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Net Capital Stock and Capital Productivity for China and Regions: 1960-2005. An Optimal Consistency Method

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Abstract

This analysis is based on the optimal consistency method (OCM) proposed by Albala-Bertrand (2003), which enables to estimate a capital stock for a benchmark year. This method, in contrast to most current approaches, pays due regards both to potential output and to the productivity of capital. From an initial OCM benchmark estimate, we produce series for the net capital stock, via a perpetual inventory method (PIM), for all China and some useful regional disaggregations over the 45-year period 1960-2005. As a by-product, we also make available the optimal productivities of incremental or "marginal" capital, corresponding to the net accumulated GFCF over 5-year sub-periods from 1960 onwards. We then attempt some structural analysis, showing that the quantity of resources rather than their quality appears to be largely behind growth rates, especially since the 1990s.

Key words: China, Benchmark Capital, Perpetual Inventory Method (PIM), Potential Output, Capital Productivity, Optimal Consistency Method (OCM), structural analysis.

JEL Classification: O4, B4, E2

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1. **Introduction**

The availability of capital stock series is a basic requirement when working with production functions to study trends in growth, productivity and technical change, among other applications. This series should be reliable, replicable and consistent for comparisons both over time and across countries. To build up such series, an appropriate benchmark capital has to be first estimated and from there an international standard perpetual inventory method (PIM) can be applied(1). There are two main approaches of estimating capital stock for a benchmark year, which are based either on a cross-section census of disaggregated capital stock for a given year or on time-series for gross fixed capital formation (GFCF) over very long periods. Most countries currently use these methods (OECD, 2001; Hofman, 2000; Maddison, 1993. Denison, 1993), including China (Chow & Li, 2002; Chow & Lin, 2002, Chow, 1993; partly Holz, 2006). These methods are however costly and time-consuming, requiring the gathering of much basic information as well as the use of some convenient assumptions and guesses.

One standard way of estimating capital stock for a benchmark is to build up a capital stock via a census, by aggregating scattered data for a given year, obtained via surveys, balance sheets, insurance reports, censuses and the like. This demands a major effort, and it can be very costly, so it is liable to be pursued only in an irregular manner. In addition, the quality of the data and the compiling methods will vary widely across countries, which makes comparisons and replicability uncertain if not impossible. A second way is to estimate the capital stock by accumulating recorded investments up to a given benchmark year, subject to an appropriate discount to reflect the depreciation of the capital. This demands less effort and is currently preferred. Most OECD and other countries use it, which facilitates international comparisons, as the procedures are standard and replicable, and therefore transparent. This is normally known as the “perpetual inventory method” or PIM (OECD, 2001; Hofman, 2000a, 2000b; Blades, 1993; Goldsmith, 1951). But when historical investments are not fully recorded and when their sources and definitions are inconsistent over time, the results are bound to depend on rough estimates, on rules of thumb, on the experiences of other countries, and so forth. All this makes the resulting benchmark-capital stock estimates accurate only within an unknown confidence interval, which cannot be determined. In addition, neither method allows for an independent check, which could establish whether the estimated benchmark capital level is too high or too low.

This paper applies to China the optimal consistency method (OCM) proposed by Albala-Bertrand (2003). This approach is based on a PIM-derived equation, optimised via linear programming, requiring only a small amount of readily available data. In addition, the initial OCM estimate can be improved by combining it with an actual PIM (OCM-PIM), requiring no additional information, as shown below. In contrast to other methods, the OCM takes account of measures of the productivity of capital and output at potential levels, which are integrated into the estimation method itself. This also contributes to dampen productivity fluctuations due to actual capital use or idleness, which can make it a reasonably accurate estimate of the capital stock. It was applied to 45 systematic years for nine OECD countries and six Latin American ones. The OCM-PIM was shown to be highly efficient, as it exhibited similar accuracy to estimates from alternative methods, showing an average departure of around 6 percent from alternative estimates, but it is virtually inexpensive in both time and funding. It works well, and it requires only small amounts of data, which are readily available. Table 1 below shows the main results from Albala-Bertrand (Ibid).

