APPENDIX 1

SUPPLEMENTARY TABLES

Table 11—Agricultural labor force (midyear) estimates, 1952 to 1977

Year	Total Population	Urban Population	Rural Population	Rural Proportion of Total Population	15-64 Age Group Total	15-64 Age Group Rural	Rural Labor Force	Agricultural Labor Force
		(millions)		(percent)		(millions)		
1952	569.900	69.0	500.900	87.9	334.875	294.355	218.183	168.677
1953	582.611	74.6	508.011	87.2	340.107	296.558	219.816	169.940
1954	596.064	79.6	516.464	86.6	345.559	299.412	221.931	171.575
1955	610.201	82.2	528.001	86.5	351.185	303.877	225.241	174.134
1956	625.004	86.0	539.004	86.2	356.940	307.825	228.167	176.396
1957	640.024	94.3	545.724	85.3	362.799	309.345	229.294	177.267
1958	654.727	102.6	552.127	84.3	368.747	310.962	230.492	178.193
1959	668.930	109.1	559.830	83.7	374.679	313.570	232.425	179.688
1960	682.091	116.0	566.091	83.0	380.427	315.730	234.026	180.925
1961	693.624	121.2	572.424	82.5	386.003	318.555	236.120	182.544
1962	705.486	124.7	580.786	82.3	392.192	322.869	239.318	185.017
1963	719.301	128.2	591.101	82.2	399.458	328.263	243.316	188.107
1964	734.359	131.0	603.359	82.2	407.812	335.064	248.357	192.005
1965	750.394	133.8	616.594	82.2	417.258	342.858	254.134	196.471
1966	766.946	136.7	630.246	82.2	427.403	351.223	260.335	201.265
1967	784.017	142.5	641.517	81.8	438.222	358.572	265.782	205.476
1968	801.983	148.5	653.483	81.5	449.907	366.599	271.732	210.076
1969	820.733	154.7	666.033	81.1	462.221	375.097	278.031	214.946
1970	840.148	158.7	681.448	81.1	474.837	385.143	285.477	220.702
1971	859.927	162.8	697.127	81.1	487.741	395.403	293.082	226.582
1972	879.520	167.1	712.420	81.0	500.654	405.535	300.592	232.388
1973	898.695	170.7	727.995	81.0	513.305	415.807	308.206	238.274
1974	917.256	174.3	742.956	81.0	525.933	425.993	315.756	244.111
1975	934.626	177.6	757.026	81.0	538.642	436.288	323.387	250.010
1976	950.744	180.6	770.144	81.0	551.453	446.677	331.077	255.956
1977	965.937	183.5	782.437	81.0	564.586	457.315	338.962	262.052

SOURCES AND NOTES TO TABLE 11

The basis of the agricultural labor force series is the assumption that the size of the labor force changes with the 15-64 age group from which most workers are drawn, rather than with the size of the total population. A change in the birth rate will immediately affect the size of the population, but it will not significantly alter the labor force until most of the children born in that year reach the age of 15. The estimate is based on a 15-64 age-group series developed by the Foreign Demographic Analysis Division of the U.S. Department of Commerce, under the direction of John Aird. The ratio of rural population to total population is developed in order to derive the proportion of the 15-64 group in rural areas. This figure is then adjusted to eliminate those members of the age group who are not actually in the labor force, giving the rural labor force. This series is further adjusted to include only those engaged in agriculture.

This estimation procedure does not explicitly take into account the transfer of middle school graduates to the countryside, rural industrialization, more extensive primary education, the increased participation of women due to labor-saving machinery (rice mills, cotton gins, etc.), and additional child-care centers. Such influences are undeniably important but are virtually impossible to quantify accurately. Fortunately, they are somewhat off-setting. Rustication of urban youth and greater participation of women increase the agricultural labor force, while growing primary education and rural industry reduce it.

Total Population

U.S. Department of Commerce, Bureau of Economic Analysis, Foreign Demographic Analysis Division (FDAD). Presented in U.S. Central Intelligence Agency (CIA), "People's Republic of China: Handbook of Economic Indicators," ER77-10508, Washington, D.C., October 1977, p. 8. As a result of the scarcity, inconsistency, and lack of precision in official Chinese population statements, there is no authoritative estimate of China's population growth. The problems in estimating the size of China's population and the divergent opinions of demographers in the field are described in John S. Aird, "Population Growth," Walter Galenson, Tu-Chang Liu, and Alexander Eckstein, eds., *Economic Trends in Communist China* (Chicago: Aldine, 1968), pp. 183-327; and Leo A. Orleans, "China's Population: Can the Contradictions be Resolved?"U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy*, (Washington, D.C.: U.S. Government Printing Office, 1975), pp. 69-80. The series used here is admittedly in the higher range of estimates, as Orleans states. It has been adopted over other lower estimates, such as Orleans's own, because it is believed to be based on the most careful, sophisticated, and extensive methodology. The methods of John Aird and the FDAD may be compared with those of Orleans and other major contributors to the field in the two articles cited above. The series is generally consistent with official Chinese data released for the 1950s. The figure for 1953 is almost exactly the population of mainland China given for June 30, 1953 in People's Republic of China, State Statistical Bureau, "Communique on the Results of the Population Census of the Whole Country," *T'ung-chi Kung-tso Kung-hsun* [Statistical Work Bulletin], November 8, 1954. (See Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China* [Chicago: Aldine, 1967], p. 123). This communique gives a total population, including Taiwanese and overseas Chinese, of 601.938 million. Subtracting the population of Taiwan (7.591 million) and the overseas Chinese (11.743 million) from this, the population of the mainland was 582.604 million. The figures for 1954 and 1957 are quite close to the numbers in People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Language Press, 1960; reprinted as Occasional Paper No. 5, Program in East Asian Studies, Western Washington State College, Bellingham, Washington, 1974), once these are adjusted to midyear coverage and to exclude Taiwan. This work gives year-end totals for 1953 (595.55 million) and 1957 (656.63 million). These include Taiwan but not overseas Chinese. The average yearly rate of increase for this period was 2.47 percent. Increasing the 1953 total and decreasing the 1957 total by half of this rate (1.235 percent) leads to midyear figures of 602.908 million for 1954 and 648.617 million for 1957. For Taiwan a 1957 year-end figure of 10.1 million for the population is given in *Ten Great Years*, and a figure of 8.617 million is given for year-end 1954 by Hu Huang-yung, "An Index Chart of Area and Population of China by Province and Region," *Ti-li Chih Shih* [Geographical Knowledge]8 (September 1957): 390-1. Decreasing each of these figures by one-half the average annual rate of growth (2.718 percent) supplies midyear estimates of 8.389 million for 1954 and 9.833 million for 1957. Subtracting these from the corresponding adjusted total population figures gives midyear mainland population estimates of 594.519 million for 1954 and 638.784 million for 1957. Each of these figures differs from the corresponding figures in this series (596.064 million and 640.024 million) by less than two million.

The series is also reasonably close to figures given for 1971-75 in one of the most recent major contributions to the study of China's population growth, based on statements by Chinese officials to visiting Americans. This is Judith Banister, "China's Demographic Transition in the Asian Context," a paper presented at the Conference on the Modern Chinese Economy in a Comparative Context, Stanford University, Stanford, Calif., January 8, 1977. Although the FDAD series differs from Banister's estimates by over 20 million for 1975, this is not serious disagreement in a field where the best estimates of leading experts may be 80 million or more apart (see, for example, Orleans's and Aird's series in Orleans, "China's Population." Banister's figures are compared to the FDAD's below.

	Banister	FDAD
	(millions)	
1971	849	860
1972	866	879
1973	882	899
1974	897	917
1975	913	935

Zhou Enlai, in his Report to the Fourth National People's Congress on January 13, 1975 (reproduced in *Hung Chi*, No. 2, 1975, p. 21) gave two conflicting figures for the 1974 population. In one account he gave an increase of 60 percent since 1949, yielding a year-end population of 890 million. In the next account he said that China's population was approaching 800 million. This discrepancy is too big to be accounted for by a switch in the definition of China from "including Taiwan," the basis for the statistics in *Ten Great Years*, to "excluding Taiwan," as Zhou may have. Taiwan's population in 1974 was about 16 million.

This pair of statements is an example of the inconsistency and confusion in Chinese population information. This inconsistency and confusion and the lack of a census more recent than 1953 explain the need to use the independently developed FDAD series.

Urban Population

The data for 1952-56 are from People's Republic of China, Data Office, "Statistical Data on the Population Census of Our Country," *T'ung-chi Kung-tso* [Statistical Work], June 14, 1957, pp. 24-5 (see Chen, *Chinese Statistics*, p. 127).

Information and estimating procedures for 1957-72 are from Bobby Williams, "China: Grain Output Growth and Productivity, 1957-72," U.S. Central Intelligence Agency, Office of Economic Research, Washington, D.C., May 1974, p. 13. (Mimeographed.)

1957. Hsueh Cheng-hsiu, "A Tentative Discussion of the Relationships between Socialist Urban Population Increase and Industrial and Agricultural Production Development," *Kuang-ming Jih-pao*, October 7, 1963, p. 3 (see John Emerson, "Employment in Mainland China: Problems and Prospects," U.S. Congress, Joint Economic Committee, *An Economic Profile of Mainland China*, 2 vols. (Washington, D.C.: U.S. Government Printing Office, 1967), 1: 419), gives a year-end urban population increase for 1957 of 38.9 percent over 1952. Using figures from the Data Office article cited above (see Chen, *Chinese Statistics*, p. 127), a 38.9 percent increase over a 1952 year-end figure of 99.5 million. The average of this and the 1956 year-end figure (89.15 million) is the 1957 midyear figure (94.325 million).

1958-60. Jen-min Jih-pao, August 25, 1960, p. 1 (see Emerson, "Employment in China," p. 419), reported an increase in the urban population of 20 million for year-end 1960 over year-end 1957. This implies a year-end 1960 figure of 119.5 million and an average annual growth rate of 6.3 percent. Interpolating between year-end 1957 and year-end 1960 produces the midyear figures shown. (These are slightly different from Williams' figures, apparently due to rounding-off differences.)

1961-63. 1963 year-end urban population of 130 million was reported in *Ta-kung Pao*, Hong Kong (January 15, 1964), translated in U.S., Consulate General, Hong Kong, *Survey of China Mainland Press* 3152, p. 7 (see Emerson, "Employment in China," p. 419). This implies an average yearly growth rate of 2.847 percent. Interpolating between year-end 1960 and year-end 1963 gives the figures shown. (Here again the figures in the table differ slightly from those given by Williams.)

1964-66. These figures assume that the 1966 midyear urban population is the same proportion of total population as in 1963 (17.8 percent) and that the urban population grew at the average annual growth rate implied by the figures for 1963 and 1966 (2.16 percent), which is also the average annual rate of growth for the total population over this period. (These figures differ slightly from Williams' because he used an earlier version of the FDAD total population series, which is not quite the same as the more recent series used here.)

1967-72. Chou Ching, "Light Industry Develops Apace," *Peking Review*, 1972, p. 12, states that "China's rural population makes up nearly 80 percent of her total." The 1972 urban population is therefore approximately 19 percent of total population, or 167.1 million.

Sung Pei-chang, secretary of the Anhwei CCP Committee, on March 4, 1973 reported that "Since the beginning of the Great Proletarian Cultural Revolution, more than 7 million educated young people in our country...have settled in the countryside ...." Anhwei Provincial Service, March 4, 1973 in U.S. Foreign Broadcast Information Service, *People's Republic of China, Daily Report*, March 8, 1973, p. 46. If it is assumed that more than 7 million young people were indeed permanently resettled in the rural areas, that other categories sent to the rural areas brought the total to 8 million, and that most of the rural-urban migration is implicit in an urban population total of 175.1 million (167.1 plus 8), then the urban figures can be derived.

Between 1966 and 1969 the urban population grew 4.2 percent annually, the average rate implicit in the increase from 136.7 million in 1966 to 175.1 million in 1972. This results in a figure of 154.7 million for 1969. Assuming that the transfer of the urban population to the countryside began to be significant in 1969-70, the figures for 1970 and 1971 are interpolated using the average yearly increase implied by the figure for 1969 and 167.1 million for 1972, 2.6 percent.

1973-77. Urban population is assumed to be 19 percent of total population for these years.

Rural Population

This column was derived by subtracting the urban population from the total population.

Rural Proportion of Total Population

This column was derived by dividing rural population by the total population.

15-64 Age Group

The total comes from FDAD figures presented in CIA, "People's Republic of China: Handbook of Economic Indicators," ER77-10508.

The estimate of the number of the age group in rural areas was derived by multiplying the total 15-64 age group by the rural proportion of the total population. This estimating procedure involves the implicit assumption that the rural 15-64 age group is the same proportion of rural population as the total 15-64 age group is of the total population. This is almost certainly not true, because birth control and health programs are less effective in rural areas than in urban areas. Such influences are almost impossible to quantify.

Rural Labor Force

This column was derived by multiplying the rural 15-64 age group figures by 0.7412. Frederick W. Crook, "The Commune System in the People's Republic of China, 1963-74," U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy* (Washington, D.C.: U.S. Government Printing Office, 1975), pp. 366-410, presents data collected from 1,400 reports on communes found in Chinese press releases from 1963 through 1974. These data indicate that the average rural household contained 4.4 members and had 1.87 labor units. Dividing the rural population for 1974 by 4.4 to obtain the number of rural households, and multiplying this number by 1.87 produces the 1974 rural labor force estimate of 315.756 million. Dividing this figure by the 1974 rural 15-64 age group number (425.993 million) supplies an estimate of the proportion of the rural 15-64 age group in the rural labor force (0.7412). The rural labor force is assumed to be in this same proportion to the rural 15-64 age group in all other years.

Agricultural Labor Force

This column was derived by multiplying the rural labor force figures by 0.7731. This ratio was developed by Anthony Tang, "Policy and Performance in Agriculture," p. 474, based on information from Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965). The ratio of agricultural population to total population was estimated to be 0.73 in C. C. Chang, *An Estimate of China's Farms and Crops* (Nanking: University of Nanking Press, 1932), p. 13 (see Liu and Yeh, *The Economy of the Chinese Mainland*, p.182) A total population of 536.3 million and rural population of 480.7 million for 1949 are given in State Statistical Bureau, "Population Statistics, 1949-56," *Tung-chi Kung-tso* [Statistical Work] June 11, 1957, pp. 24-5 (see Liu and Yeh, *The Economy of the Chinese Mainland*, p. 212). Applying the ratio of 0.73 to the total population for 1949 gives an agricultural population estimate of 391.5 million. Dividing this figure by the rural population figure gives 0.8144 as the ratio of agricultural population to rural population. Liu and Yeh find 1933 agricultural population to be 365 million, of which 18.5 million, or 5.07 percent, were engaged in nonagricultural farm subsidiary work (*The Economy of the Chinese Mainland*, p. 102). This ratio is assumed to apply to the period of this study, so agricultural labor is adjusted downward by a factor of 0.9493. The final adjustment factor, then, is 0.8144 times 0.9493, or 0.7731.

