

Capital, Complements and Productivity in China's Post-Reform Growth

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Abstract

By applying the general method of moments on the constructed physical and human capital stocks, the empirical results show that China's post-reform growth depended heavily on input of physical capital, human capital is inadequate across provinces, while economic growth is not complemented by parallel development in infrastructural and civic establishments. Difference in economic performance between coastal and inner provinces is reflected in physical inputs, and that economic activities in the non-state sector performed better than those in the state-sector.

JEL Classifications: O47, O53

Key words: Physical and human capital, productivity, complements, China provinces

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I. Introduction

Calculations from official statistics show that the People's Republic of China has experienced an average annual real GDP growth of 9.8 percent for the two decades of 1984-2004, with a double or close to double digit real annual GDP growth rate for the period of 1992-2004. Coastal provinces have generally experienced a higher growth rate than the inner provinces. One debate on China's economic growth since reform in 1978 has concentrated on productivity performance. On the one hand, empirical studies using the neo-classical Cobb-Douglas growth model have shown that China's rapid economic growth has been complemented by an average productivity growth of about 3 percent (Borensztein and Ostry 1996; Chow and Li 2002). On the other hand, the "new growth" advocates show that economic growth among a number of Asian economies tended to rely more on growth in factor inputs than on productivity (Young 1993, 1995; Kim and Lau 1994; Krugman 1994), and China's post-reform growth is more supported by numbers, such as the annual GDP growth rates, than by substance, such as improvement in civic activities and institutional development. Economic systemic change includes relative price distortion and rent-seeking activities in favored regions (Young 2000, 2003). Empirically, the lack of system change can be examined by provisions in infrastructure (e.g. road and railway constructions), civic organizations (e.g. number of civic institutions) and research and development commitments (e.g. education expenditure, development of human capital and scientific activities).

This paper first constructs the provincial physical and human capital stocks for productivity estimation. The general method of moment (GMM) with the selection of a total of seven instrumental variables is applied to the Cobb-Douglas production function to study China's productivity. The intention of using a total of seven infrastructural and civic instrument variables is to lend evidence to Young's (2003) hypothesis that China's growth has taken a faster pace than infrastructural and civic developments. The estimation of China's provincial physical capital stock is further controlled by using data from the sources of funds and ownership of funds. The sources of funds provide the institutional and managerial framework, while the ownership of funds gives the ownership advantage in capital formation. The human capital stock is expressed in the number of schooling years, adjusted by the provincial mortality and migration rates.

Section II shows the calculations of China's physical capital and human capital stocks, with reference to differences between coastal and inner provinces. Section III discusses the GMM methodology and shows the correlation between output, physical capital and human capital and the seven instrument variables. Section IV concentrates on the discussion of the empirical results and productivity estimates. References on other contemporary studies and findings will be made. Section V concludes the paper with discussion on policy implications.

II. National and Provincial Physical and Human Capital

The reliability of Chinese data has been a concern. On national income, Young (2003) and Rawski and Xiao (2001) show that the national income has been over-estimated, as different administrative tiers have inflated their reported income figures. On the contrary, official estimates of national income data reported in 2005 that China's GDP has been under-estimated.¹ Since the reform of state-owned enterprises in 1997, a large number of disposed workers from state-owned enterprises have formed their own small but independent business units that effectively have expanded the informal sector significantly. The upward revision in GDP estimate included the expanded economic activities in the service and informal sectors (e.g. Zhang 1997, 1998).²

Similarly, different variables (such as national income or sector output) have been used in constructing China's physical capital stock (Jefferson, Rawski and Zheng 1996; Wu 1995; Holz 2004a, 2004b). Holz (2006) and Chow (2006) have debated on the measurement problems in the estimation of the physical capital stock. After taken into account additional estimations and assumptions, such as scrap rate and depreciation rate of the same capital equipment at different years, Holz (2006) concluded that the estimation of China's physical capital stock estimated using different assumption do not vary much. Chow and Li (2002) has rightly pointed out that discrete statistical differences

¹ In December 2005, China's GDP has been revised upwards by US\$300 billion (*South China Morning Post*, December 13 and 21, 2005, and January 13, 2006).

² The revised GDP figures by the National Bureau of Statistics included government expenditure and income from informal sectors and covered only post-1993 data.

may cancel out each other in a trend analysis. Indeed, an OECD (2001) study even argues that the more relevant contribution of a capital asset is the flow of capital services.

To be consistent in the use of Chinese data, this paper adopts the method used in the estimation of China's physical capital in Chow and Li (2002), Li (2003) and Liu and Li (2006). The data used in empirical analysis in this paper is updated to 2004. The data for China's thirty provinces come mainly from the latest issue of the *Statistical Yearbook of China* and the *Comprehensive Statistical Data and Materials in 50 Years of New China* (1999). Chow and Li (2002) primarily employ the following four equations in deriving China's national capital stock:

$$GDP_t = C_t + GI_t + NX_t, \quad (1)$$

$$K_t = K_{t-1} + RNI_t, \quad (2)$$

$$RNI_t = RGI_t (NI_t/GI_t), \text{ and} \quad (3)$$

$$NI_t = GI_t - Dep_t. \quad (4)$$

GDP_t is Gross Domestic Product, C_t is consumption, NX_t is the net export of goods and services and GI_t is nominal investment. Physical capital stock is K_t , RNI_t is real net investment, RGI_t is real gross investment and NI_t is net investment. Dep_t is national depreciation figure, and the subscript t represents the time period. Real consumption is nominal consumption deflated by the consumption price index, while the implicit GDP deflator is used to derive the real value of net exports.

The provincial GDP deflator is used in constructing the provincial capital stock. Provincial real net investment ($PRNI$) is provincial real gross investment ($PRGI$) less provincial depreciation. The thirty provinces are grouped into twelve coastal provinces (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and Hainan), and eighteen inner provinces (Shanxi, Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xingjiang).