TABLE 1: OCM *vis-à-vis* alternative Standard Method: Surplus/Deficit

OECD

	Net Capital Stock		Surp/Def
	OCM-PIM	REF	Benchmark K (%)
Australia 82	874315	838800	**4**
87	966594	975602	**-1**
92	1071243	1103203	**-3**
A$M (1990)			
Belgium 82	17570	15301	**15**
87	18066	16524	**9**
92	18290	18844	**-3**
BFrM (1990)			
Canada 82	651932	646962	**1**
87	757993	730533	**4**
92	839678	852637	**-2**
C$M (1986)			
Finland 82	1544641	1373453	**12**
87	1589037	1575543	**1**
92	1729707	1758955	**-2**
MrkaM(1990)			
France 82	7823602	6804084	**15**
87	8769563	7718005	**14**
92	8822449	8930058	**-1**
FrM (1980)			
Norway 82	1721147	1631288	**6**
87	1917870	1916778	**0**
92	1987074	2051033	**-3**
KrM (1985)			
UK 82	1031	914	**13**
87	975	1009	**-3**
92	1037	1153	**-10**
£B (1985)			
Germany* 82	6685587	6188380	**8**
87	7507601	6804780	**10**
92	6932651	7633400	**-9**
MrkM(1991)			
USA 82	13891	12390	**12**
87	15520	14093	**10**
92	14618	15349	**-5**
US$B (1992)			

LATIN AMERICA

	Net Capital Stock		Surp/Def
	OCM-PIM	REF	Benchmark K (%)
Argentina 62	40218	41097	**-2**
77	94777	86328	**10**
92	109284	112407	**-3**
Aust.M (1980)			
Brazil 62	5117	4739	**8**
77	16808	17011	**-1**
92	34971	32923	**6**
CrzrsM(1980)			
Chile 62	1473534	1408516	**5**
77	2281624	2130859	**7**
92	2848116	3116350	**-9**
$M (1980)			
Colombia 62	1080804	1087339	**-1**
77	2007013	2091001	**-4**
92	4029898	3920450	**3**
$M (1980)			
Mexico 62	2351735	2118792	**11**
77	6834471	6590191	**4**
92	14359402	12556857	**14**
$M (1980)			
Venezuela 62	251792	244292	**3**
77	533551	529965	**1**
92	673640	733542	**-8**
BlvrsM (1980)			

* West Germany Only
REF: PIM reference values (OECD, 1997; Hofman, 2000a)
OCM-PIM: PIM applied to initial OCM base values

It can be shown that the error expectation was around 6 percent, which is comforting, especially as we know that the reference series, produced via the alternative methods, contain themselves a number of errors, associated with sources, estimation methods and guesswork. Our aim is to produce PIM series for the net fixed capital stock (NFCS), from a benchmark OCM-PIM estimation for all China and some useful regional disaggregations, for the 45-year period 1960-2005. As a by-product, we also produce the optimal productivities of incremental (or "marginal") capital for 5-year periods, corresponding to the net accumulated GFCF over such sub-periods, from 1960 onwards. In addition, with the help of related macro variables and some useful structural decomposition we show the contributions of key variables to the growth rate of *per-capita* output.

2. Methodology

Let us start with the definition of the first difference for income or output (i.e. $\Delta Y = Y_1 - Y_0$), which can be re-arranged as

$$Y_1 = Y_0 + \Delta Y \qquad (1)$$

Where "Δ" means variation and the sub-indexes "*1*" and "*0*" represent the terminal and the initial years, respectively. Y_1 is Gross Domestic Product (GDP) and ΔY represents a variation of GDP between two given years. Let us now assume that there is a relatively stable relationship between average output and average capital and also between medium-term variations in output and medium-term variations in capital. The long-term and medium-term stability of capital-output ratios or their inverse, the productivity of capital, is well supported by empirical studies that use actual data, when allowance is made for capital idleness (Thirwall, 2003). But whatever their actual variability, this proved to be no obstacle for obtaining good results as shown in Table1above. Let then k_b and k_a be the average and the incremental capital-output ratios, respectively, as:

$$k_b = K/Y \qquad (2)$$

$$k_a = \Delta K/\Delta Y \qquad (3)$$

These two ratios represent the inverse of the average productivity of capital of the economy in the long- and medium-terms, respectively. Assuming that capital depreciates at a λ rate and that investment becomes productive with one year lag, then substituting (2) and (3) into (1):

$$Y_1 = (1/k_b)K_{-1}(1 - \lambda) + (1/k_a)\Delta K_0 \quad (4)$$

Letting $(1/k_a) = \alpha_a$, $(1/k_b) = \alpha_b$, $\Delta K_0 = I_0$ and $(1 - \lambda) = \beta$, then

$$Y_1 = \alpha_b K_{-1}\beta + \alpha_a I_0 \quad (5)$$

Where I_0 represents net fixed capital formation (NFCF) at time 0, which can be found from the normally available gross fixed capital formation (GFCF) series and some knowledge about depreciation rates. The depreciation rate λ comes normally from a variety of estimating models, but it can always be made available (OECD, 2001). We then attempt to estimate α_a and the product $\alpha_b K_{-1}$ and therefore Y_1 at optimum levels. The latter will constitute a measure of potential output, as shown later.

