CAPITAL FORMATION AND ECONOMIC GROWTH IN CHINA*

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First, production functions are estimated for China's aggregate economy and for the five sectors—agriculture, industry, construction, transportation, and commerce—using annual data (some constructed by the author) from 1952 to 1980. Then, this paper measures the contribution of capital formation to the growth of these sectors, the effects of the Great Leap Forward of 1958–1962 and of the Cultural Revolution of 1966–1976 on outputs, the impact of economic reforms since 1979 on growth, the rates of return to capital, and the effects of sectorial growths on relative prices.

I. INTRODUCTION

The economic development strategy of the People's Republic of China during the three decades beginning in the early 1950s is characterized by a high rate of capital accumulation at the expense of consumption and the promotion of industry at the expense of agriculture. This paper describes the growth, fluctuations, and the allocation of resources among sectors of the Chinese economy guided by such a development strategy. To what extent has capital formation in the economy and in the five productive sectors of agriculture, industry, construction, transportation, and commerce contributed to economic growth? To what extent have outputs in the economy and in the five sectors been affected by the political disturbances of the Great Leap Forward of 1958–1962 and the Cultural Revolution of 1966–1976? What are the impacts of the economic reforms beginning in 1979 on national income and income originating in the five sectors? What have been the rates of return to capital in the economy and in the five sectors? What have been the marginal products of labor? How have the relative

*The author would like to thank President Huang Da of the People's University and China Statistical Information and Consultancy Service Centre, Beijing, for supplying unpublished official data, Jianping Mei, Gordon Rausser, two anonymous referees, and Olivier Jean Blanchard for helpful comments, and Princeton University's John M. Olin Program for the Study of Economic Organization and Public Policy, and the National Science Foundation for financial support. This paper was presented before the Conference on Investment, Trade, and Economic Development sponsored by the Institute for the Study of Free Enterprise Systems of the State University of New York at Buffalo on May 26, 1990, and before the International Conference on Quantitative Economics and Its Applications to Chinese Economic Development and Reform in the 1990s organized by the Institute of Quantitative & Technical Economics of the Chinese Academy of Social Sciences in Beijing on June 26, 1990. Comments from the participants at these conferences are gratefully acknowledged.

The Quarterly Journal of Economics, August 1993

growths of the five sectors affected the relative prices of their outputs? How was the high rate of capital formation financed? These are the major questions to be discussed.

To answer these questions, I rely on official data provided by the State Statistical Bureau. Most of the data used can be found in *Statistical Yearbook of China, 1989,* Chinese edition (to be abbreviated as *SYC89*), and the remainder are obtained by private communications with the State Statistical Bureau. I have discussed the quality of official Chinese Statistics in Chow [1986, pp. 193–94], where supporting evidence is provided for my judgment that official statistical reporting in China is by and large honest. Several factors in the collection of statistics affect their quality: the limited training of the officials, the limited financial resources of the State Statistical Bureau which is responsible for directing all activities in the collection, processing, storage, and distribution of statistics, possible political pressures to falsify statistics by the reporting units (e.g., rural communes eager to fulfill production targets during the Great Leap of 1958–1962), and on the positive side the ability of the government to reach its population at the level of city blocks and families. I have found Chinese statistics, by and large, to be internally consistent and accurate enough for empirical work after using them to study the Chinese economy in general in Chow [1985a], and to estimate a simple multiplier-accelerator model of the macroeconomy in Chow [1985b] and an econometric model of inflation in Chow [1987]. In this paper further cross-checks will be provided to ensure that the data are internally consistent and reasonable from our understanding of the economy.

In Section II some important facts concerning the growth of China's national income will be stated. Section III explains how data on capital stock are estimated. By using a one-sector model, Section IV discusses the role of capital formation on economic growth, the effects of major political disturbances and of economic reform on national output, the degree of technological change, and the marginal productivity of capital in the economy. By estimating production functions of five sectors, Section V discusses the above issues for each sector as well as the allocation of resources and pricing among the sectors. Section VI shows briefly how consumption expenditures are controlled and funds are made available for capital accumulation. A summary of findings will be provided in Section VII.

II. Growth of National Income and its Components

Chinese national income consists of net material output from the five productive sectors mentioned above. National income in constant prices is computed as the weighted sum of the real outputs of the five sectors using base-period prices as weights. Needless to say, prices are subject to government control. Base-period prices for real national income from 1949 to 1957 are 1952 prices; 1957 prices serve from 1957 to 1970; 1970 prices serve from 1970 to 1980; and 1980 prices serve from 1980 to 1988. From 1952 to 1980 the index of real national income increased from 100 to 516.3, or at an average annual rate of 0.060. Much of this growth can be attributed to the rapid growth of industry starting from a small base and the large price weights given to it.

The growth rates of the five sectors are uneven, as shown by the indices of real output given in Table I [*SYC89,* p. 30]. The industry sector grew the most rapidly, followed by construction and transportation. The agriculture sector grew the most slowly. Since prices of industrial products declined relative to prices of agricultural products, and industrial output grew much more rapidly, national income estimated by using end-of-period prices instead of beginning-of-period prices would give smaller weights to industrial products and show a smaller rate of annual growth than 0.06. For example, by using 1980 prices (as revealed by the current-value national incomes in the five sectors) to weigh the real output indices for the period 1970–1980, 1970 prices for the period 1957–1970, and 1957 prices for the period 1952–1957, one finds the resulting real national income index to have grown at an annual rate of growth of 0.054 instead of 0.060. Liu and Yeh [1963, pp. 32–33] point out that prices of agricultural products were depressed in 1952 as compared with industrial products by government policy. This would lead to a high rate of growth of estimated real national income beginning in 1952.

A second measure of economic growth is "national income available" consisting of its two components: consumption and accumulation. It equals national income plus imports minus exports plus statistical discrepancies. During the period 1952–1980 the fraction of national income available devoted to accumulation averaged to about 0.30. The official index of real consumption, exhibited in Table III, shows an increase from 100 in 1952 to 380.8 in 1980, or an average annual rate of increase of 0.049. This rate of increase slower than the 0.060 rate for real national income reflects

TABLE I
INDICES OF REAL NATIONAL INCOME

Year	National income	Agri-culture	Indus-try	Construc-tion	Transpor-tation	Commerce
1952	100.0	100.0	100.0	100.0	100.0	100.0
1953	114.0	101.6	133.6	138.1	120.0	133.0
1954	120.6	103.3	159.1	133.3	136.0	136.4
1955	128.3	111.5	169.1	152.4	140.0	137.5
1956	146.4	116.5	219.1	261.9	164.0	146.6
1957	153.0	120.1	244.5	242.9	176.0	146.6
1958	186.7	120.3	383.5	367.0	270.8	155.9
1959	202.0	100.6	501.5	388.6	356.5	170.3
1960	199.1	83.6	541.4	394.0	383.6	164.1
1961	140.0	84.7	315.9	129.5	221.1	130.1
1962	130.9	88.7	267.4	161.9	171.5	117.7
1963	144.9	98.9	300.7	205.1	176.0	120.8
1964	168.8	111.9	374.9	259.0	198.6	123.9
1965	197.4	122.9	477.7	286.0	261.7	128.0
1966	231.0	131.9	598.5	313.0	297.8	155.9
1967	214.3	134.2	504.3	296.8	239.2	164.1
1968	200.3	131.6	458.6	237.5	225.6	151.8
1969	239.0	132.2	622.3	323.8	284.3	179.6
1970	294.6	139.8	863.0	421.0	343.0	199.2
1971	315.3	142.0	979.0	468.3	370.8	201.2
1972	324.3	140.5	1043.5	452.5	389.3	208.0
1973	351.2	153.1	1134.3	457.8	412.5	224.5
1974	355.2	159.2	1128.9	484.1	394.0	220.6
1975	384.7	162.3	1297.3	542.0	444.9	220.6
1976	374.5	159.1	1249.2	568.3	426.4	214.8
1977	403.7	155.1	1434.0	578.8	491.3	242.0
1978	453.4	161.2	1679.1	573.5	546.9	296.4
1979	485.1	171.5	1814.7	584.1	560.8	316.8
1980	516.3	168.4	2012.7	757.7	584.0	318.8
1981	541.5	180.4	2046.8	770.0	607.2	379.4
1982	585.8	201.6	2170.1	806.9	681.3	397.5
1983	644.2	218.7	2383.7	954.3	755.5	449.1
1984	731.9	247.0	2738.8	1056.7	852.8	499.5
1985	830.6	253.7	3275.2	1310.6	1024.3	593.7
1986	894.5	261.4	3590.6	1540.0	1140.2	636.3
1987	985.7	273.2	4058.8	1744.8	1269.9	715.0
1988	1095.1	279.4	4765.0	1884.0	1413.6	760.8

the government policy of restricting consumption to achieve accumulation. The fraction of real national income available devoted to consumption has declined. In 1952 consumption was 477 (100,000 RMB), or 0.786 of national income available. If one estimates real national income available in 1952 prices, for which there are no official data, by using the implicit price deflator for national income, one obtains an estimator of 3047.6 for 1980 (implying an average annual growth rate of 0.0593) and a ratio 0.596 of real consumption to real income available. In current 1980 prices, consumption equals 0.685 of national income available, reflecting the larger increases in the prices of consumer goods relative to the prices of capital goods.

