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CHINA'S CAPITAL AND PRODUCTIVITY MEASUREMENT USING FINANCIAL RESOURCES

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Abstract

This paper constructs China's capital stock, which is used in conjunction with a labor variable to estimate a Cobb-Douglas production function for the Chinese economy. Two panels of data are used – one for capital formation and one for sources of investment finance. Both national and provincial data are used for these two panels, thus giving a total of four capital-stock series. The Cobb-Douglas estimates show that China's total factor productivity was about 3.4 percent in the post-reform years. Productivity of coastal provinces is higher than inner provinces. Among the various sources of investment finance, foreign direct investment is more efficient than state-funded capital stock.

Key words: China economic reform; provincial growth and productivity; financial resources.

JEL classification: O47

I. Introduction

China's open-door reform since 1978 has steadily transformed the Chinese economy and achieved continued economic growth, though there is considerable variation between provinces. How capital is measured, to what extent capital formation has led to economic growth, and the role that technological change has played in output and productivity growth are important questions. Of similar interest are the effects of regional variations and the sources of financing on the productivity of the resulting capital stock. Inefficient state planning manifests itself in the low productivity of the state-funded capital stock. Driven by the profit motive, capital stock financed by foreign investment and non-state sources may be expected to have higher productivity. Productivity in coastal provinces is likely to be higher than inner provinces that were not as quick to open to foreign direct investment following China's economic reform.

Section II uses national and provincial income and investment data to summarize Chow (1993) and Chow and Li (2002) method of capital-stock construction, and extends this work to incorporate additional capital stock based on different aggregates. Together with a labor component, Section III estimates various Cobb-Douglas formulations and their implications for capital productivity in China. The implications and conclusions are presented in Section IV.

II. Constructing China's Capital Stock

China's capital stock in year t, K_t, may be derived from three macroeconomic equations and identities. Equation (1) shows that current capital stock is related to current real net investment, RNI_t, while Equation (2) determines real net investment as a proportion of real gross investment, RGI_t, with the factor of proportionality being the ratio of net investment, NI_t, to nominal investment, GI_t.

$$K_t = K_{t-1} + RNI_t. \tag{1}$$

$$RNI_t = RGI_t\ (NI_t/GI_t). \tag{2}$$

Denoting C_t to be year t consumption and NX_t to be net export of goods and services, Gross Domestic Product is given by the identity.

$$GDP_t = C_t + GI_t + NX_t. \tag{3}$$

GI_t can then be estimated from $GDP_t - C_t - NX_t$.

In addition to Gross Domestic Product, other aggregates are employed to construct three additional capital-stock series so as to ensure data consistency and reliable stock figures. The aggregate national output and investment figures are used to construct the first national capital-stock series. The four national sources of finance (state appropriation, bank loans, foreign direct investment and self-raised funds) will be employed to construct the second national capital-stock series. Provincial aggregate output and investment figures will be compiled to form the third capital-stock series. Lastly, the provincial sources of finance will make up the fourth capital-stock series. The procedure used in deriving the national capital stock is extended to derive the capital-stock series based on other aggregates, though due to the unavailability of some Chinese data, minor adjustment is conducted in the construction procedure.

A. National Aggregates

The first decision is the initial capital stock to which the annual investment capital can be added to make up a capital series. Several capital-stock series were used in Chow (1993, Table VI and VII). The initial capital stock of 2,212.99 (100 million yuan, and hereafter) at the end of 1952 was chosen because the construction of that series was similarly based on the aggregate of net investment for the whole economy. Data on "accumulation" in official statistics were used as real net investment for the period 1953-1978 (*Statistical Yearbook of China (SYC)*, 1994, p. 41). Since the prices of investment goods remained constant in the pre-reform years, data on accumulation are considered to be on real terms. By using these "accumulation" data, a capital-stock series can be constructed. That series provides a value of capital stock of 14,111.99 at the end of 1978.

The prices of investment goods began to change after 1978 and an appropriate price index is not readily available. Since 1994, official Chinese national income statistics changed from the former "national income available," which equals "consumption + accumulation," to the Gross Domestic Product (GDP = final consumption expenditure + gross capital formation + net export of goods and services). This coverage is broader than the former "national income" statistic by the inclusion of some previously excluded service items.

Nominal GDP is found in *SYC* (1999, p. 55). Real GDP is derived proportionally from the index of real GDP (*SYC* 1999, p. 58) converted to 1978 prices using the 1978 nominal GDP. The nominal-to-real GDP ratio gives the annual implicit price deflator, which is used to deflate the net exports of goods and services (*SYC* 1999, p. 67) to obtain the real value of net exports. Real consumption is nominal consumption deflated by the consumption price index (*SYC*, 1999, p. 67 and 72). Finally, real gross investment (RGI) is obtained by subtracting real consumption and real net exports of goods and services from the official real GDP figures in 1978 prices.

Depreciation figures of individual provinces are available for 1993 (*SYC* 1995 p. 41), 1994 (*SYC* 1996, p. 51), 1996, 1997 and 1998 (*SYC* 1997 p.51, 1998 p. 66 and 1999 p. 66). Summing up the depreciation figures from all provinces for 1993, 1994, 1996 to 1998 and estimating a figure for 1995 by averaging the 1994 and 1996 figures gives a national depreciation rate (Dep), which is then used to calculate the net investment by the following equation, where t = 1993, ….,1998:

$$NI_t = GI_t - Dep_t. \tag{4}$$

With these NI_t values, the capital stock for the period from 1993 through 1998 can be derived from Equation (1). Gross investment (GI) is found in *SYC* (1999, p. 67).