The benchmark capital K_{-1} can then be estimated under different assumptions for α_b. A first assumption could be that $\alpha_b = \alpha_a$. That is, the long-term and the medium-term average productivities of capital are the same. At optimal levels, this is compatible with a Harrod-Domar production function (Jones, 1975) and with the AK endogenous growth model (Aghion & Howitt, 1998; Solow, 1994). A second, more general, assumption would be that $\alpha_b \leq \alpha_a$, i.e. the long-term average productivity is smaller than or equal to the medium-term productivity of capital. This would allow for the normal expectation that capital formation of later vintages is likely to have a higher productive quality than that of earlier vintages (see Denison, 1993; Kendrick, 1993; Hulten, 1992). The data coming from both Hofman (2000a) and OECD (1997) show that the *actual* capital-output ratio often increases over time, so a relation like $\alpha_a \geq \alpha_b$ appears more likely. Therefore, if the trend in output-capital ratios, corrected for idleness, could be estimated then a correction coefficient could be applied, as $\alpha_b =$

$c\alpha_a$, where c is a correction coefficient that can be different from one. However, this is less of a problem when using the OCM-PIM benchmark, as this tends to smoothen implicitly the existing trend, so we resort to $\alpha_b = \alpha_a$, as in Albala-Bertrand (2003).

3. Estimation Procedure

With a view to estimating α_a and the product $\alpha_b K_{-1}$ at optimal levels, i.e. avoiding fluctuation-affected estimates, we use a linear programming model based on the generalisation of equation (5) as $Y^*_t = \alpha_b K_{t-2}\beta + \alpha_a I_{t-1}$. Let $K_{t-2} = K_{by}$ be the base-year capital stock. This would correspond to the year before the 10-year time-series for *GFCF* and *GDP*, which we use to estimate the said parameters (e.g. 1951 when the GFCF series start in 1952). Then the iterative solution of the above equation for any year "*t*" is:

$$Y_t^* = \alpha_b K_{by} \beta^t + \alpha_a \sum_{i=1}^{t} I'_{i-1} \beta^{(t-i)} \qquad (6)$$

Where the year "*t*" ranges from 1 to n, K_{by} is the base-year capital stock, and "*" denotes "optimal". The initial or base-year product $\alpha_b K_{by}$ and the incremental productivity coefficient α_a are the two parameters to estimate. Notice that the latter would correspond to the "marginal" productivity of capital, i.e. the productivity of the accumulated investment over our 10-year periods. The linear programme then takes the following form (see also Albala-Bertrand 2007):

Minimise:

$$Z = \sum_{t=1}^{n} (Y_t^* - Y_t) = (\alpha_b K_{by} \sum_{t=1}^{n} \beta^t + \alpha_a \sum_{t=1}^{n} \sum_{i=1}^{t} I'_{i-1} \beta^{(t-i)}) - (\sum_{t=1}^{n} Y_t) \qquad (7)$$

Subject to:

$Y^*_t \geq Y_t$

$\alpha_b K_{by}$ and $\alpha_a \geq 0$

Where the model calculates the series Y^*_t via equation (7), n = 10, corresponding to the last year of our series (e.g. 1961 when the initial year for *GDP* and *GFCF* is 1952, the base-year capital stock then being 1951), and "t" is any year in the series.

Once we have obtained the base-year result for an initial capital, which we call the OCM benchmark capital, we can use this as the starting year for a PIM, applied to the same 10-year series used in our optimisation exercise. The capital value at the end of such series would constitute our final benchmark capital. We call this value the OCM-PIM benchmark capital, which is the one used here. As indicated earlier, given that this optimisation method includes measures of optimal capital productivity and potential output, the initial or base-year capital may already produce an acceptable benchmark capital. But given the volatility and well-known problems with the GDP and GFCF data especially before mid 1970s in China, the OCM-PIM benchmark capital will normally reduce the possible error (see Albala-Bertrand 2003).