Concerning the prices of capital goods, it has been assumed by Jefferson, Rawski, and Zheng [1989, p. 42] that "prior to 1980 changes in investment goods prices were negligible." To check this assumption and the consistency of real national income available as the sum of consumption and accumulation, I have used the implicit price deflator for national income (comparing Tables I and II) to estimate real national income available in 1952 prices. Subtracting consumption in 1952 prices from this series yields a hypothetical series of real accumulation. The ratio of accumulation in current prices to this hypothetical series gives a price index for accumulation, as shown in Table III. This index up to 1983 is not far from unity except for the years 1961–1963. The abnormally low values for 1961–1963 may be partly the result of our overestimating real accumulation during these years of economic collapse as the difference between real national income available and real consumption. Real national income available would be overestimated if its deflator did not move up sufficiently. The above index justifies the assumption to be adopted in this paper that the price index for accumulation goods between 1952 and 1983 remained constant. From 1984 on, the index is assumed to increase at the same rate as the implicit deflator for the construction sector, being 1.057, 1.150, 1.230, 1.345, and 1.531 for 1984–1988, respectively. When the accumulation data are summed over time to form capital stock in the next section, they are deflated only after 1984 as here indicated. Jefferson, Rawski, and Zheng [p. 36] start deflating capital stocks from 1981 on. The difference does not affect the production functions estimated in this paper which use data up to 1980. Using somewhat higher values for the deflator of capital goods would slightly reduce the estimated stocks of capital from

TABLE II
NATIONAL INCOME IN CURRENT PRICES

Year	National income	Agriculture	Industry	Construction	Transportation	Commerce	Per capita national income
1952	589	340	115	21	25	88	104
1953	709	374	156	28	29	122	122
1954	748	388	174	26	32	128	126
1955	788	417	179	30	33	120	129
1956	882	439	212	55	37	139	142
1957	908	425	257	45	39	142	142
1958	1118	440	401	68	59	150	171
1959	1222	376	527	76	78	165	183
1960	1220	332	565	79	84	160	183
1961	996	432	345	25	48	146	151
1962	924	444	303	32	38	107	139
1963	1000	488	337	40	39	96	147
1964	1166	549	422	50	44	101	167
1965	1387	641	505	53	58	130	194
1966	1596	692	606	58	66	164	216
1967	1467	703	505	55	52	172	197
1968	1415	714	449	44	49	159	183
1969	1617	722	587	60	62	186	203
1970	1926	778	789	80	74	205	235
1971	2077	808	891	91	80	207	247
1972	2136	808	942	88	84	214	248
1973	2318	886	1020	92	89	231	263
1974	2348	922	1015	99	85	227	261
1975	2503	946	1152	113	96	196	273
1976	2427	940	1106	120	92	169	261
1977	2644	913	1263	124	106	238	280
1978	3010	986	1487	125	118	294	315
1979	3350	1226	1628	130	121	245	346
1980	3688	1326	1804	185	126	247	376
1981	3941	1509	1840	193	131	268	397
1982	4258	1723	1948	209	147	231	422
1983	4736	1021	2136	259	166	254	464
1984	5652	2251	2516	303	205	377	547
1985	7040	2492	3163	409	259	717	674
1986	7899	2720	3573	514	320	772	747
1987	9361	3154	4262	637	365	943	872
1988	11770	3818	5432	783	438	1299	1081

TABLE III
CONSUMPTION, ACCUMULATION, AND ESTIMATED PRICE INDEX FOR ACCUMULATION

Year	National income available (100 million)	Consumption (100 million)	Accumulation (100 million)	Index of real consumption	Estimated price of accumulation
1952	607	477	130	100.0	1.000
1953	727	559	168	111.0	1.056
1954	765	570	195	112.5	1.027
1955	807	622	185	122.7	0.981
1956	888	671	217	132.1	0.912
1957	935	702	233	137.2	0.852
1958	1117	738	379	142.6	0.906
1959	1274	716	558	135.9	0.942
1960	1264	763	501	129.6	0.839
1961	1013	818	195	117.6	0.702
1962	948	849	99	124.1	0.497
1963	1047	864	183	138.8	0.791
1964	1184	921	263	151.8	0.921
1965	1347	982	365	169.5	1.138
1966	1535	1065	470	182.0	1.047
1967	1428	1124	304	192.2	1.029
1968	1409	1111	298	189.4	1.098
1969	1537	1180	357	203.0	0.966
1970	1876	1258	618	216.0	0.937
1971	2008	1324	684	226.5	0.957
1972	2052	1404	684	239.6	0.936
1973	2252	1511	741	257.1	0.946
1974	2291	1550	741	262.8	0.941
1975	2451	1621	830	274.3	0.912
1976	2424	1676	748	283.1	0.877
1977	2573	1741	832	291.5	0.901
1978	2975	1888	1087	312.9	0.948
1979	3356	2195	1161	346.7	0.961
1980	3696	2531	1165	380.8	0.946
1981	3905	2799	1106	411.0	0.922
1982	4290	3054	1236	441.4	0.902
1983	4779	3358	1421	479.2	0.921
1984	5701	3905	1796	547.4	1.034
1985	7507	4879	2628	633.8	1.198
1986	8492	5548	2944	682.3	1.222
1987	9638	6340	3298	732.1	1.327
1988	12099	7971	4128	791.8	1.447

1981 on and increase the estimates of efficiency improvement following the economic reforms.

III. Data on Accumulation and Estimates of Capital Stock

Since the analysis in this paper is based on the official data on accumulation and the data on capital stock that I have estimated from them, it is important to set forth the nature of these data and the method of estimation. Four sets of official data concerning capital formation will be used in this paper. The first is "accumulation," defined [*SYC87,* p. 798] as

> that part of the national income used for expanded reproduction, nonproductive construction and increase of production and nonproductive stock of the society. Its material form is the newly added fixed assets of material and non-material sectors (less depreciation of the fixed assets) during a given period, and circulating funds. . . . Productive accumulation includes newly added fixed assets of productive use (deducted by the wear of these assets) in material production sectors and the increase in circulating assets held by enterprises, such as stock of materials, fuels, semifinished goods, means of production (finished), stock by commercial departments, reserve of materials and so on. Nonproductive accumulation covers newly added fixed assets of nonproductive use and residential buildings (all deducted by wear and tear), as well as the increase in stock of consumer goods held by industrial enterprises or commercial departments.

I will treat accumulation as a net increase in capital stock.

The second is "newly increased fixed assets," which [*SYC87,* p. 815] "refers to the value of projects completed and put into operation or turned over to use, the purchase of equipment, tools and instruments which meet standards for fixed assets, and other costs. This is a comprehensive indicator, in value terms, of the result of investment in fixed assets. . . ." Note that "newly increased fixed assets" are only fractions of "investments in fixed assets" by Chinese official usage because work performed in investment may not produce results that meet standards for fixed assets, the factions being called "rates of fixed assets turned over to use" and varying for different periods between 60 to 87 percent [*SYC87,* p. 419]. The third and fourth are "net value of fixed assets" and "quota circulating funds" of state-owned enterprises "under the state budget" [*SYC89,* pp. 25–26]. These enterprises are state-owned "enterprises under the management of the financial budget of all levels of government" and "exclude state-owned enterprises outside the state budget as well as non-independent accounting industrial enterprises" [*SYC87,* p. 799]. "Original value of fixed assets refers to the original value of all the fixed assets owned by industrial enterprises, calculated as the cost paid at the time of purchase or construction. . . . Net value of fixed assets is obtained by deducting depreciation over the years from the original value of fixed assets" [*SYC87,* p. 907]. Circulating funds has been defined above in connection with accumulation.

Accumulation data consisting of fixed assets and circulating funds can be found in *SYC89* [p. 42]. From communications with the State Statistical Bureau, I have obtained annual data from 1952 to 1985 on accumulation of fixed assets and of circulating funds by state enterprises, urban collective enterprises, rural collective enterprises, and individuals, as shown in Table IV. My task is to distribute the accumulation of the two kinds of assets by the three types of enterprises (excluding individuals) to the five economic sectors, and to sum these accumulations over time, with appropriate initial values for 1952, to form capital stocks in the five sectors. For fixed assets of state enterprises, I rely on Table 10-28 [*SYC89,* p. 509], which gives "newly increased fixed assets through capital construction" of all state enterprises in the five sectors and other nonmaterial-producing sectors. Annual data from 1953 to 1979 (except 1966–1974) have been obtained from the State Statistical Bureau to supplement the five-year totals given in Table 10-28. Accumulations of fixed assets by state enterprises are divided among five sectors proportionally according to the supplemented table.

For circulating assets of state enterprises, I rely on Table 2-7 [*SYC89,* p. 26], which gives data only for selected years before 1975, annually after 1975, and only for state enterprises "under the management of the financial budget." The ratios in this table are used to distribute the sums, over time, of accumulations of circulating assets of state enterprises among the five sectors. The same method could be applied to estimate fixed assets of state enterprises in the five sectors by using Table 2-5 [*SYC89,* p. 26], on "net value of fixed assets." Table 10-28 is used instead because its coverage of state enterprises is broader than that of Table 2-5 and because annual data are available (except for 1966–1974). A difference between these two tables is that in Table 10-28 "agriculture, forestry, water conservancy and meteorology" are treated as one sector, while in Table 2-5 (and Table 2-7) "agriculture" constitutes a sector. My judgment is that the former sector corresponds more closely to the recorded output of the "agricultural" sector. Table IV shows that state enterprises dominate the two types of collective enterprises in accumulation.

