. In our example, 40% of the growth rate of capital intensity is actually contributing to *TFP* growth, which has also been compensating for the negative contribution of capital productivity to it, especially in the last three periods. Recall that *TFP*, theoretically, represents anything that cannot be attributed to the growth of physical capital and labour of the same proportional productive quality and conditions. The growth of capital productivity represents the rate of change in the quality of physical capital and its production environment, while the growth of capital intensity represents changes in human capital and its socio-economic conditions and adaptations to work efficiently with both more capital and new technology, and these two growth factors acting with strong interrelation. So qualitative changes seem to have also been an important part of China's fast growth.

The analysis above accounts for the evolution of some important structural contributors to the growth of the Chinese economy up until 2010. As a consequence of the international crisis and its effect on the demand for exports from the world, China seems to have becoming more orientated towards the domestic market than before. This is an ongoing process, so it is too early to know how the patterns of these and other structural variables will change in the long run.

Appendix

Apart from the estimation of the values of marginal elasticities about a given country and period, which may vary significantly between authors, there are two additional issues: (a) are elasticities constant over time? If they are not, does that make a significant difference? And (b) does the economy exhibit constant or increasing returns to scale? What is the difference between them for the contribution of total factor productivity? We assess both points below, using our data and results.

(a) Constant or Variable Elasticities?

Let us assume that the China's marginal capital elasticity α follows the same pattern over time as the optimal incremental capital elasticity $\varepsilon_{Y\text{-}K}$ of Table 3. Assuming CRS, we can then calculate G_{TFP} for China, assuming that just before the period 1981-85, α takes the values either 0.6, 0.7 or 0.8, as follows:

Table 6: Variation of α Following $\varepsilon_{Y\text{-}K}$ Pattern

Period	$\varepsilon_{Y\text{-}K}$	α=0.6	α=0.7	α=0.8
1981-1985	1.0	0.6	0.7	0.8
1986-1990	1.1	0.6	0.8	0.9
1991-1995	1.1	0.7	0.8	0.9
1996-2000	0.9	0.5	0.6	0.7
2001-2005	0.8	0.5	0.6	0.7
2006-2010	0.9	0.6	0.6	0.7
Average 1981-2010	1.0	0.6	0.7	0.8
Average 1996-2010	0.9	0.5	0.6	0.7

We then calculate the values for G_{TFP} in table below, allocating the corresponding elasticities α above for each period as follows:

Table 7: G_{TFP} under CRS with Variable α over Periods

CRS	G_{TFP}	G_{TFP}	G_{TFP}
Period	α=0.6	α=0.7	α=0.8
1981-1985	4.2	3.7	3.3
1986-1990	0.9	0.4	0.0
1991-1995	4.0	3.0	2.0
1996-2000	2.1	1.2	0.4
2001-2005	4.2	3.4	2.6
2006-2010	4.3	3.2	2.2
Average 1981-2010	3.3	2.5	1.7
Average 1996-2010	3.6	2.6	1.7

Over our periods and on average, $\alpha = 0.6$ appears as having a higher contribution than with a constant elasticity (Table 5). It shows that the contribution for the first three periods is lower, and for the latter three is larger, than in the constant case. But it can produce significant differences if α is assumed larger than 0.6, especially for the periods with larger impact in the first place. Still, even if the average were not significantly different, it seems reasonable to use the α variation allocated to each period, if conclusions require fine tuning or are meant for a particular period.

(b) CRS or IRS?

Recalling equation (9): $G_{TFP} = G'_{Y/K} + \beta G'_{K/L} + \gamma(G'_{K/L} + G_L)$, we can assess the case of constant returns to scale (CRS) as compared to increasing returns to scale (IRS). Under the latter, both capital and/or labour elasticities are likely to be larger (and both larger than one), making G_{TFP} smaller (recall also that γ would then be negative). We then show the difference between CRS and IRS for G_{TFP} in Table 8 below. So following equation (9), assuming increasing returns to scale with γ = -0.2 for

$\alpha+\beta+\gamma$ = 1, and assuming a value for capital elasticity $\alpha = 0.8$, which means that $\beta = (1-\alpha-\gamma) = 0.4$ (as was with CRS). Then the results for G_{TFP} will look pretty different, as shown below.