4. **Application, Results and Analysis**

Application and Main Results. We can now apply the above methodology, using the data for investment (GFCF) and GDP coming from official statistics[(2).] We use a conventional depreciation rate of five percent until 1970 with a linear transition of 6 percent from 1975. This simply assumes that the faster and more sophisticated accumulation of capital since then, especially after 1985, call for a higher depreciation. This of course is unimportant, as these rates could be altered at short notice if better information about them was available. We use as *initial* or *base-year* benchmarks 1951 for the national data and 1952 for the regional one. Therefore, our OCM-PIM benchmark would correspond to 1961 and 1962 respectively, but we settle for the round number of 1960 for both types, i.e. 10 years from the initial OCM base-year benchmark, which does not make much difference.

That is, to estimate the initial OCM parameters, all we require is 10-year series for GDP and GFCF, as well as an average depreciation rate. 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. This 10-year period is considered long enough to cover a cycle. But, in so far as a cycle is contained, a shorter series can also be used, if need be. Therefore, we do not expect that either a particular odd year or an odd sample could over-influence the estimations. We use the same rate of depreciation over each 10-year period, i.e. 5 or 6 percent, which are implicitly assumed to be averages over these periods. Finally, all series have been made constant to 1952 prices via appropriate deflators (3).

Table 2 below presents the national and regional net capital stock and capital intensity. This series derive from OCM-PIM applied to China as a whole and to standard regional divisions. These regions are: *East Region* (including the provinces of Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan), *West Region* (including Inner-Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang), *Northeast Region* (including Liaoning, Jilin and Heilongjiang) and *Middle Region* (including Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan). The regions have been standardised in per-labour terms, as their labour force and population sizes vary, the Northeast region being significantly smaller than the other ones, while the East region (that includes Beijing and Shanghai) being the largest one. What is striking from the outset is the fast increase in the national capital per labour (*K/L*), i.e. capital intensity, increasing by over 5 times since 1985, while only over 2 times in the 25 years before 1985. The Northeast appears to have the highest contribution on this ratio, but is also important in the other regions, especially the Middle one. The growth of capital intensity however has outpaced that of GDP, representing significant falls in capital productivity since 1990s (see structural analysis below). Table 3 below deals with this in optimal terms, which come directly from the OCM, as described above. The figures are the optimal productivity of the net investment over 5-year periods, hence “marginal” investment. At national level, it shows significant falls of capital productivity from the 1990s: 23 percent for 1990-95 and a further 12 percent for 1995-2005. This picture is similar for the regions, especially for the East.

Table 2: Net Capital Stock and Capital Intensity: National and Regional

1952 prices, 3-year moving average

	Cap Stock	Capital Intensity				
	China	China	West	East	N-East	Middle
	K	K/L	K/L	K/L	K/L	K/L
	RMB billion	RMB 1000	RMB 1000	RMB 1000	RMB 1000	RMB 1000
1960	329.0	1.3	1.7	1.0	1.5	1.2
1961	342.3	1.3	1.5	1.1	1.7	1.3
1962	345.5	1.3	1.5	1.2	1.9	1.3
1963	349.8	1.3	1.4	1.2	1.9	1.2
1964	359.7	1.3	1.4	1.2	2.0	1.2
1965	375.9	1.3	1.4	1.2	2.3	1.2
1966	393.0	1.3	1.4	1.2	2.7	1.2
1967	408.0	1.3	1.5	1.1	2.8	1.2
1968	423.1	1.3	1.6	1.1	2.2	1.2
1969	445.9	1.3	1.5	1.3	2.0	1.1
1970	470.0	1.4	1.5	1.3	1.8	1.1
1971	498.8	1.4	1.6	1.4	1.9	1.1
1972	528.2	1.5	1.9	1.4	1.7	1.1
1973	559.0	1.5	2.0	1.5	1.8	1.2
1974	594.9	1.6	1.9	1.6	1.9	1.2
1975	644.0	1.7	1.9	1.9	1.9	1.3
1976	694.7	1.8	2.1	1.9	1.9	1.3
1977	748.0	1.9	2.2	2.0	2.0	1.4
1978	806.3	2.0	2.1	2.3	2.2	1.5
1979	872.3	2.1	2.0	2.5	2.3	1.6
1980	939.5	2.2	2.0	2.7	2.4	1.7
1981	1010.1	2.3	2.0	2.9	2.4	1.7
1982	1084.9	2.4	2.0	3.2	2.5	1.8
1983	1174.4	2.5	2.0	3.4	2.6	1.9
1984	1283.3	2.7	2.0	3.7	2.8	2.0
1985	1412.4	2.8	2.0	4.0	2.9	2.1
1986	1562.1	3.0	2.0	4.4	3.1	2.3
1987	1729.6	3.3	2.1	4.8	3.3	2.4
1988	1893.7	3.5	2.1	5.3	3.5	2.5
1989	2046.0	3.5	2.0	5.5	3.4	2.5
1990	2193.1	3.5	2.0	5.6	3.4	2.5
1991	2372.2	3.6	1.9	5.8	3.5	2.5
1992	2609.4	3.9	2.0	6.5	3.7	2.7
1993	2915.4	4.4	2.1	7.3	4.0	2.9
1994	3287.1	4.9	2.3	8.4	4.2	3.1
1995	3712.1	5.4	2.4	9.6	4.6	3.4
1996	4173.5	6.1	2.6	10.9	5.0	3.8
1997	4673.8	6.7	2.7	12.2	5.4	4.2
1998	5202.4	7.4	2.9	13.6	5.8	4.5
1999	5771.4	8.1	3.2	15.1	6.2	4.9
2000	6383.7	8.8	3.5	16.6	6.8	5.3
2001	7079.0	9.7	3.8	18.2	7.3	5.8
2002	7886.5	10.7	4.3	20.0	7.9	6.4
2003	8836.5	11.9	4.9	22.0	8.5	7.1
2004	9956.9	13.2	5.5	24.2	9.4	8.0
2005	11243.3	14.8	6.3	26.9	10.3	9.0
1960-75	2.0	1.3	1.2	1.8	1.3	1.0
1975-85	2.2	1.7	1.0	2.2	1.6	1.7
1985-95	2.6	1.9	1.2	2.4	1.6	1.6
95-2005	3.0	2.7	2.6	2.8	2.2	2.6
85-2005	8.0	5.2	3.2	6.7	3.5	4.2
75-2005	17.5	8.8	3.3	14.5	5.5	7.1
	Growth	Growth	Growth			