Figure 1 shows the aggregate physical capital stock for all provinces, coastal provinces and inner provinces for the period 1978-2004. The physical capital stock of the coastal provinces is higher than that of inner provinces. Between 1984 and 2004, the

physical capital stocks of coastal and inner provinces have increased by 666.67 percent and 531.2 percent, respectively. The coastal provinces to inner provinces capital stock ratio has deteriorated over the years. Between 1984 and 2004, the ratio between coastal provinces and inner provinces has increased from 2.29:1 to 5.35:1, suggesting that coastal provinces are increasingly attractive to investment at the expense of inner provinces. By 2004, the difference in the average physical capital stock between the coastal provinces and the inner provinces is 175.86 percent.

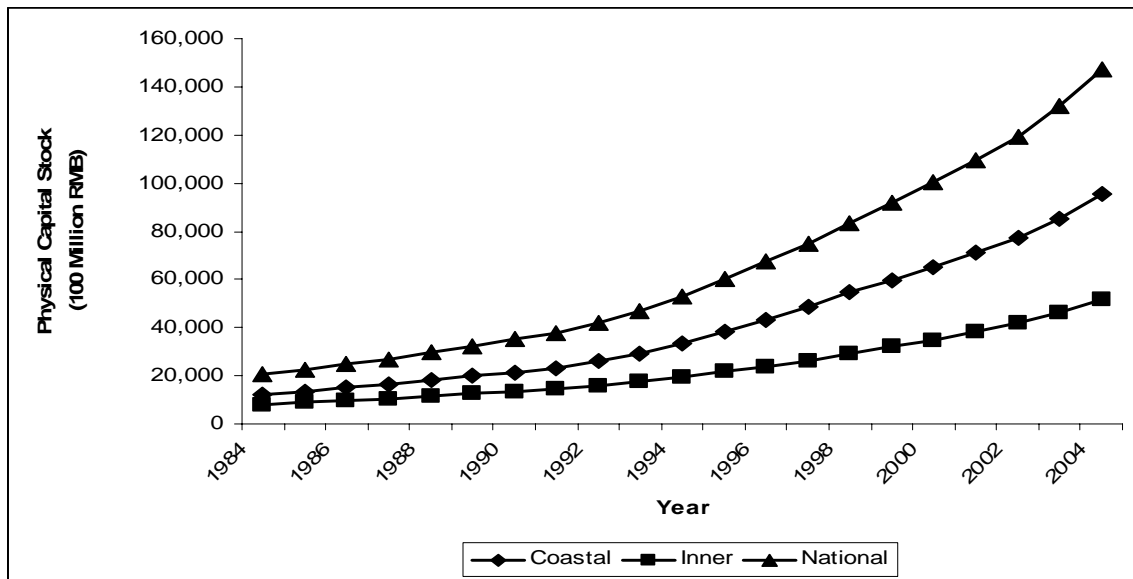


Figure 1 Total Physical Capital Stock, 1984-2004

There has been discussion on the different sources of investment in China's post-reform economy (see, for e example, Shih 2003). Empirical studies by Li and Liu (2001, 2004) and Liu and Li (2001) reported that total investment in fixed assets (*TIFA*) in Chinese statistics since 1981 is divided institutionally into four sources of funds and different ownership patterns. The four sources of funds are: 1) state budget appropriation (*SA*) which refers to central and local government funds earmarked for capital construction and innovation projects and transfer funds to banks as loan for capital construction project; 2) national domestic bank loans (*DL*) that refer to enterprises and institutions funds borrowed from banks and non-bank financial institutions; 3) utilized foreign direct investment (*FI*) that refers to foreign funds in fixed assets, foreign funds borrowed and

managed by the government and individual units, foreign funds in joint venture programs, grants and donations; and 4) self-raised funds and others (*SR*) that contain funds received and raised by non-government and local-government enterprises engaged in construction activities.

Total investment in fixed assets by ownership is grouped under three categories. State ownership (*SO*) consists of investments by state enterprises and is divided into capital construction, technical upgrading and transformation, other investment in fixed assets and development in real estate. Collective ownership (*CO*) includes investments in township and village enterprises by urban collective and rural collective units. Investment by individual units (*IO*) is divided into investment of residential buildings in cities, county towns and industrial and mining areas, and investment of rural residential building and in productive fixed assets. Since 1992, four additional categories of joint ownership (*JO*), shareholding (*SH*), foreign funds (*FF*) and funds from Hong Kong, Macau and Taiwan and other economic units (*HMTO*) are included in the new ownership groupings. These new items, however, expanded considerably in the 1990s.³

By comparing state and non-state sources of funding or ownership, one can see the extent to which China's post-reform economic growth mimics a full-fledged market economy. Although there is overlapping between the sources and ownership of funds classifications, total investment in fixed assets classified under sources and ownership of funds can be used as a control variable in China's physical capital stock estimation if one can ensure that the coefficients in the regression between the constructed net investment figures (namely the real net investment figures, *RNI*, derived from Equation (3)) and total investment in fixed assets figures (*TIFA*) using the 1981-2004 data are statistically significant and acceptable. Real total investment in fixed assets (*RTIFA*) is derived from deflating gross TIFA by the investment index. These estimated regressions are:

For sources of funds (1985-2004),

$$\ln R\hat{N}I_t = -0.5887 + 0.9564 \ln RTIFA_t . \quad (5)$$

(0.0484) (0.0058)

³ The four items (JO, SH, FF and HMTO) under ownership classification produced a slightly larger percentage share than the Utilized Foreign Direct Investment category under the sources of funds. This is due to the fact that the "Others" in the category of "Self-raised Funds and Others" include overseas Chinese investment that should belong to the Utilized Foreign Direct Investment category.