An additional step is needed to find the depreciation rates for the period 1979 to 1992 because a capital stock for 1992 is needed for the 1993-1998 series. We apply a tentative rate of depreciation equal to four percent (0.96) to generate a temporary capital-stock series, say K^*_t, for the period 1979-1992, and when t = 1979, the K^*_{t-1} is 14,111.99.

$$K_t^* = 0.96\, K_{t-1}^* + RGI_t. \tag{5}$$

The $K^*_{t=1992}$ is used as input to Equation (1) to generate a temporary capital-stock series for the period 1993-1998. In turn, this temporary capital stock series is used to work out an implied depreciation rate, d, from the following equation, with t = 1993, ….1998:

$$1 - d_t = (K_t - RGI_t)/K_{t-1}. \quad (6)$$

This yields implied depreciation coefficients of 0.9549, 0.9520, 0.9492, 0.9450, 0.9394 and 0.9358, for the six successive years. The mean depreciation rate of 0.946 is used to construct the capital-stock series for the period 1979 to 1992 from the following equation:

$$K_t = 0.946\ K_{t-1} + RGI_t. \quad (7)$$

The revised capital stock of 1992 generated from Equation (7) is used to work out the final capital-stock series from Equation (1) for the period 1993-1998. These steps complete the procedure used to derive the capital stock for the 1952-1978, 1979-1992, and 1993-1998 periods, as reported in Chow and Li (2002). By 1998, China's capital stock was 87,764.476, as shown in Table 1.

B. National Sources of Finance

In the *Statistical Yearbook of China* (*SYC*), total investment in fixed assets (TIFA) is divided into different sources of financing. These figures can be utilized to construct the capital stock if a proper relation between the constructed net investment figures and "total investment in fixed assets" is established. Net investment occurs as a result of expenditures on "investment in fixed assets." The connection between the two is imperfect for two reasons. First, capital stock includes both fixed assets and working capital, the latter being referred to as "circulation fund" in *Statistical Yearbook of China*. Thus data on investment in fixed assets are not inclusive enough, although they constitute a large fraction of the total that ranges between 60 and 85 percent (see Table IV of Chow 1993).

Table 1 – National Economic Data

Year	RGDP	L	Dep	IPD	K
1952	799.32	2.0729			2,212.993
1953	911.22	2.1364			2,380.993
1954	963.98	2.1832			2,575.993
1955	1,025.52	2.2328			2,760.993
1956	1,170.20	2.3018			2,977.993
1957	1,222.95	2.3771			3,210.993
1958	1,492.32	2.6600			3,589.993
1959	1,614.62	2.6173			4,147.993
1960	1,591.44	2.5880			4,648.993
1961	1,119.04	2.5590			4,843.993
1962	1,046.31	2.5910			4,942.993
1963	1,158.21	2.6640			5,125.993
1964	1,349.25	2.7736			5,388.993
1965	1,577.85	2.8670			5,753.993
1966	1,846.42	2.9805			6,223.993
1967	1,712.93	3.0814			6,527.993
1968	1,601.03	3.1915			6,825.993
1969	1,910.37	3.3225			7,182.993
1970	2,354.79	3.4432			7,800.993
1971	2,520.24	3.5620			8,484.993
1972	2,592.18	3.5854			9,132.993
1973	2,807.20	3.6652			9,873.993
1974	2,839.17	3.7369			10,614.993
1975	3,074.97	3.8168			11,444.993
1976	2,993.44	3.8834			12,192.993
1977	3,226.84	3.9377			13,024.993
1978	3,624.10	4.0152		100.00	14,111.993
1979	3,899.53	4.1024		103.56	14,882.124
1980	4,203.96	4.2361		107.47	15,735.359
1981	4,425.03	4.3725		109.88	16,569.286
1982	4,823.68	4.5295		109.76	17,653.459
1983	5,349.17	4.6436		110.94	18,991.843
1984	6,160.97	4.8197		116.39	20,627.591
1985	6,990.89	4.9873		128.23	22,598.034
1986	7,610.61	5.1282		134.05	24,876.884
1987	8,491.27	5.2783		140.88	27,413.644
1988	9,448.03	5.4334		158.00	30,524.741
1989	9,832.18	5.5329		171.98	33,773.284
1990	10,209.09	6.3909		181.68	36,805.533
1991	11,147.73	6.4799		193.92	40,115.037
1992	12,735.09	6.5554		209.17	44,131.925
1993	14,452.91	6.6373	3,989.12	239.64	50,105.391
1994	16,283.08	6.7199	5,406.88	287.17	56,732.505
1995	17,993.66	6.7947	7,094.10	324.99	64,013.641
1996	19,718.73	6.8850	8,781.32	344.26	71,700.806
1997	21,454.67	6.9600	10,486.41	347.07	79,542.496
1998	23,129.01	6.9957	11,981.24	343.27	87,764.476

Note: RGDP = GDP (100 million 1978 yuan); L = labor force (100 million);
Dep = depreciation (100 million current yuan); IPD = implicit price deflator;
K = capital stock (100 million 1978 yuan).
Source: *China Statistical Yearbook*, various issues.