TABLE IV
ACCUMULATION BY THREE TYPES OF ENTERPRISES AND INDIVIDUALS

	State enterprises		Urban collectives		Rural collectives		Individuals
Year	Total	Fixed assets	Total	Fixed assets	Total	Fixed assets	Total
1952	103	43	10	1	15	11	2
1953	142	71	12	3	12	9	2
1954	153	87	25	8	13	10	4
1955	148	91	24	7	11	9	2
1956	145	137	33	7	35	31	4
1957	203	126	3	2	25	10	2
1958	359	259	3	2	13	15	4
1959	523	338	4	2	28	29	3
1960	492	384	5	4	2	9	2
1961	176	135	7	4	10	7	2
1962	62	73	6	4	27	15	4
1963	127	93	6	4	44	30	6
1964	195	149	7	5	51	39	10
1965	291	191	9	6	53	44	12
1966	377	233	15	9	63	50	15
1967	231	136	10	7	48	44	15
1968	229	98	7	5	47	48	15
1969	284	210	10	7	48	46	15
1970	508	331	13	8	79	62	18
1971	564	373	15	10	85	65	20
1972	521	366	21	14	84	77	22
1973	602	375	22	15	94	89	23
1974	570	399	25	18	118	108	28
1975	630	473	27	20	142	124	31
1976	554	443	29	22	134	127	31
1977	616	446	32	24	152	143	32
1978	847	572	36	26	169	150	35
1979	874	590	40	28	178	151	69
1980	863	613	44	30	141	133	117
1981	791	496	48	32	144	127	123
1982	848	650	55	35	197	148	136
1983	961	731	58	38	226	180	176
1984	1162	934	98	53	330	265	206
1985	1920	1335	158	92	325	314	245

Accumulations of fixed assets by urban collective enterprises are distributed 0.77 to industry, 0.03 to construction, 0.045 to transportation, 0.020 to commerce, and 0.045 to agriculture from 1952 to 1977, and from 1978 on by using a table on sectorial

investments by urban collectives obtained from the State Statistical Bureau. The above stated fractions before 1977 are averages for 1978 and 1979. Accumulations of fixed assets by rural collectives are distributed 0.6 to industry, 0.12 to agriculture, 0.04 to construction, 0.04 to transportation, and none to commerce according to fragmentary data for the eighties given in *SYC81* [p. 193], *SYC83* [p. 206], *SYC85* [pp. 297–98], *SYC86* [p. 124], and *SYC89* [p. 559]. Initial values of fixed assets of state, urban-collective, and rural-collective enterprises combined are obtained by expanding the initial values given in Table 2-5 [*SYC89,* p. 25], for state enterprises by the ratios of total accumulations from 1953 to 1957 for the estimated series and the series given in the above table except for agriculture for which no initial value is recorded.

Accumulations of circulating funds by urban and rural collectives are distributed to the five sectors by using as ratios of circulating funds to fixed assets 0.41 for industry, 1.0 in 1952–1975, and 0.8 in 1976–1985 for construction; 0.08 for transportation; 9.0 in 1952–1970, 7.0 in 1971–1979, and 5.0 in 1980–1985 for commerce; and 0.8 for agriculture. These ratios are based on comparison of Table 2-7 and Table 2-5 [*SYC89,* pp. 25–26]. The products of these ratios and the fractions stated in the last paragraph for distributing the accumulations of fixed assets in urban collectives and rural collectives are used as proportions to divide circulating funds in the five sectors. Initial 1952 values of circulating funds of state, urban-collective, and rural-collective enterprises combined are obtained by expanding the initial values given in Table 2-7 [*SYC89,* p. 26] for state enterprises by the ratios of total accumulations from 1953 to 1957 for the estimated series and the series given in the above table, except for agriculture for which no initial value is recorded. The initial capital stock for agriculture in 1952 will be discussed in subsection V.A below. Our estimates of the components of capital stock are given in Table V, with zero initial value for agriculture.

IV. ONE-SECTOR ANALYSIS OF GROWTH, FLUCTUATIONS, AND REFORM

Using the capital stock data of the last section, and the national income (in 1952 prices), and labor force data from *SYC89* [pp. 29–30, 101], presented, respectively, in Tables II, I, and X, one can estimate an aggregate production function to study economic growth, fluctuations, and the effects of economic reform since 1980. For this purpose, land is combined with capital stock.

TABLE V
ESTIMATES OF CAPITAL STOCK IN FIVE SECTORS

Year	Agriculture		Industry		Construction		Transportation		Commerce	
	Total	Fixed	Total	Fixed	Total	Fixed	Total	Fixed	Total	Fixed
1952	0.0	0.0	248.0	158.8	9.0	3.1	152.3	141.9	173.3	11.8
1953	8.2	6.9	299.1	191.9	18.2	6.8	162.6	151.4	228.7	14.4
1954	15.5	12.3	366.3	237.4	27.8	10.8	179.7	167.7	285.3	19.0
1955	24.6	19.9	436.8	288.2	36.9	15.0	198.0	185.4	334.7	22.9
1956	44.5	37.1	539.2	372.3	47.5	23.2	219.3	206.3	356.8	31.0
1957	59.1	47.9	632.0	443.0	59.2	28.2	243.4	229.6	415.1	34.9
1958	85.7	74.9	844.4	614.1	61.6	31.9	287.4	268.4	452.8	41.0
1959	113.9	103.3	1147.8	839.3	67.4	39.8	350.4	321.6	520.0	50.0
1960	152.2	143.2	1436.6	1086.5	73.9	48.2	406.3	371.8	563.7	58.6
1961	170.5	160.2	1545.4	1174.5	76.1	50.4	427.9	391.2	582.4	61.4
1962	189.2	176.2	1600.0	1224.9	79.0	51.7	437.2	400.9	585.0	62.7
1963	220.4	203.8	1682.0	1292.6	83.8	54.6	445.1	410.0	614.0	65.0
1964	254.5	234.7	1805.5	1401.7	91.1	60.0	460.5	426.8	655.2	68.9
1965	287.3	265.2	1957.2	1533.6	100.0	66.5	494.2	463.8	727.8	74.0
1966	319.0	293.2	2198.5	1697.6	108.8	74.2	537.3	502.9	810.2	79.6
1967	338.4	311.4	2352.1	1803.7	114.2	79.4	563.4	526.4	966.1	83.0
1968	353.3	326.5	2496.4	1889.8	118.1	83.8	584.5	544.0	938.5	85.4
1969	379.3	351.8	2682.7	2037.5	125.2	90.8	621.7	579.2	990.6	90.5
1970	422.4	390.3	3001.0	2261.6	137.1	101.2	681.6	634.2	1096.4	98.5
1971	479.0	430.4	3335.8	2511.9	153.8	112.0	759.9	706.0	1202.6	110.3
1972	531.5	471.6	3657.0	2768.7	169.0	123.3	836.2	777.1	1297.1	122.0
1973	590.0	515.0	4015.7	3038.4	186.1	135.3	917.1	850.5	1423.6	134.0
1974	650.8	563.0	4384.2	3334.9	204.0	148.6	1001.5	929.1	1530.2	146.9
1975	722.2	619.7	4805.3	3700.9	225.4	164.8	1092.7	1018.4	1622.3	163.2
1976	804.5	684.2	5239.1	4037.7	246.2	179.7	1185.3	1103.9	1661.8	178.3
1977	870.3	744.1	5661.4	4408.5	261.9	194.2	1263.3	1179.0	1819.8	194.3
1978	1007.9	812.78	6158.5	4826.2	284.6	212.0	1383.6	1299.0	2007.7	213.6
1979	1101.1	887.5	6680.1	5273.3	311.6	232.9	1464.9	1374.6	2200.3	236.8
1980	1165.4	953.3	7126.0	5674.2	351.0	251.2	1551.1	1466.7	2434.2	268.5
1981	1210.9	998.7	7587.3	6025.4	383.2	267.1	1597.5	1515.7	2706.3	299.6
1982	1279.7	1054.0	8060.4	6418.4	414.4	287.1	1686.8	1609.1	2970.1	346.7
1983	1367.0	1134.9	8614.4	6860.3	451.7	309.5	1796.1	1714.1	3193.5	390.8
1984	1435.1	1210.3	9391.4	7406.8	520.5	350.3	1957.4	1867.1	3257.9	444.6
1985	1578.6	1291.6	10514.0	8079.4	606.9	385.1	2205.7	2085.4	3053.5	524.3

Tentatively let the initial capital in agriculture in 1952 be 450 (100 million yuan), which will be justified in subsection V.A below, and let the initial value of land be 720. This value of land is estimated by attributing 0.40 of the agricultural output 340 to land and

assuming an annual yield of 0.19 (the yield is also to be justified in subsection V.A). The total value of capital and land, including 582.67 for nonagriculture as given in Table V, would be about 1750 in 1952, when national income equals 589. The capital output ratio of 1750/589 or 2.97 appears to be a reasonable figure. The sensitivities of our results to the initial capital stock will be examined below.