For ownership of funds (1984-2004),

$$\ln R\hat{N}I_t = 0.0153 + 0.9352 \ln RTIFA_t . \quad (6)$$

(0.0799) (0.0146)

The regression coefficients shown in Equations (5) and (6) confirm that net investment in constant prices can be estimated by using *RTIFA*. Taking the anti-log of the predicted value of $\ln R\hat{N}I$ in each case gives a new series of net investment figures, say I^*_t , formed from the *TIFA* figures for the period $t = 1981, \dots, 2004$. The new investment series, I^*_t , is divided into four sources of funds, with $i = 1, 2, 3$ and 4 , or with $i = 1, 2$ and 3 in the three cases of ownership for the period 1982-1992, and $i = 1, 2, \dots, 7$ for the seven cases of ownership for the period 1993-2004. Similarly, the initial capital stock for both classifications is required. A constant ratio based on the five years experience of 1981-1985 is created for the sources of finance. In the case of ownership, the two five year periods are 1982-1986 and 1993-2004 for the two sub-periods 1982-1992 and 1993-2004, respectively. This procedure produces three sets of ratios which sum to unity that are used to divide the initial value of capital stock into different respective capital stocks under sources of fund and ownership of fund.

The physical capital stock funded by state appropriation and domestic bank loans are grouped together in Figure 2, while collective ownership and individual ownership are grouped into one category in Figure 3. Figure 2 shows that self-raised funds and others is the largest source of capital funding. Despite the evidence that China has attracted large foreign direct investment, Figure 3 shows that state ownership is still the main form of capital ownership. Both the non-state (collective and individual) and foreign ownership is still low, while state ownership has begun to fall since the early 1990s.

In the case of physical capital stock constructed from sources of funds, the capital stock funded by state appropriation and domestic loan is larger in the inner provinces than the coastal provinces. The capita stock funded by self-raised funds is particularly large in the coastal provinces. In the case of capital stock constructed from ownership, state owned capital is larger than the combined level of collective ownership and individual ownership, though state ownership especially among coastal provinces is declining gradually over the years. The ownership involving external investors

(shareholding, joint venture, foreign owned and funds from Hong Kong, Macau and Taiwan and other economic units) are gradually expanding relative to collective and individual ownership, especially since the turn of the century.