Secondly, “investment in fixed assets” is always larger than the “newly increase in fixed assets” because of wastage or failure of some investment expenditures to result in an actual increase in the capital stock (see Chow, 1993, p 816, paragraph 3). Furthermore, “investment in fixed assets” refers to gross investment, but net investment is needed to construct a capital-stock series. As a result of these differences, “total investment in fixed assets” and aggregate net investment in China are different. For the years 1995 and 1996 respectively, “total investment in fixed assets” is 20,019.26 and 22,947.03, and “gross capital formation” is 23,877.26 and 26,867.2 (*SYC 1995*, p. 46 and 149), implying net investment of 16,783.2 and 18,085.9.

Since 1981, the four sources of total investment in fixed assets (TIFA) are state appropriation (SA), domestic bank loans (DL), foreign direct investment (FI), and self-raised funds and others (SRF) (*SYC* 1999 Table 6.3). By definition (*SYC* 1995, p. 193), state appropriation refers to the appropriation in the budget of the central and local governments earmarked for capital construction and innovation projects and funds to bank loans issued for capital construction projects. These are mainly state construction and infrastructure projects, though many state appropriations are given to industries that generate output. Domestic national bank loans are funds borrowed by enterprises and institutions from domestic bank and non-bank financial institutions, and include various types of loans issues by banks. Bank loans are given mainly to state-owned enterprises for production purposes, though the high level of non-performing loans resulted in a considerable amount of bad debt among national banks. Utilized foreign direct investment refers to foreign funds in fixed assets, foreign funds borrowed and managed by government and by individual units, and foreign funds in joint ventures. Self-raised funds are institutional and local government funds given to enterprises for fixed-asset investment. These include bonds issued by individual enterprise and funds channeled through local governments. All other fixed-asset investments, such as funds supplied by overseas Chinese are included under self-raised funds.

Table 2 - Sources of Investment in Fixed Assets (*TIFA*), (Rmb 100 Million)

Year	*TIFA*	State Appropriation (% of TIFA)	Domestic Loans (% of TIFA)	Self-Raised Funds and Others (% of TIFA)	Foreign Investment (% of TIFA)
1981	961.0	269.76 (28.1)	122.00 (12.7)	532.89 (55.5)	36.36 (3.8)
1982	1,230.4	279.26 (22.7)	176.12 (14.3)	714.51 (58.1)	60.51 (4.9)
1983	1,430.1	339.71 (23.8)	175.50 (12.3)	848.30 (59.3)	66.55 (4.7)
1984	1,832.9	421.00 (23.0)	258.47 (14.1)	1,082.74 (59.1)	70.66 (3.9)
1985	2,543.2	407.80 (16.0)	510.27 (20.1)	1,533.64 (60.3)	91.48 (3.6)
1986	3,120.6	455.62 (14.6)	658.46 (21.1)	1,869.19 (59.9)	137.31 (4.4)
1987	3,791.7	496.64 (13.1)	871.98 (23.0)	2,241.11 (59.1)	181.97 (4.8)
1988	4,653.8	431.96 (9.3)	977.84 (21.0)	2,968.69 (63.8)	275.31 (5.9)
1989	4,410.4	366.05 (8.3)	762.98 (17.3)	2,990.28 (67.8)	291.08 (6.6)
1990	4,517.0	393.03 (8.7)	885.45 (19.6)	2,954.41 (65.4)	284.61 (6.3)
1991	5,594.5	380.43 (6.8)	1,314.73 (23.5)	3,580.44 (64.0)	318.89 (5.7)
1992	8,080.1	347.46 (4.3)	2,214.03 (27.4)	5,049.95 (62.5)	468.66 (5.8)
1993	13,072.3	483.67 (3.7)	3,071.99 (23.5)	8,562.36 (65.5)	954.28 (7.3)
1994	17,827.1	529.57 (3.0)	3,997.64 (22.4)	11,530.96 (64.7)	1,768.95 (9.9)
1995	20,524.3	621.05 (3.0)	4,198.73 (20.5)	13,409.19 (65.3)	2,295.89 (11.2)
1996	23,358.6	625.88 (2.7)	4,573.69 (19.6)	15,412.40 (66.0)	2,746.59 (11.8)
1997	25,259.7	696.74 (2.8)	4,782.55 (18.9)	17,096.49 (67.7)	2,683.89 (10.6)
1998	28,716.9	1,197.39 (4.2)	5,542.89 (19.3)	19,359.61 (67.4)	2,617.03 (9.1)

Source: *China Statistical Yearbook 1999*, Table 6.3.

As shown in Table 2, state appropriation, which is traditionally the largest source of fixed-asset investment, has declined in percentage terms considerably and quite regularly over the 18-years period, though in value terms it has also increased a lot. National bank domestic loans have expanded and have probably absorbed some of the state appropriations. Foreign direct investment is lowest in absolute terms but has experienced the highest rate of expansion in recent years. By the early 1990s, the nominal value of foreign direct investment has overtaken that of state appropriations. Self-raised funds have become the largest source of financing, occupying over 50 percent of total.