K: Net Capital Stock, L: Labour

Table 3: OCM-Optimal "Marginal"* Productivity of Investment

1952 prices, 3-year moving average

	National	Regional			
		West	East	N-East	Middle
	RMBunit	RMBunit	RMBunit	RMBunit	RMBunit
5-Year Overlap**					
1960-65	0.514	0.27	0.63	0.75	0.47
1965-70	0.393	0.27	0.46	0.92	0.30
1970-75	0.365	0.33	0.38	0.73	0.33
1975-80	0.468	0.57	0.42	0.82	0.82
1980-85	0.483	0.65	0.38	0.87	0.36
1985-90	0.503	0.64	0.41	0.77	0.44
1990-95	0.388	0.68	0.28	0.75	0.37
1995-2005	0.343	0.48	0.29	0.78	0.31

* "Marginal": 5-year accumulated net investment

** Except 1995-2005

Structural Analysis. Given a definition of average capital productivity, as $\alpha = Y/K$, where Y: *GDP* and K: net capital stock, then we have:

$$Y = \alpha K \tag{8}$$

Calculating the first difference of (8) can help the description of the above results. Then dividing by Y_0 to transform it into a growth rate and manipulating, we get an accounting decomposition for the growth rate of GDP as:

$$G_Y = \alpha v + G_\alpha \tag{9}$$

Where $G_Y = \Delta Y/Y_0$ (growth rate of GDP), $v = \Delta K/Y_0$ (net investment ratio), $G_Y = \Delta Y/Y_0$ (growth rate of Y) and $G_\alpha = \Delta\alpha/\alpha_0$ (growth rate of capital productivity). If there was no change in capital productivity, then (9) reduces to the first RHS (right-hand side) term, which in *ex-post* terms represents the well known *ex-ante* Harrod-Domar growth model or the AK endogenous model (Thirlwall, 2003; Aghion & Howitt, 1998; Jones, 1975). From (9), it can be seen that if G_α becomes negative it will partly eat out the *GDP* growth rate via both its growth rate and its level. First, it will subtract from *GDP* growth from the second RHS term and, second, it will reduce the first RHS term, as α would now become smaller. In other words, the *GDP* growth would appear as growing only due the quantity of capital, less than compensating for the latter's loss of quality and that of the productive process. More particularly, the definition of capital productivity can be transformed *as* $\alpha = (Y/L)/(K/L) = \beta/\gamma$. That is, capital productivity is equal to labour productivity divided by capital intensity, which in continuous-time growth terms becomes:

$$G_\alpha = G_\beta - G_\gamma \tag{10}$$

Where G_β: growth rate of labour productivity and G_γ: growth rate of capital intensity. If the latter is larger than the former, then the growth rate of capital productivity will fall, which is what we can observe from the data in the Appendix.