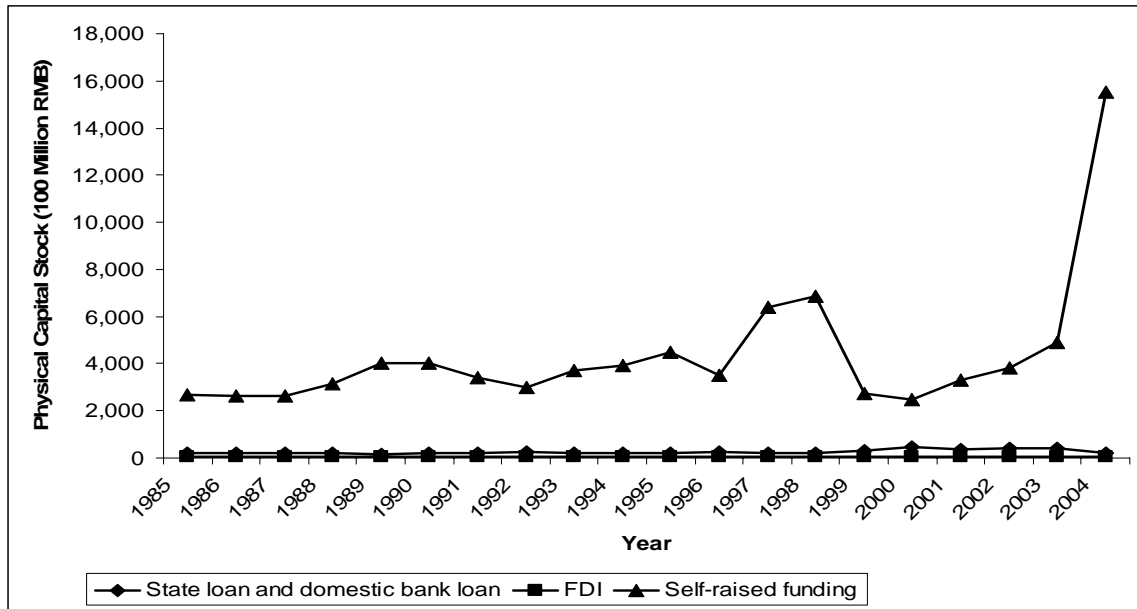


Figure 2 Total Physical Capital Stock by Sources of Funds, 1985-2004

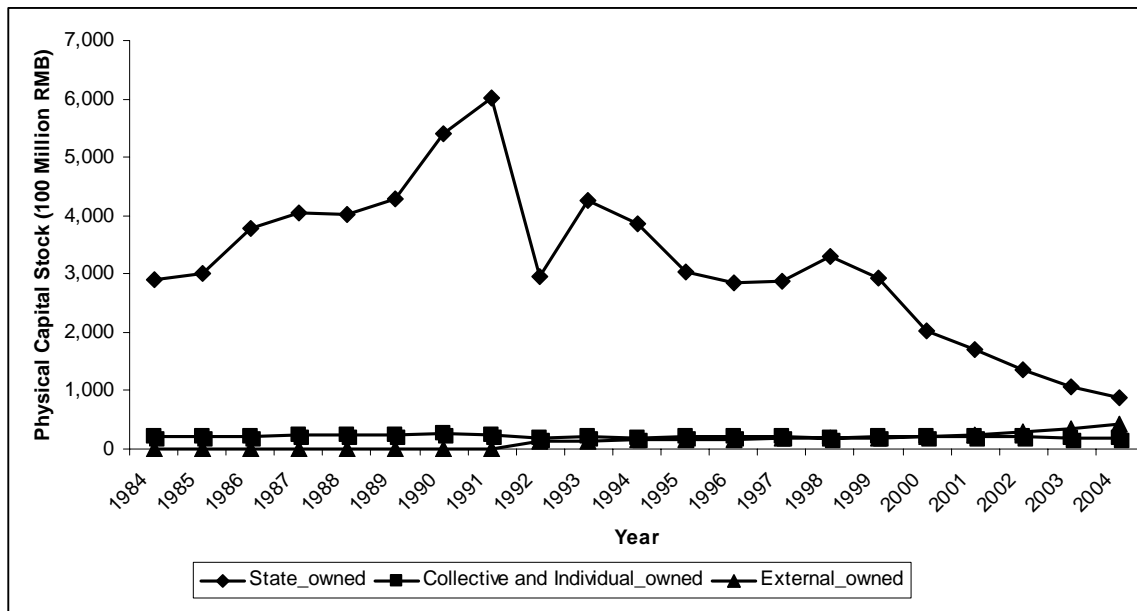


Figure 3 Total Physical Capital Stock by Ownership of Funds, 1984-2004

In the case of human capital, studies show that total years of schooling derived from educational enrolment ratios, international test scores and number of workers that passed through primary, secondary and tertiary education can be used as proxies for human capital (Barro and Lee 1993, 1996 and 2001; Benhabib and Spiegel 2005; Gemmell 1996). Equally, life expectancy indicated by the mortality rate can impact on human capital (Barro and Lee 2001; Howitt 2005), though earlier statistics on mortality in China has also been challenged (Barnister and Preston 1981). Studies on provincial migration (Du, Park and Wang 2005; Zhang *et al* 2005) suggest that migration helps the poor in securing a higher income return.

Various assumptions and proxies have been used in constructing China's human capital stock (Young 2003; Wang and Yao 2003). Liu and Li (2006, Table 2 and Appendix B) elaborated on China's post-reform education performance and constructed China's human capital stock using a perpetual inventory approach (Barro and Lee 1993, 1996, 2001). The initial human capital is derived from using the data in the two Population Censuses of 1990 and 2000. The annual graduates of the six schooling levels (Higher Education with 14.5 years, Specialized Secondary, Vocational Secondary and Senior Secondary with 11 years, Junior Secondary with 8 years and Primary Education with 5 years) and the total number of persons that attained the various school levels within the age of 15-64 years in 1990 are used as the benchmark. Liu and Li (2006) applied the following formula to calculate the total number of schooling years per capita as the human capital stock:

$$H_{j,t} = (5H_{1,j,t} + 8H_{2,j,t} + 11H_{3,j,t} + 11H_{4,j,t} + 11H_{5,j,t} + 14.5H_{6,j,t}) / Pop_{j,t}, \quad (7)$$

where $H_{j,t}$ is the level of human capital stock for province j at time t , and $Pop_{j,t}$ is the population aged 15-64 of province j at time t . Data on the annual graduates in each schooling level are adjusted by the mortality rate and inter-provincial migration figures. However, the statistics on the number of graduates at Specialized Secondary and Vocational Secondary education levels are no longer available from 2004 onwards. To be consistent with the human capital stock in Liu and Li (2006), the data on human capital stock can only be extended to 2000.

Figure 4 shows China's national and regional human capital stock measured in terms of the average school years.⁴ The average number of schooling years has improved from a national average of 4 years in 1984 to about 6 years in 2000.⁵ The human capital of coastal provinces is higher than the national average, but the reverse is true in the case of the inner provinces. The gap of the human capital stock between coastal and inner provinces has begun to widen since the early 1990s.

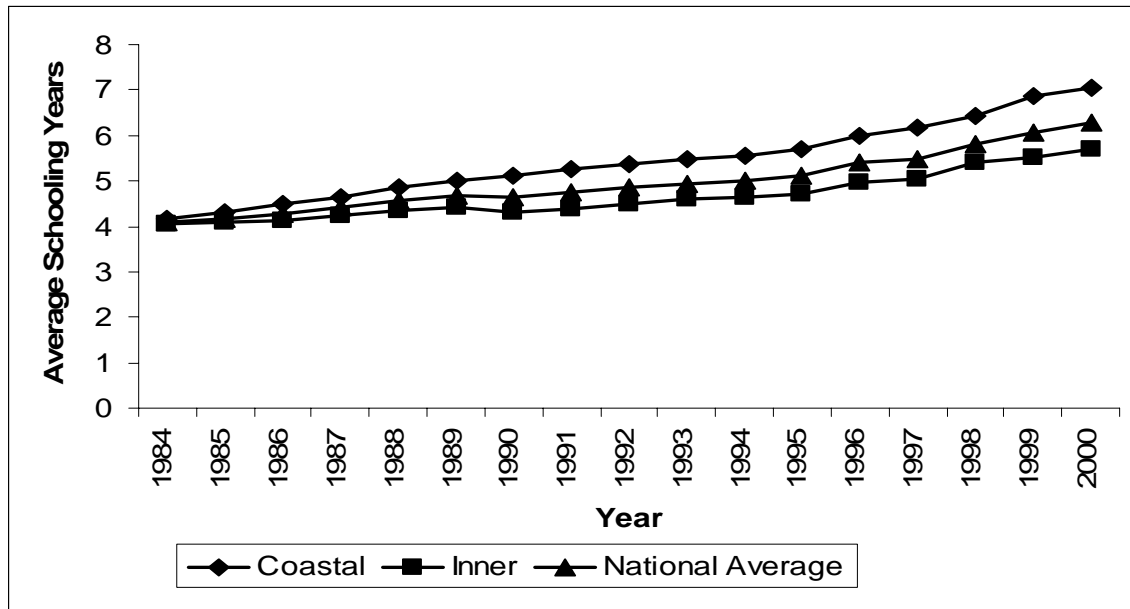


Figure 4 Average Schooling Years by Regions, 1984-2000

III. Estimating the Production Function with Panel Data

The relationship between output (Y_t) and input of physical capital stock (K_t), human capital stock (H_t) and labor (L_t) can be considered by the following Cobb-Douglas production:

$$Y_t = A_t K_t^\alpha L_t^\beta H_t^\gamma, \quad (8)$$

⁴ As compared to Wang and Yao (2003, Appendix A), the overall human capital stock in Figure 4 is slightly higher. This is because Vocational Secondary schooling is included in the estimation.

