APPENDIX 1

THE TOTAL AMOUNT OF FOODGRAINS REQUIRED IN 1985 TO SUPPLY THE NET INCREMENT TO THE 1979-85 POPULATION WITH THE 1978 AVERAGE RATION

The numbers of children growing up between 1979 and 1985 were calculated from estimates of midyear population and birth rates prepared by John Aird.[331] Using the birth rate for each year and the previous year's population, the number of births in each year between 1964 and 1978 was calculated. When added together, they give a total of 202,056,000 for those born between 1964 and 1970 (who will be between 15 and 21 years old in 1985) and 220,949,000 for those born between 1971 and 1978 (who will be between 7 and 14 years old in 1985). Estimates of births and deaths between 1979 and 1985 are shown in Table 12.

In 1978 consumers born between 1964 and 1970 are assumed to have each consumed an average of 62.5 percent of an adult's level of consumption (they were then between 8 and 14 years old). In 1985 they are assumed to consume 100 percent of an adult's ration. The difference is 37.5 percent of an adult's consumption per person. Multiplying this by the number of consumers in the group gives their consumption in numbers of adult equivalents relative to 1978: 0.375 (202,056,000) = 75,771,000.

In 1978 consumers born between 1971 and 1978 are assumed to have each consumed an average of 17.5 percent of an adult's ration (they were then between 0 and 7 years old); it is assumed that the difference between their average annual consumption in 1978 and in 1985 is 41.25 percent of an adult's consumption per child. Multiplying adult equivalents relative to 1985: 0.4125 (202,949,000) = 91,141,000.

The consumption of those born between 1979 and 1985 (see Table 12) is assumed to average 15 percent of an adult's consumption level in 1985 (when they will be between 0 and 6 years old). Multiplying this by the number of consumers in the group gives their numbers in adult equivalents relative to 1985:

Aird	Official A	Official B
151,364,000	3116,799,000	114,097,000
0.15	0.15	0.15
22,705,000	17,520,000	17,115,000

The total expected deaths are the sum of all expected deaths between 1979 and 1985 derived from each set of estimates (see Table 12). The totals are 59,908,000 for the Aird estimates, 43,425,000 for the Official A estimates, and 50,590,000 for the Official B estimates.

Foodgrain consumption per capita in 1978 was estimated by Stone to be 201 kilograms per year, after 2 percent was deducted for national, provincial, and local stockpiling.[332] This figure was computed using a population estimate for 1978 of 1,002,437,000. The total amount of foodgrains available would be about 201.49 million metric tons (of processed grain). In 1978 the total number of children was estimated to be 423.005 million; of adults, 579.432 million. Children (all those between 0 and 14 years old) are expected to consume on average 40 percent of an adult's ration. They therefore consumed an estimated 169.202 million adult equivalents in 1978, which makes consumption in 1978 equal to 748.634 million adult equivalents. This figure divided into the 201.49 million metric tons available for human consumption yields 269.1 kilograms per adult equivalent. This is the estimated 1978 adult ration.

Net additional consumption in 1985 is the sum (in adult equivalents) of consumers who will be 15-21 years old (born between 1964 and 1970), those who will be 7-14 years old (born between 1971 and 1978), and those who will be between 0 and 6 years old, minus the total of expected deaths. Multiplying the net additional consumption for each set of estimates (in thousands of adult equivalents) by 0.2691 metric tons per adult equivalent gives the estimates of additional

Table 12—Estimated midyear population, births, deaths, birth rates, and death rates, 1979-85

Year	Midyear Population			Births			Deaths			Birth Rate			Death Rate		
	Aird	Official A	Official B	Aird	Official A	Official B	Aird	Official A	Official B	Aird	Official A	Official B	Aird	Official A	Official B
					(1,000)							(percent)			
1979	1,017,477	1,013,464	1,014,516	23,156	17,041	17,543	8,521	6,015	7,017	2.31	1.70[a]	1.75	0.85	0.60	0.70
1980	1,031,988	1,023,598	1,024,661	22,486	16,215	17,247	8,547	6,081	7,102	2.21	1.60	1.70	0.84	0.60	0.70
1981	1,045,507	1,033,843	1,034,293	22,085	16,378	16,804	8,566	6,142	7,173	2.14[a]	1.60	1.64	0.83[a]	0.60	0.70
1982	1,058,576	1,044,173	1,043,395	21,642	16,541	16,342	8,573	6,203	7,240	2.07[a]	1.60	1.58	0.82[a]	0.60	0.70
1983	1,071,173	1,054,614	1,051,951	21,172	16,707	15,860	8,574	6,265	7,304	2.00[a]	1.60	1.52	0.81[a]	0.60	0.70
1984	1,083,277	1,065,160	1,059,946	20,674	16,874	15,358	8,569	6,328	7,364	1.93[a]	1.60	1.46	0.80[a]	0.60	0.70
1985	1,094,868	1,075,812	1,067,365	20,149	17,043	14,943	8,558	6,391	7,420	1.86	1.60	1.40	0.79	0.60	0.70
Total				151,364	116,799	114,097	59,908	43,425	50,590						