Table 8: TFP Growth Contribution of under CRS and IRS

CRS	CHINA	EAST	WEST	CENTRAL	N-EAST
(α = 0.6, β = 0.4)	G_{TFP}	G_{TFP}	G_{TFP}	G_{TFP}	G_{TFP}
1981-1985	4.1	2.8	6.9	4.4	3.1
1986-1990	1.1	0.9	2.9	0.4	1.4
1991-1995	4.6	5.6	4.2	4.4	2.6
1996-2000	1.6	1.9	1.5	1.2	3.3
2001-2005	3.2	3.7	1.2	3.9	0.1
2006-2010	3.8	4.3	1.0	3.4	0.2
Average 1981-2010	3.1	3.2	2.9	2.9	1.8
Average 1996-2010	2.9	3.3	1.2	2.8	1.2

IRS	CHINA	EAST	WEST	CENTRAL	N-EAST
(α = 0.8, β = 0.4, γ = -0.2)	G_{TFP}	G_{TFP}	G_{TFP}	G_{TFP}	G_{TFP}
1981-1985	2.4	0.6	6.1	2.6	1.5
1986-1990	-0.7	-1.3	1.9	-1.3	-0.1
1991-1995	2.4	2.9	2.7	2.6	1.1
1996-2000	-0.6	-0.5	-0.3	-0.8	1.9
2001-2005	1.1	2.0	-2.0	2.1	-3.0
2006-2010	1.4	2.2	-2.2	0.8	-3.4
Average 1981-2010	1.0	1.0	1.0	1.0	-0.4
Average 1996-2010	0.6	1.2	-1.5	0.7	-1.5

As can be seen, under IRS for China as whole, the growth of TFP is positive but significantly smaller than with CRS, and is negative in two of them, 1986-90 and 1996-2000, with an average of -0.7 and -0.6 respectively percentage points. The West and Northeast regions show the most intense negative TFP contribution, especially over 2001-2010. Of course, the values above depend on both the elasticity of capital α and by how much the addition of the elasticity of capital and labour exceeds one (i.e. $-\gamma$). For contrast, the above example assumed $\alpha = 0.8$ and an excess of 20 percent over unity, which may be too high. In the case of CRS some 29% of growth could be explained via *TFP*, but in the case of IRS, capital and labour are assumed to have enhanced themselves endogenously, being pulled by productive and organizational changes, reducing therefore the role of the exogenous *TFP*. This means that qualitative changes, and probably some inspiration, have also played a role by being at least in part pushed through capital accumulation.

So then, the results for China much depend on whether the elasticities are constant over time and more significantly whether the economy exhibits constant or increasing returns to scale.

Notes

(1) We proposed and applied this method, which we termed OCM (optimal consistent method), to OECD and Latin American countries, showing comforting levels of accuracy between our capital stock series and those coming from other official sources, despite the use of significantly less data (see Albala-Bertrand 2010). In addition, Hao (2006, 2004) compared results from the OCM for China and other existing capital series for China (e.g. Chow & Li 2002, Chow 1993a & 1993b, Chow and Lin 2002, partly Holz 2006), showing similar levels of accuracy. In contrast to other methods, the OCM takes account of measures of the productivity of capital and output at optimal levels, which are integrated into the estimation method itself. This in addition contributes to dampen productivity fluctuations due to actual capital use or idleness, which may improve the estimate of a capital stock benchmark.

(2) Linear programming is an empirical technique that optimizes an objective function via its defining parameters, subject to given inequality constraints, by means of the Simplex method (Hess, 2002). For the optimization, we use the GAMS (General Algebraic Modelling System) software. We estimate our optimal parameters over 5-year periods, so we assume them constant at optimal level, over such periods. The constancy of capital-output ratios, especially at optimal levels, is a reasonable assumption, which can come about either via correcting capital series by removing idle capital (which is hardly straightforward) or by optimizing the productive capacity of uncorrected series of capital or investment over the target periods, as we have done here (Albala-Bertrand 2010, Albala-Bertrand & Hao 2007, Thirlwall 2011). We also

assume that capital is the dominant factor of production, in the sense that it drags or pulls the other factors in the economy. This is standard assumption, explicitly or not, in many growth models and empirical models, e.g. Harrod-Domar model or the AK endogenous model, among others (Thirlwall 2011, Taylor 2004, Aghion & Howitt, 1998, Blades 1993, Jones 1975), which should be acceptable, especially when focussing in shorter periods, and also when labour availability does not seem to be a constraint, as in China over our target period.