⁵ China's average schooling years derived for 1985, 1990, 1995 and 2000 are 4.17, 4.62, 5.10 and 6.27 years, respectively. Based on the enrolment ratios for the total population aged 25 and above, Barro and Lee's (2001) estimates are 4.15, 5.23, 5.48 and 5.74 years, respectively.

where A_t is the technology change at time t , α , β and γ are parameters that measure the marginal productivities. We assume a constant return to scale as in Chow and Li (2002) and Li (2003) and the three parameters (α , β and γ) are assumed to sum to unity.

Variables Y , K and H are expressed in per capita form. Applying the logarithmic differencing of variables on both sides, and suppose that technology grows with the form, $A_t = \exp(a + bt)$, and with the use of panel data, the disturbance is specified by the two-way error component model (Wansbeek and Kapteyn 1989; Baltagi 2001), the regression model becomes:

$$Dy_{it} = b + \alpha Dk_{it} + \gamma Dh_{it} + \mu_i + \lambda_t + v_{it}, \quad (9)$$

where the subscript i indicates province i , μ_i and λ_t measure the unobservable provincial effects and time effects, respectively, and v_{it} denotes the remaining disturbances with mean zero and variance σ_v^2 . D indicates the first difference

Since human capital may correlate with the residual, a two-step efficient generalized method of moments (GMM) estimation is applied. The efficient GMM estimator minimizes the GMM criterion function, $J = Ng'wg$, where N is the sample size, g is the orthogonality or moment condition that specifies all exogenous variables or instruments in the equation are uncorrelated with the error terms, and w is an efficient weighting matrix. The efficient GMM is robust in the presence of heteroskedasticity. The reported Hansen J statistics is a heteroskedastic-consistent Lagrange multiplier test of the null hypothesis that the excluded instruments are correctly excluded from the restricted model. The C statistics is a test of exogeneity of one or more instruments, which is distributed as chi-square in the number of instruments tested (Hansen 1982; Baum, Schaffer and Stillman 2002; Wooldridge 2002).

In order to examine the impact of complements on economic growth, a total of seven variables are used as instruments in the GMM estimations. They are the growth rates of real export per labor (EXL), medical persons per labor (MED), number of hospital beds per labor (BED), average wage ($WAGE$), number of urban telephone subscriptions per labor (TEL) and cars per labor (CAR). These instrument variables should correlate

with the regressors but not with the error term and provide enough variability to estimate the parameters (Ferreira and Rossi 2003).

An understanding on the factors that complement growth can provide additional evidence on growth. This can be done by looking at the correlation analysis between the three macroeconomic variables of output (y), physical capital (k) and human capital (h), and the seven instrument variables used in the GMM estimation. Table 1 show that in general the correlation ratios between the seven instrument variables and output per labor are less than 0.1 in the three provinces categories. There are five (four) correlations between the instrument variables and physical capital per labor are less than 0.3 in all provinces and coastal provinces (inner provinces); the same is true with human capital per labor. Reading along the rows, one sees that correlation is weak (with ratio of less than 0.5 among output, physical capital and human capital per labor) in real export, wage, number of urban telephone subscribers and number of cars. On the contrary, the growth in the number of medical persons, beds in health institutions, road length and cars show strongest correlation with human capital, suggesting that better provisions in health and medical infrastructure and communication and road networks can improve economic growth and the quality of human capital considerably.

Table 1 Correlation Matrix of Variables (Per Capita)

	All Provinces			Coastal Provinces			Inner Provinces		
	Dy	Dk	Dh	Dy	Dk	Dh	Dy	Dk	Dh
$D2.EXL$	0.0593	0.0567	0.0596	0.0332	0.0314	0.0737	0.0856	0.0703	0.0584
$D2.MED$	-0.0066	0.3744*	0.3797*	-0.0207	0.4705*	0.4276*	0.0204	0.3504*	0.4214*
$D2.ROAD$	0.0151	0.1843*	0.2870*	0.0155	0.1579#	0.2912*	0.0341	0.3617*	0.3040*
$D2.WAGE$	0.0420	0.0300	0.0177	0.0475	0.0291	0.0061	0.0575	0.0354	0.0355
$D2.TEL$	-0.0870*	0.0520	0.0587	-0.1444	0.1257	0.1101	-0.0826	0.0496	0.0696
$D2.CAR$	0.0058	0.1139#	0.1277*	0.0197	0.1393+	0.1340+	0.0126	0.1305#	0.1299#
$D2.BED$	0.0103	0.3780*	0.3639*	0.0107	0.4617*	0.4421*	0.0163	0.3380*	0.3117*

Notes: y = output; k = capital stock; h = human capital stock; EXL = export; MED = number of medical persons; $ROAD$ = road length; $WAGE$ = wage; TEL = number of urban telephone subscribers; CAR = number of cars; and BED = numbers of beds in health institutes. *, # and + indicate that the correlation coefficient is significant at 1, 5 and 10 percent level, respectively. D and $D2$ indicate the first and second difference, respectively.

The aggregate capital stock in the Cobb-Douglas function can alternatively be decomposed into different sources of finance and types of ownership with the intention to examine the output contribution by individual capital stock components. In the case of source of funds, the components of capital stock come from the state sector (state

appropriation and domestic bank loans), non-state sector and foreign sector. Capital efficiency performance should be different among these respective sources. Similarly, in the case of ownership, capital stock is either owned by the state sector, non-state sector (collective and individual) and foreign sector. The empirical estimations on the performance of the different components of the capital stock are considered along with the human capital stock at the provincial level.