Sources: Aird: U.S. Central Intelligence Agency. National Foreign Assessment Center, "China: A Statistical Compendium," ER79-10374. Washington, D.C., July 1979, p. 5. Official A and B: Bruce Stone, *A Review of Chinese Agricultural Statistics, 1949-79*, Research Report 16 (Washington, D.C.,: International Food Policy Research Institute, forthcoming), Table 1, discussion.

Notes: The series of estimates from Aird are based on birth and death rates and the midyear 1978 population figure developed by Aird and published in the CIA publication listed above.

The official birth rate for 1978 was given as 1.8 percent; the official death rate was given as 0.6–0.7 percent. The Official A series assumes a death rate of 0.6 percent for the entire period and a birth rate falling to 1.6 percent in 1980, fulfilling the official target for the rate of natural increase (1.0 percent). The birth rate is then assumed to remain constant through 1985.

The Official B series assumes the higher official death rate (0.7 percent). Birth rates are assumed to fall to 1.7 percent in 1980 and then to 1.4 percent in 1985, which would meet the target rate of natural increase of 7 per thousand in 1985. This is a Chinese scientist's estimate. The official target is 5 per thousand.

All midyear population figures are based on Aird's midyear 1978 population figure. These and the birth and death figures are derived using the birth and death rates shown in the table.

[a] These rates are interpolated.

consumption required in million metric tons of processed grain in 1985:

Aird	Official A	Official B
129,709	141,007	133,437
0.2691	0.2691	0.2691
34.905	37.945	35.908

These figures can be put in terms of unprocessed grain by dividing them by 82.5 percent,[333] giving totals of 42.3 million metric tons for the Aird estimates, 46.0 million metric tons for the Official A estimates, and 43.5 million metric tons for the Official B estimates.

FOOTNOTES

[331] Reproduced in CIA, "China: A Statistical Compendium," ER79-10374.

[332] See Bruce Stone, *A Review of Chinese Agricultural Statistics*, Research Report No. 16 (Washington, D.C.: International Food Policy Research Institute, forthcoming), Table 4.

[333] See ibid. The processing loss figure is based on estimates of grain composition in 1977. The 1985 composition proportions will not be radically different, but the proportion of rice (which is subject to the greatest processing loss) may decline on the order of 2-3 percent, so the composite processing loss may fall by less than a percent.

APPENDIX 2

TOWARD A MORE APPROPRIATE METHODOLOGY FOR PURSUING THE MACROECONOMIC PARTIALS APPROACH: JUSTIFICATION FOR CHOICE OF METHODOLOGY AND EVALUATIVE PERIODS

The best method of assessing the expected impact of fertilizer application on grain output would perhaps be to compare longitudinal studies for a broad cross section of representative locations. Unfortunately, this is not yet possible for China for the 1970s, so the aggregate record must be relied on. It must also be recognized that large increases in grain output are not solely the result of applying more fertilizer, but of applying a controlled package of inputs, including higher or faster yielding seed varieties; extensive, intensive, and reliable irrigation; improved nutrient delivery and pest control; and often considerably altered field preparation and management practices.

If all available aggregated information is dumped into a regression equation, however, there are immediate a priori expectations of very strong multicollinearity among "independent" variables. Furthermore, data for China on several of the inputs are unavailable for many years or are defined inconsistently, while data for others are difficult to quantify appropriately. If, in addition, the years are thrown out in which the best data on nutrient application or grain output is still questionable, there must be an expectation of highly biased coefficients surrounded by wide confidence intervals.[334]

It should not, therefore, be quickly concluded that the kind of simplistic macroeconomic partials approach employed by Chao and Stavis[335] is inferior in all cases to somewhat more complex techniques such as input-output or multivariate regression analysis. Chao and Stavis compare increments in national aggregate fertilizer production and imports with increases in aggregate grain output, then calculate "response ratios" by simple division. This kind of approach has many biases, risks, and limitations, but the problems are immediately apparent. These response ratios are only rough "consistency" coefficients, but even at this level a number of basic refinements can be suggested.