(3) We assume that the depreciation rate is the same over our 5-year periods, which should not be a problem, as these rates at macro level are mostly conventional data (Hofman 2000a, 2000b, OECD 2001, Maddison 1993). We then use a conventional depreciation rate of 5%, which is about the one normally assumed in other Chinese studies (e.g. Perkins 1998, Woo 1998, Wang & Fan 2000, Wang & Yao, 2001, Hao, 2004; 2006, Zhang 2008).

(4) We are aware of the problems with China official statistics, so we can only use them with caution (Holtz 2006). Our main data sources were the two volumes for "The Gross Domestic Product of China" (NBS 2007). These provide series of GDP and its main components from 1952 to 2002, and GDP at current and constant price. Implicit GDP deflators were derived from here so that to have all series in constant terms. In turn, for data from 2003 to 2010, we use the Statistical Yearbook of China and the National Bureau of Statistics of China online. We also use "50 Years of Comprehensive Statistical Data and Materials of the New China" (NBS 1999), which provide both national and provincial data from 1949 to 1998. For labour data, we use the same official sources, which records the well-known statistical jump in labour-to-population

data in the 4th Population Census from 1990 onwards. Given that all our variables are transformed into three-year moving averages, and in addition our periods are further 5-year averages, then such jump is partly smoothened out. But also given that our variables are expressed in growth rates, then except for the average years where the already damp-downed jump is contained this should not be much of a problem. But caution should be taken when using such labour-related data for comparisons over time. Despite this, capital intensity (*K/L*) and its growth over time, especially in the last decade, are still massive.

(5) These regions are: East Region (i.e. provinces of Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan), West Region (i.e. Inner-Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang), Central Region (i.e. Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan) and Northeast Region (i.e. Liaoning, Jilin and Heilongjiang)

(6) From the indicated sources, we derived the implicit price deflator for both *GDP* and *GCF* for total China. The provincial data however is less complete than at national level. There is some lack of data for *GDP* and/or *GCF*, such as Jiangxi (1952-1978), Guangdong (1952-1977), Hainan (1952-1977), and Tibet (1952-1991). *GCF* data is not available for Tianjin (1952-1988), Guangdong (1952-1977), Hainan (1952-1990), and Tibet (1952-1992, 2003, 2004). Hao (2006, 2004) estimated such data with the *GCF* of border provinces that are deemed to have similar economic levels. For example, the *GCF* of Jiangxi (1952-1978) is estimated by the average of the Hubei and Hunan data. This is the data use in this paper, so some caution should be exercised.

(7) The incremental income elasticity of capital can be defined as $\varepsilon_{Y\text{-}K}$ = $(\Delta Y/\Delta K)(K/Y)$. Then $\Delta Y/\Delta K$ comes from our 5-year incremental optimal capital productivity, while for *K/Y* or *1/(Y/K)* we used the 20-year average of $\Delta Y/\Delta K$. The justification for the latter is that we are using a 5% yearly depreciation rate via a geometric erosion, which means that by the year 20th only a negligible geometrical residual remains. This then will give us a $\varepsilon_{Y\text{-}K}$ at optimal level.

(8) Of course, the estimation of capital elasticities is a cottage industry, so other authors produce elasticities significantly different from the ones used here. For example, World Bank (2005), Wang and Yao (2008), Zheng et al.(2008), Jefferson et al (2008) and so on. Given the variability on this, the ones used in this paper should be taken with caution, but the point is to show a TFP decomposition and in passing the difference between using CRS and IRS, whatever the initial levels of elasticities.

(9) That is to say that given a constant elasticity of capital (or labour), any additional percent increase in the factor, will produce exactly the same proportional effect on income as any previous percent increase of that factor, decreasing returns notwithstanding. Physical capital growth, via investment, is counted at the cost of production or its market value, and that of labour in employment levels, whether in number of hours or that of individuals. This have little to do with the productivity of capital or labour, which is then, in growth terms, encapsulated in a fixed elasticity over time.

(10) This is what is sometimes called technological change, i.e. a societal concept, as distinct from technical change, i.e. mostly an engineering concept. So it is rather misleading, if not unkind, to claim that China's high growth rates are

mostly due to brute quantities, rather than qualitative changes. The other claim is that as soon as these gains are fulfilled, this type of *TFP* is exhaustible. But this ignores that, on the one hand, this type of *TFP* sets a high platform for endogenous innovation and, on the other, even if that was not the case, there is nothing that prevents China from locking to the *TFP* of development countries via imports of technology and know-how, as they have largely done so far. A mixed of these two is of course more likely.

References

Aghion, P. and Howitt, P. (1998) *Endogenous Growth Theory* (Cambridge, Mass., MIT Press).