Figure I plots log (national income/labor) against log (capital/labor) for the years 1952–1985. If the years from 1958 (when the Great Leap began and agricultural output might have been overestimated) to 1969 are omitted, the points from 1952 to 1980 are fairly close to a straight line, as shown in Figure II. Figure I also shows the tremendous economic losses of the Great Leap and the improved productivity from 1981 to 1985 which might be attributed to economic reforms. The estimation of production functions presented below is based on the *assumption* that the years from 1958 to 1969 are abnormal because of the great upheavals of the Great Leap Forward movement and the Cultural Revolution. In 1958 Chairman Mao Zedong launched the Great Leap, reorganized agricultural production into Communes, and demanded unrealistic production targets. The economic failures afterwards are well-recognized historical facts and are demonstrated by Figure I. Figure I shows the agreement of official data with well-established historical evidence. Thus, to exclude the years 1958 to 1969 in estimating an aggregate production function is a reasonable and rewarding procedure. However, if a reader still wishes to question the exclusion of these years, my answer is that it is *interesting* to

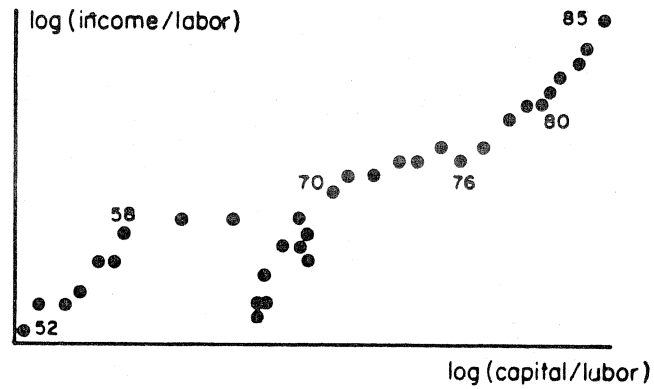

FIGURE I

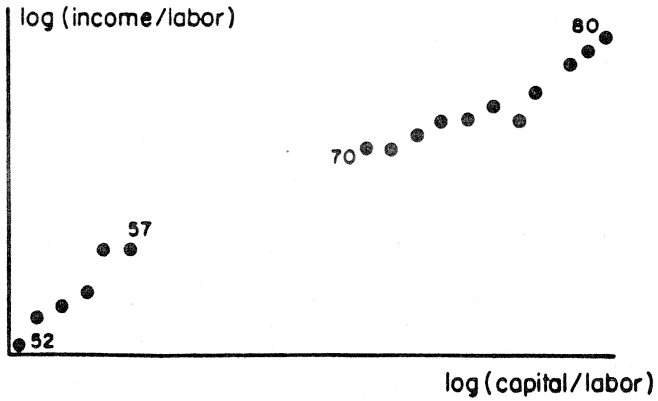

FIGURE II

find out how abnormal the excluded years are *if* the remaining years up to 1980 are *assumed* normal years, as most readers familiar with this period of Chinese history would agree. Data are provided in this paper for any reader who wishes to select some other years as abnormal to draw her own conclusions.

Realizing the possible inaccuracy of the initial stock estimate, I have regressed log income on log capital and log labor from 1952 to 1980, omitting 1958 to 1969, using initial capital stocks ranging from 1550 to 1950 and obtained the results of Table VI. The standard errors (in parentheses) of the coefficients, except for log capital, are very large. The estimates of the coefficient of log labor are unreliable. However, the failure to estimate accurately the relative effects of capital and labor does not prevent the data from

TABLE VI
AGGREGATE PRODUCTION FUNCTIONS

1952 capital	Intercept	Coefficient ln capital	Coefficient ln labor	R^2/s
1550	1.331 (1.007)	0.6952 (0.1939)	0.0232 (0.5755)	0.9953/0.0418
1650	1.428 (1.032)	0.6624 (0.1945)	0.1694 (0.5630)	0.9951/0.0428
1750	1.517 (1.052)	0.6332 (0.1945)	0.2981 (0.5495)	0.9949/0.0436
1850	1.596 (1.069)	0.6074 (0.1941)	0.4108 (0.5357)	0.9947/0.0444
1950	1.666 (1.084)	0.5848 (0.1934)	0.5093 (0.5219)	0.9946/0.0450
2213	1.307 (1.065)	0.6353 (0.1862)	0.3584 (0.5067)	0.9951/0.0427

throwing light on the existence of technological change from 1952 to 1980, the economic losses due to the Great Leap and the Cultural Revolution, the effects of economic reform, and the rates of return to capital. These questions are studied by using 1550, 1750, and 1950 as initial stocks.

The absence of technological change is apparent from Figure Ib. By adding a linear trend to the regressions of log (income/labor) on log (capital/labor) using 1550, 1750, and 1950 as initial capital stock one obtains the results of Table VII. Thus, the absence of technological change is confirmed.

The regressions of Table VII using the logs of ratios to labor impose the constraint that the exponents of capital and labor in the Cobb-Douglas production function sum to one, and yield much smaller standard errors for the capital (and labor, by implication) coefficient, reductions from about 0.19 to about 0.02. While the imposition of this linear restriction reduces the originally large standard errors of the regression coefficients, it hardly affects the goodness of fit of the regression, as measured by the standard deviation s of its residuals. For those who are curious about the effects of omitted observations, I can report, using 1750 as initial 1952 capital stock, that unconstrained estimates of the (log) capital and labor coefficients are −0.233 (0.231) and 2.740 (0.684), respectively, for the sample period 1952–1980, and −0.277 (0.228) and 2.990 (0.626) for the sample period 1952–1985. Constrained to sum to one, the capital coefficient is estimated to be 0.587 (0.067) from the sample of 1952–1980 and 0.682 (0.055) from the sample of 1952–1985. I do not regard these results as very interesting. More interesting are the results reported below when one *assumes*

TABLE VII
AGGREGATE PRODUCTION FUNCTIONS

1952 capital	Intercept	Coefficient ln (cap/labor)	Coefficient trend	R^2/s
1550	2.065 (0.142)	0.5530 (0.0191)		0.9825/0.0411
	2.729 (3.492)	1.2820 (0.5309)	−0.0375 (0.0273)	0.9846/0.0400
1750	1.718 (0.158)	0.5958 (0.0211)		0.9815/0.0422
	0.270 (3.236)	0.8123 (0.4838)	−0.0103 (0.0231)	0.9818/0.0434
1950	1.361 (0.177)	0.6396 (0.0234)		0.9803/0.0436
	2.051 (2.875)	0.5379 (0.4234)	0.0045 (0.0188)	0.9804/0.0450
2213	1.328 (0.168)	0.6317 (0.0219)		0.9823/0.0413
	0.336 (2.878)	0.7749 (0.4155)	−0.0065 (0.0187)	0.9825/0.0426

the years 1958–1969 to be abnormal and ends the sample period in 1980 in order to see what the data for the unfitted years would look like.

Table VIII presents the deviations of observed real incomes from the estimates by the regression equations of Table VI as fractions of the latter, using 1550, 1750, and 1950 as initial capital stock. Estimates of the loss of national income range from 0.30 to 0.26 in 1961, from 0.36 to 0.32 in 1962, from 0.31 to 0.28 in 1963, are insignificantly small in 1966, increase to approximately 0.14, 0.23, and 0.12 in 1967–1969, and decrease to zero in 1970. The effect of economic reforms on total productivity is about 0.04 in 1981, 0.07 in 1982, 0.12 in 1983, 0.20 in 1984, and 0.30 in 1985. The marginal product of one yuan of capital ranges from 0.19 to 0.28 in 1952 and from 0.12 to 0.15 in 1980. In 1985 it rises to about 0.125×1.293 or 0.16, when the effect 0.293 due to economic reforms is incorporated.

The results of regressions using 1750 as initial capital remain almost identical if, instead, the capital stock is estimated simply by summing the accumulation data of Table III, with 2213 as the initial capital in 1952 (2213 being 1750 times 1.26457, the ratio of total accumulations of the two series from 1953 to 1985). The last of aggregate production functions in Tables VI and VII marked with 2213 initial capital employs this alternative capital series. When this series is linked in 1985 with the original series (with 1750 initial capital), the percentage deviations of national income from the regression (with 1750 initial capital) for 1985 to 1988 are, respectively, 0.293, 0.301, 0.344, and 0.400.