SOURCES AND NOTES TO TABLE 12

Feed

The quantity of feed is assumed to have a constant relationship to the numbers of livestock and poultry. It is calculated by multiplying the value of livestock, excluding poultry (from Table 15), by 0.101, and that total by 1.04 (adopted from Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and*

Table 12—Current inputs, 1952 to 1977

Year	Feed	Seed	Insecticide	Chemical Fertilizer Gross Weight	Chemical Fertilizer Nutrients	Organic Fertilizer Nutrients	Total Fertilizer Nutrients
	(billion 1952 yuan)		(thousand metric tons)	(million metric tons)			
1952	1.14	1.15	15	0.463	0.09	10.14	10.23
1953	1.21	1.17	19	0.690	0.14	10.92	11.06
1954	1.23	1.20	41	0.967	0.19	11.41	11.60
1955	1.20	1.23	67	1.417	0.28	11.72	12.00
1956	1.25	1.29	159	1.800	0.36	12.37	12.73
1957	1.32	1.28	149	2.437	0.49	13.03	13.52
1958	1.55	1.27	246	2.843	0.56	14.23	14.79
1959	1.39	1.23	326	3.330	0.66	13.48	14.14
1960	1.22	1.19	405	3.270	0.65	12.50	13.15
1961	1.15	1.16	256	3.520	0.70	12.00	12.70
1962	1.22	1.18	283	4.507	0.89	12.20	13.09
1963	1.36	1.21	312	6.040	1.19	13.67	14.86
1964	1.47	1.24	345	8.313	1.63	15.23	16.86
1965	1.65	1.27	380	10.530	2.06	16.95	19.01
1966	1.73	1.26	420	12.613	2.49	17.56	20.05
1967	1.77	1.27	464	14.223	2.83	17.60	20.43
1968	1.74	1.27	512	15.773	3.15	17.48	20.63
1969	1.73	1.27	565	18.300	3.65	17.67	21.32
1970	1.84	1.28	624	21.153	4.22	18.40	22.62
1971	1.97	1.30	689	24.393	4.86	19.47	24.33
1972	2.15	1.30	761	28.000	5.58	20.63	26.21
1973	2.04	1.32	859	29.897	5.96	20.42	26.38
1974	2.17	1.33	970	31.821	6.37	21.25	27.62
1975	2.27	1.35	1,095	33.354	6.65	22.08	28.73
1976	2.32	1.36	1,236	32.500	6.50	22.52	29.02
1977	2.35	1.38	1,395	42.500	8.50	22.99	31.49

Economic Development, 1933-59 [Princeton: Princeton University Press, 1965], p. 406, to allow for value of poultry). The coefficient, 0.101, is the ratio of average feed expense (6.63) to average value of livestock per farm (65.76) for the 2,866 farms examined by John Lossing Buck in his study, *Chinese Farm Economy* (Chicago: University of Chicago Press, 1930), pp. 57, 75. This method and figure are used by Liu and Yeh, *The Economy of the Chinese Mainland*, p. 418. The estimation procedure is likely to underestimate the quantity of feed for later years as livestock numbers expanded more than the farm population and the agricultural sector. This follows since the use of grains as feed expands more rapidly than livestock numbers under these circumstances. FAO estimates that for the mid-1970s the proportion of grains used as feed was 12 percent. The figure used here is 7 percent (an estimated feed value of 2.27 billion yuan for 1975 divided by the estimated value of grains in Table 1). However, the probable error is insignificant in relation to the value aggregates as quality makes the value ratio smaller than the quantity ratio.

Seed

The quantity of seed applied per hectare is assumed to be constant, implying that the total quantity of seed utilized varies with sown area. It is calculated in value terms at constant prices by multiplying by 8.14 the total sown area from Table 14 and dividing by a thousand. The figure 8.14 is the ratio of total expense for seed to total sown area in hectares or the average value of seed per sown hectare. The People's Republic of China, State Statistical Bureau, "Data on the 1955 Survey of Income and Expenditures of Agricultural Cooperatives," *Hsin-hua Pan-yueh-k'an*, December 1956, pp. 63-5 reported that in 24 provinces seed expenditure equalled 4.4 percent of the gross value of plant products (see Liu and Yeh, *The Economy of the Chinese Mainland*, p. 412). According to Liu and Yeh (p. 400), communist data indicate an adjusted estimated gross value of plant products for 1954 of 27.36 billion 1952 yuan, which implies a value of 1.20 billion 1952 yuan for seed in that year. Dividing this total by the sown area figure for 1954 of 0.1479 billion hectares (see Table 14) produces the figure of 8.14 yuan worth of seed per hectare.

Insecticide

There seems to be virtually no information on absolute quantities of insecticide available except for 1952-57. There are statements relating the size of insecticide output in 1972 and 1973 to its size in 1965, but a figure for 1965 can only be built on speculation.

1952-57. People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Language Press, 1960; reprinted as Occasional Paper No. 5, Program in East Asian Studies, Western Washington State College, Bellingham, Washington, 1974), p. 121.

1958-61. The figure for 1958 from State Statistical Bureau, *Ten Great Years* (478,000 metric tons) is assumed to be exaggerated, reflecting the breakdown of the statistical system during the Great Leap Forward. The estimated output of industrial producer goods and of chemical fertilizers are used as indicators of insecticide production in these years in order to take account of the catastrophic effects of the Great Leap Forward and the years of crisis that followed it. The low point for the production of nearly all industrial and agricultural goods in this period was 1961. After 1961 production of most goods increased steadily. Insecticide production is assumed to have grown more rapidly and declined less rapidly than that of most industrial producer goods because it was an important input to agriculture. It is assumed to have grown less rapidly than chemical fertilizer production which was considered more essential to agricultural production. On the basis of these assumptions, insecticide production for 1958-61 is estimated to change each year by the simple average of the proportional changes in production of industrial producer goods and chemical fertilizers. These proportional changes are defined as the ratio of output in one year to output in the year before. These changes and the change of insecticide production are:

	Industrial Producer Goods	Chemical Fertilizer	Insecticide
1958	1.610	1.686	1.648
1959	1.267	1.385	1.326
1960	1.137	1.345	1.241
1961	0.530	0.733	0.632

The industrial producer goods index and chemical fertilizer output series were obtained from U.S. Central Intelligence Agency (CIA), National Foreign Assessment Center, "People's Republic of China: Handbook of Economic Indicators," ER76-10540, Washington, D.C., August 1976, pp. 17, 23.

1962-72. Peking Review, November 2, 1973, reported that insecticide production in 1972 was over twice production in 1965. (See Nai-Ruenn Chen, "An Assessment of Chinese Economic Data: Availability, Reliability, and Usability," U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy* (Washington, D.C.: U.S. Government Printing Office, 1975), p. 65. The average annual rate of growth implied by this increase (about 10.41 percent) is assumed to apply to the entire period.

1973. U.S., Foreign Broadcast Information Service, *People's Republic of China, Daily Report*, January 11, 1974, reports that output in 1973 was over 2.26 times output in 1965. (See Chen, "An Assessment of Chinese Data.")

1974-77. Output in both these years is assumed to increase at the same rate as the increase from 1972 to 1973, about 12.88 percent.

Chemical Fertilizer, Gross Weight

U.S. Central Intelligence Agency, "People's Republic of China: Chemical Fertilizer Supplies, 1949-74," AER75-70, Washington, D.C., August 1975, p. 4. This series represents total chemical fertilizer consumed, that is, it includes imports and production of ammonium nitrate. The figures presented here are three-year moving averages of those in the source, that is:

$$Wy_t = \frac{Wy_{t-1} + Wy_t + Wy_{t+1}}{3}$$

where Wy is equal to the weight year and t is 1975. The purpose of this adjustment is to minimize the year-to-year discrepancies between consumption and available supply arising from inventory changes. The CIA series continues through 1975 (U.S. Central Intelligence Agency, National Foreign Assessment Center, "China: Handbook of Economic Indicators," ER77-10508, Washington, D.C., October 1977, pp. 12 and 22). The Department of Agriculture's tentative judgment that 8.5 million metric tons (42 million gross weight) of nutrients were supplied in 1977 and its guess that 6.5 million metric tons (33 million gross weight) were supplied in 1976 were used in the series. (U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *People's Republic of China Agricultural Situation: Review of 1977 and Outlook for 1978* [Washington, D.C.: USDA, 1978], p. 19). The CIA's most recent nutrient estimates are 5.9 and 9.1 million metric tons for 1976 and 1977 (U.S. Central Intelligence Agency, "China: Economic Indicators," ER78-10750, Washington, D.C., December 1978). It is not considered worthwhile to make extensive new calculations to reflect the new tentative CIA figures.

Chemical Fertilizer, Nutrients

CIA, "Handbook of Economic Indicators," ER76-10540, p. 13. This series gives the weight of the primary nutrient content of chemical fertilizer. It is also a series of three-year averages. For the 1976-77 estimates see the notes for the gross weight of chemical fertilizer.

Organic Fertilizer Nutrients

This series is from Table 17.

Total Fertilizer Nutrients

This is the sum of the nutrients from chemical and organic fertilizers.

Table 13—Current input indexes, 1952 to 1977

Year	Feed Index[a]	Seed Index[a]	Index of Insecticides and Other Costs[b]	All Fertilizer Nutrient Index[c]	Current Input Index[d]
1952	100	100	100	100	100
1953	106	102	127	108	107
1954	108	104	273	113	118
1955	105	107	447	117	128
1956	110	112	1,059	124	161
1957	116	111	993	132	164
1958	136	110	1,640	145	204
1959	122	107	2,173	138	220
1960	107	103	2,700	129	235
1961	101	101	1,707	124	186
1962	107	103	1,887	128	198
1963	119	105	2,080	145	220
1964	129	108	2,300	165	244
1965	145	110	2,533	186	271
1966	152	109	2,800	196	290
1967	155	110	3,093	200	306
1968	153	110	3,413	202	321
1969	152	110	3,767	208	341
1970	161	111	4,160	221	367
1971	173	113	4,593	238	400
1972	188	113	5,073	256	435
1973	179	115	5,727	258	464
1974	190	116	6,467	270	506
1975	199	117	7,300	281	552
1976	204	118	8,240	284	596
1977	206	120	9,300	308	659

SOURCES AND NOTES TO TABLE 13

The indexes for feed, seed, and all fertilizer nutrients are calculated from Table 6. The index of insecticides and other costs is calculated from Table 1.

The current input index is the weighted sum of the other four indexes in the table. The weights are valued weights taken from the period 1952-57. The six-year value total for feed is from Table 12; for seed, from Table 14; and for insecticides, from Table 12. For all fertilizers the six-year total cost of purchased fertilizers (chemical and oil cake fertilizers) is obtained from Table 1. According to a Communist study (Farmer's Bank) cited in Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965), p. 411, purchased fertilizers accounted for 23 percent of all fertilizer costs. The total cost of purchased fertilizers (7.05 billion yuan) is divided by 0.23 to arrive at a total of 30.65 billion yuan for all fertilizers. The value weights and the percentage weights actually used in making the aggregation are:

	(billion 1952 yuan)	(percent)
Feed	7.35	15.5
Seed	7.32	15.5
Insecticides and others	2.10	4.4
Fertilizers	30.65[37]	64.6
Total	47.42	100.0

The alternative is to take the results of three other Communist surveys cited in Liu and Yeh, *The Economy of the Chinese Mainland*, p. 411, which gave average total fertilizer costs of 22 percent of the gross value of plant products. Estimation of total fertilizer costs on this basis, using Liu and Yeh's estimates of value of plant products for 1952-57, yields similar results.

Where the growth rates of the subcategories (for example, chemical fertilizer with a 1977 index of 9,179 percent organic fertilizer with a 1977 index of only 227 percent) are widely divergent, disaggregation may mean widely different aggregate increases even when the weights are the same (that is, the weight of fertilizer is the sum of the weights of the subcategories). Thus, had we chosen to construct the aggregate input

Table 14—Land input, 1952 to 1977

Year	Cultivated Area	Irrigated Area	Cultivated Area Adjusted for Irrigation	Sown Area	Multiple Cropping Index	Sown Area Adjusted for Irrigation	Modified Multiple Cropping Index	Effective Sown Area Adjusted for Irrigation and Multiple Cropping	Land Input Index
	(million hectares)					(million hectares)		(million hectares)	
1952	107.9	21.3	113.2	141.3	130.9	148.2	115.45	130.7	100.0
1953	108.5	22.0	114.0	144.0	132.7	151.3	116.35	132.6	101.5
1954	109.4	23.3	115.2	147.9	135.3	155.9	117.65	135.5	103.7
1955	110.1	24.7	116.3	151.1	137.2	159.7	118.60	137.9	105.5
1956	111.8	32.0	119.8	159.2	142.3	170.5	121.15	145.1	111.0
1957	111.8	34.7	120.5	157.2	140.6	169.4	120.30	145.0	110.9
1958	107.8	34.7	116.5	156.3	145.0	168.9	122.50	142.7	109.2
1959	107.3	33.8	115.7	151.6	141.2	163.4	120.60	139.5	106.7
1960	107.2	32.9	115.4	146.9	137.0	158.1	118.50	136.7	104.6
1961	107.1	32.1	115.1	142.2	132.8	152.9	116.40	134.0	102.5
1962	107.0	33.0	115.2	145.7	136.1	156.8	118.05	136.0	104.1
1963	107.0	34.0	115.5	149.3	139.4	161.0	119.70	138.3	105.8
1964	107.0	33.3	115.3	152.5	142.6	164.4	121.30	139.9	107.0
1965	107.0	34.7	115.7	156.0	145.8	168.7	122.90	142.2	108.8
1966	107.0	37.3	116.3	155.6	145.4	169.1	122.70	142.7	109.2
1967	107.0	38.0	116.5	155.8	145.6	169.6	122.80	143.1	109.5
1968	107.0	38.7	116.7	156.1	145.9	170.3	122.95	143.5	109.8
1969	107.0	39.4	116.9	156.6	146.4	171.1	123.20	144.0	110.2
1970	107.0	40.3	117.1	157.5	147.2	172.4	123.60	144.7	110.7
1971	107.0	41.5	117.4	159.3	148.9	174.8	124.45	146.1	111.8
1972	107.0	42.5	117.6	160.4	149.9	176.3	124.95	146.9	112.4
1973	107.0	44.0	118.0	162.2	151.6	178.9	125.80	148.4	113.5
1974	107.0	45.3	118.3	163.9	153.2	181.2	126.60	149.8	114.6
1975	107.0	48.0	119.0	165.7	154.9	184.3	127.45	151.7	116.1
1976	107.0	48.0	119.0	167.3	156.4	186.1	128.20	152.6	116.8
1977	107.0	48.0	119.0	169.0	157.9	187.9	128.95	153.5	117.4

index from the indexes for seed, feed, insecticides and other costs, and separate indexes for chemical and organic fertilizers, the aggregate index for 1977 would have been 1,143 percent as compared with 659 percent calculated from the same component indexes and weights but with the two fertilizer subcategories lumped together.