Albala-Bertrand, J.M. & Hao, F. (2007) "Net Capital Stock and Capital Productivity for China and Regions: 1960-2005. An Optimal Consistency Method". Queen Mary, University of London, *Department of Economics Working Paper* No. 610.

Albala-Bertrand, J.M. (2010) "A Contribution to Estimate a Benchmark Capital Stock. An Optimal Consistency Method", *International Review of Applied Economics*, Vol. 24, No.6, pp. 633-47.

Blades, D. (1993) “Comparing Capital Stocks”, in Adam Szirmai, Bart van Ark and Dirk Pilat (eds.) *Explaining Economic Growth* – Essays in Honour of Angus Maddison (Amsterdam, North-Holland), pp. 399-409.

Cai, F. & Wang, M. (2010) “Growth and structural changes in employment in transition China”, *Journal of Comparative Economics* Vol. 38, pp. 71–81.

Chow, G and Lin, A. (2002) “Accounting for Economic Growth in Taiwan and Mainland China: A Comparative Analysis”, *Journal of Comparative Economics* Vol. 30, pp.507–30.

Chow, G. (1993a). “Capital formation and economic growth in China”, *Quarterly Journal of Economics*, Vol. 108, No. 3, pp. 809 – 42.

Chow, G. (2004) Economic Reform and Growth in China, A*nnals of Economics and Finance* Vol. 5, pp. 127–52.

Chow, G. and Li, K.W. (2002) “China’s Economic Growth: 1952-2010”, *Economic Development and Cultural Change*, Vol. 51, No. 1, pp. 247-56.

Chow, G.C. (1993b) “Another look at the rate of increase in TFP in China”, *Journal of Chinese Economic and Business Studies* Vol. 6, No. 2, pp. 219–24.

DeLong, J.B. (2008), "Capital and Its Complements: International Capital Mobility and Economic Growth in the Twenty-First Century", http://www.j-bradford-delong.net/2008_pdf/20080521_capital.pdf.

Denison, E.F. (1993) “The Growth Accounting Tradition and the Proximate Sources of Growth”, in Adam Szirmai, Bart van Ark and Dirk Pilat (eds.) *Explaining Economic Growth* – Essays in Honour of Angus Maddison (Amsterdam, North-Holland), pp.37-64.

Fu X., (2004), “Limited linkages from growth engines and regional disparities in China”, *Journal of Comparative Economics*, No. 32, 148-64.

Golley, J. & Meng, X. (2011), Has China run out of surplus labour? *China Economic Review* Vol. 22, No. 4, pp. 555–72.

Hao, F. (2004) “Research about Our Country’s Capital Stock”, *Dissertation Submitted to TUFE*.

Hao F. (2006). “Estimate of Provincial Capital Stock in China: 1952-2004”, *Journal of Data Analysis (Taiwan)*, Vol. 1, No. 6, pp. 6-13.

He, D. & Zhang, W. (2010) “How Dependent Is the Chinese Economy on Exports and in What Sense Has its Growth Been Export-Led?” *Journal of Asian Economics*, Vol. 1, No.21, pp 87-104

Hess, P. (2002) *Using Mathematics in Economics Analysis* (New Jersey, Prentice

Hall).

Hofman, A. (2000a) *The Economic Development of Latin America in the Twentieth Century* (Cheltenham, Edward Elgar).

Hofman , A. (2000b) "Standardised Capital Stock Estimates in Latin America: a 1950-94 Update", *Cambridge Journal of Economics*, No 24, pp 45-86.

Holz, C. (2006) "New Capital Estimates for China", *China Economic Review*, No. 17, 142-85.

Hu, Z. L., & Khan, M. S. (1997) "Why is China growing so fast?" *IMF Staff Papers*, Washington, DC: International Monetary Fund.

Hulten, C.R. (1992) "Growth Accounting When Technical Change is Embodied Capital", *American Economic Review*, Vol. 82, No.4, pp. 565-82.

Jefferson G.H., Rawski, T.G. and Zhang, Y. (2008) "Productivity Growth and Convergence Across China's Industrial Economy", *Journal of Chinese Economic and Business Studies* Vol. 6, No. 2, pp. 121-40.

Jones, H. (1975) *An Introduction to Modern Theories of Growth* (Middlesex, Thomas Nelson & Sons).

Kendrick, J.W. (1993) "How Much Capital Explain?", in Adam Szirmai, Bart van Ark and Dirk Pilat (eds.) *Explaining Economic Growth* – Essays in Honour of Angus Maddison (Amsterdam, North-Holland), pp.129-45.