The aggregate production function obtained by using a capital stock series that is simply the sum of official data on accumulation (meaning "net" addition to capital) yields the important conclusion that technological progress was absent in 1952–1980, as seen in the bottom row of Table VII. This conclusion may be questioned because official data on accumulation may be overestimated due to the low depreciation rates employed. Overestimation of capital stock growth would lead to underestimation of technical progress, as illustrated by the three regressions with trend in Table VII using three different initial values of capital that correspond to three (decreasing) sets of rates of capital accumulation. There are two responses to this question. First, plausible magnitudes of official underestimation of the depreciation rate, or overestimation of capital stock growth, is unlikely to change this conclusion as a

TABLE VIII
PERCENTAGE DEVIATIONS OF NATIONAL INCOME AND MARGINAL VALUE PRODUCT OF CAPITAL

1952 capital	Deviations of national income			Marginal value product of capital		
	1550	1750	1950	1550	1750	1950
1952	−0.074	−0.061	−0.085	0.285	0.232	0.193
1953	−0.004	−0.009	−0.018	0.278	0.228	0.191
1954	−0.010	−0.010	−0.010	0.271	0.223	0.187
1955	−0.006	−0.002	0.001	0.264	0.218	0.184
1956	0.070	0.075	0.075	0.258	0.214	0.181
1957	0.050	0.057	0.062	0.251	0.210	0.179
1958	0.169	0.157	0.148	0.242	0.208	0.181
1959	0.139	0.145	0.153	0.231	0.195	0.169
1960	0.021	0.048	0.069	0.222	0.186	0.160
1961	−0.304	−0.280	−0.262	0.219	0.183	0.157
1962	−0.360	−0.339	−0.323	0.217	0.182	0.156
1963	−0.311	−0.291	−0.276	0.815	0.181	0.156
1964	−0.228	−0.210	−0.197	0.211	0.180	0.156
1965	−0.139	−0.123	−0.110	0.207	0.177	0.155
1966	−0.522	−0.037	−0.026	0.202	0.174	0.153
1967	−0.152	−0.143	−0.136	0.199	0.173	0.152
1968	−0.234	−0.230	−0.227	0.196	0.171	0.152
1969	−0.121	−0.122	−0.123	0.193	0.170	0.152
1970	0.017	0.014	0.011	0.188	0.167	0.150
1971	0.022	0.016	0.012	0.183	0.163	0.147
1972	−0.005	−0.006	−0.007	0.179	0.159	0.143
1973	0.017	0.017	0.016	0.175	0.155	0.140
1974	−0.025	−0.025	−0.025	0.171	0.152	0.137
1975	0.001	0.001	0.001	0.167	0.149	0.135
1976	−0.071	−0.071	−0.070	0.163	0.146	0.132
1977	−0.047	−0.046	−0.044	0.160	0.143	0.129
1978	0.006	0.011	0.013	0.156	0.139	0.126
1979	0.024	0.026	0.028	0.152	0.136	0.124
1980	0.040	0.038	0.037	0.150	0.135	0.123
1981	0.044	0.038	0.033	0.147	0.133	0.121
1982	0.081	0.068	0.060	0.144	0.131	0.121
1983	0.137	0.121	0.110	0.142	0.129	0.119
1984	0.231	0.207	0.190	0.139	0.128	0.118
1985	0.324	0.293	0.271	0.136	0.125	0.116

comparison of the above three regressions suggests. Second, the conclusion that there was no technical progress according to official statistics is itself interesting. The Chinese government has reported a great deal of capital accumulation. To find out that such accumulated capital does not lead to improved total productivity in the period 1952–1980 is an interesting result. This result is consistent with the official data cited in Chow [1985a, p. 123], where a plot of log of output per worker against log of recorded capital per worker for state industrial enterprises in seven selected years from 1952 to 1981 is very close to a straight line, with a slope of 0.602 (0.027). The seven years 1952, 1957, 1965, 1975, and 1979–1981 were selected because data for other years were not published in 1983 when Chow [1985a] was written.

Since the absence of technological progress in China from 1952 to 1980 is a major conclusion of this paper, and the conclusion is reached by regression analysis using the Cobb-Douglas production function with an exponential trend included, one should look at the data differently and examine the robustness of this conclusion. Because of the high correlation between the capital stock and the trend variables, it might be difficult to assess accurately their relative importance in explaining the growth of output in time-series analysis. Note, however, that in spite of the high correlation, our time-series data did eliminate the trend variable as insignificant while maintaining the significance of the capital stock variable. Before providing additional evidence, consider some basic facts concerning the growth accounting for the aggregate Chinese economy. The exponential rates of growth of output, capital (1750 in 1952) and labor according to the data used to estimate the aggregate production functions of Table VII are, respectively, 0.05863, 0.07374, and 0.02553, implying annual growth rates of 6.04, 7.65, and 2.59 percent. Weighting the exponential rates of capital and labor by 0.6 and 0.4, respectively, would generate an exponential growth rate of output of 0.0545, almost sufficient to explain the observed rate of 0.0586. The above are growth rates computed from endpoints of the data. If we regress log output minus 0.6 log capital minus 0.4 log labor on trend using data from 1952 to 1980 (omitting 1958–1969), the coefficient of the trend variable is −0.00022 with a standard error of 0.00101. Changing the coefficient of log capital to 0.5, 0.4, and 0.3, with the coefficient of log labor being 0.5, 0.6, and 0.7 would yield trend coefficients of 0.0045 (0.0010), 0.0093 (0.0010), and 0.0141 (0.0010). The standard errors of the regressions for capital exponent of 0.6, 0.5, 0.4, and 0.3 are, respectively, 0.04220, 0.04253, 0.04293, and 0.04356. Thus, the goodness of fit becomes worse as the capital exponent decreases from 0.6.

To provide cross-sectional evidence for using a capital exponent of 0.6, which would imply the absence of technical progress, I first cite the study of Mankiw, Romer, and Weil [1992, Table 1], where, using the framework of a Solow model and cross-country data for 98 nonoil countries and 75 OECD countries, the authors found a capital coefficient of 0.60 (0.02) and 0.59 (0.02), respectively. Second, using the share of labor income to total income in China, one may consider a year 1953 when the economy was still mostly a market economy. In 1953 the wage income of the nonagricultural labor force was 179 (see Table XVI and the discussion of Section VI below), while the total national income from the four nonagricultural sectors was 335 (see Table II), implying a labor share of 0.53. Similar calculations for 1967 and 1970 give labor shares of 0.44 and 0.32, respectively. One might argue that these low labor shares are the result of deliberate government policy to restrict labor income in order to finance a high rate of capital formation, but even a 0.5 coefficient for labor would imply less than one half of 1 percent annual growth contributed by technological progress.

Third, a cross-section estimate of the labor share in Chinese agriculture for the period 1921–1924 can be obtained from the classic study of Buck [1930]; who surveyed 2866 farms in seventeen localities and seven provinces in China. Total farm receipts (including value of products from the farm used by the family) averaged 376.24 yuan [p. 86]. Value added per farm is obtained by subtracting cash expenditures 40.11 other than expenditures on labor [p. 86], yielding 336.13 yuan. Expenditures on hired labor plus imputed value of family labor equals 24.87 plus 64.22 or 89.09 [p. 86], which does not include the value of the labor of the farm operator [p. 75]. To include the latter, note that there were 2.29 man-equivalent workers per farm [p. 50], which I translate to 3.29 working persons including the farm operator. Multiplying labor cost 89.09 by 3.29/2.29 gives 127.99. The labor share is 127.77/336.13 or 0.38, close to the 0.40 figure used in our analysis.

V. Analysis of Five Sectors

Estimates of capital stocks presented in Table V, net output data in Table I, and labor force data in *SYC89* [pp. 102, 105],

supplemented by communication with the State Statistical Bureau as presented in Table IX, have been used to estimate production functions for five sectors. For agriculture I have considered different values for the initial capital stock in 1952 and employed an addition input variable "sown area" [*SYC89,* p. 192; *SYC84,* p. 137]. The reported sown area did not increase much in the sample period, being 2.12 billion mu in 1952 and 2.20 billion mu in 1980.

A. Production Function for Agriculture

To find reasonable estimates of the stock of capital in agriculture in 1952, I first referred to Tang [1981] and found an estimate of 112.9 (100 million RMB) in 1952, an increase by 17.95 from 1952 to 1957, and an increase by 205.40 (100 million 1952 RMB) from 1952 to 1980. The large discrepancies between these increases and the corresponding increases in my series for agriculture presented in Table V are very puzzling. Our series of capital stock increases by 59.10 from 1952 to 1957 and by 1165.48 from 1952 to 1980, three to five times Tang's. The coverages of the two series must be different, with ours including circulating assets and covering "agriculture, forestry, water conservancy and meteorology." Without being able to resolve the difference, I had to find an independent estimate of 1952 capital in agriculture.

In 1985 the "original value of fixed assets for production" per peasant household is reported to be 792.53 [*SYC86,* p. 109]. Multiplied by approximately 161 million farm households [*SYC86,* pp. 73, 84], this gives an estimate of about 1276 (100,000 RMB).

TABLE IX
AGRICULTURE PRODUCTION FUNCTIONS

1952 capital	Intercept	Capital	Labor	Land	Trend	R^2/s
250	−7.682	0.2102	0.2305	0.9959		0.9830
	(2.193)	(0.0376)	(0.1102)	(0.2372)		0.02750
	−8.879	0.2964	0.3007	1.054	−0.0069	0.9830
	(7.453)	(0.4847)	(0.4095)	(0.407)	(0.3085)	0.02859
450	−8.563	0.2501	0.3167	1.034		0.9832
	(2.888)	(0.0443)	(0.0946)	(0.235)		0.02732
	−11.255	0.4246	0.4980	1.160	−0.0117	0.9833
	(8.798)	(0.5384)	(0.5657)	(0.456)	(0.0361)	(0.02830)
650	−9.090	0.2906	0.3589	1.046		0.9834
	(2.876)	(0.0512)	(0.0870)	(0.234)		0.02719
	−13.232	0.5646	0.6449	1.228	−0.0159	0.9836
	(9.783)	(0.6190)	(0.6499)	(0.475)	(0.0358)	(0.02807)

This estimate, plus circulating assets and public goods but subtracting depreciation, is broadly consistent with our estimate of 1579 for the increase of capital in the agriculture sector from 1952 to 1985, and equals four times Tang's estimate of 318.3 for capital in 1980. Our estimates of increases from 1952 to 1957 and from 1952 to 1980 are, respectively, 59.10/17.95 or 3.29 and 1165.48/205.40 or 5.67 times Tang's. Quadrupling Tang's initial estimate would give 450 as 1952 capital stock. To estimate capital stock independently, one may attribute 0.25 of the 1952 agricultural output of 340 to capital and use a rate of return for capital of 0.19. The resulting estimate happens to be 450 also. When I use 450 as initial capital to estimate a production function reported in Table IX, I have found 0.25 as the share of output contributed by capital and 0.19 as the annual rate of return to capital in 1952 in Table XI. Thus, the 450 estimate is reasonable and consistent with the regression results. After the above was written, I discovered an estimate by Liu [1968, p. 171], "Total farm capital was therefore 40.95 billion yuan in 1952." This estimate excludes rural residential housing and is close to our 45.0 billion figure for capital in the agricultural sector. To examine the sensitivities of the results to initial estimates of capital, I have used 250, 450, and 650 as initial estimates and report three sets of results from Cobb-Douglas production functions below covering the sample period 1952–1980, omitting 1958–1969.