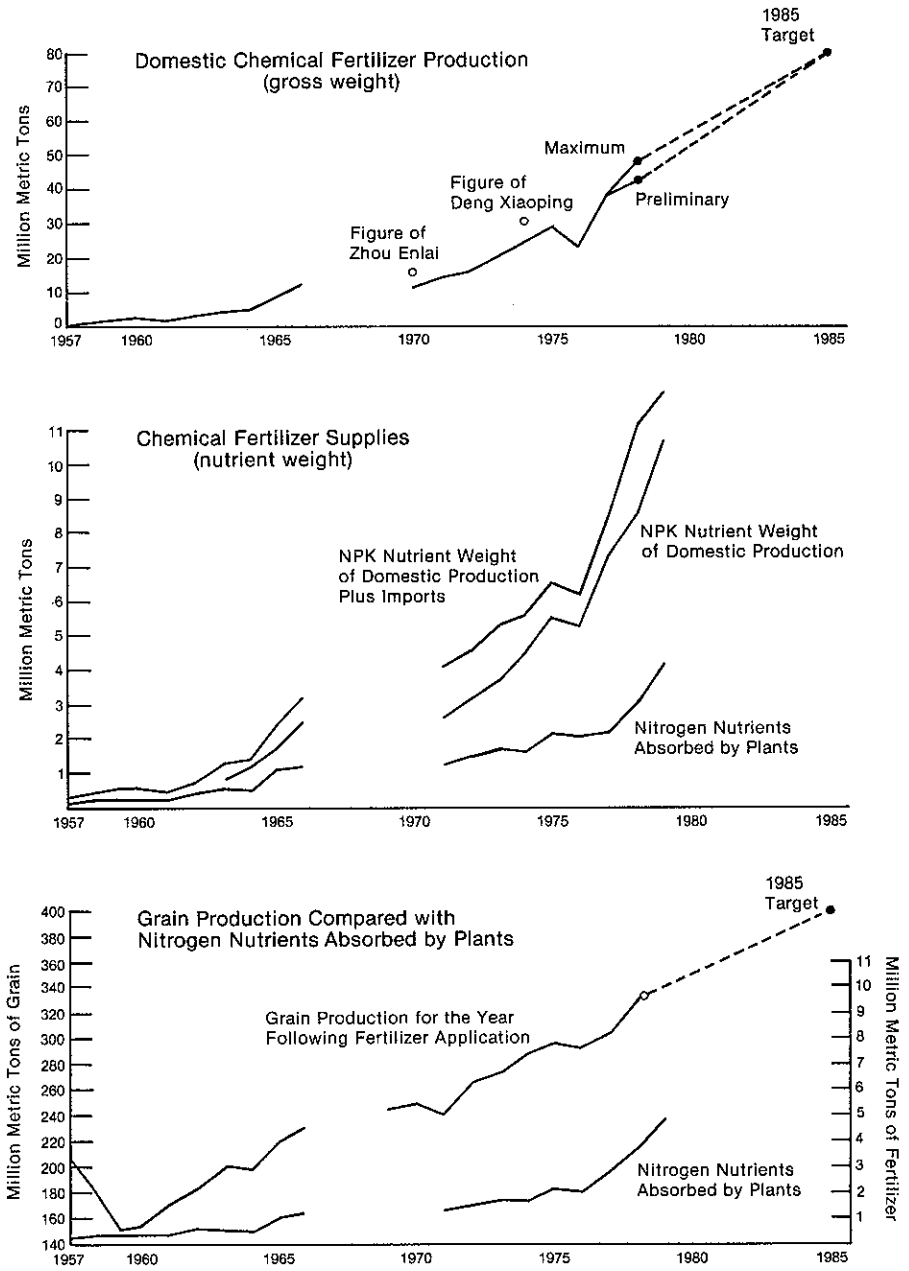
First of all, fertilizer statistics must not be used in gross weight terms. The nutrient content of fertilizers produced in the People's Republic has varied from around 1 percent to over 80 percent. The gross weight composition among these varieties of fertilizer shifted drastically between the mid-1960s and the late 1970s. Its future composition is problematic principally because of the unresolved controversy over small plant production.[336] Therefore the 1985 target for gross weight output, 80 million metric tons, is not a useful measure of planned supply from domestic sources.