For a more complete picture, we can define α in per-labour terms as above, and dividing Y by the population N, equation (8) becomes $Y/N = \alpha(K/L)(L/N)$ or saving notation $y = \alpha\gamma\delta$, where $y = Y/N$ (*GDP per capita*) and $\delta : L/N$ (labour participation ratio). Then, calculating the first difference and manipulating as above, we obtain a decomposition for the growth rate of GDP *per-capita* as:

$$G_y = (\alpha v' + G_\alpha)(1 + G_\delta) + G_\delta \tag{11}$$

Where $G_y = \Delta y/y_0$ (growth rate of GDP *per-capita*), $v' = \Delta(K/L)/(Y_0/L_0)$ or saving notation $v' = \Delta\gamma/\beta_0$ (investment ratio in per-labour terms) and $G_\delta = \Delta\delta/\delta_0$ (growth rate of labour participation). *If* $G_\delta = 0$, then we are back to a relation similar to equation (9), but now the first RHS term contains the investment ratio (v') in per-labour terms as defined above. If $G_\delta = 0$, then the increase in the labour force will fully compensate for the increase in population, so the latter has no effect on the growth rate of *GDP per-capita*. But more to the point, if G_δ is positive, then labour participation will contribute to the growth rate of *GDP per capita* in two ways: directly and in interaction with the other variables. It can be seen in Table 5 in the Appendix that on the whole this seems to be true for both the national and the regional data. Especially since 1980, the national participation ratio has moved up from 43 to 58 percent, an increase of a massive 40 percent. This has had an important positive contribution to the growth of *GDP per-capita*. Table 4 below summarises the accounting contributions of capital intensity, capital productivity and labour participation to the growth rate of GDP *per-capita.* The contributions are expressed in percentage points, which added up amount to the growth rate of GDP *per capita* in percentage terms.

Table 4: Main Contributions to the growth rate of GDP *per capita*

	GDP	K/L	Y/K	L/N
	Per capita growth rate	Capital Intensity	Capital Productivity	Labour Participation
	Percentage	Percentage Points		
National				
1960-75	2.36	2.46	-0.38	0.28
1975-85	6.84	5.34	0.27	1.23
1985-95	8.90	6.83	0.22	1.85
95-2005	8.45	10.37	-2.19	0.27
West				
1960-75	1.68	1.26	-0.40	0.82
1975-85	7.12	0.62	4.50	2.00
1985-95	7.27	2.08	3.06	2.13
95-2005	8.26	9.61	-1.46	0.11
East				
1960-75	3.28	5.94	-1.83	-0.83
1975-85	7.35	7.90	-2.01	1.47
1985-95	10.40	9.24	-0.46	1.62
95-2005	8.59	10.88	-2.32	0.03
Northeast				
1960-75	1.46	4.68	-0.97	-2.26
1975-85	5.51	3.77	0.67	1.07
1985-95	6.99	4.82	0.29	1.88
95-2005	7.16	7.64	-0.42	-0.05
Middle				
1960-75	1.87	0.49	0.87	0.51
1975-85	6.71	5.24	1.22	0.25
1985-95	7.94	5.07	1.07	1.80
95-2005	8.58	10.19	-2.16	0.54

Labour participation appears as significantly adding to the growth rate, especially from 1975 onwards. This also means that despite losses in capital productivity, increases in labour participation appear as compensating for it in many years, especially in the East region for the 1975-1995 period. Since then, labour participation appears as less than compensating for the losses in capital productivity, or adding to the losses as in the Northeast region. It should also be noticed that the growth rate of labour participation has significantly slowed down in the last decade, as shown in the Appendix. At any rate, capital intensity is by far the main accounting contributor to the growth rate of GDP p*er-capita*. So the quantities of resources more than their qualities appear to be the driving force behind the growth of output. This of course has a limit, but whether this boundary might be approaching it would be anybody's guess (4).

5. **Conclusion**

We have shown that the optimal consistency method associated with the perpetual inventory method (OCM-PIM) can produce both a usable benchmark capital stock and appropriate estimates for the optimal productivity of capital. There was no attempt at comparing our capital series with that of other authors, as the basic data for *GDP* and *GFCF* as well as for the depreciation rates, differ from author to author. It can however be shown, as Albala-Bertrand (2003) did, that in equality of basic conditions the OCM-PIM is likely to produce a very close result to that of alternative PIM-based methods. But it is significantly more efficient in terms of cost, time and not least basic data requirement.