The regression coefficients are not very sensitive to variations of the initial capital stock from 250 to 650. The coefficient of log land is high perhaps because the variations in land use through time are not properly reported. When a linear trend is added, its coefficient is very small as compared with the standard error, suggesting no technical change through time. Because of multicollinearity, the standard errors of the other coefficients greatly increase when trend is added, but the results stand up in spite of the presence of trend. Omitting the trend variable, I present in Table XI the percentage deviations of actual output from the regressions with three different initial capital stocks as fractions of the latter, and the associated marginal value products of capital estimated from the regression equations. The deviations show the enormous losses (of about one-quarter) in the years 1960–1963 due to the Great Leap but smaller losses than for aggregate output in the 1967–1969 period due to the Cultural Revolution. The improvement in productivity from 1981 on has been greater in agriculture than in the economy as a whole, as is generally recognized. These

TABLE X
LABOR FORCE IN FIVE SECTORS (10,000)

Year	Total	Agriculture	Industry	Construction	Transportation	Commerce
1952	20729	17317	1246	285	235	579
1953	21364	17747	1373	342	257	940
1954	21832	18151	1501	381	259	833
1955	22328	18592	1400	513	272	809
1956	23018	18544	1375	1093	275	828
1957	23771	19309	1401	741	442	846
1958	26600	15490	4416	2660	852	1751
1959	26173	16271	2881	2521	684	1865
1960	25880	17016	2979	1133	730	2047
1961	25590	19747	2224	632	546	629
1962	25910	21276	1705	354	455	828
1963	26640	21966	1632	406	468	831
1964	27736	22801	1695	488	479	841
1965	28670	23396	1828	580	491	861
1966	29805	24297	1974	626	502	880
1967	30814	25165	2032	629	516	918
1968	31915	26063	2092	651	576	940
1969	33225	27117	2365	665	571	921
1970	34432	27811	2809	709	584	945
1971	35620	28397	3233	757	605	998
1972	35854	28283	3496	780	605	1003
1973	36652	28857	3704	788	603	991
1974	37369	29218	3900	812	632	1032
1975	38168	29456	4284	868	666	1098
1976	38834	29443	4692	919	694	1172
1977	39377	29340	4809	1022	742	1224
1978	40152	28373	6091	1065	749	1155
1979	41024	28692	6298	1155	789	1248
1980	42361	29181	6714	1221	846	1381
1981	43725	29836	6975	1274	833	1511
1982	45295	30917	7204	1340	850	1604
1983	46436	31209	7397	1481	906	1762
1984	48197	30927	7930	1858	1080	2036
1985	49873	31187	8349	2175	1222	2363
1986	51282	31311	8980	2376	1305	2485
1987	52783	31720	9343	2526	1373	2655
1988	54334	32308	9661	2634	1434	2829

TABLE XI
PERCENTAGE DEVIATIONS OF AGRICULTURE OUTPUTS FROM REGRESSION AND MARGINAL VALUE PRODUCT OF CAPITAL

	Percentage deviations of output			Marginal value products of capital		
	Initial 1952 capital			Initial 1952 capital		
Year	250	450	650	250	450	650
1952	0.010	0.011	0.012	0.283	0.187	0.150
1953	−0.006	−0.006	−0.005	0.283	0.190	0.153
1954	−0.026	−0.027	−0.027	0.286	0.194	0.158
1955	0.016	0.014	0.014	0.286	0.197	0.161
1956	−0.006	−0.005	−0.004	0.284	0.201	0.166
1957	0.017	0.018	0.019	0.273	0.197	0.164
1958	0.090	0.118	0.132	0.235	0.171	0.143
1959	−0.055	−0.028	−0.015	0.209	0.156	0.132
1960	−0.280	−0.260	−0.251	0.206	0.160	0.137
1961	−0.266	−0.253	−0.246	0.196	0.155	0.135
1962	−0.235	−0.225	−0.220	0.189	0.152	0.134
1963	−0.166	−0.154	−0.149	0.180	0.148	0.132
1964	−0.099	−0.088	−0.083	0.176	0.148	0.133
1965	−0.028	−0.016	−0.011	0.168	0.134	0.127
1966	−0.002	−0.006	−0.011	0.166	0.145	0.133
1967	0.013	0.020	0.024	0.161	0.142	0.131
1968	0.016	0.022	0.025	0.153	0.136	0.126
1969	−0.006	−0.003	−0.001	0.151	0.136	0.127
1970	0.013	0.014	0.015	0.147	0.134	0.127
1971	−0.009	−0.008	−0.007	0.140	0.131	0.125
1972	−0.047	−0.046	−0.046	0.135	0.128	0.123
1973	0.014	0.014	0.014	0.129	0.123	0.120
1974	0.035	0.034	0.034	0.122	0.119	0.117
1975	0.030	0.029	0.029	0.116	0.114	0.114
1976	−0.008	−0.009	−0.009	0.109	0.109	0.109
1977	−0.042	−0.043	−0.042	0.103	0.104	0.105
1978	−0.026	−0.024	−0.023	0.094	0.096	0.098
1979	0.029	0.030	0.031	0.088	0.091	0.094
1980	0.011	0.010	0.010	0.084	0.088	0.091
1981	0.080	0.077	0.075	0.082	0.086	0.089
1982	0.188	0.181	0.178	0.079	0.084	0.088
1983	0.278	0.269	0.264	0.077	0.081	0.085
1984	0.432	0.422	0.416	0.073	0.078	0.083
1985	0.449	0.436	0.428	0.068	0.074	0.079

results are not sensitive to the values of the initial capital stock in 1952. Our estimates of percentage deviations of agricultural output, being 0.077, 0.181, 0.269, and 0.422 for 1981–1984, respectively, are close to the estimates of total productivity increases of 0.105, 0.203, 0.270, and 0.406 for these years given by McMillan, Whalley, and Zhu [1989, p. 794], although these authors did not estimate an aggregate production function for Chinese agriculture using regression analysis. The estimates of the rates of return to capital in agriculture are reasonable. Even these estimates are not very sensitive to the large variations in the values of initial capital stock, except for the early years before 1963 when the three estimates are, respectively, 0.18, 0.15, and 0.13, with a large initial stock associated with a low value of the rate of return to capital.

B. Production Functions for Four Nonagricultural Sectors

By using the net output data of Table I, capital stock data of Table V, and labor force data of Table X, Cobb-Douglas production functions have been estimated for the four nonagricultural sectors, as shown in Table XII. When in doubt, CES production functions have also been estimated, but they show no appreciable improvement. The sample period covers 1952–1980, but the omitted years vary somewhat among the four sectors, as chosen partly by the goodness of fit. For industry only the years 1961–1968 are omitted, as a plot of log (output/labor) against log (capital/labor) for the remaining years shows the points to be close to a straight line. A part of Chinese history, confirmed by our data, is that in the beginning of the Great Leap and during much of the Cultural Revolution, industrial production was less affected than agriculture, reflecting a government policy to maintain the growth of industry in years of political disturbance. For construction the sample begins in 1954 as the recorded initial capital in 1952 is very small, and only years 1961–1962 and 1968 among the remaining years appear to show abnormally low outputs, perhaps reflecting the same government policy as industry. The results are very similar when the entire period 1961–1968 is excluded. For transportation the excluded years are 1959–1969. For commerce they are 1958–1968 and 1975–1977, the latter possibly reflecting the disruptive effects of the Cultural Revolution. In each case, a linear trend is added to test the presence of technological change. None is found, except for industry which shows a negative trend.