With the exception of the 1976-79 period, for which Chinese production has been published in terms of nutrient weight, estimates of nutrient supply depend upon (a) import statistics; (b) estimates of domestic production in gross weight products; (c) estimates of the composition of gross weight output among varieties of fertilizer, which are approximate at best for most years; (d) the optimistic assumption that gross weight produced in each category reached the expected nutrient weight standard; and (e) fairly heroic assumptions about the percentage of production and imports actually supplied to agriculture and the percentage of supply that is applied to foodgrain acreage. Unfortunately, there are still controversies over even the appropriate aggregate gross weight statistics, although the situation is rapidly improving.[337]

It should be mentioned that two commonly cited statements by high-ranking Chinese officials about gross weight production were rejected in the Stone series for the years with which they are usually associated (although they conform well with Stone's estimates for the respective succeeding years) since they seem to be inconsistent with the remaining body of material now available (see Figure 3).

These difficulties notwithstanding, the relatively large amount of obtainable information on Chinese fertilizer production and

Figure 3—Domestic chemical fertilizer production, 1957-85; Chemical fertilizer supplies, 1957-79; and grain production compared with nitrogen nutrients absorbed by plants, 1957-85



Note: The gaps between 1966 and 1971 are for the first phase of the Cultural Revolution.

Sources: Bruce Stone, "A Review of Chinese Agricultural Statistics," International Food Policy Research Institute, Washington, D.C. June 13, 1979, Tables 15 and 16; Bruce Stone, "A Series of Chemical Fertilizer Nutrients Absorbed in Chinese Agriculture with Implications for Foodgrain Yield Response," a paper prepared for the Workshop on Agriculture and Rural Development in the People's Republic of China, Cornell University, Ithaca, N.Y., May 17–19, 1979, revised May 1980.

the crippling distortions introduced when gross weight statistics alone are used, suggests that an effort to estimate the yearly availability of nutrients is likely to improve the analysis significantly.

The next observation is that lagged averages of estimated grain output and fertilizer supply should be used rather than single-year comparisons. The most obvious difficulty with the latter is the impact of weather fluctuations on grain harvests, which may dwarf all other effects. The problem is particularly acute when the base and terminal periods are separated by only a few years as is the case with Chao's study. Even when three- or five-year averages are used, the base and terminal periods selected should contain similar proportions of favorable, average, and poor weather years. A preponderance of poor weather years should particularly be avoided, even when the base and terminal periods are otherwise comparable, since in China harvest loss in below-"normal" years varies more drastically than bumper crop increments.[338]

Also, increases in nutrient production from year to year often vary substantially in China even within five-year plans,[339] so the timing of application and the actual benefit to crops of fertilizer production and imports must be considered. Even ignoring peculiar inventory accumulation, over half of a year's fertilizer output is not applied before that year's crops are harvested. Furthermore, there is a strong tendency for the nutrient base provided by non-nitrogenous fertilizers, especially phosphates, to be fixed by metallic elements in the soil (especially iron, aluminum, magnesium, and calcium). This impedes close contact with the root system and results in slow absorption and growth response.[340] Therefore, the maximum impact of phosphate and potassic fertilizers may not occur until some years after they are applied. Owing to these considerations, a three- to five-year moving average is recommended with a one-year lag between the grain harvest data and the fertilizer production and import data.

It may be legitimate to ignore non-nitrogenous applications, and assume that they are supplied in proportions appropriate to the actual application level of nitrogenous fertilizers. This would resolve the problem of slow and variable absorption rates for phosphatic and potassic nutrients and would circumvent the poorer data on varietal composition of these fertilizers. The size and appropriate interpretation of the consistency coefficients thus obtained will be different, of course.