To trace the capital formation process on the expenditures on investment in fixed assets, we regress real net investment (RNI) on real total investment in fixed assets (RTIFA) using 1981-1998 sample-period data. The real total investment in fixed assets (RTIFA) can be derived from deflating gross TIFA by the investment index (nominal gross investment / real gross investment, setting 1978 = 100). The estimated regression is:

$$\mathit{Ln}\ \mathrm{RNI}_t = 0.20695 + 0.94808\ \mathit{ln}\ \mathrm{RTIFA}_t + \varepsilon_t, \qquad (8)$$
$$\qquad (0.1981) \quad (0.0238)$$

where ε_t is the year-t residual. The adjusted R^2 is 0.9894. Equation (8) shows that net investment in constant prices can be estimated quite accurately by using RTIFA. Taking the anti-log of the predicted value of *ln* RNI gives a new series of net investment figures, say I^*_t, formed from the TIFA figures for the period t = 1981, ….1998. The new investment series, I^*_t, is then divided into four sources of finance (i = 1, 2, 3 and 4) based on the real total investment in fixed assets ratio shown in Equation (9).

$$\mathrm{RTIFA}_{it} / \mathrm{RTIFA}_t. \qquad (9)$$

A series of I^*_{it} is then generated, with i = SA, DL, FI, and SRF. Similarly, the initial capital stock for the four sources of finance is required. A constant ratio for the four individual sources is created from the following equation:

$$\Sigma_{(1981\text{-}85)}\ \mathrm{RTIFA}_i / \Sigma_{(1981\text{-}85)}\ \mathrm{RTIFA}. \qquad (10)$$

This produces the following ratios which sum to unity: RTIFA (SA) = 0.2178, RTIFA (DL) = 0.1526, RTIFA (FI) = 0.0411 and RTIFA (SRF) = 0.5885. These ratios are used to divide the 1980 value of capital stock (K_{1980} = 15,735.359, shown in Table 1) into four respective $K_{i(1980)}$. Thus, applying Equation (11), which is similar to Equation (1), a series of K_{it} is derived from TIFA, as shown in Table 3.

$$K_{it} = K_{it-1} + I^*_{it}. \qquad (11)$$

Table 3 - National Capital Stock Constructed from the Four Sources of Finance

	Total Capital	State Appropriation	Domestic Bank Loans	Foreign Direct Investment	Self-raised Funds & Other
1980	15,735.36	3,426.665	2,401.684	646.348	9,260.662
1981	16,613.21	3,673.083	2,513.127	679.562	9,747.441
1982	17,781.42	3,938.227	2,680.344	737.013	10,425.833
1983	19,149.94	4,263.318	2,848.292	800.699	11,237.628
1984	20,788.15	4,639.607	3,079.312	863.855	12,205.379
1985	22,693.05	4,945.057	3,461.514	932.375	13,354.105
1986	25,003.13	5,282.339	3,948.953	1,034.022	14,737.812
1987	27,746.85	5,641.715	4,579.930	1,165.698	16,359.511
1988	30,859.61	5,930.638	5,233.972	1,349.843	18,345.161
1989	33,709.78	6,167.193	5,727.039	1,537.950	20,277.594
1990	36,453.59	6,405.910	6,264.839	1,710.815	22,072.030
1991	39,606.94	6,620.340	7,005.889	1,890.558	24,090.150
1992	43,695.63	6,796.162	8,126.233	2,127.709	26,645.526
1993	49,200.90	6,999.854	9,419.971	2,529.595	30,251.481
1994	55,756.75	7,194.602	10,890.086	3,180.119	34,491.943
1995	62,586.85	7,401.270	12,287.307	3,944.127	38,954.149
1996	70,159.26	7,604.168	13,770.011	4,834.520	43,950.559
1997	78,520.39	7,834.794	15,353.070	5,722.907	49,609.620
1998	88,170.73	8,237.178	17,215.761	6,602.361	56,115.426

Source: *China Statistical Yearbook*, various issues.

C. Provinces

Data are collected for thirty provinces.[1] These provinces are classified into eleven coastal provinces (Beijing, Tianjin, Heibei, Liaoning, Jiangsu, Zhejiang, Shandong, Guangdong, Hainan, Shanghai and Fujian) and nineteen inner provinces (Shanxi, Jilin, Anhui, Henan, Hunan, Yunnan, Gansu, Ningxia, Guangxi, Tibet, Mongolia, Heilongjiang, Jiangxi, Hubei, Guizhou, Shaanxi, Qinghai, Xinjiang and Sichuan). Gross provincial investment figures are not available until 1984 (with only three omissions: Xinjiang in 1984, and Shanghai and Tibet in 1998).

The steps in constructing provincial capital stocks are similar to the steps in the construction of the national capital stock. The only exception is that the provincial GDP deflator is used throughout. Provincial real net investment (PRNI) is provincial real gross investment (PRGI) less provincial depreciation. Since an investment deflator for the provinces is unavailable, the provincial GDP deflator is used to deflate the provincial depreciation figures. Provincial depreciation values are used for the 1993-1998 period, while an implied depreciation value based on Equations (5), (6) and (7) was used to generate the depreciation value for the period 1984-1992. A deflated average depreciation rate for all provinces is 4.451 percent, while the rate for the coastal provinces and inner provinces are, respectively, 4.627 percent and 4.347 percent. Although there are variations, coastal provinces face a higher depreciation rate than inner provinces. The difference of 0.28 percent between the average of coastal and inner provinces suggests that the returns to investments in the coastal provinces are "over-estimated," and investment returns in the inner provinces are "under-estimated."