SOURCES AND NOTES TO TABLE 14

This table derives a single measure of land input for each year taking into account both irrigation and multiple cropping.

Cultivated Area

The 1952-58 figures are from People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Language Press, 1960; reprinted as Occasional Paper No. 5, Program in East Asian Studies, Western Washington State College, Bellingham, Washington, 1974) p. 96.

The figures from 1959 through 1977 are from U.S. Central Intelligence Agency, "Agricultural Acreage in Communist China, 1949-68: A Statistical Compilation," Washington, D.C.: 1969, Table 1.

It shows that in 1962 cultivated area began to be reported as about 107 million hectares. The figures for 1960 and 1961 were interpolated using the average annual rate of change implied by the 1959 and 1962 numbers. Dwight H. Perkins, "Constraints Influencing China's Agricultural Performance," U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy* (Washington, D.C.: U.S. Government Printing Office, 1977), p. 353, reports that delegations visiting China in 1973 and 1974 were also given the figure of 107 million hectares. This figure is perceived as constant for recent years by most China scholars.

Irrigated Area

1952-57. State Statistical Bureau, *Ten Great Years.*

1963. Jen-min Jih-pao, November 30, 1963, p. 1. (See Leslie T. C. Kuo, *The Technical Transformation of Agriculture in Communist China* [New York: Praeger, 1972], p. 80.)

1964. Economic Reporter (Hong Kong), No. 895, November 16, 1964. (See Kuo, *Technical Transformation,* p. 80.) Perkins, "Constraints Influencing Performance," also gives this figure.

1965. Jen-min Jih-pao, September 30, 1965, p. 2. (See Kuo, *Technical Transformation,* p. 80.)

1966. Jen-min Jih-pao, September 30, 1966, p. 3. (See Kuo, *Technical Transformation,* p. 80.)

1973. The 1973 figure was given to a delegation of American water management specialists. *Peking Review,* January 4, 1974, indicates that irrigated area was increased by 1.4 million hectares between 1972 and 1973. (See Perkins, "Constraints Influencing Performance.")

1974. U.S. Department of Agriculture, Economic Research Service, *The Agricultural Situation in the People's Republic of China and Other Asian Communist Countries: Review of 1975 and Outlook for 1976,* Foreign Agricultural Economic Report No. 124 (Washington, D.C.: USDA, 1976), pp. 26-8. The figure given is the maximum total estimated from provincial irrigated area reports.

1975. Peking Review, October 8, 1976, p. 47. From 1965 to 1975 "the irrigated acreage was extended each year by an average of 1.33 million hectares." The 1975 figure is calculated to be 13.1 million hectares plus the 1965 figure.

1976-77. According to U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *People's Republic of China Agricultural Situation: Review of 1977 and Outlook for 1978* (Washington, D.C.: USDA, 1978), p. 20, the 1977 acreage was reported to be three times the 1949 acreage of 16 million hectares. The 1976 figure is our estimate.

Figures for the years for which information on irrigated area is not available (1958-62) were interpolated as shown below, using the method developed by Norman M. Kaplan and Richard H. Moorsteen, *Indexes of Soviet Industrial Output* (Santa Monica, Cal.: Rand Corp., 1960), pp. 61-8.[38]

Year	Benchmark Index	Interpolat-ing Index	Final Index
1957	100.0	100.0	100.0
1958		99.4	99.9
1959		96.4	97.4
1960		93.4	94.9
1961		90.5	92.4
1962		92.7	95.1
1963	98.0	95.0	98.0
1966	100.0	100.0	100.0
1967		100.1	101.8
1968		100.3	103.7
1969		100.6	105.7
1970		101.2	108.1
1971		102.4	111.2
1972	113.9	103.1	113.9

For an explanation of the method see the sown area series in Robert Michael Field, "Civilian Industrial Production in the People's Republic of China: 1949-74," U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy* (Washington, D.C.: U.S. Government Printing Office, 1975),pp. 171-172. It is assumed that a positive relationship exists between increases in irrigated and sown area. Since cultivated area has changed little, growth in sown area has had to come about by increases in multiple cropping. Chinese press reports indicate that most of the changes in cropping patterns used to bring this about—such as the northward advance of rice cultivation and the spread of early rice varieties—require increases in irrigation.

Cultivated Area Adjusted for Irrigation

John Lossing Buck (*Land Utilization in China*, 3 vols. [Chicago: University of Chicago Press, 1937], Study, pp. 230-1) found from his sample that in North China's wheat region, irrigation increased wheat and millet yields (other things being equal) by 60-70 percent, adding that in the Central and South China rice region the increases were much smaller. Limited Communist data showed larger increases. Two sources cited wheat and millet yield increases of a little over 100 percent in the wheat region and rice yield increases of 40-60 percent in the rice region (*Jen-min Jih-pao*, December 22, 1957 and *People's China*, No. 2, 1957, p. 27). But as Kang Chao noted, these yield increments were results of the package applied on irrigated land. Since improved seed-fertilizer technology is reflected in the total factor productivity index, a pre-World War II Japanese government sample survey, which, after separating the contribution of additional fertilizers, shows a 10 percent difference in rice yield between improved paddy land (mainly with provisions for irrigation and drainage) and unimproved land (Yujiro Hayami, *A Century of Agricultural Growth in Japan* [Minneapolis: University of Minnesota Press, 1975], p. 192). This figure and the higher estimates for China yield 25 percent for the approximate average increment in yield from irrigation.

In this light each irrigated unit of area is equivalent to 1.25 units of standard (non-irrigated) cultivated land. Cultivated area adjusted for irrigation is thus the sum of one-fourth of the irrigated area and the cultivated area.

Buck's statement does not imply that irrigation in the rice region was relatively developed. The opposite is true for reasons that do not necessarily conflict with Buck's point. The rice region had lower costs for installing and operating irrigation facilities and equipment, and time to permit more intensive use of land. The latter effect is captured by increases in sown or cropped areas relative to cultivated areas. Our concern here is to adjust crop areas for the yield effect of water projects. The Japanese survey results, obtained by imputing yield increases separately to land improvement and to augmented fertilizer use, assume separability or independence of effects. The 10 percent yield response attributed to water measures was probably underestimated. Buck's figures, on the other hand, were probably inflated by increased fertilization that accompanied irrigation. The choice of seed varieties, too, is part of the water-seed-fertilizer package. The question whether the effects of factors are independent of each other undermines the methodology used to account for growth according to factor contributions. This is basically a question of taste. As Solow put it, either the methodology appeals or it doesn't. The matter is beyond recourse to fancy theories about index numbers, aggregation, or production functions.

Sown Area

1952-58. State Statistical Bureau, *Ten Great Years*, p. 96.

1959-65. Edwin F. Jones, "The Emerging Pattern of China's Economic Revolution," U.S. Congress, Joint Economic Committee, *An Economic Profile of Mainland China*, 2 vols. (Washington, D.C.: U.S. Government Printing Office, 1967), 1: 94, develops the 1961 and 1965 figures from fragmentary information. Intervening years are estimated by linear interpolation. (See Anthony M. Tang, "Input-Output Relations in the Agriculture of Communist China, 1952-65," in W. A. Douglas Jackson, ed., *Agrarian Policies and Problems in Communist and Non-Communist Countries* [Seattle: University of Washington Press, 1971], p. 285.)

1966-72. Sown area for these years is the sum of estimates of area sown to grain and a constant 38.52 million hectares as an estimate of the area sown with nongrain crops. The estimates of area sown with grain were developed by Bobby A. Williams, "China: Grain Output Growth and Productivity, 1957-72," U.S. Central Intelligence Agency, Office of Economic Research, Washington, D.C., May 1974, Table 4. (Mimeographed.)

Williams' 1966 figure is an unpublished estimate by A. L. Erisman. For 1967-68 he assumed that the increase in total grain area consisted entirely of an increase of 0.604 million hectares reported for early rice between 1966 and 1968. This increase is divided equally between 1967 and 1968. His 1969 figure is from a report in the U.S. Foreign Broadcast Information Service (FBIS), *People's Republic of China, Daily Report*, September 2, 1969, p. B3, that early rice area increased 6 percent, or 0.554 million hectares. This is assumed to be the total grain area increase. FBIS, *PRC*, August 31, 1971, reported an increase in early rice area of 1.8 million hectares in 1971. Data for Anhwei, Fukien, Hunan, and Kwangsi indicate that the increase was about 16.9 percent of the 1970 figure. This implies that the 1970 early rice area was 10.651 million hectares, and the 1971 area was 12.451 million hectares. The early rice area increases of 0.861 million hectares for 1970 and 1.8 million hectares for 1971 are again assumed by Williams to account for the total increase in grain area. Williams assumed that grain area in 1972 increased at the average annual growth rate for 1968-71, 9 percent.

A constant term was chosen as an estimate for new grain area because there is not enough evidence available to form a basis for a more satisfactory estimating procedure. Nongrain area—calculated by subtracting area sown with grain from total sown area—ranged from 28.94 million hectares in 1952 to 42.23 million hectares in 1959, and from 29.57 million hectares in 1961 to 41.00 million hectares in 1965. In 1964 the area sown with nongrain crops was 35.8 percent of total cultivated area (38.31 million hectares), and in 1965 it was 38.32 percent of cultivated area. The constant figure of 38.52 million hectares, or 36 percent of cultivated area was chosen as an estimated mean around which nongrain area might fluctuate after 1965, on the basis of several considerations.

The steady increase in nongrain area from 1961 to 1965 was part of the recovery from the crisis years of 1959-61; grain area shows a similar recovery pattern. By 1965 the precrisis maximum had nearly been reached, implying that further expansion might be more difficult. Also, steady population growth required that top priority be given to the production of grain, implying that expansion of area sown with grain might crowd out expansion of nongrain area.

The increased production of most nongrain crops may be accounted for as readily by higher yields—resulting from improved seed varieties, increased irrigation and fertilizer—as by increased area.

The estimated multiple-cropping index produced by this method is consistent with the indexes of the preceding years and with fragmentary evidence from China. For instance, FBIS, *PRC*, January 8, 1975 reports that the multiple-cropping index in Szechuan—a major agricultural province with cropping patterns between the largely single-crop wheat system of the North and the double-crop rice system of the South (see U.S. Central Intelligence Agency, *People's Republic of China: Atlas* [Washington, D.C.: U.S. Government Printing Office, 1971] pp. 58-9)—was 143.7 percent in 1969, and 146 percent in 1973. For these years the method used here gives figures of 146.4 percent and 151.6 percent respectively, indicating that the use of a constant for nongrain area has probably not resulted in serious underestimation.

1973-77. Total sown area is assumed to increase at the average annual rate for 1961 to 1972 (1.1 percent).

The final figures from this estimation procedure compare favorably with estimates made by official organizations. The Food and Agriculture Organization of the United Nations, *FAO Production Yearbook 1975*, Vol. 28 (Rome: FAO, 1976) reports sown area figures which add up to 168.1 million hectares compared with the figure of 165.7 million hectares derived here. The U.S. Department of Agriculture, Economic Research Service, *People's Republic of China Agricultural Situation: Review of 1976 and Outlook for 1977*, Foreign Agricultural Report No. 137 (Washington, D.C.: USDA, 1977), estimates the area sown with grains, oilseeds, and cotton to be 155.4 million hectares in 1975, yielding an index for 1952 (133.2 million hectares planted to the same crops) of 116.7 percent which is quite close to the index of 117.3 percent produced by the estimates derived here for the same years. For complete USDA area and yield estimates on the major crops listed above, see Tables 1 and 2.

Multiple-Cropping Index (MCI)

The MCI is calculated as the ratio of total sown area to cultivated area.

Sown Area Adjusted for Irrigation

The contribution of irrigated area to sown area is taken into account by multiplying the cultivated area adjusted for irrigation by the MCI.

Modified Multiple-Cropping Index (MMCI)

The MMCI corrects for the overstatement of effective crop area (as a flow concept) inherent in the common MCI. The overstatement results from the fact that land that is double-cropped does not yield twice as much as the same land single-cropped, using similar technology. This is true even if both crops are identical. The overstatement is amplified if the second crop is a lesser, secondary crop adopted to fit into more restricted time-weather limits. Several examples of this phenomenon were mentioned to Gilbert Etienne by provincial officials.[39]

Hupeh (average provincial yields):	
Early paddy	3,750 kg/hectare
Late paddy	2,625 kg/hectare
Changsha, Hunan (an advanced area):	
Early paddy	4,350 kg/hectare
Late paddy	3,000 kg/hectare
Hunan (average provincial yields):	
Traditional varieties	
Early paddy	3,750 kg/hectare
Late paddy	2,400 kg/hectare
High-yield varieties	
Early paddy	5,250 kg/hectare
Late paddy	3,750 kg/hectare

To derive a crude estimate of the relevant discount factor, which when applied would give effective sown area corrected for the multiple-cropping bias (and, by virtue of the adjustments for irrigation in cultivated area adjusted for irrigation and the MCI), a comparison was made with contemporary rice yields of Japan, South Korea, and Taiwan. The yields have increased in all three in a roughly parallel manner in recent years. The reference year used is 1975 because harvest conditions were normal in all three countries during that year.

Taiwan grows two crops of rice a year, while Japan and Korea grow one. Taiwan's institutions and technology in rice cultivation are in between the other two. Thus, the average of the yields of Japan and Korea may indicate what Taiwan's rice yield would have been if it were single-cropped. U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular: Rice*, FRI-76, May 1976, showed the following rice yields for 1975: 5.95 metric tons/hectare for Japan, 5.32 metric tons/hectare for South Korea, and 4.32 metric tons/hectare (an average for the early and late crops) for Taiwan. Multiplying Taiwan's figure by 2 to allow for double-cropping, and dividing the product by the average of Japan's and Korea's yields, produces a ratio of approximately 1.5. Though a comparable ration cannot be inferred from the Communist data given to Etienne, the estimated ratio of 1.5 appears plausible in relation to them. The estimated ratio implies that the production of one unit of double-cropped land is equivalent to the productivity of 1.5 units of single-cropped (identical) land. An MCI of

150 percent implies that 50 percent of the cultivated area is double-cropped, which translates into 75 percent in effective single-cropped-area terms by virtue of the 1.5 productivity ratio. To this figure of 75 percent is added the other half of the total cultivated area that is single-cropped. The MMCI is thus 75 percent plus 50 percent (single-cropped area) or 125 percent. Mechanically, MMCI is conveniently calculated as:

$$MMCI = 100 + \tfrac{1}{2}(MCI - 100).$$

Effective Sown Area Adjusted for Irrigation and Multiple-Cropping Bias

The final effective sown area figure is calculated as effective cultivated area, quality-adjusted for irrigation, multipled by the MMCI.

Land Input Index

For this index, 1952 is equal to 100.