The aggregate capital stock is decomposed into three types of capital inputs based on the four sources of total investment in fixed assets: state appropriation and domestic bank loans (sa_dl), foreign investments (fi) and self-raising funds and others (sr), denoted as k_{sa_dl} , k_{fi} and k_{sr} , respectively. The regression model becomes:

$$Dy_{it} = b + \alpha_1 Dk_{sa_dl,it} + \alpha_2 Dk_{fi,it} + \alpha_3 Dk_{sr,it} + \gamma Dh_{it} + \mu_i + \lambda_t + v_{it}. \quad (10)$$

In the case of the capital stocks classified under different ownerships, the capital variables of joint owned, shareholding, foreign fund and funds from Hong Kong, Macau and Taiwan and other economic units are being grouped into one category of external ownership (for), while the capital variables of collective and individual owned are being grouped into the category of non-state sector (ic). This reduces the number of ownership capital stocks into three categories of state owned, non-state owned and external owned, denoted by k_{so} , k_{ic} , and k_{for} , respectively. The regression model then becomes:

$$Dy_{it} = b + \alpha_1 Dk_{so,it} + \alpha_2 Dk_{ic,it} + \alpha_3 Dk_{for,it} + \gamma Dh_{it} + \mu_i + \lambda_t + v_{it}. \quad (11)$$

In addition to the development of infrastructural and civic establishment in China's post-reform economy, it is expected that difference sources of investment funds could induce different institutional and managerial advantages, while difference ownership of investment funds induce different ownership advantages. Furthermore, it is assumed that non-state investments facilitate economic growth. Typically, non-state capital funds should be more productive than state-capital.

IV. Empirical Results on Growth and Productivity

This section shows the empirical results of factors that complement provincial economic growth and the effect of sources and ownership of funds on productivity. Table 2 shows the coefficient estimates of Equation (9). By using the provincial infrastructure indicators as instruments to examine the complement effects on growth, Table 2 reports the GMM estimation for all provinces, coastal provinces and inner provinces. In general, the Hansen J statistics support the excluded indicators (such as medical persons, road networks, wage, urban telephone subscribers, cars and beds in health institutions) as valid instruments. The C statistics suggested that physical capital and export per labor are exogenous.

Table 2 shows that the effect of human capital is robust in various specifications, suggesting strongly that human capital is an essential factor for economic growth. However, in the case of physical capital, its positive effect on economic growth is robust for all provinces and coastal provinces, but the effect is not statistically significant for inner provinces. These results indicate that investment in physical capital is an essential factor for economic growth, particularly in the coastal provinces, but the effect of investments in the inner provinces is weak in the post-reform period.

We next explore the effect of the sources and ownership of funds on economic growth, as indicated by Equations (10) and (11), respectively. Tables 3 and 4 report the effects of physical capital derived, respectively, from sources of funds and ownership of funds for all provinces, coastal and inner provinces. For Equation (10), both one-way (time dummies) and two-way (time and province dummies) regressions are applied to the provincial panel data. The one-way regressions show robust results, as indicated by the coefficients in column (1) of Table 3. Similar to Table 2, the effect of human capital is consistent in all three cases. Among the three forms of physical capital stocks classified under the sources of funds, capital from self-raised funds showed a significant estimate in all provinces and coastal provinces. A similar conclusion can be reached with the estimates from foreign investment, suggesting that the non-state sources (self-raised funds and foreign investment) contributed significantly to economic growth. State source of funds (state appropriation and domestic bank loans) showed a lower level of

significance in all provinces and coastal provinces, suggesting that state funds are becoming less significant and less productive in the overall growth performance.

Table 2 Estimation Results Based on Provincial Panel Data, 1985-2000

Dependent variable: $D.y$			
	(1) All provinces	(2) Coastal provinces	(3) Inner provinces
Constant	0.0706 *** (0.0089)	0.0639 *** (0.0130)	0.0516 *** (0.0141)
$D.k$	0.4848 *** (0.1049)	0.3473 ** (0.1383)	0.2639 (0.1641)
$D.h^{\wedge}$	0.2540 *** (0.0752)	0.3385 *** (0.0961)	0.3595 *** (0.1187)
1987	-0.0299 *** (0.0099)	-0.0025 (0.0144)	-0.0075 (0.0115)
1988	-0.02600 *** (0.0102)	-0.0005 (0.0155)	-0.0462 *** (0.0098)
1989	-0.0795 *** (0.0087)	-0.0686 *** (0.0129)	-0.0380 *** (0.0097)
1990	-0.0654 *** (0.0084)	-0.0468 *** (0.0128)	-0.0253 ** (0.0109)
1991	-0.0388 *** (0.0100)	0.0469 *** (0.0169)	0.0151 (0.0109)
1993	-0.0017 (0.0101)	0.0424 ** (0.0166)	0.0214 * (0.0113)
1994	-0.0085 (0.0104)	0.0242 (0.0154)	0.0217 * (0.0114)
1995	-0.0229 ** (0.0103)	-0.0033 (0.0166)	0.0157 (0.0106)
1996	-0.0330 *** (0.0088)	-0.0259 * (0.0136)	0.0060 (0.0099)
1997	-0.0290 *** (0.0087)	-0.0124 (0.0126)	0.0086 (0.0088)
1998	-0.0408 *** (0.0088)	-0.0195 (0.0121)	-0.0038 (0.0088)
1999	-0.0363 *** (0.0095)	-0.0121 (0.0130)	-0.0009 (0.0089)
2000	-0.0347 *** (0.0085)	-0.0133 (0.0120)	-0.0022 (0.0085)
Centered R^2	0.69	0.74	0.69
Uncentered R^2	0.92	0.94	0.92
Hansen J statistics	7.229	4.761	6.545
C statistics	2.108	1.148	0.994
No. of observations	412	166	245

Notes: The numbers in the parentheses are robust standard errors. \wedge denotes the endogenous variable. $D2.EXL$, $D2.MED$, $D2.ROAD$, $D2.WAGE$, $D2.TEL$, $D2.CAR$ and $D2.BED$ and year dummies are used as instruments. The C statistics test (Difference-in-Sargan test) shows the exogeneity of $D.k$ and $D2.EXL$. ***, ** and * denotes a significance level of 1%, 5% and 10%, respectively.