The provincial capital ratios derived from Equation (12) are applied to the national capital in 1984 (which is 20,627.591). For each province, j:

$$(\Sigma_{(1985\text{-}88)}\ PRGI_j\ /\ \Sigma_{(1985\text{-}88)}\ PRGI). \qquad (12)$$

The five provinces with the larges ratios are Liaoning (14.15), Jiangsu (8.57), Shanghai (7.34), Shandong (6.41) and Guangdong (5.50). The smallest five provinces are Tibet (0.34), Hainan (0.56), Ningxia (0.58), Qinghai (0.65) and Guizhou (1.12). Using provincial capital, Equation (1) is applied to calculate the capital for thirty provinces for the period 1993-1998. Together with the provincial capital generated for 1984-1992, we have the provincial capital for the coastal and inner provinces as shown in Tables 4 and 5.

This exercise effectively disaggregated the national capital by provincial capital in the 1984-1998 period. There is, however, a discrepancy in the total value of capital stock. In 1997, for example, the national capital stock reported in Chow and Li (2002) is 79,542.496. The capital stock from the four sources is 78,520.39 (a difference of 1.3%). The capital stock from the sum of the thirty provinces amounts to 75,466.62 (a difference of 5.1%). We attributed these differences to reporting error and inventory.

[1] Provincial data are collected from numerous provincial yearbooks. These will not be reproduced here, but are available upon request.

Table 4 - Provincial Capital: Coastal Provinces

	Beijing	Tianjin	Heibei	Liaoning	Jiangsu	Zhejiang
1984	862.10	564.05	634.05	2,918.82	1,767.25	962.40
1985	944.06	621.95	684.91	3,276.35	1,910.82	1,053.83
1986	1,037.27	687.23	736.68	3,661.53	2,096.52	1,159.31
1987	1,161.45	741.37	785.53	4,102.01	2,302.09	1,288.12
1988	1,293.93	829.81	850.83	4,593.92	2,550.00	1,424.59
1989	1,441.82	905.23	891.97	5,094.64	2,764.01	1,537.82
1990	1,583.40	969.67	939.83	5,592.89	2,998.40	1,610.82
1991	1,712.98	1,052.31	1,001.66	6,117.85	3,269.53	1,720.76
1992	1,881.56	1,170.70	1,121.35	6,708.90	3,712.56	1,911.73
1993	2,146.78	1,320.64	1,269.90	7,414.65	4,311.21	2,218.23
1994	2,468.13	1,491.37	1,441.48	8,202.27	4,952.42	2,552.29
1995	2,873.32	1,660.62	1,652.46	9,027.82	5,646.78	3,024.12
1996	3,188.52	1,834.51	1,918.97	9,907.47	6,373.08	3,538.13
1997	3,519.30	2,025.64	2,221.06	10,869.99	7,106.96	4,079.66
1998	3,876.95	2,231.14	2,571.67	11,896.91	7,956.21	4,697.52

	Shandong	Guangdong	Hainan	Shanghai	Fujian
1984	1,321.95	1,134.93	114.74	1,513.92	370.14
1985	1,418.77	1,209.01	127.71	1,657.97	398.79
1986	1,522.92	1,287.66	142.54	1,836.07	436.04
1987	1,669.42	1,386.80	155.64	2,012.97	476.23
1988	1,833.35	1,516.87	169.12	2,253.95	518.00
1989	2,001.10	1,649.66	184.72	2,487.70	557.77
1990	2,178.50	1,787.32	208.35	2,672.76	597.23
1991	2,410.89	1,950.73	233.47	2,839.49	649.39
1992	2,715.08	2,245.79	281.91	3,084.49	724.82
1993	3,124.15	2,707.77	337.76	3,435.92	847.74
1994	3,546.37	3,227.25	402.72	3,917.56	1,029.74
1995	4,020.06	3,751.95	459.37	4,521.09	1,241.40
1996	4,575.77	4,295.39	501.70	5,246.11	1,481.34
1997	5,172.86	4,803.01	541.40	5,970.31	1,746.48
1998	5,805.49	5,380.64	585.30		2,053.62

Source: Various issues of China's provincial statistical yearbook.

Table 5 - Provincial Capital: Inner Provinces

	Shanxi	Mongolia	Jilin	Heilongjiang	Anhui	Jiangxi	Henan
1984	551.86	311.66	428.79	734.80	581.47	427.52	948.17
1985	615.92	346.65	469.38	808.89	635.03	464.30	1,035.86
1986	678.97	377.04	508.73	890.93	697.43	506.72	1,118.61
1987	749.62	408.31	556.78	976.39	757.44	555.15	1,218.02
1988	815.57	457.03	611.60	1,061.99	817.95	616.64	1,348.30
1989	880.04	503.51	664.57	1,149.40	869.39	670.86	1,477.81
1990	945.64	552.26	729.40	1,243.89	924.98	711.58	1,601.70
1991	999.05	602.36	793.70	1,327.08	977.55	759.16	1,739.91
1992	1,072.37	676.25	857.65	1,421.00	1,054.28	839.84	1,928.65
1993	1,162.18	773.60	941.40	1,535.50	1,168.33	956.77	2,123.14
1994	1,269.62	866.68	1,039.29	1,652.16	1,324.83	1,077.05	2,337.68
1995	1,363.06	959.21	1,148.06	1,778.94	1,513.88	1,203.94	2,604.98
1996	1,464.97	1,066.32	1,286.46	1,914.62	1,731.00	1,337.91	2,901.70
1997	1,584.91	1,174.35	1,388.89	2,048.90	1,969.28	1,490.94	3,235.37
1998	1,760.01	1,289.11	1,509.10	2,228.24	2,207.69	1,649.95	3,611.61