Almost all Chinese soils are deficient in nitrogen, according to both prewar and postwar surveys.[341] Only half or less[342] are deficient in phosphorus. In general, phosphorus-deficient soils are located south of the Yangtse, but are also found in large areas of Inner Mongolian grasslands, the Fen and Wei River Basins in the northwest, the sandy and loess hillock areas of west Shanxi and north Shaanxi, the salinized lands extending from Yangliuqing (Hebei) to Dezhou (Shandong), in numerous salinized or alkaline tracts by the Yellow River, and among yellowish red soils in Heilongjiang.[343]

But less then 2 percent of fertilizer imports have been phosphates,[344] which suggests that scarcity of this input has not normally been considered a major constraint. Rock phosphorus has been discovered extensively throughout China. Mines and small factories for extraction and rudimentary processing of the ore for fertilizer use have developed rapidly since the 1950s. Large plants have also been built, producing higher-nutrient phosphate fertilizers such as triple superphosphate (containing 45 percent phosphorus) and mixed NPK fertilizers as well as more standard varieties such as calcium superphosphate and calcium magnesium phosphate, which are also produced in small plants.

The proportion of small-plant product in total output of phosphate fertilizer had already reached 75 percent by 1972.[345] For the most part the production processes used in these small factories are relatively simple. Often the phosphate rock is simply powdered for direct application after being mixed with other materials such as organic manure and lime. In other factories the ore is heated in the presence of magnesium to fabricate calcium magnesium phosphate.[346] Generally speaking, small phosphate plants may be set up quickly to respond to demand requirements in diverse locations, including those with little industrial experience.

The People's Republic has tried to produce phosphates in specific ratios to nitrogenous fertilizers. Nitrogen has often been applied locally in excess of the appropriate ratios, but, in general, national imbalances have usually been caused by shortages of nitrogen. Phosphorous production has often been cut back as a result.[347] (The opening of foreign-contracted synthetic ammonia plants

may alter this situation temporarily.)

The proportion of lands deficient in potassium is lower still.[348] The People's Republic has depended on organic fertilizers to supply crop requirements owing to the high proportion of potassium as well as nitrogen in, especially, animal manures, plant residues, and green manure.[349] The high labor requirements and slow growth in the availability of natural fertilizers have necessitated a steady increase in the factory production of potassic fertilizers since the mid-1960s. They have also caused imports of fertilizers to become regular since the late 1960s and to grow markedly in 1973 and 1974. But the volumes involved are still small and manageable compared to nitrogen deliveries.[350]

One other problem is that even estimates of nutrients supplied may incorporate a distortion. Phosphatic and potassic fertilizers are not generally prone to evaporation and are not easily washed from fields with drainage.[351] But nitrogen, which dominates both domestic production and imports of chemical fertilizer in China,[352] has a high rate of evaporation and is easily eroded away by water and wind, especially when applied by broadcast methods. There seem to be significant differences in the volatility of the various nitrogenous fertilizers. One Chinese study conducted by the Soil and Fertilizer Research Institute of the Fujian Provincial Institute of Agricultural Science indicated that the surface soil evaporation rate is generally greater than 50 percent for nitrogenous fertilizers used in China but is greater than 70 percent for ammonium bicarbonate and aqueous ammonia produced in small plants.[353] Western scientists suggest that even 70 percent may be too low for small plant products.[354]

Although the figures are rough, discounting 50 percent for nitrogenous fertilizers from large plants (including imports) and 70 percent for small plant output corrects for evaporation and leaching in the nitrogen nutrient series. This series then provides a general indication of the quantity of nitrogen nutrients absorbed by crops from year to year. The results of this exercise have been graphed in Figure 3 together with grain production lagged one year and series for gross weight of domestic fertilizer production and for production plus imports of all NPK nutrients. Of course, if the scale in each case is carefully chosen, any of the series may be made to appear to conform in a general way with the grain output series. But with the exception of the Great Leap Forward period and its aftermath (including two years of extremely poor weather), the "N- nutrients absorbed" line seems to fit the lagged grain output line particularly well. Both a priori considerations and the comparison in Figure 3 suggest that the use of some estimated "nutrients absorbed" series (perhaps merely nitrogen absorbed from chemical sources) may be most advisable.