Li, K. (2003) "China's Capital and Productivity Measurement Using Financial Resources", Yale University*, Economic Growth Center Discussion Paper* No. 851.

Li, Z. and Tang, G. (2003) "Capital Formation and Adjustment of Capital Stock:

Analysis of China during Transition”, *Journal of Economic Research*, No.2.

Liu, Q. (2012) "Unemployment and Labor Force Participation in Urban China". *China Economic Review* Vol. 23, No.1, pp. 18-33.

Luo X. (2004), "The Role of Infrastructure Investment Location on China’s Western Development", *World Bank Working Paper* No. 3345.

Luo, X. & Zhu, N. (2006) “China’s Lagging Region Development and Targeted Transportation Infrastructure Investments”, in Anwar, S., Shen, C. and Zou, H. (eds) *Regional Disparities in China*, Washington D.C.: World Bank, pp. 45-59.

Maddison, A. (1993) *Standardised Estimates of Fixed Capital: A Six Country Comparison* (Essays on Innovation, Natural Resources and the International Economy, Montedison, Milan, Ferrazi Montedison Group).

Mankiw, G., Romer, D. and Weil, D. (1992) “A Contribution to the Empirics of Economic Growth” *Quarterly Journal of Economics* 107: 407–37.

NBS (2007) *The Gross Domestic Product of China: 1952-2004* (Beijing: China Statistics Publishing House).

NBS. (1999) *50 Years of Comprehensive Statistical Data and Materials of the New China* (NBS, Beijing: China Statistics Publishing House).

OECD (1997) *Flows and Stocks of Fixed Capital 1971-1996* (Paris, OECD).

OECD (2001) *Measuring Capital* (OECD Manual, Paris, OECD).

Perkins, D. H. (1998), “Reforming China’s Economic System,” *Journal of Economic Literature*, Vol. 26, No. 2, pp. 601-45.

Prasad, E. & Wei, S. (2005) “The Chinese Approach To Capital Inflows: Patterns and Possible Explanations”, *NBER Working Paper* No. 11306.

Taylor, L. (2004) *Reconstructing Macroeconomics. Structuralist Proposals and Critiques of the Mainstream* (London, Harvard University Press).

Thirwall, A.P. (2011) *Economics of Development* (9th Edition, New York: Palgrave Macmillan).

Wang, X. and Fan, G. (2000) *Sustainability of Chinese Economy* (Beijing: Economic Science Press).

Wang, Y. & Yao, Y. (2002) "Sources of China's Economic Growth 1952–1999: Incorporating Human Capital Accumulation", *China Economic Review* No. 14, pp.32-52.

Woo, W. T. (1998) "TFP in China: The Primary Role of Labour Reallocation from Rural Sector", *Journal of Economic Research*, No.3, pp. 22-35.

World Bank (2005) "China Integration of National Product and Factor Markets Economic Benefits and Policy Recommendations", *World Bank Report* No. 31973-CHA.

Yao, S., & Zhang, Z. (2001) "On Regional Inequality and Diverging Clubs: a Case Study of Contemporary China", *Journal of Comparative Economics*, No. 29, pp.466-84.

Young, A. (2000, August). "Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period*", NBER Working Paper* No. 7856.

Zhang, J. (2008) “Estimation of China’s Provincial Capital Stock (1952–2004) with Applications”, *Journal of Chinese Economic and Business Studies* Vol. 6, No. 2, May 2008, 177–96.

Zhang, X. & Tan, K. (2007) "Incremental Reform and Distortions in China's Product and Factor Markets", *The World Bank Economic Review*, Vol. 21, No. 2, pp. 279-99.

Zhen, J., Hu, A, & Bigsten, A. (2009) “Can China’s Growth be Sustained? A Productivity Perspective” *World Development*, Vol. 37, No. 4, pp 874-88.

Zheng, J., Wang, Z. and Shi, J (2008) “Industrial Productivity Performance in Chinese Regions (1987–2002): A Decomposition Approach”, *Journal of Chinese Economic and Business Studies*, Vol. 6, No. 2, 157–75.

Queen Mary
University of London

This working paper has been produced by the School of Economics and Finance at Queen Mary, University of London

School of Economics and Finance
Queen Mary, University of London
Mile End Road
London E1 4NS
Tel: +44 (0)20 7882 7356
Fax: +44 (0)20 8983 3580
Web: www.econ.qmul.ac.uk/papers/wp.htm