Table 3 Estimation Results based on Provincial Panel Data:
Capital by Sources of Funds, 1985-2000

	(1) <i>D.y</i> (All)	(2) <i>D.y</i> (All)	(3) <i>D.y</i> (Coastal)	(4) <i>D.y</i> (Inner)
Constant	0.0930 *** (0.0061)	0.0706 *** (0.0199)	0.1071 *** (0.0101)	0.0832 *** (0.0072)
<i>D.k_sa_dl</i>	0.0202 * (0.0106)	0.0088 (0.0088)	0.0567 * (0.0312)	0.0053 (0.0094)
<i>D.k_fi</i>	0.0239 ** (0.0114)	0.0144 (0.0100)	0.0431 * (0.0242)	0.0152 (0.0115)
<i>D.k_sr</i>	0.0204 ** (0.0090)	0.0127 (0.0079)	0.0453 ** (0.0211)	0.0092 (0.0093)
<i>D.h</i>	0.4369 *** (0.0252)	0.4536 *** (0.0249)	0.3759 *** (0.0475)	0.4459 *** (0.0330)
R^2	0.63	0.72	0.71	0.68
Time_dummies	F = 31.51 ***	F = 32.45 ***	F = 20.89 ***	F = 17.34 ***
Province_dummies	-	F = 6.08 ***	-	-
No. of observations	440	440	178	262

Notes: The dependent variable in each regression is the growth of provincial real GDP. The numbers in the parentheses under the estimated coefficients are robust standard errors. ***, ** and * denotes a significance level of 1%, 5% and 10%, respectively.

The estimates of the three sources of funds for the inner provinces are insignificant, implying that the capital funds available to the inner provinces have been low and unable to generate a significant impact on economic growth. These results do reflect that economic policies on the deepening and widening of financial sources for investment in physical capital in the inner provinces has not been as robust as those in coastal provinces.

The estimates based on the classification of the capital stock under the ownership of funds reflect the ownership advantage. Since the data for external ownership that included share-holding, joint venture, foreign funds and funds from Hong Kong, Macau, Taiwan and others are available only from 1992 onwards, columns (1) to (3) in Table 4 show the results for the whole sample period of 1985-2000, while columns (4) to (6) give the sub-sample result for the period 1992-2000 only. Similar to previous results, Table 4 also shows that the coefficient of human capital is positive and significant in all cases.

For the whole sample period, the coefficient for the physical capital derived from collective and individual ownerships are negative, especially in the inner provinces, as shown in columns (1) and (3) of Table 4. One can argue that although capital from non-state ownership is a significant contributor to economic growth, its level is still low.

Non-state ownership probably could be more productive should its size increases. The productive effect of state-owned capital stock is both insignificant and negative. When foreign ownership is considered, one finds a significant impact of foreign capital across all provinces in post-reform China economy, as shown in column (4) of Tale 4.

Table 4 Estimation Results based on Provincial Panel Data:
Capital by Ownership of Funds

1985-2000	(1) <i>D.y</i> (All)	(2) <i>D.y</i> (Coastal)	(3) <i>D.y</i> (Inner)
Constant	0.0830 *** (0.0196)	0.1558 *** (0.0157)	0.1043 *** (0.0073)
<i>D.k_so</i>	-0.0113 (0.0075)	-0.0092 (0.0110)	-0.0072 (0.0051)
<i>D.k_ic</i>	-0.0191 * (0.0098)	-0.0052 (0.0138)	-0.0336 *** (0.0115)
<i>D.h</i>	0.4909 *** (0.0240)	0.5302 *** (0.0344)	0.4817 *** (0.0290)
R^2	0.72	0.77	0.74
Time_dummies	F = 31.32 ***	F = 27.3 ***	F = 20.02 ***
Province_dummies	F = 6.42 ***	F = 4.19 ***	F = 4.83
No. of observations	440	178	262
1992-2000	(4) <i>D.y</i> (All)	(5) <i>D.y</i> (Coastal)	(6) <i>D.y</i> (Inner)
Constant	0.0706 *** (0.0192)	0.1711 *** (0.0076)	0.0833 *** (0.0049)
<i>D.k_so</i>	0.0119 (0.0106)	0.0004 (0.0015)	-0.0061 (0.0117)
<i>D.k_for</i>	0.0486 ** (0.0229)	0.0228 (0.0369)	0.0148 (0.0253)
<i>D.k_ic</i>	0.0284 * (0.0161)	0.0094 (0.0183)	-0.0199 (0.0202)
<i>D.h</i>	0.4559 *** (0.0283)	0.4947 *** (0.0518)	0.4883 *** (0.0424)
R^2	0.83	0.90	0.82
Time_dummies	F = 19.86 ***	F = 28.13 ***	F = 6.85 ***
Province_dummies	F = 7.84 ***	F = 6.93 ***	F = 7.2 ***
No. of observations	233	95	138

Notes: The dependent variable in each regression is the growth of provincial real GDP. The numbers in the parentheses are robust standard errors. ***, ** and * denotes a significance level of 1%, 5% and 10%, respectively.

The regression results shown in Table 2, columns (1), (3) and (4) of Table 3, and columns (4) to (6) of Table 4 can be used to calculate China's total factor productivity (TFP). The growth of TFP equals to output growth minus the total contribution of growth in physical capital, human capital and labor. The provincial panel data gives a national

average TFP of 3.14 percent for the entire sample period of 1985-2000 as shown in Table 5, while both the sources of funds and ownership of funds give a higher but similar estimate of 8.65 percent for the period 1985-2000 and 8.6 percent for the period 1992-2000, respectively. The TFP performance of the coastal provinces is expected to be higher than the inner provinces. Such a difference is small in the provincial panel data (5.3 percent and 4.28 percent for coastal and inner provinces, respectively), but the difference gets slightly larger in both the sources of funds and ownership of funds, as shown in Table 5.

Physical capital is the key contributor to GDP growth, accounting for 49.7 percent at the national level. Between the coastal provinces and inner provinces, physical capital contributed more to GDP growth in the coastal provinces (34.8%) than in the inner provinces (27.5%). On the contrary, due probably to the lower level of human capital, the contribution by human capital to GDP growth turned out to be the highest in the inner provinces (15.6%). Contribution by total factor productivity to growth at the national level is 36.2 percent, while the contribution to coastal provinces (49.6%) and inner provinces (49.8%) are similar. Human capital contributes more to GDP growth than labor, though their contribution is higher in the inner provinces than in the coastal provinces, due probably to the lower level of human capital in the inner provinces and the migration from inner provinces to coastal provinces.