The inclusion of estimates of organic fertilizer nutrients should also be considered. The main arguments in favor of including them are that they still constitute the majority of nutrients applied and that the quantities applied may still be growing, though the proportion of nutrients they contribute declined substantially in 1949-76 and began falling rapidly in 1977-78.[355] The most powerful argument against inclusion is that the quality of these statistics is very low. The quality problems, as well as reasons for suspecting both upward and downward biases in the series available, have been discussed at length in another work.[356]

Suffice it to say that any investigation into the statistical bases of organic fertilizer estimates is likely to suggest that including them in the present analysis is risky. The amounts applied over the 1950s are known only in the broadest sense but are based for the most part on official Chinese estimates and parameters. Aggregate figures for the 1960s and 1970s are apt to be much weaker since many of the estimates of several of the organic components must rely on data segments from the 1950s. Nevertheless, in terms of national aggregates, any trends of increase or decline are likely to be gradual compared with the trends for chemical fertilizers. This suggests that, with a few exceptions, increments of nutrient supply within periods of moderate length may be largely of chemical fertilizer. Stone's rough estimates, which, for lack of better information, assume constant utilization rates after 1965, indicate that the supply of organic manures changed little between 1971 and 1977 (except for 1976 when a drop in the hog population caused by fodder shortages and disadvantageous prices may have caused a significant decrease of the manure supply).[357] For the present analysis the simplifying assumption has been made that increases in the availability and progress of storage, fermentation, and cake manufacture, and in methods and timing of application have

been offset by declines in the utilization rates between the base and final periods. This assumption allows us to omit an estimate of natural fertilizer nutrients.

If organic supply estimates are used, however, some estimate for nutrient loss before and after field application should be made. The resultant estimates should then be averaged for, perhaps, three-year periods and added to similarly averaged estimates of nutrients absorbed from chemical sources. In estimating nutrients absorbed from organic sources, care should be taken not to confuse Chinese data on speeds of absorption for various components with rates (or extents) of absorption by crops, as some have done.[358]

Appropriate base and terminal periods for calculating a consistency coefficient must satisfy a number of requirements outlined above and other a priori considerations. The process of appropriate selection severely restricts the choice of periods. The 1950s should not be used as a base. The proportion of chemical fertilizers devoted to nongrain crops was large and variable. Application to grain crops was skewed toward a few of the most favorable farmlands, yet application in inappropriate proportions and other errors leading to waste seem to have been common. The 1950s are too distant to shed useful light on the 1979-85 period, particularly as changes in total nutrient effectiveness in the 1950s and early 1960s were much more likely to be dominated by changes in the quantities of natural fertilizer nutrients absorbed by crops—quantities for which existing estimates are poor.

The 1960s also present problems, however. A base period should not be chosen during which grain production had not yet recovered from the massive decline accompanying and following the Great Leap Forward. Likewise, the first phase of the Cultural Revolution in the latter 1960s should be avoided. Official grain output figures for 1968 and 1969 were not released. Western estimates generally show declines that may have resulted as much from the particular political difficulties of the period as from more easily quantifiable causes. Moreover, estimates of chemical fertilizer application in even gross weight terms are questionable for the 1967-70 period.

What remains are the periods 1963-66 for fertilizer application, 1964-67 for grain production, and the early 1970s for both. The problem with selecting the latter as a base is that any three-year period chosen will of necessity be close to the terminal period, raising the expected variance of the estimated coefficient—a problem exacerbated by the preponderance of very poor weather between 1976 and 1978. Any rough attempt to match weather conditions in base and terminal periods, then, would push the latter into the early 1970s as well.

Fortunately, the 1964-66 and 1965-67 periods each contain an "average," "good," and "poor" weather year, although it should be remembered that the weather in 1967 was exceptionally favorable—certainly the best in the history of the People's Republic and one of the most favorable years in twentieth century China. Among potential terminal periods, both 1972-74 and 1974-76, like the base periods, include a good, average, and poor weather year. The four-year periods 1972-75 and 1973-76 may also be considered average, as they each include one good, one poor, and two average years.

There are several important ways in which the consistency coefficient estimates provided in this paper could be improved should more data become available. Any difficulties regarding organic manure estimation, especially national averages of utilization rates, fermentation gains, preapplication losses, and green manure and oil cake output may become less important in the future if such data are published by the Chinese. The senes might also be improved by distributing the data for phosphatic and potassic nutrients absorbed for each year over several years and using a two-year weighted moving average for nitrogen. Finally, no statistics have been made available estimating the percentage of fertilizers applied to foodgrains. This percentage varied substantially during the 1950s. The estimates appearing here have assumed that it was 90 percent from the mid-1960s onward. This assumption is based upon Chao's research, which concluded that that was the percentage for 1965.[359]

[334]See Stone, "A Review of Statistics," Tables 10-19; and Stone, "A Series of Nutrients."

[335]Chao, "The Production and Application of Fertilizers"; and Stavis, "China's Agriculture.".