If we impose the restriction that the coefficients of log labor and log capital sum to one by regressing log (output/labor) on log (capital/labor), the results for each sector are given in the last two regressions in Table XII: the first without a trend; and the second with a trend. The coefficients for log capital do not change much but have smaller standard errors. The negative trend for industry

TABLE XII
PRODUCTION FUNCTIONS OF NONAGRICULTURE SECTORS

Sector	Sample period	Intercept	Capital	Labor	Trend	R^2/s
Industry	1952–1980 excluding 1961–1968	1.787	0.6824	0.3179		0.9936
		(0.356)	(0.0361)	(0.0742)		0.0800
		0.605	0.8846	0.3021	−0.0229	0.9953
		(0.575)	(0.0882)	(0.0659)	(0.0093)	0.0707
Constrained		1.785	0.6826			0.9745
		(0.222)	(0.0253)			0.0779
		1.295	0.7473		−0.0048	0.9759
		(0.528)	(0.0681)		(0.0047)	0.0778
Construction	1954–1980 excluding 1961, 1962, 1968	2.776	0.5170	0.3660		0.9616
		(0.183)	(0.0276)	(0.0405)		0.0901
		2.672	0.5450	0.3624	−0.0023	0.9619
		(.910)	(0.2408)	(0.0516)	(0.0200)	0.0923
Constrained		2.836	0.5489			0.9457
		(0.205)	(0.0280)			0.1017
		2.297	0.6475		−0.0108	0.9590
		(0.275)	(0.0453)		(0.0041)	0.0905
Transportation	1952–1980 excluding 1959–1969	2.579	0.4689	0.4221		0.9897
		(0.418)	(0.0362)	(0.0683)		0.0637
		2.085	0.5609	0.4118	−0.0073	0.9898
		(4.016)	(0.7446)	(0.1091)	(0.0590)	0.0659
Constrained		3.419	0.4132			0.8975
		(0.325)	(0.0349)			0.0749
		1.921	0.5915		−0.0097	0.9307
		(0.623)	(0.0728)		(0.0036)	0.0636
Commerce	1953–1980 excluding 1958–1968 1975–1977	5.692	0.2199	0.8755		0.9737
		(0.620)	(0.0343)	(0.1778)		0.0548
		4.922	0.4060	0.9701	−0.0166	0.9746
		(1.484)	(0.3256)	(0.2464)	(0.0289)	0.0566
Constrained		5.318	0.2367			0.9110
		(0.194)	(0.0213)			0.0535
		5.724	0.1855		0.0036	0.9125
		(0.983)	(0.1232)		(0.0085)	0.0554

becomes insignificant, while the negative trends for construction and transportation become significant. All results support the conclusion of no positive technological change in these four sectors of the Chinese economy.

Table XIII shows the percentage deviations of actual outputs

TABLE XIII
PERCENTAGE DEVIATIONS OF OUTPUT OF NONAGRICULTURE SECTORS

Year	Industry	Construction	Transportation	Commerce
1952	−0.133	0.542	−0.125	−0.269
1953	−0.012	0.384	−0.019	−0.053
1954	−0.004	0.321	0.057	0.027
1955	−0.040	−0.086	0.019	0.027
1956	0.083	0.046	0.132	0.058
1957	0.078	−0.002	−0.053	0.004
1958	−0.036	−0.075	0.022	−0.446
1959	0.171	−0.046	0.345	−0.444
1960	0.073	0.235	0.314	−0.515
1961	−0.346	−0.505	−0.165	−0.158
1962	−0.412	−0.249	−0.307	−0.238
1963	−0.352	−0.123	−0.303	−0.229
1964	−0.240	−0.008	−0.234	−0.228
1965	−0.105	−0.020	−0.033	−0.237
1966	0.011	−0.002	0.048	−0.109
1967	−0.194	−0.078	−0.186	−0.110
1968	−0.303	−0.284	−0.280	−0.207
1969	−0.134	−0.061	−0.115	−0.057
1970	0.054	0.138	0.013	0.000
1971	0.064	0.165	0.025	−0.056
1972	0.039	0.060	0.029	−0.045
1973	0.040	0.017	0.045	0.021
1974	−0.041	0.014	−0.061	−0.047
1975	0.005	0.053	−0.004	−0.109
1976	−0.114	0.033	−0.097	−0.185
1977	−0.043	−0.020	−0.018	−0.133
1978	−0.018	−0.084	0.043	0.093
1979	−0.007	−0.136	0.019	0.070
1980	0.033	0.033	0.003	−0.036
1981	−0.006	−0.012	0.035	0.036
1982	0.001	−0.024	0.122	0.009
1983	0.042	0.064	0.176	0.033
1984	0.104	0.008	0.184	0.008
1985	0.202	0.090	0.277	0.067

in the five sectors from their regression equations (imposing no restrictions and omitting the trend variable). The negative effects of the Great Leap on industry and construction outputs did not occur until 1961 and were more severe than in agriculture. 1968 was a bad year for both, with negative deviations of approximately 30 percent. The positive effects of economic reform after 1980 are slower to occur and smaller in industry than in agriculture; they are hardly detectable in construction. Transportation output was abnormally high in 1959–1960, only to experience large negative effects of the Great Leap in 1961–1964 and of the Cultural Revolution in 1968. The positive effects of reform for transportation are larger than in industry but smaller than in agriculture. For commerce the effects of the Great Leap began in 1958 and were very severe, being over 40 percent during 1958–1960 and continuing to 1968. No improvement in total factor productivity after 1980 can be discerned.

C. Resource Allocation in Five Sectors

Did supply and demand affect the prices of products of the five sectors? Price indices in 1980 (with 1952 = 100) obtained by taking the ratios of current to real outputs in Tables I and II are 231.6 for agriculture, 77.94 for industry, 116.3 for construction, 86.3 for transportation, and 88.04 for commerce. Divided by the implicit deflator of national income, the relative price indices of the five sectors are, respectively, 191.0, 64.27, 95.90, 71.16, and 72.59. On the supply side, indices of per capita output in 1980 (with 1952 = 100) obtained by dividing the output indices of Table I by a population index of 1.7171 for 1980 [*SYC89,* p. 87] are 98.07 for agriculture, 1172.15 for industry, 441.26 for construction, 340.11 for transportation, and 185.66 for commerce. On the demand side, per capital real national income (with 1952 = 100) is 300.7 in 1980, while per capita consumption is 221.8 (see Table III).

Changes in supply and demand clearly affected the prices of agricultural and industrial products. For agriculture, output per capita in 1980 remained about the same as in 1952, while per capita total consumption more than doubled. For industry output, per capita was about twelve times in 1980, while per capita real national income was only three times, national income being used to measure the force of demand, since before 1980 more than half of industrial products consisted of producer goods of "heavy industry." There is no question that in 1980, demand exceeded supply at 1952 prices for agriculture, and supply exceeded demand

at 1952 prices for industry, at least partly causing the price changes to 191.0 and 64.27. Assume per capita demand functions with constant total consumption (or income) and own-price elasticities. If total consumption elasticity is 0.79 for agricultural products (see Chow [1985a, p. 165]), the total consumption effect on demand would be $2.218^{.79}$ or 1.876. A price elasticity of -1.00 would restrict demand to 0.9807 of the 1952 level, assuming equilibrium in 1952 and 1980. For industrial products an income elasticity of 2 applied to 3.007 would be consistent with a price elasticity of -0.59 to explain the price reduction to 0.6427 in 1980.

The explanations by supply and demand for the remaining three sectors with smaller price changes are less clearcut, but still plausible. For construction, since relative price remained almost the same, an income elasticity of 1.35 could explain the increase in per capita demand to 4.41. For transportation, income and price elasticities of 1 and -0.36 could explain the price reduction to 0.7716. For commerce, total consumption and price elasticities of 0.6 and -0.44, respectively, could explain the price reduction to 0.7259.

The rates of return (in 1952 output value) to capital accumulated in the five sectors have been computed from production functions reported in Tables IX and XII and are presented in Tables XI and XIV. Adjusted by prices in 1980, the rates in 1980 (with standard errors in parentheses) are 0.20 (0.077) in agriculture, 0.17 (0.029) in industry, 0.26 (0.041) in construction, 0.038 (0.018) in transportation, and 0.023 (0.026) in commerce. The very low rate of return for transportation may reflect the fact that much of transportation facilities, including highways and waterways, is a public good of which the marginal value product of capital is not explicitly included in the measured output. The rates of return to investment and pricing in railroads deserve to be further examined. The very low rate of return in commerce is accounted for by the very large quantity of circulating assets (being five to nine times fixed assets according to Table V and *SYC89* [pp. 25–26]). These circulating assets are recorded officially as a part of accumulation. The presence of large quantities in commerce with a very low rate of return might suggest the inefficient use of these assets.

Marginal value products of labor estimated from production functions of Tables IX and XII are presented in Table XV. In 1980 prices they are 142 (67) in agriculture, 827 (370) in industry, 537 (152) in construction, 627 (414) in transportation, and 1632 (2335) in commerce. For reference the 1980 average annual wage is 784 in industry, 857 in construction, 842 in transportation, and 694 in

TABLE XIV
RATES OF RETURN TO CAPITAL
(IN 1952 OUTPUT VALUE)

Year	Industry	Construction	Transportation	Commerce
1952	0.365	0.781	0.088	0.153
1953	0.355	0.594	0.088	0.119
1954	0.342	0.504	0.084	0.090
1955	0.316	0.490	0.081	0.077
1956	0.294	0.573	0.077	0.075
1957	0.282	0.446	0.090	0.068
1958	0.370	0.699	0.108	0.120
1959	0.293	0.656	0.089	0.114
1960	0.276	0.468	0.084	0.116
1961	0.245	0.373	0.073	0.051
1962	0.223	0.296	0.066	0.051
1963	0.217	0.303	0.067	0.049
1964	0.214	0.311	0.066	0.047
1965	0.214	0.317	0.064	0.045
1966	0.211	0.313	0.062	0.042
1967	0.209	0.306	0.061	0.041
1968	0.207	0.305	0.063	0.040
1969	0.210	0.299	0.061	0.037
1970	0.214	0.293	0.058	0.035
1971	0.217	0.284	0.056	0.034
1972	0.216	0.274	0.053	0.032
1973	0.213	0.263	0.050	0.030
1974	0.211	0.254	0.049	0.029
1975	0.211	0.248	0.048	0.030
1976	0.211	0.243	0.047	0.031
1977	0.208	0.245	0.046	0.030
1978	0.218	0.239	0.044	0.026
1979	0.215	0.235	0.044	0.026
1980	0.215	0.227	0.044	0.025
1981	0.213	0.221	0.043	0.026
1982	0.211	0.217	0.042	0.026
1983	0.208	0.216	0.042	0.026
1984	0.207	0.219	0.043	0.030
1985	0.203	0.215	0.043	0.035

commerce [*SYC89*, p. 139]. Note the large standard errors in our estimates of the marginal value products of labor, especially for commerce. Not much inference can be drawn from them, except perhaps to note the low value for agriculture, a fact recognized to be associated with high population density.