The estimated of the sources of growth and contribution to growth based on the sources of funds and ownership of funds in Table 5 are considered as a control factor to the performance of the TFP estimates. While the sources of funds provide a control on institutional and management factors, the ownership of funds provides the control on ownership advantage. In the contribution to growth, the TFP figure is the residual that theoretically picks up various unquantifiable factors including technological change. The higher TFP figures under both the sources of funds and ownership of funds shown in Table 5 suggested that improvement on institutional and corporate management and/or a clear ownership pattern could result in higher growth, in addition to technological change and progress.

Table 5 Sources of and Contribution to GDP Growth (%)

	Sources of Growth			Contribution to Growth		
	National	Coastal	Inner	National	Coastal	Inner
<u>All Provinces</u>						
<u>(1985-2000)</u>						
GDP	9.43	10.68	8.59			
Physical Capital	4.68	3.72	2.36	49.7	34.8	27.5
Human Capital	0.97	1.32	1.34	10.3	12.4	15.6
Labor	0.37	0.34	0.61	3.9	3.2	7.2
Total Factor Productivity	3.41	5.30	4.28	36.2	49.6	49.8
<u>Sources of Funds</u>						
<u>(1985-2000)</u>						
GDP	9.43	10.68	8.59			
Physical Capital	0.07	1.88	1.70	0.79	3.65	0.48
SA and DL	0.06	0.15	0.02	0.62	1.40	0.18
Foreign investment	0.02	0.15	0.02	0.17	1.43	0.19
Self-raised funds, others	0.00	0.09	0.00	0.00	0.82	0.11
Human Capital	1.67	1.49	1.66	17.7	13.97	19.29
Labor	0.70	0.51	0.86	7.43	4.75	9.99
Total Factor Productivity	8.65	8.29	6.03	91.77	77.64	70.24
<u>Ownership of Funds</u>						
<u>(1992-2000)</u>						
GDP	10.46	11.54	9.75			
Physical Capital	0.14	0.07	0.04	1.30	0.64	0.35
State ownership	-0.02	0.00	0.02	-0.23	0.00	0.17
Collective & Individual	0.13	0.06	0.04	1.22	0.53	0.39
Foreign Ownership	0.03	0.01	-0.02	0.31	0.11	-0.21
Human Capital	1.49	1.67	1.55	14.19	14.46	15.92
Labor	0.25	0.07	0.43	2.39	0.07	4.39
Total Factor Productivity	8.60	9.73	7.74	82.12	97.33	79.34

Notes: SA = State appropriation and DL = National domestic loans.

The national TFP figures under both sources of funds (8.65%) and ownership of funds (8.6%) are similar, though the TFP figures for the coastal provinces in both cases are higher than the TFP figures in the inner provinces. The national TFP tends to contribute more to growth when the sources of funds are controlled (91.77%) than when the ownership of funds are controlled (82.12%), though in both cases, the TFP could contribute more to growth in the coastal provinces than in the inner provinces. This further lends support to Young's (2003) thesis that institutional, infrastructural and civic improvements can have a greater impact on productivity and growth.

Although the method of estimation used differed, a national TFP growth rate of 3.41 percent is comparable to other studies (Borensztein and Ostry 1996; Chow and Li 2002; Li 2003). Wang and Yao (2003) use a growth accounting approach, and show that despite a higher growth rates in both physical and human capital, the growth of TFP is lower at 2.41 percent. Young (2003) questions the relevance of the GDP deflator and shows an adjusted result is one half of the unadjusted growth rates. For example, the growth rate of TFP is adjusted from 3.0 percent to 1.4 percent, suggesting the conclusion that there is no capital deepening in China's post-reform growth.

V. Conclusion

The neo-classical Cobb Douglas production function estimations using the GMM and a number of instrument variables produce a few relevant findings. Post-reform economic growth in China is dominated by the large injection of physical funds which explained about 50 percent of growth. This result is similar to the argument used in other Asian economies by Young (1993, 1995), Kim and Lau (1994) and Krugman (1994).

Although productivity growth is considerably large at around 36 percent, the contribution by both labor and human capital amounts to only about 14 percent, suggesting that the impact of education on growth has been marginal. The low contribution of human capital to growth shall be an important concern. While the state has been the main source of education expenditure, increase in non-state sources on education, training and development, especially along the coastal provinces can hasten human capital development. While the focus has been on tertiary education, the China economy may need to embark massively on vocational training that increases the supply of middle management positions for businesses and other economic activities.

There are clear differences between coastal and inner provinces. Despite the debate on income equality between coastal and inner provinces (Fleisher and Chen 1997; Chen and Fleisher 1996), the equally critical problem is the difference in capital inputs. Economic growth in coastal provinces rely more on foreign funds and domestic bank loans, while due to a lack of substitutes and less attractive to foreign investors, state funding has remained important in inner provinces. The non-state sector is strong in

coastal provinces, but development in economic infrastructure and civic activities can help to deepen economic growth, especially in inner provinces in order to attract new investment to remote regions. Large scale infrastructure projects, such as power supply and railway and land transportation network involving large fixed cost should be expanded in order to open up the less developed areas. Once these regions are accessible, the greater pace of urbanization and industrialization can be extended to inner regions that provide new and added economic opportunities. Local industries that serve nearby regions can then be established using non-state resources.

In conclusion, there are broadly three policy implications on China's post-reform economic growth. Despite the large public expenditure on education, incentives should be given to the establishment of vocational training institutions that aims to increase the supply of middle-management qualifications, in addition to the academic graduates from tertiary institutions. Physical infrastructure in the form of mass transport network and communication, health promotion and protection institutions are urgently required, especially in inner provinces. Policy should also gear to the development of civic infrastructure at different administrative levels. Examples of civic development include the institution of professional qualifications and standardized measurements and controls in professional practices.

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