SOURCES AND NOTES TO TABLE 15

Detailed information on livestock holdings is available only for 1952-58. Scattered statements relating holdings in years after 1949 have appeared in the 1970s. Holdings in the intervening years were estimated by a least square regression analysis of the relationships between the livestock series and the complete series available for livestock exports and grain production. The regressions were run using the grain output series estimated or pieced together in U.S. Central Intelligence Agency (CIA), National Foreign Assessment Center, "People's Republic of China: Handbook of Economic Indicators," ER76-10540, Washington, D.C., August 1976, p. 11. The CIA has since developed a new series (see Table 17). Elsewhere in this work, the grain series (and the aggregate value output estimates based on it) is adapted from 1978 USDA estimates (U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *People's Republic of China Agricultural Situation: Review of 1977 and Outlook for 1978* (Washington, D.C.: USDA, 1978), pp. 30-2). It is not considered

Table 15—Livestock: estimated (year end) holdings, total value of holdings, value of livestock produced, 1952 to 1977

Year	Draft Animals	Hogs	Sheep and Goats	Total Value	Value of Production
	(million head)			(billion 1952 yuan)	
1952	78.31	92.95	66.90	10.86	4.97
1953	82.72	98.92	76.66	11.56	5.16
1954	86.18	94.82	82.76	11.69	4.90
1955	87.38	85.97	87.94	11.41	4.40
1956	86.05	98.00	93.91	11.91	4.88
1957	83.46	115.00	98.58	12.53	6.06
1958	85.06	160.00	108.86	14.81	7.43
1959	81.79	136.10	81.99	13.24	5.58
1960	79.58	105.53	78.25	11.63	4.54
1961	73.41	101.72	78.25	10.98	4.33
1962	70.87	115.46	100.07	11.59	5.39
1963	76.78	136.62	96.96	13.00	6.73
1964	82.88	148.30	104.44	14.06	7.23
1965	91.19	167.66	115.67	15.69	8.30
1966	92.40	183.07	119.41	16.52	8.35
1967	86.41	198.68	130.64	16.86	8.45
1968	83.79	198.29	119.41	16.55	8.34
1969	87.00	190.81	123.16	16.49	8.51
1970	87.80	210.36	138.13	17.57	9.43
1971	92.13	230.92	130.09	18.79	10.34
1972	95.04	259.88	148.21	20.49	11.60
1973	97.94	233.45	145.61	19.47	10.04
1974	100.84	252.80	157.84	20.69	11.31
1975	103.82	268.20	160.58	21.65	11.84
1976	106.89	272.10	162.10	22.08	11.92
1977	110.06	273.50	160.58	22.37	11.97

worthwhile to rerun the regressions and make new estimates of animal numbers that will differ only marginally from the estimates already made. New grain output estimates for 1974-77 are substituted for the old estimates in the regressions. The "Total Value" column gives the value of the stock of animals in constant prices, while the "Value of Production" column presents the flow value of livestock produced or consumed. All figures are for the end of the year. Data presented directly by the PRC, or derived on the basis of official statements include:

1952-58

Peoples's Republic of China, Ministry of Agriculture, Bureau of Planning, *A Collection of Statistical Data on Agricultural Production of China and Other Major Countries* (Peking: Agricultural Publishing House, 1958) pp. 65-78, quoted in Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China,* (Chicago: Aldine, 1967), p. 340. Before 1957 the reporting date for livestock was July 1. The year-end estimates in this table for 1952-55 were calculated by simply taking the average of each midyear number and that of the following year. Beginning in 1957, the reporting date became December 31. For 1956, therefore, year-end draft animal and sheep and goat numbers were estimated by calculating the average six-month growth rates implied by the midyear 1956 and year-end 1957 figures, then increasing the midyear 1956 numbers by these rates. The 1956 year-end hog figure is given in People's Republic of China, State Statistical Bureau, "Communique on Fulfillment of the National Economic Plan in 1956," *Hsin-hua Pan-yueh-k'an*, September 17, 1957, pp. 201-5. (See Ta-chung Liu and Kung-chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* [Princeton: Princeton University Press, 1965], p. 364.)

The 1958 figures are from People's Republic of China, State Statistical Bureau, *Communique on the Development of the National Economy in 1958* (Peking: T'ung-chi Ch'u-pan-she, 1959), p. 21. (See Chen, *Chinese Statistics*, p. 340.) They are given as year-end figures.

1961, 1962, 1965, 1971, 1972

The remaining data were derived from official statements. They cannot be presented in chronological order, since 1965 and 1971 are given in relation to 1972, and 1962 in relation to 1971.

For the 1972 figures U.S. Foreign Broadcast Information Service (FBIS), *People's Republic of China, Daily Report*, September 19, 1973, p. B7, reports that between 1949 and 1972 draft animals increased 59 percent, hogs increased "4.5 fold," and sheep and goats increased "3.5 fold." "4.5 fold" is taken to mean "4.5 times a large as." A discussion of these terms is given in U.S. Department of Agriculture, Economic Research Service, *The Agricultural Situation in the People's Republic of China and Other Asian Communist Countries: Review of 1973 and Outlook for 1974*, ERS-Foreign 362 (Washington, D.C.: USDA, 1974), pp. 5-7. In 1949 China had 59.775 million draft animals, 57.752 million hogs, and 42.347 million sheep and goats. (Ministry of Agriculture, Bureau of Planning, *A Collection of Data*.)

FBIS, *PRC*, September 19, 1933, p. B7 states: "China registered the biggest increase in livestock in 1972." This statement implies that the increase in livestock between 1971 and 1972 was greater than any previous increase. The largest known increase took place between 1956 and 1957, when total numbers of livestock grew from 277.96 million head to 327.93 million head, a change of 49.97 million head. Assume, then, that the total increase between 1971 and 1972 was 50 million head. In order to allocate this increase among the three categories, their proportions of the change in total livestock numbers from 1952 to 1958 were calculated. Draft animals made up 5.83 percent of the increase, hogs made up 57.92 percent, and sheep and goats made up 36.25 percent. The increases between 1971 and 1972 are assumed to be in the same proportions between 1952 and 1957. The 1971 figures are derived by subtracting the appropriate proportions of 50 million head from the 1972 numbers.

FBIS, *PRC*, October 3, 1972, p. B7, gives the relationship between 1962 and 1971 figures. In relation to 1962, "... the number of pigs by the end of 1971 had doubled. The increase was 30 percent for draft animals and sheep ...." The 1962 figures were calculated by dividing the 1971 number of hogs by 2 and the numbers of draft animals and of sheep and goats by 1.3.

For the number of hogs, according to FBIS, *PRC*, September 19, 1973, p. B8, "The number of pigs in 1972 was 55 percent above 1965 ...." According to *Peking Review*, October 17, 1975, p. 23, "The inventory of live pigs by the end of June 1975 was more than four times that of 1949." Approximating "more than" as 10 percent and using the 1949 hog figure cited above, this statement implies a 1975 midyear hog total of 236.78 million (57.752 million multiplied by 4.1). This figure is adjusted to the end of the year by increasing it by one-half the average annual growth rate implied by the 1965-72 increase.

Estimates for Regression Analysis

The official and derived figures for draft animals listed above (1952-58, 1962, 1971,

1972) were tested for relationships with possible related series, including grain production, livestock exports to Hong Kong, and livestock exports to the "Free World" and the U.S.S.R. The best relationship was found with exports of meat and live animals to the "Free World" and the U.S.S.R. for 1955-73 (see Table 14). Figures for 1959-61, 1963-70, and 1973 were then estimated using the following equation:

$$\text{Draft Animals} = \underset{(2.7199)}{69.646} + \underset{(0.02240)}{0.14356}\,(\text{world and U.S.S.R. exports});$$

(standard errors)

$R^2 = 0.8914$, $n = 7$.

Because the export series does not include 1974-77 draft animal totals, these totals were assumed to increase at the average annual growth rate implicit in the 30 percent increase from 1962 to 1971 (see above).

Intuitive reasoning and an examination of Chinese press reports on hog production lead to the conclusion that hog numbers are affected by grain production in both the current and the preceding year. Articles such as the *Peking Review* piece cited above for the 1975 hog figure (October 17, 1975, p. 23), repeatedly link increases in hog production to high levels of grain output. The FBIS article cited for the 1965 hog figure (September 19, 1973, p. B8) states that hogs are fed grain and fermented feed composed of stalks of maize, sorghum, beans, wild plants, and other materials. Ideally, then, an equation for estimating missing hog numbers would be derived by a multiple regression using current grain production and grain production lagged one year as independent variables. When this regression was carried out for the hog figures mentioned above (1952-55, 1962, 1965, 1971, 1972, and 1975), and a figure of 56.89 million for 1951 (Liu and Yeh, *The Economy of the Chinese Mainland*, p. 364), the resulting R^2 value and "F-statistic" showed that both variables were indeed relevant. The "t-statistics" and standard errors, however, indicated such a high degree of multicollinearity that the grain coefficients could not be considered reliable within any practical confidence interval.

$$\text{Hogs}_t = -149.68 + 0.44764\,(\text{Grain}_t) + 1.1292\,(\text{Grain}_{t-1});$$

(standard errors) (37.309) (0.84337) (0.75261)

(t statistics) (−4.0119) (0.53077) (1.5004)

$R_2 = 0.93156$, $n = 12$, F statistic = 61.251.

The specific problem which this equation presents for estimation purposes is the relatively heavy weight that it allots to the lagged grain influence. In some cases this causes the predicted numbers of hogs to rise in years when grain production seriously fell. This behavior is contrary to what little information exists about hog numbers in the years for which data are not available. In particular, livestock and meat exports to the "Free World" and the U.S.S.R. (see Table 14) fell sharply in 1959 and 1968, both years of major declines in grain production.

In order to incorporate more equal influences for the two grain variables in the estimation procedure, individual regressions were carried out using grain output and lagged grain output as the single independent variables:

$$\text{Hogs}_t = \underset{(130.731)}{-156.29} + \underset{(0.1579)}{1.5743}\,(\text{Grain}_t);$$

(standard errors)

$R^2 = 0.90037$, $n = 13$.

$$\text{Hogs}_t = \underset{(25.382)}{-135.66} \quad \underset{(0.13263)}{1.52219}\,(\text{Grain}_{t-1});$$

(standard errors)

$R^2 = 0.92942$, $n = 12$.

The missing hog figures were then predicted using each of these equations separately, and the results were averaged to obtain the final estimates. In effect, this constitutes a redistribution of the weights attached to the two variables in the multiple regression model and a concurrent adjustment of the constant term, as follows:

$$\text{Hogs}_t = -145.975 + 0.78715\,(\text{Grain}_t) + 0.76095\,(\text{Grain}_{t-1}),$$

where the constant term is the average of the two simple regression constants, and the grain coefficients are each one-half of those in their respective single variable equations.

The CIA gave the following estimates of hog numbers in U.S. Central Intelligence Agency, National Foreign Assessment Center, "China: Economic Indicators," ER77-10508, Washington, D.C., October 1977, p. 11: for 1970, 226 million head (compare our regression estimate of 210); for 1974, 261 (253); for 1976, 280 (272).

The sheep and goat data (1952-58, 1962, 1971, 1972, and a figure of 56.84 million for 1951 from Liu and Yeh, *The Economy of the Chinese Mainland*, p. 364) were found to have a strong relationship with grain production. The missing years were estimated using the following equation:

$$\text{Sheep and goats} = \underset{(11.162)}{-41.513} + \underset{(0.06003)}{0.74849}\,(\text{Grain});$$

(standard errors)

$R^2 = 0.94532$, $n = 11$.

Value

The total value of livestock holdings is the sum of the numbers of draft animals, hogs, sheep, and goats multiplied by their prices in 1952 yuan. These prices were 77.3 yuan for draft animals, 46 yuan for hogs, and 8 yuan for sheep and goats (from Liu and Yeh, *The Economy of the Chinese Mainland*, pp. 136, 384). The composite price for draft animals is a weighted average of the prices of the major types of animals, where the weights were the average proportions of the various types in the draft animal totals for 1951-57 (see the notes to Table 12).

	Cattle	Horses	Mules	Donkeys
Average proportion of draft animal total	0.753	0.082	0.02	0.145
Price (yuan)	75.0	110.0	160.0	59.2
		Weighted average = 77.3 yuan		

The value of livestock production for a given year is assumed to consist of the change in value of livestock holdings over the previous year and the value of slaughtered or utilized livestock. The change in value of livestock holdings is simply calculated by adding the changes for each category multiplied by their prices. The number of of livestock that are slaughtered or die of other causes is calculated as a proportion of the previous year's holdings (the utilization rate), to avoid including animals reported as part of the increase in holdings. The value of livestock utilized is then derived by multiplying the number of animals utilized by their price:

Value of livestock utilized =
(million 1952 yuan)

$$0.138 \times (\text{draft animals}_{t-1}) \times 77.3 \text{ yuan} + 0.8 \times \text{hogs}_{t-1} \times 46 \text{ yuan} + 0.4 \times (\text{sheep and goats}_{t-1}) \times 8 \text{ yuan}.$$

The utilization rates are developed in Liu and Yeh, *The Economy of the Chinese Mainland*, pp. 310-11, from the following sources: Republic of China, Ministry of Agriculture and Forestry, *Nung-lin T'ung-chi Shou-t'se* [Handbook of Agricultural and Forest Statistics] (Nanking: Ministry of Agriculture and Forestry, 1948), p. 59; Chang Chung-wan and Hwang Wei-yi, *Tsu-kuo Ti Hsu-mo Yu Hsu-han Tzu-yuan* [Animal Husbandry and Animal Products of our Fatherland] (Shanghai: Yung-hsiang Book Co., 1953), p. 207; Hsu Cheng-ying, *Chung-kuo Chih Hsu-mo* [Animal Husbandry in China] (Shanghai: Yung-hsiang Book Co., 1959), p. 41. A composite rate for draft animals was calculated from Liu and Yeh's figures in the same way as the composite price in the previous note:

	Cattle	Horses	Mules	Donkeys
Average proportion of draft animal total	0.753	0.082	0.02	0.145
Utilization rate	0.15	0.1	0.1	0.1
		Weighted average =		0.138

Table 16—China: estimated and projected (midyear) population, 1949 to 2000

Year	Population	Vital Rates Per 1,000 Persons: Natural Increase	Births	Deaths
	(thousands)			
1949	537,918	12.0	45.4	33.4
1950	547,364	13.5	45.4	31.9
1951	558,096	15.1	45.3	30.2
1952	569,904	18.0	45.2	27.2
1953	582,603	22.5	45.0	22.5
1954	596,064	23.1	44.1	21.0
1955	610,201	23.8	43.1	19.4
1956	625,004	24.2	42.6	18.5
1957	640,024	23.3	41.3	18.0
1958	654,727	22.1	40.2	18.1
1959	668,930	20.8	40.1	19.3
1960	682,091	18.2	39.9	21.7
1961	693,624	15.4	39.1	23.7
1962	705,486	18.5	37.7	19.2
1963	719,301	20.3	37.6	17.4
1964	734,359	21.2	37.2	16.0
1965	750,394	22.0	36.5	14.4
1966	766,946	21.6	36.2	14.6
1967	784,017	22.4	36.2	13.8
1968	801,983	22.9	36.3	13.4
1969	820,733	23.3	36.3	12.9
1970	840,148	23.4	35.7	12.3
1971	859,927	23.1	34.9	11.8
1972	879,520	22.0	33.5	11.6
1973	898,695	21.2	32.0	10.8
1974	917,256	19.7	30.0	10.2
1975	934,626	17.8	27.6	9.8
1976	950,744	16.4	25.5	9.1
1977	965,937	15.3	24.1	8.8
1978	980,417	14.4	23.0	8.6
1979	994,332	13.7	22.1	8.4
1980	1,007,858	13.3	21.5	8.2
1985	1,075,999	13.2	21.1	7.9
1990	1,151,665	14.0	21.9	7.9
1995	1,237,029	14.5	22.7	8.1
2000	1,328,645	13.7	22.0	8.3

SOURCES AND NOTES TO TABLE 16

These figures are estimates prepared by the U.S. Department of Commerce, Bureau of Economic Analysis, Foreign Demographic Analysis Division. They can be found in U.S. Central Intelligence Agency, National Foreign Assessment Center, "China: Economic Indicators," ER77-10508, Washington, D.C., October 1977, p. 8.