TABLE XV
MARGINAL VALUE PRODUCT OF LABOR
(IN 1952 OUTPUT VALUE)

Year	Agriculture*	Industry	Construction	Transportation	Commerce
1952	62	338	175	513	1077
1953	62	360	224	502	1151
1954	63	389	261	524	1226
1955	64	460	250	533	1275
1956	68	538	176	556	1289
1957	66	592	253	444	1329
1958	75	329	115	328	1238
1959	68	544	124	409	1266
1960	72	619	216	422	1274
1961	62	795	318	512	1436
1962	58	975	468	574	1437
1963	57	1040	443	570	1452
1964	58	1063	411	571	1471
1965	58	1067	387	582	1501
1966	58	1096	385	597	1532
1967	56	1126	394	601	1547
1968	53	1150	392	574	1570
1969	53	1110	398	594	1593
1970	53	1066	401	612	1623
1971	54	1041	408	631	1646
1972	56	1051	420	660	1672
1973	56	1077	439	691	1709
1974	57	1104	452	700	1728
1975	58	1102	456	708	1737
1976	59	1099	460	718	1732
1977	59	1139	444	712	1757
1978	63	1027	452	739	1809
1979	62	1061	450	736	1828
1980	62	1061	462	727	1846
1981	60	1079	470	743	1868
1982	59	1100	474	754	1893
1983	59	1131	465	748	1901
1984	60	1144	434	704	1875
1985	62	1193	425	693	1814

*Initial capital in 1952 is 450.

VI. FINANCING CAPITAL ACCUMULATION

The financing for capital accumulation has been achieved mainly through keeping the consumption of peasants roughly equal to the income of the agricultural sector and the consumption

of nonagricultural residents roughly equal to total wage. This observation is evident from the data on Table XVI (see *SYC89* [pp. 38, 138]).

Comparing consumption (in current prices) of peasants in Table XVI with income of the agricultural sector in Table II, one finds the ratio of the former to the latter to fall between 0.90 and 1.07 in all years from 1954 to 1984. Government exercises some control over the money income of peasants by setting purchasing prices of farm and sideline products. The index of these prices [*SYC89,* p. 688] is almost identical to the implicit price deflator for the agricultural sector obtained from comparing Tables I and II. Comparing consumption of nonagricultural residents in Table XVI with estimated wage income, which equals average annual wage of staff and workers [*SYC89,* p. 138] times nonagricultural labor force (Table X), one finds the ratio of the former to the latter to fall between 0.84 and 1.05 in the years 1952 to 1980, excluding 1956 and 1958–1963. By controlling the wage rate, the government can limit the consumption of nonagricultural residents.

VII. SUMMARY

Using official information on "newly increased fixed assets through capital construction" of all state-owned enterprises and on circulating funds of state-owned enterprises "under the state budget," I have estimated capital stock annually from 1952 to 1985 in the five income-producing sectors of the Chinese economy by distributing official data on net capital accumulation of fixed and circulating assets in three types of enterprises to the five sectors. These estimates, together with official data on net income, labor force, and agricultural land, are used to estimate production functions for the aggregate economy and the five production sectors.

The production functions estimated are used to access the economic losses in the aggregate economy and in the five sectors due to the Great Leap and the Cultural Revolution, and to measure the improvement of productivity in the 1980s after the economic reforms. The percentage losses in 1962 are about 0.34 for the aggregate economy, 0.22 for agriculture, 0.41 for industry, 0.25 for construction, 0.31 for transportation, and 0.24 for commerce. The percentage gains in 1985 are about 0.30 for the aggregate economy, 0.44 for agriculture, 0.20 for industry, none for construction, 0.28 for transportation, and none for commerce.

The capital coefficients of Cobb-Douglas production functions

TABLE XVI
CONSUMPTION OF PEASANTS AND NONAGRICULTURAL RESIDENTS AND RELATED VARIABLES

Year	Consumption of peasants	Consumption of non-agricultural residents	Estimated income of non-agricultural residents	Ratio of column 1 to agriculture income	Ratio of column 2 to column 3
1952	298	136	152	0.876	0.896
1953	332	176	179	0.888	0.983
1954	348	179	190	0.897	0.941
1955	389	186	197	0.933	0.945
1956	397	216	269	0.904	0.803
1957	412	237	278	0.969	0.851
1958	435	248	595	0.989	0.416
1959	339	302	507	0.902	0.596
1960	346	337	453	1.042	0.744
1961	418	337	298	0.968	1.131
1962	459	322	255	1.034	1.261
1963	487	306	269	0.998	1.137
1964	539	302	289	0.982	1.044
1965	581	314	311	0.906	1.009
1966	637	332	321	0.921	1.034
1967	679	347	332	0.966	1.046
1968	670	350	338	0.938	1.037
1969	705	363	351	0.976	1.034
1970	770	375	371	0.990	1.010
1971	804	391	404	0.995	0.967
1972	824	439	445	1.020	0.986
1973	898	466	458	1.014	1.018
1974	915	481	476	0.992	1.010
1975	946	504	505	1.000	0.997
1976	965	537	540	1.027	0.994
1977	974	579	578	1.067	1.002
1978	1043	630	724	1.058	0.870
1979	1212	698	824	0.989	0.847
1980	1384	839	1004	1.044	0.835
1981	1572	901	1072	1.042	0.840
1982	1737	951	1147	1.008	0.829
1983	1941	1016	1258	1.010	0.808
1984	2232	1163	1682	0.992	0.691
1985	2728	1512	2145	1.095	0.705
1986	2994	1779	2654	1.101	0.670
1987	3381	2096	3073	1.072	0.682
1988	4166	2792	3848	1.091	0.726

are about 0.60 for the aggregate economy, 0.25 for agriculture, 0.68 for industry, 0.52 for construction, 0.47 for transportation, and 0.22 for commerce, with the rate of return to capital in 1980 being, respectively, 0.16, 0.20, 0.17, 0.26, 0.04 (not including social return to transportation capital), and 0.02 (including much circulating assets in commerce). From 1952 to 1985 aggregate income grew by an average rate of 0.06 of which 0.045 is attributed to the 0.076 growth rate of capital (including land). The average annual growth rates of the five sectors are, respectively, 0.019, 0.113, 0.075, 0.065, and 0.042, of which 0.015, 0.085, 0.052, 0.040, and 0.021 are attributable to capital growth rates of 0.064, 0.127, 0.102, 0.086, and 0.099 in these sectors (beginning date being 1954 for construction). The marginal value products of labor have not been accurately estimated. Changes in prices in the five sectors appear to be broadly consistent with the changes in supply relative to demand.

A major theme in the study of economic growth since Solow's classic paper [1956] has been the explanation of technological progress without which any theory on the growth of western economies is deficient. Romer [1990] is a recent example of this theme. A major finding of this paper is that technological change was absent in the growth of the Chinese economy from 1952 to 1980. Solow's classic paper, absent technical progress, would do well in explaining China's growth during this period, with capital formation playing an important role as the Chinese economic planners and Solow's theory intended.

If one accepts the empirical finding of no technological change in China from 1952 to 1980, one may try to explain why it happened. It is an accepted fact that the Chinese economic planners tried to introduce industrial technology and the method of planning from the Soviet Union in the 1950s and began the First Five-Year Plan in 1953. The Chinese planners also tried to increase output by investing a large fraction of national output in industry, especially heavy industry. This paper has described the increases in outputs in five sectors and in total through capital formation in these sectors by using sectorial and aggregate production functions. There is no reason to assume that technological progress occurred during the period up to 1980. Economic cooperation with the Soviet Union ended in the 1960s. Without incentives from private enterprises to innovate, where could technological progress have come? I have found no theory to support the assertion that central planning will produce technological progress. It might happen, as suggested by Young [1992] for the case of Singapore,

that much government direction in industrial investment does not lead to an increase in total factor productivity. Although technological progress defined in the context of Solow's [1956] growth model is an important phenomenon to explain for a market economy like the United States, one cannot presume its existence in a country like China during a period when private initiatives for innovations or adopting new technology from abroad appeared to be absent. For such an economy one does not need to find explanations for the varying rates of productivity changes as Romer [1987] attempted to do for the United States. However, after the reforms in the 1980s when profit-seeking enterprises began to grow, the study of technological progress in China is an important and interesting topic for further research.

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