By using some structural equations we can also observe that the *GDP per-capita* growth rate appears to rely largely on the high quantities of capital and labour rather than on increases in the capital productivity. At the same time, it was shown that that appears to be the result of a growth of capital intensity that grows significantly faster than labour productivity as well as significant increases in labour participation. For as long as China can incorporate unused or under-utilised resources, especially labour, that may be less of a problem, but this is an issue worth having in mind.

Notes

(1) The perpetual inventory method (PIM) defines this year's net capital (K_0) as equal to last year's net capital (K_{-1}) normally discounted by a geometrical depreciation pattern via a depreciation rate (λ), plus this year's gross fixed capital formation ($GFCF_0$) as: $K_0 = K_{-1} (1 - \lambda) + GFCF_0$ (see Albala-Bertrand 2003).

(2) The main source was the two volumes for "The Gross Domestic Product of China" (NBS, 1996, 2004). These provide series of GDP and its main components from 1952 to 2002, both at current and constant price. In turn, for data from 2003 onwards, we use the Statistical Yearbook of China (2004, 2005 and 2006).

(3) From the sources above, we derived the implicit price deflator for both GDP and GFCF for total China. The provincial data however is less complete than at national level. There is some lack for GDP and/or GFCF data, such as GFCF in current prices for Jiangxi (1952-1978), Guangdong (1952-1977), Hainan (1952-1977), and Tibet (1952-1991). GFCF data is in turn lacking for Tianjin (1952-1988), Guangdong (1952-1977), Hainan (1952-1990), and Tibet (1952-1992, 2003, 2004). We estimated such data with the GFCF of border provinces that are deemed to have similar economic levels. For example, the GFCF of Jiangxi (1952-1978) is estimated by the average of the Hubei and Hunan data. For a more detailed explanation of such data adjustments and other related issues, see Hao (2006) and Hao (2004). As to population and labour data, the most important source is "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 data since 1999, we use Statistical Yearbook of China (various years).

(4) The fall in the GDP growth rate may have little to do with the setting of decreasing returns to capital per unit of labour. Decreasing returns at macro level is an axiomatic assumption that feeds neoclassical theoretical models that are set up for the very long term, e.g. Solow model (Solow, 1994). We instead focus on medium-term performance. But even neoclassical endogenous growth theorists, let alone heterodox economists (Thirlwall, 2003), have questioned the validity of such a strong assumption. We take here a more empirical approach, attempting to describe structure, so Equation (9) through (11) are meant as descriptive relationships based on consistent accounting, which show the contribution of key variables to growth. These ex-post equations are not meant to be behavioural, but can be transformed into ex-ante behavioural equations in Structuralist fashion (see Taylor, 2004). The key variables can then be explained by a variety of reasons, associated with institutions and policy, which is beyond the scope of this paper.

Appendix

Table 5: National and Regional Key Variables (1952 prices, 3-year moving average)