[336]Stone, "A Series of Nutrients"; and Stone, "A Review of Statistics," Tables 15 and 16.

[337]Ibid.

[338]See footnote 20 for the locality-specific manifestation of this phenomenon. For the most part, and especially in China, fluctuations even out over the nation as a whole, with good years for some localities, largely cancelling out bad years for others so that aggregate output variations are not nearly so drastic. But, particularly when severe drought strikes north China, "bad" years over extensive areas can result in sharp drops in national output.

[339]Stone, "A Series of Nutrients"; and Stone, "A Review of Statistics," Tables 15 and 16.

[340]Also see Hou Te-pang, "The Application of Phosphate Fertilizer in China," *Shanghai Wen-hui-pao*, December 27, 1965; trans. in U.S. Consulate General, Hong Kong, *Survey of the Chinese Mainland Press*, Supplement No. 148, pp. 18-21.

[341]According to a survey of 170 field experiments in 14 provinces beginning 1935, 74 percent were deficient (N.F. Chang and H.L. Richardson, "Use of Soil Fertilization in China," *Nature*, 49 (April 11, 1942). According to Li Qinggui in *Renmin Ribao* [People's Daily], December 25, 1962, p. 5, 80 percent were deficient (the exact date and nature of this estimate are unknown); and according to prewar estimates cited in M. Lamer, *The World Fertilizer Economy* (Stanford: Stanford University Press, 1957), pp. 426-7, 80-96 percent were deficient.

[342]According to Chang and Richardson, "Use of Soil Fertilization," 38 percent were; according to Li, *Renmin Ribao* [People's Daily], December 25, 1962, p. 5, 50 percent were; according to the studies cited in Lamer, *The World Fertilizer Economy*, 40-55 percent were.

[343]Hou Te-pang, "The Application of Phosphate," pp. 20-1.

[344]Based on unpublished research findings of H. J. Groen and F. L. Smith appearing in Alva Lewis Erisman, "China: Agriculture in the 1970s," in U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy* (Washington, D.C.: U.S. Government Printing Office, 1975), p. 333.

[345]Stone, "A Series of Nutrients."

[346]American Rural Small-Scale Industry Delegation, *Rural Small-Scale Industry in the People's Republic of China* (Berkeley, Cal.: University of California Press, 1977), pp. 173-4.

[347]Stone, "A Series of Nutrients." The "proper" application ratio between nitrogen and phosphates was described "for most Chinese soils" as 1.4-2.0:1.0 in 1960 in *T'u-jang Hsueh-pao* [Soil Science], No. 2, 1960, pp. 79-100; cited in Liu, *China's Fertilizer Economy*, p. 115. When the ratio exceeds 2.5:1.0, yields of almost all types of rice are said to decline. Since domestic production and imports of nitrogen exceed this ratio, evaporation and leaching may be responsible for a duration of the nitrogen constraint.

[348]The proportion was 12 percent according to Chang and Richardson, "Use of Soil Fertilization"; 15 percent according to Li, *Renmin Ribao*, [People's Daily], December 25, 1962; and 15-24 percent according to the studies cited in Lamer, *The World Fertilizer Economy*.

[349]See Stone, "A Series of Nutrients."

[350]Groen and Smith in Erisman, "China: Agriculture in the 1970s."

[351]Hou Te-pang, "The Application of Phosphate."

[352]83 percent of the chemical fertilizer nutrients produced in China in 1979 were nitrogenous (Xinhua, news bulletin, April 30, 1980; FBIS, *PRC*, April 30, 1980, p. L2). 96 percent of chemical fertilizer nutrients imported between 1949 and 1974 were nitrogenous (Groen and Smith in Erisman, "China: Agriculture in the 1970s").

[353]Stone, "A Series of Nutrients"; see especially, FBIS, *PRC*, April 30, 1979, pp. L13, L14.

[354]John W. Mellor, International Food Policy Research Institute, conversation, Washington, D.C., June 15, 1979.

[355]Stone, "A Review of Statistics," Table 17.

[356]Ibid.

[357]Ibid.; and Stone, "A Series of Nutrients."

[358]Specifically, Chao, *Agricultural Production*, and "The Production and Application of Fertilizers" which is based on *Agricultural Production*. Also see Stavis' low estimate in "Making Green Revolution," which follows Chao's methods. Finally, see the discussion in Stone, "A Review of Statistics," Table 17.

[359]Chao, *Agricultural Production*, p. 160.

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