	Hubei	Hunan	Guizhou	Yunan	Shaanxi	Gansu	Qinghai
1984	764.74	528.86	231.23	304.41	579.42	302.78	133.86
1985	836.76	567.49	255.74	336.02	645.37	329.87	151.13
1986	907.78	616.76	281.26	368.47	711.95	365.41	164.45
1987	981.94	673.48	308.56	397.95	783.06	399.04	182.92
1988	1,081.19	740.63	338.17	435.71	860.17	440.24	204.08
1989	1,143.07	789.85	368.78	475.55	967.72	486.50	211.55
1990	1,224.11	833.81	394.95	514.13	1,042.14	537.21	219.14
1991	1,305.92	890.97	422.61	569.86	1,122.55	587.76	228.37
1992	1,413.81	972.07	455.61	644.54	1,196.29	642.42	238.11
1993	1,577.95	1,080.60	496.40	745.06	1,308.08	704.25	251.81
1994	1,797.22	1,210.82	532.83	845.87	1,428.95	767.84	264.77
1995	2,042.74	1,360.08	588.21	941.05	1,561.70	838.22	280.61
1996	2,306.22	1,502.81	646.81	1,045.85	1,697.25	915.48	298.90
1997	2,602.39	1,657.80	715.34	1,168.04	1,820.62	1,006.89	321.70
1998	2,928.73	1,841.75	799.44	1,306.07	1,979.73	1,111.78	348.01

	Ningxia	Xinjiang	Guangxi	Sichuan	Tibet
1984	119.98	296.43	294.64	851.76	70.87
1985	131.96	329.15	327.25	914.05	88.99
1986	147.06	360.62	362.66	982.39	95.63
1987	162.70	395.56	398.04	1,061.71	104.92
1988	181.74	438.28	434.72	1,147.21	112.40
1989	199.52	486.60	465.07	1,222.49	126.98
1990	216.63	537.11	488.58	1,293.13	136.89
1991	233.46	593.85	521.39	1,371.89	157.17
1992	250.88	678.69	582.57	1,483.35	177.92
1993	271.88	788.97	669.24	1,598.45	197.62
1994	291.00	917.24	767.02	1,735.89	218.04
1995	310.21	1,017.13	883.29	1,905.86	234.50
1996	331.86	1,098.76	981.50	2,097.12	249.49
1997	353.90	1,200.80	1,069.93	2,338.72	261.17
1998	382.22	1,330.91	1,178.76	2,602.61	

Source: Various issues of China’s provincial statistical yearbook.

D. Provincial Sources of Finance

Most provinces have their provincial total investment in fixed assets (TIFA) and the four sources of finance (SA, DL, FI and SRF) for the period 1985-1998, with the following exceptions.[2] Mongolia's data covers 1985-1996, while Tibet, Shanghai and Guangxi have only 1995-1997 figures. Fujian has only 1996 data. Guangdong's provincial TIFA data began from 1990. Sichuan's missing data included 1993-1995 and 1997-1998. Lastly, Qinghai's data began from 1987. The provincial GDP deflators are used to deflate the nominal provincial TIFA figures to obtain the provincial RTIFA figures.

Previous procedures are repeated in order to obtain I^*_{ijt} for the provinces, with different intercept and coefficients in Equation (8). Equation (10) is used to construct the initial K_{ijt} (t = 1984) for each province; the period used is 1985-1988. These ratios confirm that SRF is the largest source among the four sources (with the smallest of 0.38 for Qinghai and largest of 0.70 for Hunan), followed by DL (smallest of 0.10 for Henan, largest of 0.31 for Shanxi), SA (smallest of 0.05 for Zhejiang, largest of 0.23 for Gansu) and FI (smallest of 0.00 for Shanxi and Guizhou, largest of 0.13 for Shandong).

Equation (13), which is similar to Equation (11), is used to add the provincial I^*_{ijt} to the provincial initial K_{ijt} (t = 1984) and to obtain a sequence of provincial capital stock for the four sources for the period 1984-1998. These capital-stock figures cover ten coastal and fifteen inner provinces (due to incomplete data, Tibet, Guangdong, Guangxi, Fujian and Shanghai are excluded).[3]

$$K_{ijt} = K_{ijt-1} + I^*_{ijt}. \qquad (13)$$

Chow and Li (2002) constructed the capital-stock series based on national aggregate data. This paper constructs three additional series from the four sources of finance, from provincial capital, and from provincial sources of finance.

[2] Provincial sources of finance data are too numerous to report here but are available upon request.
[3] These capital figures are not included in this paper, but are available upon request.

III. Production Function: Aggregate and by Source

A Cobb-Douglas production function is employed to estimate the extent of technical progress, provincial differences, and impact of the four sources of finance. In the following two Cobb-Douglas equations, a trend variable, T (with 1978 = 1 and 1985 = 1 respectively in Equations (14) and (15)), is included with the GDP and labor force (L) data (*SYC* 1999, p. 55, 58 and 155, and provincial statistical yearbooks).

$$Ln\ (\text{GDP/L})_{jt} = \alpha_0 + \alpha_1\ ln\ (\text{K/L})_{jt} + \alpha_2\ \text{T}; \tag{14}$$

$$Ln\ \text{GDP}_{jt} = \beta_0 + \beta_1\ ln\ \text{L}_{jt} + \beta_2\ ln\ \text{SA}_{jt} + \beta_3\ ln\ \text{DL}_{jt} + \beta_4\ ln\ \text{FI}_{jt} + \beta_5\ ln\ \text{SRF}_{jt} + \beta_6\ \text{T}. \tag{15}$$

Constant returns to scale are assumed in Equation (14) (see Chow and Li 2002). Equation (15) breaks down the regression by looking at the impact of individual sources of finance together with the labor variable.