	GDP		Y/N		L/N		Y/K		Y/L		K/L		$\Delta K/Y_0$	$\Delta(K/L)/(Yo/Lo)$
	Y	GY	y	Gy	δ	Gδ	α	Gα	β	Gβ	γ	Gγ	v	v'
	Times	Growth rate	Times	Growth rate	Times	Growth Rate	Times	Growth Rate	Times	Growth Rate	Times	Growth Rate	RMB unit	RMB unit
	Growth	Average	Growth	Average	Growth	Average	Growth	Average	Growth	Average	Growth	Average	Average	Average
NATIONAL														
1960-75	2.07	0.05	1.49	0.02	1.06	0.00	1.06	0.00	1.41	0.02	1.33	0.02	0.12	0.06
1975-85	2.33	0.08	2.04	0.07	1.14	0.01	1.06	0.00	1.79	0.06	1.68	0.05	0.20	0.13
1985-95	2.63	0.10	2.30	0.09	1.20	0.02	1.00	0.00	1.92	0.07	1.92	0.07	0.23	0.16
95-2005	2.39	0.09	2.22	0.08	1.03	0.00	0.79	-0.02	2.15	0.08	2.72	0.11	0.30	0.27
85-2005	6.30	0.10	5.10	0.09	1.23	0.01	0.79	-0.01	4.14	0.07	5.22	0.09	0.27	0.21
75-2005	14.71	0.09	10.39	0.08	1.40	0.01	0.84	-0.01	7.39	0.07	8.77	0.08	0.25	0.19
WEST REGION														
1960-75	1.98	0.04	1.36	0.02	1.10	0.01	1.07	0.00	1.23	0.01	1.15	0.01	0.16	0.04
1975-85	2.47	0.09	2.14	0.07	1.27	0.02	1.65	0.04	1.69	0.05	1.02	0.01	0.14	0.02
1985-95	2.25	0.09	1.95	0.07	1.24	0.02	1.28	0.03	1.58	0.05	1.23	0.02	0.11	0.04
95-2005	2.40	0.10	2.13	0.08	0.99	0.00	0.81	-0.01	2.12	0.08	2.61	0.10	0.21	0.18
85-2005	5.40	0.09	4.16	0.08	1.23	0.01	1.04	0.01	3.33	0.06	3.21	0.06	0.16	0.11
75-2005	13.36	0.09	8.93	0.07	1.56	0.01	1.72	0.02	5.63	0.06	3.28	0.04	0.16	0.08
EAST REGION														
1960-75	2.22	0.05	1.68	0.03	1.07	0.00	0.86	-0.02	1.57	0.03	1.83	0.05	0.13	0.09
1975-85	2.40	0.09	2.11	0.07	1.14	0.02	0.86	-0.02	1.85	0.06	2.15	0.08	0.27	0.20
1985-95	3.03	0.12	2.66	0.10	1.17	0.02	0.94	0.00	2.28	0.09	2.41	0.09	0.32	0.24
95-2005	2.50	0.10	2.23	0.09	1.01	0.00	0.79	-0.02	2.20	0.08	2.79	0.11	0.37	0.33
85-2005	7.59	0.11	5.92	0.09	1.17	0.01	0.74	-0.01	5.01	0.08	6.74	0.10	0.34	0.28
75-2005	18.24	0.10	12.52	0.09	1.34	0.01	0.64	-0.02	9.29	0.07	14.52	0.09	0.32	0.25
NORTH_EAST REGION														
1960-75	1.92	0.04	1.35	0.01	0.94	0.00	1.15	0.00	1.43	0.03	1.25	0.03	0.07	0.05
1975-85	1.97	0.07	1.73	0.06	1.12	0.01	0.99	0.01	1.55	0.05	1.56	0.04	0.08	0.05
1985-95	2.12	0.08	1.93	0.07	1.20	0.02	1.01	0.00	1.61	0.05	1.58	0.05	0.10	0.06
95-2005	2.10	0.08	2.05	0.07	1.15	0.01	0.96	-0.01	2.15	0.08	2.23	0.08	0.11	0.11
85-2005	4.44	0.08	3.94	0.07	1.38	0.02	0.98	0.00	3.45	0.06	3.53	0.07	0.10	0.08
75-2005	8.73	0.07	6.83	0.07	1.54	0.01	0.97	0.00	5.34	0.06	5.50	0.06	0.10	0.07
MIDDLE REGION														
1960-75	1.98	0.04	1.41	0.02	1.06	0.00	1.31	0.01	1.33	0.01	1.02	0.00	0.09	0.01
1975-85	2.38	0.08	2.06	0.07	1.04	0.00	1.16	0.01	1.98	0.06	1.70	0.05	0.21	0.16
1985-95	2.41	0.09	2.09	0.08	1.19	0.02	1.10	0.01	1.75	0.06	1.60	0.05	0.22	0.13
95-2005	2.25	0.09	2.24	0.09	1.07	0.01	0.78	-0.02	2.05	0.08	2.62	0.10	0.29	0.27
85-2005	5.43	0.09	4.69	0.08	1.28	0.01	0.86	-0.01	3.59	0.07	4.18	0.07	0.26	0.20
75-2005	12.90	0.09	9.64	0.08	1.33	0.01	1.00	0.00	7.09	0.07	7.12	0.07	0.24	0.18

K:	Net Capital Stock	β = Y/L:	Labour Productivity
Y:	GDP	Gβ:	Growth rate of Y/L
GY:	Growth rate of GDP	γ = K/L:	Capital Intensity
y = Y/N:	GDP per capita	Gγ:	Growth rate of K/L
Gy:	Growth rate of GDP per capita	v=ΔK/Y0:	Net Investment Ratio (for GY)
δ = L/N:	Labour Participation Ratio	v'=Δ(K/L)/(Y/L):	Net Investment Ratio (for Gy)
Gδ:	Growth rate of L/N		
α = Y/K:	Capital Productivity		
Gα:	Growth rate of Y/K		

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