SOURCES AND NOTES TO TABLE 17

There has been little fundamental disagreement about the calculation of organic fertilizer quantities since the development of estimates in Owen L. Dawson, "Fertilizer Supply and Food Requirement," in John Lossing Buck, Owen L. Dawson, and Yuan-li Wu, *Food and Agriculture in Communist China* (Stanford: Stanford University Press, 1966), pp. 101-48. There are wide differences in the quantities of fertilizer and nutrient content estimated by various scholars, but these have resulted from differences in coefficient or component estimates rather than methods. The calculating methods and coefficients used for this table were adopted from the "Appendix on Organic Fertilizer," of James Kilpatrick's "The Role of Chemical Fertilizer in the Development of Chinese Agriculture" (Ph.D. dissertation, University of Michigan, forthcoming). His permission to use this material is gratefully acknowledged. The estimates in Kilpatrick's appendix are based primarily on the Dawson article cited above and Shigeru Ishikawa, "Changes in the Structure of Agricultural Production in Mainland China," in W. A. Douglas Jackson, ed., *Agrarian Policies and Problems in Communist and Non-Communist Countries* (Seattle: University of Washington Press, 1971), pp. 346-77. Another major recent set of estimates was developed by Kang Chao in his study, *Agricultural Production in Communist China: 1949-65* (Madison: University of Wisconsin Press, 1970), pp. 144-63, 310-14. Chao's work is also based largely on Dawson, and differs only slightly from Kilpatrick's methodology.

The estimation procedures and sources of information used for the organic fertilizer components are explained below.

Night Soil

Each member of the population is assumed to produce 500 kilograms of night soil per year. (Ministry of Agriculture, "The State of Utilization of Night Soils, Rubbish, and Other Miscellaneous Manures in Various Urban Districts and Our Opinion Regarding It," *Chung-kuo Nung-pao*, No. 7, 1956 (quoted in Ishikawa, "Changes in Structure," p. 369); *Jen-min Jih-pao*, November 18, 1957, quoted in Chao, *Agricultural Production*, p. 312). The percentage of night soil actually utilized is assumed to vary between rural and urban areas, and over time. The following rural and urban utilization rate figures were adopted from Kilpatrick, "Role of Chemical Fertilizer":

Table 17—Organic fertilizer sources, estimated quantities utilized, and nutrient content, 1952 to 1977

Year	Night Soil	Hog Manure	Draft Animal Manure	Green Manure	Oil Cake	Compost	River and Pond Mud and Other	Total Gross Weight	Nutrient Content
					(million metric tons)				
1952	185.66	130.13	422.09	11.2	4.66	73.71	114.09	941.5	10.14
1953	194.82	142.44	458.60	14.3	4.86	77.86	122.60	1,015.5	10.92
1954	205.02	140.33	491.05	18.3	4.45	81.12	131.74	1,072.0	11.41
1955	215.85	130.67	511.35	23.5	4.47	82.25	141.56	1,109.7	11.72
1956	227.41	152.88	516.82	30.1	5.01	81.00	152.12	1,165.3	12.37
1957	237.15	184.00	514.11	38.5	4.92	78.56	152.12	1,209.4	13.03
1958	241.37	256.00	523.97	49.2	5.14	80.06	152.12	1,307.9	14.23
1959	245.75	217.76	503.84	40.6	5.63	76.99	152.12	1,242.7	13.48
1960	249.64	168.85	490.19	39.4	4.02	74.90	152.12	1,179.4	12.50
1961	253.21	162.76	452.21	39.4	3.87	69.10	152.12	1,132.7	12.00
1962	257.25	184.74	436.56	44.3	3.77	66.71	152.12	1,145.5	12.20
1963	272.87	226.79	490.72	59.9	3.45	72.27	152.12	1,278.1	13.67
1964	292.59	258.04	555.19	81.0	3.40	78.01	152.12	1,420.4	15.23
1965	310.92	301.79	631.94	85.7	3.35	85.83	152.12	1,571.6	16.95
1966	317.79	329.52	640.33	90.6	3.33	86.97	152.12	1,620.6	17.56
1967	324.31	357.62	598.85	95.8	3.41	81.34	152.12	1,613.4	17.60
1968	331.19	356.91	580.69	101.3	3.18	78.87	152.12	1,604.3	17.48
1969	338.39	343.45	602.91	107.1	3.04	81.89	152.12	1,629.0	17.67
1970	346.33	378.64	608.47	113.3	3.38	82.65	152.12	1,684.9	18.40
1971	354.41	415.66	638.46	119.8	3.87	86.72	152.12	1,771.0	19.47
1972	362.36	467.78	658.63	126.7	4.26	89.46	152.12	1,861.4	20.63
1973	370.27	420.20	678.73	134.0	4.90	92.19	152.12	1,852.6	20.42
1974	377.91	455.04	698.82	141.7	4.65	94.92	152.12	1,925.2	21.25
1975	385.06	482.79	719.47	149.9	4.90	97.72	152.12	1,992.0	22.08
1976	391.71	489.78	740.75	158.5	4.41	100.62	152.12	2,037.9	22.52
1977	397.97	492.30	762.72	167.6	4.66	103.60	152.12	2,081.0	22.99

	Rural	Urban
	(percent)	
1952	70	30
1956	. . .	40
1957	80	40
1962	80	40
1965	90	50
1972	90	50

The 1956, 1957, and 1962 figures were found in Ishikawa, "Changes in Structure," p. 369. Ishikawa derived them from the source mentioned above. (A similar rural series is presented in Chao, *Agricultural Production*, p. 313.) Values for intervening years were interpolated to produce complete rural and urban utilization rate series. The night soil figures were then calculated from the rural and urban population series in Table 11 according to the following formula:

Night soil utilized = 0.5 × (rural pop.)

× (rural utilization rate) + (urban pop.)

× (urban utilization rate).

Hog Manure

Hogs are assumed to produce 2 metric tons of manure per head each year. (Chinese Agricultural Academy, Institute for Research on Soil and Fertilizer, *Chung-kuo Fei-liao Kai-lun* [General Treatise on Fertilizer in China] [Shanghai: Shanghai Science and Technology Publishing Co., 1962], pp. 58-9, quoted in Ishikawa, "Changes in Structure," pp. 368-69; *Jen-min Jih-pao*, November 18, 1957, quoted in Chao, *Agricultural Production*, p. 312.) The percentage utilized each year is assumed to be the same as the rural utilization rate for night soil. The hog manure figures, then, are calculated from the hog holdings series in Table 15, as follows:

Hog manure utilized =

2 × (hog holdings)

× (rural utilization rate).

Draft Animal Manure

Draft animals are assumed to produce an average of 7.7 metric tons of manure per year. Ishikawa reports ("Changes in Structure," p. 369) that *Chung-kuo Fei-liao Kai-Lun* gives figures of 9 metric tons per year for cattle and 5 metric tons for horses. An average figure for draft animals was calculated using as weights the average proportions of cattle, horses, mules, and donkeys in the draft animal totals for 1951-57 (People's Republic of China, Ministry of Agriculture, Bureau of Planning, *A Collection of Statistical Data on Agricultural Production of China and Other Major Countries* (Peking: Agricultural Publishing House, 1958), pp. 65-78; quoted in Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China* [Chicago: Aldine, 1967], p. 340). Buffalo are included as cattle (this is the procedure followed in Ta-chung Liu and Kung-chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965). Mules are assumed to produce the same amount of manure as horses, and donkeys (asses) are assumed to produce one-half this amount (2.5 metric tons).

	Cattle	Horses	Mules	Donkeys
Average proportion of draft animal total	0.753	0.082	0.020	0.145
Manure produced (metric tons)	9.0	5.0	5.0	2.5
	Weighted	average =	7.7	metric tons

The utilization rate is assumed to be the same as the rural night soil utilization rate. Draft manure utilized each year is calculated using the draft animal figures from Table 15 according to the following formula:

$$\text{Draft animal manure utilized} = (\text{draft animal holdings}) \times (\text{rural utilization rate}).$$

Chao and Kilpatrick both use an average of 5 metric tons per year for draft animals. Chao's source for this figure is *Jen-min Jih-pao*, November 18, 1957. Ishikawa's figures were used here because they come from a more recent and more specialized publication. Dawson, "Fertilizer Supply," p. 139 uses an annual manure production figure of 7 metric tons for each "animal unit"; John Lossing Buck, *Chinese Farm Economy* (Chicago: University of Chicago Press, 1930), p. 224 uses 8 metric tons; John Lossing Buck, *Land Utilization in China*, 3 vols. (Chicago: University of Chicago Press, 1937), Study, p. 258 uses 7.99 metric tons. One animal unit is equal to: one ox, one horse, one mule, two-thirds water buffalo, or two donkeys (Buck, *Land Utilization in China*, Study, p. 473). Buck's values imply production of 8 metric tons per ox, horse, or mule, 12 metric tons per buffalo, and 4 metric tons per donkey. Using individual weights of 0.595 for cattle and 0.158 for buffalo (yearly proportional averages as above), and the other weights previously used, a weighted average for annual draft animal production of 8.052 is derived. The same procedure applied to Dawson's figure leads to an average of 7.045. Both of these figures are sufficiently close to 7.7 to support the use of Ishikawa's numbers.

Green Manure

For 1952-57, People's Republic of China, Ministry of Agriculture, Department of Soil and Fertilizer, "Performance of the Work Relating to Fertilizer in Our Country for the Past Ten Years," *Chung-kuo Nung-pao* [China Agriculture Journal], No. 17, 1959, p. 25 (see Ishikawa, "Changes in Structure," pp. 369-70; Chao, *Agricultural Production*, p. 312), reports 2.3 million hectares of green manure and yield of 4.875 metric tons per hectare for 1952, and 3.42 million hectares and 11.25 metric tons per hectare for 1957. These figures imply totals of 11.2 million metric tons for 1952 and 38.5 million metric tons for 1957. Figures for 1953-56 were interpolated using 28 percent as the average annual rate of growth between 1952 and 1957.

The same source as 1952 and 1957 gives an area of 4.2 million hectares and a yield of 18.7 metric tons per hectare for 1958. The yield figure is believed to be seriously exaggerated (Chao, *Agricultural Production*, p. 312). Chao, Ishikawa, and Kilpatrick all adopt a yield estimate of 15 metric tons per hectare for 1964 and 1965. This implies an average annual growth in yield of 4.2 percent.

Increasing the 1957 yield figure of 11.25 metric tons per hectare by 4.2 percent produces a yield estimate for 1958 of 11.72 metric tons per hectare, and an output estimate of 49.2 million metric tons.

Assuming that the production of green manure was influenced by the same climatic and organizational forces that depressed grain output in 1959-62, the amount of green manure changed in the same proportion as grain output in that period.

Jen-min Jih-pao, June 5, 1965, reported 5.4 million hectares of green manure in 1964 (Chao, *Agricultural Production*, p. 312; Ishikawa, "Changes in Structure," p. 370). Assuming yields of 15 metric tons per hectare as mentioned above, total output was 81 million metric tons. It is assumed that output for 1963 increased at the average annual rate implied by the figures for 1962 and 1964.

China Reconstructs, quoted in Kilpatrick, "Role of Chemical Fertilizer" reports 6.7 million hectares of green manure for 1973. Assuming that yield had increased to 20 metric tons per hectare by 1973, production was 134 million metric tons. 1965-72 are interpolated using the annual growth rate of 5.75 percent implied by the 1964 and 1973 figures.

Output is assumed to have continued to increase at the 1964-65 rate between 1974 and 1977.

Oil Cake

Oil cake fertilizer consumption is assumed to fluctuate with soybean production (Table 1) at a constant ratio of 0.49 (oil cake/soybeans). India, Ministry of Food and Agriculture, *Report of the Indian Delegation to China on Agricultural Planning and Techniques* (New Delhi: Ministry of Food and Agriculture, 1956), p. 146, (see Chao, *Agricultural Production*, p. 311; Ishikawa, "Changes in Structure," pp. 368-70), reports that a total of 4.5 million tons of oil seed cakes were used as fertilizer in 1955. The largest component was soybean cake. Chao states that soybean cake constituted two-thirds of the total, which is also the figure given in Dawson, "Fertilizer Supply," p. 139. The soybean series is used to estimate oil cake utilization, then, because of the predominant soybean component in the oil cake total, and because of the thin data base on production of the other oil seeds. The figure of 0.49 is simply the ratio of oil cake (4.5 million metric tons) to soybean production (9.12 million metric tons) in 1955. It may be noted that T. H. Shen, *Agricultural Resources of China* (Ithaca, N.Y.: Cornell University Press, 1951), p. 34, estimated Chinese oil cake production (presumably prewar) to be 5.8 million metric tons annually. When allowance is made for the "small part" used as animal feed, Shen's rough estimate is consistent with the 4.5 million given to the Indian delegation as oil cakes used for fertilizer. U.S. Department of Agriculture uses an estimated ratio of soymeal production to soybean production of 0.358 (as compared with 0.747 for the U.S. where most beans are crushed for oil and meal or exported whole). These rates are calculated from U.S. Department of Agriculture, Foreign Agricultural Service, *World Agricultural Production and Trade* (Washington, D.C.: USDA, 1975), p. 13. When the rate for China is blown up (that is, divided by two-thirds as used earlier) to include all oil cakes (or meal), it yields 0.537 as an estimate of the ratio of oil cake production to soybean production. This is very close to the 0.49 ratio adopted in this study when allowance is again made for oil cakes fed to the animals.

Compost

The quantity of barn compost and outdoor compost of litter material and plant residues is assumed to change with holdings of draft animals (Table 4) from a base figure of 81 million metric tons for 1956. This figure was estimated by Dawson, "Fertilizer Supply," p. 138), and the method is used by Chao, *Agricultural Production*, p. 310 and Kilpatrick, "Role of Chemical Fertilizer."