The functional form for the sources of finance raises a multiplicative relationship. In some ways, state appropriation and domestic bank loans complement each other because state-owned enterprises in China can secure funds from either source. Grouping these two sources will give three substitutable sources of finance: state funding (state appropriation and domestic bank loans), non-state funding (self-raised funds) and foreign direct investment.

In the marketization and economic liberalization process, the complementary relationship still exists between state appropriation and domestic bank loans because state-owned enterprises have to account for the fund used, and domestic bank loans, which require repayment, are rapidly replacing state appropriation, which is a state support. Non-state-owned enterprises can secure loans either from domestic banks, local governments or bonds raised in the market. Self-raised funds are substitute to state appropriation because the former is raised through the market and increasingly output efficiency will become the criterion for securing funding. Beginning from the early 1990s, especially along the coastal regions, national domestic banks charge a higher interest rate on loans given to non-state-enterprises. Since foreign direct investments are competitive source of finance, they normally go to non-state-owned enterprises and definitely are substitute to all the three other local sources of finance.

In Chow and Li (2002), the estimates of α_1 and α_2 (and their standard errors) are 0.6284 (0.0258) and 0.0262 (0.0024). After adjusting for serial correlation, Chow and Li (2002) conclude that an average of three percent productivity growth since China's economic reform in the period 1978-1998 is reasonable. In order to examine the consistency between the national aggregate stock derived in Table 1 and the capital stock derived from the four sources of finances in Table 3, the coefficient estimates in Equation (14) are tested for the period 1952-1998, with the capital stock for the period 1952-1979 (with the exclusion for the Cultural Revolution years of 1958-1969, as in Chow 1993) from Table 1 and for the period 1980-1998 from Table 3. This estimated production function is shown by regression 1 in Table 6. This result is acceptable since it is close to the estimates in Chow and Li (2002).

Coastal provinces are expected to perform better than inner provinces. This can be seen from the growth rate between the two types of provinces. Using the result in Chow and Li (2002) and setting the coefficients of α_1 and α_2 in Equation (14) equal to 0.6 and 0.3, respectively, the following equation is applied to find the K/L value of individual provinces:

$$(ln\ K/L_{j,\ 1998} - ln\ K/L_{j,\ 1984}) / 14. \qquad (16)$$

There is a total of 14 years in the sample, with the exception of Shanghai and Tibet that had only 13 years. Assuming Equation (16), which gives the increase in K/L between 1998 and 1994, produces an estimate of 0.08, the contribution to GDP/L from the Cobb-Douglas production function is 0.078 (= 0.6x0.08 + 0.03); or, output is growing at an annual rate of 7.8 percent for that particular province. Table 7 shows these calculations for each province for the period 1984-1998. The eleven coastal provinces generally experienced a higher growth rate than the inner regions, with an average of 9.18 percent. Although the average of the nineteen inner provinces amounted to 6.98 percent, the difference is only 2.2 percent. Given a constant α_1 and α_2, these differences reflect the difference in their capital stocks.

The provincial capital stock (Tables 4 and 5) is used to estimate regressions 2 and 3 in Table 6. A coastal dummy is included in regression 3. Regression 2 in Table 6 gives a slightly larger estimate of α_1 and a lower trend estimate, suggesting that the capital-stock series derived from provincial data tends to be lower than the capital-stock series derived from national aggregates. Regression 3 uses a coastal dummy, with a value of unity if *j* is a coastal province and zero if it is an inner province. The regression estimates confirm that the coastal provinces are more productive than inner provinces by about 36.1 percent. With the coastal dummy, the estimate of α_1 is slightly smaller, suggesting that the capital stock played a weaker role when a distinction is made between the coastal and inner regions. The trend estimate of 3.38 percent is slightly larger than the 3 percent reported in Chow and Li (2002), confirming and thus reinforces the difference in total factor productivity between the regions.

The capital-stock series derived from the provincial sources of finance is used to estimate regressions 4 and 5 in Table 6, with a coastal dummy included in regression 5. The coastal dummy improved the results in several ways. Regression 5 shows constant returns to scale (the estimates of the labor and the four sources of capital stocks sum to 1.0977, and 0.6252 when labor are excluded). The SRF coefficient is the largest, taking about 0.5880 (0.3676/0.6252) of the impact on output, suggesting that SRF probably exhibits at best constant returns, since SRF comprises about 50 to 60 percent of total investment in fixed asset (see Table 2). The impact of SA is about 0.2047 (0.128/0.6252), suggesting that SA is still an important variable in the inner provinces where the state sector is important. Furthermore, SA will be used to build up infrastructure and social capital that may require a long payback period. A low coefficient estimate is reasonable. The performance of DL is weak, as its impact is about 0.0646 (0.0404/0.6252). The provision of DL by state banks has not been productive. This is probably due to its persistent high level of non-performing loans and the “soft” nature of bank loans in supporting state organizations. The performance of FI is strong, as it takes 0.1426 (0.0892/0.6252), or 14.26 percent, of the total impact, bearing in mind that it has the smallest value among the four sources.