River and Pond Mud and Other

In the words of Chao (*Agricultural Production*, p. 312), "This item is meant to contain all the unimportant types of natural fertilizer that have only marginal contributions." Using an analysis of cropping areas and the location of suitable bodies of water, along with the probable effect of government directives, Dawson derives an estimate of river and pond mud available for use as fertilizer in 1956 of 144 million metric tons, ("Fertilizer Supply," pp. 138, 140). He estimates the amount of "other" minor natural fertilizers available at 8.12 million metric tons. The total for 1956, then, is 152.12 million metric tons. This is assumed to be one-third greater than the amount used in 1952 (Kilpatrick, "Role of Chemical Fertilizer"). Estimates for 1953-55 are interpolated using the average annual rate of growth implied by the 1952-56 increase. The quantity used is assumed to have remained constant after 1956 (Kilpatrick, "Role of Chemical Fertilizer").

Total Gross Weight

This is gross weight of all organic fertilizers utilized, or simply the sum of the other columns in this table.

Total Nutrient Content

The weight of plant nutrients supplied by organic fertilizer is calculated as the sum of the components, each weighted by its ratio of plant nutrient to gross weight:

$$\text{Nutrient content} = 0.011 \times (\text{night soil}) + 0.0141 \times (\text{hog manure}) \times (\text{draft animal manure}) + 0.0091 \times (\text{green manure}) + 0.105 \times (\text{oil cake}) + 0.01 \times (\text{compost}) + 0.0055 \times (\text{mud, etc.}).$$

These are the coefficients used by Kilpatrick and Ishikawa. Their sources are (see Ishikawa, "Changes in Structure," pp. 368-70): for night soil, *Chung-kuo Nung-pao* [China Agriculture Bulletin], No. 7, 1959, p. 36; for hog manure, draft animal manure, and oil cake: Chinese Agricultural Academy, *Chung-kuo Fei-liao Kai-lun*, p. 57. The green manure figures also came from *Chung-kuo Fei-liao Kai-lun*, but include figures from *Jen-min Jih-pao*, November 18, 1957; and Liu Pai-kao, "Preliminary Studies, on a Few Problems Concerning Cropping Systems," *Ching-chi Yen-chin* [Economic Studies], No. 4, 1963. The compost coefficients are from Dawson, "Fertilizer Supply," pp. 139-40; the coefficients for mud, etc., are from Wang Chi-ming, "Strenuous Accumulation and Rational Application of Fertilizers," *New China Semi-Monthly*, No. 24, December 1957 (see Dawson, "Fertilizer Supply," p. 140).

These coefficients are similar to those used in Chao, *Agricultural Production*, p. 145. Chao's nutrient content series (p. 311) is much smaller than that presented here, however, because he multiplies each nutrient content figure by an "absorption rate" that ranges between 0.1 and 0.65 for the various fertilizers. The absorption rate is intended to represent the proportion of the nutrient content which is actually absorbed by the plants. Although Chao bases his absorption rates on official Chinese studies, they are not employed in this paper because they have not been adequately studied in other countries. Shigeru Ishikawa, a leading student of Chinese agriculture along with Chao, put the 1956-57 per hectare (of cultivated land) application of all fertilizers at 135 kilograms (with nitrogen accounting for 61 kilograms). This is to be compared with our estimate of 115 kilograms. Ishikawa estimated the rate for 1974 at 175 kilograms. (See Ishikawa, "China's Food and Agriculture: A Turning Point," *Food Policy* 2 (May 1977): p. 96. It is estimated to be 198 kilograms in this study.

SOURCES AND NOTES TO TABLE 18

Tractors

For 1952-64, 1966, 1970, and 1972-76, U. S. Central Intelligence Agency (CIA), "China: Economic Indicators," ER 77-10508, Washington, D.C., October 1977, p. 13. The intervening years were estimated from data on tractor production, CIA, "China: Economic Indicators," ER77-10508, p. 18, using the following procedure.

Inventory (I) for a given year was calculated as the sum of the inventory for the previous year less the depreciation rate (d), and the production of the previous year:

$$\text{Tractor}_t - (\text{tractor}_{t-1})(I - d) + (\text{tractor output}_{t-1})$$

An average rate of depreciation of 6.6 percent was derived for 1961-64 as the

Table 18—Farm machinery, 1952 to 1977

Year	Inventory of Tractors: Number	Inventory of Tractors: Horsepower	Inventory of Powered Irrigation Equipment	Total Horsepower
	(1,000 15 horsepower units)	(1,000)	(1,000 horsepower)	
1952	2.0	30	153	183
1953	2.7	40	200	240
1954	5.1	77	260	337
1955	8.1	121	338	459
1956	19.4	291	508	799
1957	24.6	369	560	929
1958	45.3	680	1,280	1,960
1959	59.0	885	2,535	3,420
1960	79.0	735	4,145	4,880
1961	95.0	1,425	4,845	6,270
1962	103.0	1,545	5,800	7,345
1963	115.0	1,725	6,440	8,165
1964	123.0	1,845	7,300	9,145
1965	134.4	2,016	8,450	10,466
1966	153.6	2,304	9,980	12,284
1967	178.1	2,671	10,695	13,366
1968	195.4	2.931	12,742	15,673
1969	216.1	3,242	14,790	18,032
1970	293.0	4,395	16,911	21,306
1971	352.7	5,290	20,000	25,290
1972	484.1	7,262	24,016	31,278
1973	639.5	9,592	30,000	39,592
1974	836.2	12,543	36,000	48,543
1975	971.8	14,577	40,000	54,577
1976	1,187.3	17,810	43,500	61,310
1977	1,300.0	19,500	47,000	66,500

average ratio of the difference between the previous year's inventory plus production and the current year's inventory, to the previous year's inventory, that is,

$$d_t = \frac{\text{Tractor}_{t-1} + \text{tractor output}_{t-1} - \text{tractor}_t}{\text{tractor}_{t-1}}$$

Powered Irrigation Equipment

For 1955-74, CIA, *China: Economic Indicators.* Estimates for 1952-54 are missing in the source and were interpolated using the average annual growth rate implied by the 1955 number and the figure of 118 given for 1951. The estimates for 1975 and 1977 are from Jack Craig, Jim Lewek, and Gordon Cole, "A Survey of China's Machine-Building Industry," U.S. Congress, Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C.: U.S. Government Printing Office, 1978), p. 319. The figure for 1976 is interpolated.

Table 19—Chinese exports of live animals and meat to the free world and the U.S.S.R., 1955 to 1973

Year	Current Value	Deflator	Constant 1963 Value
	($ million)		
1955	109.511	102	107.364
1956	104.195	101	103.163
1957	76.484	104	73.542
1958	124.268	101	123.038
1959	84.609	100	84.609
1960	62.949	91	69.175
1961	24.133	92	26.231
1962	31.157	93	33.502
1963	49.720	100	49.720
1964	95.847	104	92.161
1965	150.073	100	150.073
1966	158.504	100	158.504
1967	115.642	99	116.810
1968	97.560	99	98.545
1969	128.149	106	120.895
1970	135.337	107	126.483
1971	177.211	114	155.448
1972	221.137	118	187.404
1973	289.738	147	197.101

SOURCES AND NOTES TO TABLE 19

The current value figures are from the data file entitled "Commodity Composition of the Foreign Trade of the People's Republic of China with the Free World and the USSR, 1955-73," (Ann Arbor, 1974) developed by the University of Michigan Project on the Foreign Trade of the People's Republic of China, under the direction of Professor Alexander Eckstein.

Deflator

The deflator is derived by dividing current value of exports by the 1963 value of exports and multiplying the result by 100. These deflators were found in U.N., Department of Economic and Social Affairs, Statistical Office, *Yearbook of International Trade Statistics, 1964*, 2 vols. (ST/ESA/STAT/SER. G/13), 1965; U.N., Department of Economic and Social Affairs, Statistical Office, *Yearbook of International Trade Statistics, 1965*, 2 vols. (ST/ESA/STAT/SER. G/14), 1966; U.N., Department of Economic and Social Affairs, Statistical Office, *Yearbook of International Trade Statistics, 1974*, 2 vols. (ST/ESA/STAT/SER. G/23), 1975. The series given here is for Standard International Trade Classification categories 0 (Food and Live Animals) and 1 (Beverages and Tobacco), and is taken from the tables for exports to developing market economies.

Constant 1963 Value Terms

This column was computed by dividing the current value by the deflator divided by 100.

SOURCES AND NOTES TO TABLE 20

These weights are based on factor income shares or relative value of service flows of factors. International data are not strictly comparable.

The 1952-56 weights for Taiwan are from Yhi-min Ho, *Agricultural Development of Taiwan, 1903-60* (Nashville: Vanderbilt University Press, 1966), p. 63.

The 1951-55 and 1968-72 weights for Taiwan are from T.H. Lee, *Growth Rates of Taiwan Agriculture, 1911-72* (Taipei: Joint Commission on Rural Reconstruction, 1975), p. 75.

The 1933-37 weights for Japan are from Anthony M. Tang, "Research and Education in Japanese Agricultural Development," *Riron Keizai Gaku* [The Economic Studies Quarterly], May 1963, p. 93.

The 1930-35 and 1960-65 weights for Japan are from Yujiro Hayami, *A Century of Agricultural Growth in Japan* (Minneapolis: University of Minnesota Press, 1975), p. 97. The elasticities are estimated from a large number of cross-section production function studies.

The weights for Panajachel are from T.W.

Table 20—Relative input weights of selected countries and China

Country	Year	Relative Input Weights			
		Labor	Land	Capital	Current Input
		(percent)			
Taiwan	1952-56	45	25	11	19
Taiwan	1951-55	47	26	8	19
Taiwan	1968-72	42	29	6	23
Japan	1933-37	52	26	8	14
Japan	1930-35	50	30	10	10
Elasticity		40	15	15	30
Japan	1960-65	50	20	10	20
Elasticity		30	20	30	20
Panajachel	1936	84	10	2	4
United States	1949	33	19	48	...
China	1952-57	58	27	15	...
China	1952-57	50	25	10	15

Schultz, *Transforming Traditional Agriculture* (New Haven: Yale University Press, 1964), pp. 99-100. Panajachel is a primitive Guatemalan Indian village.

The 1949 weights for the United States are from Zvi Griliches, "Sources of Measured Productivity Growth: United States Agriculture, 1940-60,"*Journal of Political Economy* 71 (August 1963): 336.

The 1952-57 weights for China are those used in Table 4 to calculate the aggregate input index and in Table 5 to calculate the primary input index.

The weights for the United States in 1949 and the first set of weights for China, 1952-57 are for the primary factors of production (labor, land, and capital) and exclude current inputs. For China the human and animal labor used to gather, transport, and spread organic fertilizer is estimated with the procedure used to derive the primary input index of Table 5. The labor weight of 8 percent estimated in Table 5 is thus allocated equally to the labor and farm capital input categories (whose weights before allocation were 54 percent and 11 percent, respectively). The equal allocation is consistent with the human and animal labor mix reported in a Chinese study investigating the labor content of organic fertilizers.

FOOTNOTES

[37] This includes 2.85 billion yuan of chemical fertilizers.

[38] The benchmark index is the index of known irrigated area data. The interpolating index is the index of sown area figures. The final index is calculated according to the formula:

$$KM_t = \left(\frac{1+a}{1+b}\right)\left(\frac{I_t}{I_{t-1}}\right) KM_{t-1}$$

where KM = Kaplan-Moorsteen final index, I = interpolating index, a = average annual rate of growth of benchmark index, and b = average annual rate of growth of interpoating index. For 1957-63: a = 0.00336, b = −0.0085. For 1966-72: a = 0.02193, b = 0.0051.

[39] Gilbert Etienne, ed., *China's Agricultural Development* (Geneva: Asian Documentation and Research Center, Graduate Institute of International Studies, 1974), pp. 22-3.

APPENDIX 2:

EXPANDED NOTES ON TEXT TABLES

The following material is presented for those who wish to retrace or recalculate any of the entries in the tables accompanying the text.

TABLE 1

Gross Value of Agricultural Output (GVAO)

Estimation of a complete GVAO series proceeded in three stages: collection of Chinese data on GVAO; adjustment of the Chinese figures to a single price scale and uniform coverage; determination of a relationship between the adjusted Chinese data and the series on the value of grain, soybeans, cotton, and livestock produced, and estimation of missing GVAO data using this relationship. The figures for 1952-57 are from People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Languages Press, 1960), pp. 16, 91. They are in 1952 prices. The figure for 1957, in that year's prices, is 53.70.

State Statistical Bureau, *Ten Great Years*, notes that "The gross output value of agriculture covers agriculture, forestry, animal husbandry, agricultural side-occupations, and fishery (exclusive of fishing by mechanical means). Handicrafts consumed at the rural source of production and preliminary processing of agricultural products are included in the gross output value of agriculture for 1949-57, but excluded for subsequent years."

Wuhan Iron and Steel Company, Workers' Theoretical Group, "Only Socialism Can Save China," *Wu-han Ta-hsueh Hsueh-pao* [Wuhan University Journal], Nos. 1-2, 1975, states that agricultural output in 1970 was 2.5 times that in 1949. "Fundamentals of Political Economy" Writing Group, *Cheng-chih Ching-chi-hsueh* [Fundamentals of Political Economy] (Shanghai: People's Press, 1974), p. 102 gives the same figure.

According to Shigeru Ishikawa, "Prospects of the Chinese Economy: Trends and Cycles," *Pacific Community* 4 (January 1973): 254: "It is known that the Chinese practice of compiling production indexes is to use the Laspeyres method for each respective period for which the same fixed prices are used and to use the link-index method for linking the indexes of the periods under different fixed prices." Accordingly, the two GVAO figures given in State Statistical Bureau, *Ten Great Years*, for 1957 and the note quoted above imply a link index of 53.7/60.35 not only for 1952-57 prices, but also for the difference in GVAO coverage implied for the periods before and after 1957. Therefore, in calculating a GVAO figure from the statement that 1970 output was 2.5 times output in 1949, the 1949 figure of 32.59 billion 1952 yuan (State Statistical Bureau, *Ten Great Years*, p. 16) is first converted to post-1957 prices and coverage by multiplying it by the link-index:

$$\underset{\text{(billion 1957 yuan)}}{\text{GVAO (1970)}} = 2.5 \times \frac{53.70}{60.35} \times 32.599 = 72.499 \ .$$

Use of this procedure is supported by a statement made by Zhou Enlai to Edgar Snow that GVAO in 1970 was US$ 30 billion. At the official exchange rate of 2.4 yuan = US$ 1, this figure converts to 72 billion yuan. (Edgar Snow, "The Open Door," *The New Republic*, March 27, 1971, p. 21, in Dwight H. Perkins, "Constraints Influencing China's Agricultural Performance," U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy* (Washington, D.C.: U.S. Government Printing Office, 1975), p. 351. Perkins has shown that this number was probably calculated in 1957 prices. (Dwight H. Perkins, "Growth and Changing Structure of China's Twentieth-Century Economy," *China's Modern Economy in Historical Perspective*, ed. Dwight H. Perkins [Stanford, Cal.: Stanford University Press, 1975], p. 254.)