Table 6 – China Productivity Based on Provincial and Sources of Finance Data.

Regression	Intercept	*Ln* (K/L)	*Ln* Lab	*Ln* SA	*Ln* DL	*Ln* FI	*Ln* SRF	Trend	Coastal	R^2/s/DW
1. Time series	1.6694*	0.6272*						0.0267*		0.9948/0.0439/
1952-57, 70-98	(0.1869)	(0.0243)						(0.0028)		0.0679
2. Panel data	1.3074*	0.6991*						0.0245*		0.8308/0.2877/
1984-98	(0.1490)	(0.0174)						(0.0034)		0.101
3. Panel data	2.2217*	0.5749*						0.0338*	0.3610*	0.8734/0.2489/
1984-98	(0.1489)	(0.0182)						(0.0031)	(0.0294)	0.151
4. Panel data	2.4196*		0.3994*	0.0450	0.1089⊆	0.1087*	0.4414*	0.0128*		0.9390/0.2341/
1984-98	(0.2471)		(0.0297)	(0.0329)	(0.0478)	(0.0201)	(0.0577)	(0.0036)		0.162
5. Panel data	2.9263*		0.4725*	0.1280*	0.0404	0.0892*	0.3676*	0.0240*	0.2012*	0.9430/0.2263/
1984-98	(0.2588)		(0.0321)	(0.0358)	(0.0481)	(0.0199)	(0.0576)	(0.0041)	(0.0395)	0.190

Note: The dependent variable for regressions 1, 2 and 3 is *ln* GDP/L. The dependent variable for regressions 4 and 5 is *ln* GDP.
* and ⊆ = statistically significant at 1% and 5% level, respectively.

Table 7 - Growth in Provincial GDP: 1984-1998.

Coastal Province	Growth Rate	Inner Province	Growth Rate
Zhejiang	10.25	Xinjiang	9.31
Hainan	9.98	Tibet	8.95
Shangai	9.82	Mongolia	8.44
Jiangsu	9.64	Hubei	8.33
Fujian	9.47	Yunnan	8.09
Beijing	9.28	Heibei	7.97
Liaoning	8.94	Guangxi	7.46
Tianjin	8.91	Jiangxi	7.44
Guangdong	8.54	Anhui	6.82
Shandong	8.15	Hunan	6.78
Average	9.18	Shaanxi	6.70
		Shanxi	6.68
		Henan	6.68
		Gansu	6.54
		Jilin	6.44
		Sichuan	6.42
		Guizhou	6.28
		Heilongjiang	5.67
		Ningxia	5.38
		Qinghai	4.28
		Average	6.98

One can extend the analysis to take into account the relative size of the four capital sources. As the period under investigation is 1984-1998, the year 1991 can conveniently be used as the median year and the proportions for the four capital sources can be calculated. The latter are 0.16 for SA, 0.17 for DL, 0.048 for FI and 0.608 for SRF (see Table 3). Dividing the coefficient estimates in regression 5 by these ratios, we find that the impact of SA is 0.8 (0.1280/0.16), SRF is 0.6046 (0.3676/0.608), DL is 0.2376 (0.0404/0.17) and FI is 1.8583 (0.0892/0.048). These calculations show that although the impact of SA is even higher (0.8 > 0.2047), its impact is similar to SRF (0.6046), suggesting that state influence is still high in both components, since a considerable amount of SRF comes from local government sources. FI is the only capital source that produces an increasing return to scale and is most efficient. DL is still the least efficient, suggesting that bank reform is urgently needed.

IV. Conclusion

Although a number of studies attempted to estimate China's capital stock based on sectoral or industrial figures (Jefferson, Rawski and Zheng 1996, Jefferson, Rawski, Wang and Zheng 2000), a reliable measurement on China's capital stock can be constructed from national and provincial GDP and sources of investment figures. GDP figures are more comprehensive and should produce a more accurate capital-stock series.

Among the four investment sources, foreign direct investment should be emphasized, as it is the most efficient source. Institutional rigidities have to be removed in order to attract more foreign direct investment. Private funds produce only a constant return to scale, suggesting there is room for improvement in their efficient usage. State support will still be required, especially in the poorer regions, but should allow a greater degree of marketization and liberalization as reform progresses. Reform of banking practices is urgently needed if bank loans are to contribute positively and efficiently to output and productivity. The presence of bank debts and non-performing loans lowers productivity. Ultimately, banks must behave like a banking firm and should not be tided with the debt burden of state-owned enterprises.

Productivity on coastal provinces is in general higher than in the inner provinces. This is because coastal provinces pursued economic reform earlier and faster than did the inner provinces. Coastal provinces have attracted more foreign direct investment than have the inner provinces, which remain highly reliant on state funding support.

We recognize various drawbacks in this paper. One is the accuracy of Chinese data. This paper concerns the past trends of the variables and their results would not be affected by biases in the levels of the variables as long as the variables are persistent. The possibility of the endogeneity of the explanatory variables is the second problem, but this problem may not be serious because both capital and labor appear to be exogeneous and not influenced by output. The simple Cobb-Douglas construction we used cannot isolate the contributions of human capital, technological change and improvements in allocation efficiency to output growth, but provides an embracing result on China's productivity.

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