Officials of China's International Trade Promotion Committee told the delegation of the Center for Research on Trade Structure of China and Asia that the total value of production of industry and agriculture combined in 1971 was 8.2 times the value in

1949, and the total value of production of industry only in 1971 was 21.3 times the value in 1949. (Center for Research on Trade Structure of China and Asia, *Chinese Views on the Future of Sino-Japanese Economic Relationship* [Tokyo: Center for Research on Trade Structure of China and Asia, 1972] [in Japanese]; in Ishikawa, "Prospects of the Chinese Economy"). GVAO is calculated as the difference implied by these ratios, between the values of combined industrial and agricultural output and industrial output alone. State Statistical Bureau, *Ten Great Years*, p. 16, supplies the following information:

	Industry and Agriculture	Industry
	(billion yuan)	
1949 value of production in 1952 prices	46.61	14.02
1957 value of production		
1952 prices	138.74	78.39
1957 prices	124.10	70.40

Converting the 1949 values to 1957 prices using their implied link indexes, and multiplying them by 8.2 and 21.3, respectively, produces the 1971 values:

1971 Industry and agriculture =
(billion 1957 yuan)

$$8.2 \times \frac{124.10}{138.74} \times 46.61 = 341.872\,.$$

$$\text{1971 Industry alone (billion 1957 yuan)} = 21.3 \times \frac{14.02}{78.39} = 268.188.$$

Subtracting the value of industrial production from the value of industrial and agricultural production gives the 1971 GVAO, 73.684 billion 1957 yuan.

"Fundamentals" Writing Group, *Cheng-chi ching-chi-hsueh*, p. 406, states that GVAO in 1973 was 2.8 times that in 1949. Using this number, 1973 GVAO is calculated by the same method as 1970 GVAO:

1973 GVAO =
(billion 1957 yuan)

$$2.8 \times \frac{53.70}{60.35} \times 32.59 = 81.197.$$

The 1970, 1971, and 1973 references—except for the Edgar Snow citation—and calculating procedures were supplied by Robert Michael Field.

Given figures for 1952-57 in 1952 prices and pre-1957 coverage and for 1957 and the remaining data points in 1957 prices and post-1957 coverage, with the two 1957 figures supplying the 1952-57 link index, the entire series may be expressed either in 1952 prices and pre-1957 coverage, or 1957 prices and post-1957 coverage. Ideally, it would be preferable to express the series in 1957 prices and post-1957 coverage, since this seems to be the form of recent Chinese statements. Unfortunately, this would be inconsistent with the partial GVAO series (the value of livestock produced, grains, soybeans, and cotton). Furthermore, there is insufficient price data for 1956 to convert the partial GVAO series to 1957 prices. Consequently, the GVAO series is converted to constant 1952 prices and coverage by multiplying the figures derived above for 1970, 1971, and 1973 by the 1952-57 link index, 60.35/53.70, and using the 1952 price figure for 1957.

A relationship between the partial GVAO series and the known GVAO figures (1952-57, 1970, 1971, 1973) was calculated by least squares regression analysis. The missing GVAO figures were then estimated by means of the regression equation:

GVAO =
(standard errors)

$$\underset{(3.0724)}{-5.2363} + \underset{(0.0860)}{1.9962} \times (\text{partial GVAO})\;;$$

$R^2 = 0.9876$, $n = 9$.

The standard error and "t-statistic" of the constant term indicate that it is not significantly different from zero at the 5 percent level. This implies that the possibility that the regression line passes through the origin—that a zero value for partial GVAO would be accompanied by zero GVAO—cannot be rejected, a result which is consistent with the importance to total GVAO of the products included in the partial GVAO. It also implies that the partial GVAO sum may have maintained a more or less constant ratio to total GVAO over the years. This deduction is not entirely plausible, but it is probably a fairly good approximation considering, again, the importance—both direct and indirect—of the partial GVAO products for total farm output.

The GVAO series using the pre-1957 coverage was first multiplied by the 1952-57 link index, 53.70/60.35, to convert it into 1957 prices and post-1957 coverage. It was then divided by a price ratio of 1.075 to convert it to 1952 prices.

The problem of determining a 1952-57 price index for agricultural products is quite difficult, and the figure of 107.5 adopted here can only be regarded as a tentative approximation. The problem is stated by Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965) p. 135:

> Quotations of farm prices for 1957 are even more scarce than for 1952...two different indexes of 1957 prices are available, both with 1952 as the base year. The government procurement price index of agricultural products for 1957 is 122.4 (see State Statistical Bureau, *Ten Great Years*, p. 122). The second index is derived from figures on on the total value of agricultural production in an article by Po I-po, the Communist Vice Premier and Chairman of the State Economic Commission, who gave the gross value of agricultural production in 1957 at 64.87 billion in 1957 prices and 60.35 billion in 1952 prices. The price index in 1957 is therefore 107.5 with 1952 as 100. This index indicates that government procurement prices may not have been used for products consumed by farm households and that the prices of agricultural products not under the government procurement program rose less than those covered in the program.

The statement by Po I-po ("Report on the Draft 1958 National Economic Plan," *Hsin-hua Pan-yueh-k'an* [New China Semi-Monthly], No. 5, March 1958, pp. 13, 15) is somewhat less clear than Liu and Yeh imply. On page 13 Po states that 1957 agricultural output was 60.35 billion yuan in constant 1952 prices. He does not actually give a figure for 1957 GVAO in 1957 prices. On page 15 he says that planned GVAO for 1958, calculated in constant 1957 prices, is 68.83 billion yuan, and that this is an increase of 6.1 percent in 1957. Dividing 68.83 billion yuan by 1.061 produces the implied 1957 GVAO in 1957 prices, 64.87 billion yuan. Dividing this figure by 60.35 billion yuan results in the 107.5 price index. The issue is clouded, however, by a later paragraph on page 15 where Po states that planned 1958 GVAO would amount to 64.25 billion yuan if calculated in constant 1952 prices. If this figure is divided into the figure of 68.83 billion yuan for the same year in 1957 prices, the implied index is 107.1. Because of this discrepancy and because Po makes no mention of the pre- and post-1957 coverage difference, this article is a very unsatisfactory basis for the 107.5 price index. For lack of any better information, however, and because it seems plausible, it has been adopted here.

Possible support for a 1952-57 price index of about 107.5, and an unsettling comment on the reliability of Chinese figures may be inferred from a figure for GVAO that was not mentioned above. U.S., Foreign Broadcast Information Service (FBIS), *Daily Report: People's Republic of China*, February 25, 1977, p. E5, reports that Shanghai City Service in Mandarin, on February 10, 1977, broadcast a "Second Shanghai Talk on Mao's 'Ten Relations,'" which mentioned that from 1949 to 1973, "total agricultural output value" increased by 130 percent. If the formula used to calculate 1970 and 1973 GVAO is used with this figure, the result is 66.70 billion 1957 yuan. This figure is clearly too low to be consistent with the other known GVAO numbers. If, however, the 1949 GVAO number is not adjusted by the link index, and is simply multiplied by 2.3, the result is 74.957 billion yuan, which is quite close to the figure obtained above for 1973 GVAO in post-1957 coverage and 1952 prices (75.532 billion 1952 yuan). A possible explanation is that the Shanghai lecturer mistakenly adjusted the 1973 GVAO figure by the 1952-57 price index rather than the link index before determining its relation to the 1949 figure. If this did in fact happen, the implied price index would be 81.197/74.957 = 108.3, which is reasonably close to the 107.5 index used here.

It is clear that uncertainty clouds any choice of the 1952-57 price index; however, Liu and Yeh's preference for the lower (derived from Po I-po) index of 107.5 percent appears to be well founded and is adopted in this study. It is important to note, however, that once one accepts that the link-ratio (60.35/53.70 = 1.123) based on the two 1957 GVAO figures given in State Statistical

Bureau, *Ten Great Years* accurately reflects the 1952-57 price change and the pre- and post-1957 coverage change, the choice of price index (whether 107.5 percent or 122.4 percent) influences only the absolute magnitude of the GVAO and not its index. This proposition is proved as follows.

Note that the link ratio (R) of 1.123 operates as a constraint such that choice of price index (P) automatically fixes the coverage factor or index (C). Denoting the 1957 price index (1952 = 100), derived by Liu and Yeh from Po I-po, "Report on the 1958 Plan," by Liu and Yeh) by P_1 (107.5) and the government procurement price index for 1957 by P_2 (122.4), with C_1 and C_2 standing for the corresponding coverage index (pre-1957 or post-1957) under each price index,

$$R = \frac{C_1}{P_1} = \frac{C_2}{P_2} = 1.23. \qquad (1)$$

The GVAO series provides proof of this proposition. It is expressed in 1952 prices and uses the post-1957 coverage. This series deflates all official post-1957 values (reported in 1957 prices) by P_1 (107.5 percent), leaving C_1 at 120.7 percent (that is, the pre-1957 coverage implied by choice of P_1 is 20.7 percent larger than the post-1957 coverage). Let this series be represented by V_1. Adoption of the procurement price index, P_2 (122.4 percent) in deflating the GVAO series leads to an implied coverage difference, C_2 of 137.6 percent. Let V_2 denote this new constant-price GVAO series. The calculations of C_1 and C_2 are based on the constraint shown in relation (1) above. From the GVAO post-1957 coverage series, V_1, the new series, V_2, can be arrived at with the following relations (using 1958 and 1952 to illustrate):

$$V_2\,(1958) = V_1\,(1958) \cdot \frac{P_1}{P_2} = V_1\,(1958) \cdot \frac{107.5}{122.4}, \qquad (2)$$

$$V_2\,(1952) = V_1\,(1952) \cdot \frac{C_1}{C_2} = V_1\,(1952) \cdot \frac{120.7}{137.6}. \qquad (3)$$

Relation (2) is self-explanatory. Relation (3) obtains because, whereas for all years after 1957 GVAO was reported in 1957 prices and deflated to express it in 1952 prices, GVAO for the years before 1957 has been adjusted to conform with the new and narrower coverage adopted for GVAO using post-1957 coverage.

By virtue of relation (1), we obtain, by dividing (2) by (3)

$$\frac{V_2\,(1958)}{V_2\,(1952)} = \frac{V_1\,(1958)}{V_1\,(1952)} \qquad (4)$$

This relation shows that the GVAO index uses the post-1957 coverage independent of the price index chosen.

In the current literature where the data fragments are from Chinese sources, the gross value figures shown are in 1957 prices and post-1957 coverage. For the convenience of the readers our entire series from 1949 through 1977 is presented in these terms:

Gross Value of Agricultural Output
(billion 1957 yuan; post-1957 coverage)

1949	28.92	1963	52.45
1950	34.13	1964	57.03
1951	37.34	1965	60.56
1952	43.06	1966	64.40
1953	44.41	1967	68.29
1954	45.89	1968	64.32
1955	49.42	1969	65.53
1956	51.87	1970	72.50
1957	53.70	1971	73.68
1958	59.86	1972	77.09
1959	48.31	1973	81.20
1960	41.03	1974	83.36
1961	43.15	1975	85.24
1962	47.96	1976	85.41
		1977	84.73

The adjusted gross value of agricultural output (AGVAO) is calculated by subtracting the sum value of feed and seed (Table 12) from GVAO in post-1957 coverage. This adjustment eliminates double counting caused by the inclusion in GVAO of agricultural outputs used as inputs within agriculture. To conserve space AGVAO in the now defunct pre-1957 coverage is not presented.

Liu and Yeh, *The Economy of the Chinese Mainland*, p. 414 estimates "insecticides and other" (that is, fuel, electric power, irrigation expenses, plant disease control agents) costs at an average of 0.9 percent of the gross value of plant products for the period

1952-57. Other categories of costs were also given as average percentages for the period. The ratio for the "insecticide and others" category, because of its small base and unusually high rates of growth, is best estimated for the 1952 base by taking into account both the growth of plant output and the (faster) growth of "insecticides and other." From the estimated physical series on insecticides (Table 2), assumed to be a proxy for the "insecticides and other" input category, the geometric mean of the annual growth rates is extracted and denoted by r. A similar geometric mean rate, i, is extracted from Liu and Yeh's "adjusted" gross value of plant products for 1952-57 (*The Economy of the Chinese Mainland*, p. 397). The mean growth rates per year are 58 percent for r and 3.62 percent for i.

The earlier expression that "insecticide and other" costs accounted for 0.9 percent of total plant product value during 1952-57 can now be formally written as (using C_{52} to stand for 1952 costs and Y_{52} for 1952 plant produce value):

$$\frac{C_{52}}{Y_{52}}\left[1 + \frac{1+r}{1+i} + \left(\frac{1+r}{1+i}\right)^{2} + \ldots + \left(\frac{1+r}{1+i}\right)^{5}\right]\frac{1}{6} = 0.009.$$

When 0.58 percent is substituted for r and 0.0362 for i, C_{52}/Y_{52} is 0.0026 or 0.26 percent. This ratio multiplied by Liu and Yeh's 1952 estimate of "adjusted" gross value of plant products of 26.75 billion yuan, yields an estimated cost of "insecticides and other miscellaneous inputs" of 0.07 billion yuan for 1952.

The value series for other years in the period is assumed to move with the insecticide quantity series (Table 12). To obtain the full series, the 1952 estimate of 0.07 billion yuan is multiplied by the index of insecticide quantity (1952 = 100 percent).

The chemical fertilizer value series is calculated by multiplying the chemical fertilizer quantity series (Table 12) by a price taken from Alexander Eckstein, *The National Income of Communist China*, (New York: Free Press, 1962), p. 114. Eckstein obtained nine price quotations for chemical fertilizer. From these quotations he suggests a unit price of 366 yuan per metric ton as representative since this price was derived from figures for a large transaction.

Unfortunately, Eckstein does not cite the specific source of his price quotations. The price is, however, consistent with information in known sources. He cites a report in *Hsin-hua Yueh Pao* [New China Monthly] No. 2, 1954, p. 162, which states that in 1952, 300,000 tons of chemical and 2 million tons of cake fertilizer valued at 406.12 million yuan were distributed. When multiplied by these quantities, the prices of 366 yuan per ton for chemical and 148 yuan per ton for cake fertilizer lead to a total value of 405.8 million yuan, which is very close to the 406.12 million yuan reported in the article.

Eckstein's chemical fertilizer price is also consistent with documented fertilizer price data collected in Jung-chao Liu, *China's Fertilizer Economy* (Chicago: Aldine, 1970). Using Liu's price data (p. 89) and weighting the prices according to type composition, a rough estimate is derived of 374 yuan per ton of chemical fertilizer in 1953. Eckstein's 366 yuan per ton is not out of line with this.

The rough estimate was calculated using the following information from Liu, *China's Fertilizer Economy*. Ammonium sulfate made up 91 percent of domestically produced fertilizer in 1953. Ammonium nitrate made up the remaining 9 percent (p. 12). Ammonium sulfate made up 76 percent of imported fertilizer, and superphosphate made up the remaining 24 percent (pp. 61, 64). Of the total fertilizer supply, 66 percent was domestically produced and 34 percent was imported (p. 50).

The implied composition of chemical fertilizer supply in 1953 was ammonium sulfate, 85.9 percent; ammonium nitrate, 5.9 percent; and superphosphate, 8.2 percent. Using this percentage breakdown, the price data are weighted (p. 89), so that ammonium sulfate is 390 yuan per metric ton; ammonium nitrate is 316 yuan per metric ton; and superphosphate is 245 yuan per metric ton.

The price of ammonium sulfate, the major component of chemical fertilizer supply, is for 1953. Although the prices for ammonium nitrate and superphosphate are for 1956, they are used to calculate our rough estimate because other information is lacking. The resulting price for chemical fertilizers is 374 yuan per metric ton.

The cake fertilizer value series is calculated by multiplying the oil cake quantity series (Table 17) by a price taken from Eckstein, *National Income*, p. 114. Like the price for chemical fertilizers, this price, 148 yuan per metric ton, was selected as representative from a number of different quotations. Like the price for chemical fertilizers, Eckstein does not quote a specific source for this price.

It is, however, consistent with information in other known sources. Besides Po I-po, "Report on the 1958 Plan," we found a report in Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China* (Chicago: Aldine, 1967), p. 419. Chen quotes a price of 7.00 yuan per 50 kilograms or 140 yuan per metric ton in Shanghai in 1952 from Chinese National Academy of Sciences, Shanghai Economic Research Institute and Institute of the Shanghai Academy of Social Sciences, Economic Research Institute, *Chieh-fung Chien-kuo Wu-chia Tzu-liao Hui-pien* [A Collection of Shanghai Price Data Before and After the Liberation (1921-1957)] (Shanghai: Shanghai People's Press, 1958), pp. 470-563.

TABLE 2

If correct, the ratio between the State Statistical Bureau (SSB) figures and our estimates is a GDP implicit deflator for agriculture. In these terms what may be considered the index of "purchasing prices for agricultural products" (in the SSB's language) for 1977 (1952 = 100 percent) comes to 170 percent (134/79). The procedure assumes no change in the coverage or definition of the gross value of agricultural output (GVAO) by the SSB between 1957 and now. (For the coverage issue see Appendix 2, Table 1.) The implicit 1977 price index of 170 percent is very close to the published fragments on farm purchase prices from Chinese sources as pieced together by China scholars. The index of 167 percent was reported for 1973 in *Liaoning Ta-hsueh Hsueh-pao*, No. 1, February 1977, as shown in Bruce Stone's companion study to the present work, while Peter Schran inferred an index of 165 percent for 1974 from *Peking Review*, May 9, 1975, p. 18 (as shown in his "China's Price Stability," *Journal of Comparative Economics* [December 1977], p. 375). Against our plausible 1977 GVAO estimate (hence, our entire time series) the U.S. Central Intelligence Agency (CIA) estimates appear to be significantly understated. The CIA estimates produced a GVAO index of 171 percent for 1977 (1952 = 100 percent) compared to our 197 percent (see U.S. Central Intelligence Agency, National Foreign Assessment Center, "China: A Statistical Compendium," ER79-10374, Washington, D.C., July 1979, p. 3).

The only large apparent gap between our estimates and the official statistics concerns insecticides. Its weight is small, so that our aggregate input index would be little changed even if the difference cannot be reconciled. Used as a proxy (in percentage growth terms) for a group of modern current inputs consisting mainly of electric power, fuel, and other forms of energy our estimates appear more reasonable than the official ones, whose growth rates are much lower. See, for instance, the CIA estimates in the above table of total energy consumption growth in agriculture between 1952 and 1977-78. Moreover, our insecticides consumption estimates are built up from the 1952-57 figures from People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Languages Press, 1960), which represented quantities "supplied to agriculture" whereas the recent SSB releases include only domestic output (which is less than the supplied amount by the unknown imported quantity).

The CIA estimate for 1977 fertilizer consumption is 8.881 million metric tons given along with domestic production figures which agree completely with the official releases shown above. (See U.S. Central Intelligence Agency, "Handbook of Economic Statistics, 1979" ER79-10274, Washington, D.C., August 1979, pp. 173 and 225-8.)

TABLE 3

Potatoes

A recent reinterpretation of the grain data, Robert Michael Field and James A. Kilpatrick, "Chinese Grain Production: An Interpretation of the Data," *China Quarterly* 74 (June 1978): 369-84, argues that since 1970 the official data fragments included potatoes in grain equivalent weight at the ratio of five to one. The reconstructed grain series (which also assumed that soybeans have been included in "official" grain figures since 1964) is best regarded as tentative until new evidence becomes available. As the series now stands, it raises more questions than it answers. An authoritative Chinese source which official Washington is not yet prepared to identify has indicated a different date for the introduction of the five-to-one potato-grain conversion rate than Field and Kilpatrick assume.

Total Grain

This is the sum of the figures for rice, wheat, coarse grains, and potatoes. It excludes soybeans.

Total Grain Value

Output between 1952 and 1977 is the sum of the four grain categories multiplied by their prices, which are 106 yuan for rice, 160 yuan for wheat, 120 yuan for coarse grains, and 160 yuan for potatoes. The prices were developed for 1952 in Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965), p. 136. 1952 prices are used because there is more detailed information than for any later year. (See Liu and Yeh, *The Economy of the Chinese Mainland*, p. 138.) Liu and Yeh present the prices as yuan per picul (1 picul = 50 kilograms). They have been converted to yuan per metric ton by multiplying them by 20. The price for potatoes was then multiplied by four to calculate the cost per grain-equivalent metric ton.

To determine value between 1958 and 1977, an aggregate grain price estimate was calculated by adding the prices of the individual types of grain, each weighted by its average proportion in total grain output between 1951 and 1957. The weights for 1951 were rice, 60.55; wheat, 17.55; coarse grains, 43.25; potatoes, 14.00; and all grains, 135.05.

	Rice	Wheat	Coarse Grains	Potatoes
Average proportion of total grain output	0.45	0.13	0.31	0.11
Price per metric ton	106.00	160.00	120.00	160.00

Weighted average = 123.3 yuan per metric ton

Total grain output value, then, is simply estimated as total grain output times 123.3 yuan. Underlying this procedure is the assumption that the composition of total grain is stable—a plausible assumption in light of the U.S. Department of Agriculture estimates of output by grain category shown above in the figures for rice, wheat, coarse grains, and potatoes. For 1975 the proportions calculated from these estimates are: 0.44 for rice, 0.15 for wheat, 0.31 for coarse grains, and 0.10 for potatoes. This is close to the composition in 1951.

Value of Soybeans

The price of soybeans is 140 yuan per metric ton. The value of soybeans is equal to 14 yuan times soybean output.

Value of Cotton

The price of cotton is 1,698 yuan per metric ton. The value of cotton is equal to 1,698 yuan times cotton output.

TABLE 4

Detailed data on poultry numbers and prices are only available for 1952. Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965), pp. 403-6, calculated the value of the stock of poultry in 1952 and estimated values for other years by assuming a constant proportional relationship between the value of livestock holdings and the value of poultry. They found the value of poultry to be 3.85 percent of the value of livestock holdings in 1952. Due to the nearly complete lack of information on poultry since 1952, this procedure has been used to estimate the value of poultry for this series.

The value of machinery is crudely estimated by multiplying the total horsepower of tractors and irrigation power equipment (from Table 18) by the weighted average of 1952 draft animal prices (of 77.3 yuan from the notes to Table 7). This is probably a low estimate of the cost of farm machinery per horsepower. The U.S. Central Intelligence Agency, using scattered Chinese sources, placed the 1958 price of a 2.1 horsepower motor and pump set for irrigation at 211.83 yuan and the 1957 price of a standard 15 horsepower tractor at 10,371 yuan (U.S. Central Intelligence Agency, "Prices of Machinery and Equipment in the PRC," AER75-76, Washington, D.C., May 1975, pp. 15-6). Actual 1952 machinery prices are preferable, but consistent, detailed data are not available.

Weights were chosen, after examination of a number of national agricultural growth accounting studies, as reasonable approximations of the Chinese factor income shares or relative value (imputed where necessary, as for land) of service flows. Data on the sample countries are in Table 20. It should be noted that the aggregate input index is only moderately sensitive to choice of weights. Thus, if Taiwan's factor income shares for 1951-55 and for 1968-72 are used, the 1977 aggregate input index becomes 249 percent and 263 percent respectively. Japan's 1933-37 and 1960-65 income share weights produce indexes of 224 percent and 258 percent, while Japan's estimated "modal" output elasticities with respect to each of the four categories of inputs for the same two periods lead to indexes of 315 percent and 277 percent. These comparisons and the broad aggregation of input subcategories (a point explained in the notes to Table 13) suggest that the estimated aggregate input index is probably conservative.

TABLE 5

There is ample evidence to suggest that Chinese agriculture had not recovered from the cumulative effects of the Sino-Japanese War (1937-45) and the Civil War (1945-49) by 1952. A detailed argument is advanced in Anthony M. Tang, "Policy and Performance in Agriculture," in Walter Galenson, Ta-Chung Liu, and Alexander Eckstein, eds., *Economic Trends in Communist China* (Chicago: Aldine, 1968), pp. 459-509. The GVAO was adjusted for this by raising the 1952 output value by 6 percent, the 1953 output value by 4.5 percent, and so on.

The value of organic fertilizers derives from the extensive use of labor for gathering, transporting, and spreading. Hence, their inclusion in the primary input index reflects the increased intensity of use of the Chinese farm labor force, a fact well-known to China scholars. Self-supplied fertilizer index is calculated from Table 17 by subtracting purchased oil cake nutrients (quantity of oil cake used multiplied by 0.105) from total organic nutrients. An indication of the magnitude of labor content is given in *Ching Chi Yeng Chiu*, No. 4, 1965, which reported on the use of 35-45 days of human labor and 20-25 days of animal labor in Liaoning Province to 100 kilograms of nitrogen in farm yard manure (or about 30 tons in natural weight)! Ishikawa, who cited the study, observed that the application of manure increasingly exceeded 30 tons per hectare in many localities (Shigeru Ishikawa, "China's Food and Agriculture: A Turning Point," *Food Policy* 2 (May 1977): 96.

The weights for the primary input index are 50 percent for labor, 25 percent for land, and 10 percent for capital, as used earlier in calculating the aggregate input index. The weight for nonpurchased fertilizer reflects the fact that it is only a part of total current inputs used. This fraction is estimated at 49.8 percent from the 1952-57 totals of feed and seed costs (Table 12), insecticides (Table 1), and purchased fertilizers (Table 1), with the imputed value of nonpurchased fertilizers estimated from the Communist source statement (see Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* [Princeton: Princeton University Press, 1965], p. 411), that purchased fertilizer cost constitutes 23 percent of total fertilizer cost. So estimated, the value of nonpurchased fertilizers came to 23.6 billion yuan, while all other current inputs totaled 23.8 billion yuan in 1952-57. The weight for nonpurchased fertilizers is thus 49.8 percent of the weight used earlier for all current inputs (15 percent) or 7.47 percent relative to the original sum of weights. The new weights releveled to add up to 100 percent are: 54 percent for labor, 27 percent for land, 11 percent for capital, and 8 percent for nonpurchased fertilizer (actually for labor embodied).

TABLE 6

Estimated Consumption

It is assumed that no well-articulated national stock policy was in operation before 1955 when "unified purchase and supply" of grains was introduced throughout the country. For 1955-59 it is assumed that because of the relative food security that a friendly Soviet Union was expected to provide in a national emergency and because of the need to amortize the Soviet loan (repaid partly with shipments of soybeans and other agricultural products), stock changes in China were to smooth out short-term weather-associated supply fluctuations and not to build up a strategic reserve. Hence, estimated consumption in year t is the average of supply in t, t-1, and t-2. As a moving average it is centered on year t-1. To "recenter" it on year t, the average is inflated by 2.35 percent, the long-term exponential growth rate from the fitted trend to the grain output series (1952-77). For 1960-64 it is assumed that Peking saw the need for a strategic food reserve but the food crisis growing out of the Great Leap Forward and a run of adverse weather caused short-term subsistence to override longer-term strategic reserve considerations. Hence, for this period also the estimation procedure for grain consumption for 1955-59 is applied. The moving average method resulted in -22.6 million metric tons for 1959 and -25.7 million metric tons for 1960 as stock changes. Subjecting the draw down to the accumulated 1958 total stock of 19 million metric tons as a limit, we arbitrarily assign -10.0 and -9.0 as stock withdrawals for 1959 and 1960.

For 1965-77 stock changes are assumed to have a dual role: to smooth out short-run supply fluctuations and to build up a national strategic food reserve. Thus, the three-term moving average method (along with the recentering procedure) is retained; however, each year's current supply is first diminished by 0.5 percent before being averaged to allow for the annual set-aside for the strategic reserve. It is to be noted that because of the higher average rate of supply increase since the Great Leap Foward (about 3 percent per year) compared with the long-term rate of 2.35 percent used to recenter the moving averages, the effective set-aside amounted actually to 1.15 percent of each year's (smoothed) supply. In these terms the estimated stock buildup reached 48.1 million metric tons by 1977—a figure consistent with the 40-million-metric-ton total used by Zhou Enlai on several occasions to indicate the size of China's accumulated grain stocks. Li Ziannian later added that the long-range target was a stock of 80 million metric tons (Shigeru Ishikawa, "China's Food and Agriculture: A Turning Point," *Food Policy* 2 (May 1977): 90.

TABLE 8

Feed accounted for about 12 percent of total grain consumption in recent years in China according to the Food and Agriculture Organization of the United Nations. Ishikawa makes an estimate for 1977 of 17 percent (Shigeru Ishikawa, "China's Food and Agriculture: A Turning Point,"*Food Policy* 2 [May 1977]: 90-102). Our estimated proportion used in this paper is lower (Tables 3 and 15) but consistent, since our value ratio should be smaller than the FAO-Ishikawa quantity ratio. Twenty percent is a plausible average feed/total grain ratio for the 1977-2000 period—one that allows for the expected rising trend.

Viewing projected indirect demand increase as the increase in demand for feedgrains, it is instructive to compare the estimates of this paper with the historical rates of Japan and Taiwan (from U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agricultural Circular: Grains*, FG9-76, May 1976, pp. 21 and 58). From 1960 to 1975, Japan's feedgrain consumption rose from 3.0 to 11.7 million metric tons or 10 percent a year; while Taiwan's increased (starting its feedgrain import explosion later) from 0.064 to 1.195 million metric tons or more than 20 percent a year. These figures place our high-low estimates for China in a good perspective. By 1975-76 Japan's feed/total grain ratio had reached 36 percent and Taiwan's 21 percent, while the U.S. ratio had long stabilized at around 75-80 percent (from USDA data).

Projected increases of all-grain demand can be calculated either by using the all-demand income elasticity or by taking the weighted average (weights being 0.8 and 0.2 as indicated above) of the two projected annual increases for direct and indirect demand. These all-demand rates of increase are to be compared with our historical total grain production and consumption (annual growth rates of 2.35 percent and 2.45 percent respectively).

This procedure assumes equality between domestic production and consumption. Alternatively, grain consumption can be used (as estimated in Table 6) as a benchmark (278.8 million metric tons for 1977) instead of production. In the latter case the 2000 projections are (from high to low): 847, 396, and 549 million metric tons.