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UTILIZATION OF AGRICULTURAL INPUTS

Agricultural Transformation in The People's Republic of China

China's comprehensive experiment with technical transformation of agriculture officially began with the 10th Plenary Session of the 8th Central Committee of the CCP in September 1962.[138] Of course, a wide variety of transformational efforts predate 1962, but they generally seem to have lacked temporal continuity and coordination; they did not receive sufficiently broad-based and whole-hearted support from state and Party officials. Through 1957 a development strategy emphasizing the concentration of resources on the expansion of industrial producers' goods, a central focus of attention on national security, and preoccupation with organizational reform in both rural and urban sectors resulted in low priority for technical transformation. During this period real resources moved out of the agricultural sector.[139] Industry absorbed the largest and an increasing share of the state's basic construction investment. Not only did agriculture's direct share decline from 5.0 to 2.9 percent, but the share of infrastructural investment in water control—the key to technical transformation—dropped from 8.9 to 5.0 percent of the total.[140] Despite the location of almost nine-tenths of the population in rural areas,[141] agriculture's share of gross fixed investments[142] (including modern and traditional farm implements, carts and livestock, land reclamation, peasant water control and other imputed investments) declined rapidly from 31.8 to 23.5 percent, while industry's share rose from 22.0 to 36.5 percent.

Reported fixed investments burgeoned in 1958 and 1959 to levels not again claimed until late in the 1960s, but a large portion of the projects were "indigenous" ones planned in response to Great Leap policies. They were of uncertain real value if they were undertaken at all. Total fixed investment then fell to around the 1953 level over the 1960-62 period of severe agricultural failures and industrial stalls.[143] The unreliability of all of the statistics during this period makes estimation of agriculture's share unfruitful. It should be noted, however, that attempts to increase agricultural investment and production relied heavily on labor-intensive methods. The early and mid-1960s were marked by a particular concentration of scientific and technical efforts on the goal of agricultural transformation.[144] Sharp increases in the production and delivery of various industrial inputs to agriculture began to be recorded in the late 1950s and early 1960s, but output in several of these categories either declined again in one or more of the disaster years, or else cannot be clearly documented at all until about 1962. In 1963, the year after the pledge to promote technical transformation, it is clear that production and delivery in all categories were rapidly increasing, as was the sector's share in gross fixed investment.[145]

Statistics for the first phase of the Cultural Revolution (1966-69)[146] are again scarce, but the period clearly saw agricultural stagnation, at least scattered industrial slowdowns, failures to deliver agricultural inputs, a drop in agriculture's investment share, an eclipse of scientific and technical manpower, and greater reliance on motivation through development of public-mindedness and patriotism as opposed to individual and small group self-interest.[147]

Chinese authorities became recommitted in the early 1970s to the goals of technical transformation. This resulted in an acceleration of industrial production of inputs to agriculture, greater infrastructural efforts, and twists in terms of trade to facilitate farm production expansion. After a year of poor weather in 1972, foodgrain output enjoyed rapid recovery and growth (through 1975) until events accompanying the mid-1970s political conflict slowed down the input growth rate and alienated peasants. Contrary to previous policy, manpower and finances were expropriated from production teams for large infrastructural projects, the benefits of which did not accrue in any clear and immediate way to the teams involved. The tendency of local administrative cadre to dictate decisions about what, when, and how to produce seems to have been particularly acute in this period.[148] Furthermore, the desperately needed improvement in the rural terms of trade evidently ground to a halt around 1973-74, far short of the degree of change necessary to ensure broad participation in technical transformation. On the contrary, the 1975-77 period was marked by a degeneration in this ratio back to the level of 1964-65.[149]

Since 1978, however, China has once again embarked on a recommitment to agriculture involving further twists in the terms of trade, accelerated production of industrial inputs to the farm sector, intensified infrastructural investment, and an incentive scheme favoring successful localities to a greater extent than ever before. Several questions, however, come to mind. Will the commitment be observed? Will it be sufficient? Will it be interrupted?

Early indications are that the commitment is serious. The rural incentive structure outlined by the Plenary Session in December 1978, reiterated in major speeches at the 5th National People's Congress (June 1979), and embodied in the 1979 National Economic Plan and Draft State Budget is the most extreme since collectivization and has already been buttressed by long-term grain import agreements and a reform in the structure of state procurements of farm produce. Peasants are now afforded considerably greater latitude in production decisions than in the last two decades and will receive more pecuniary benefits from successful decisions than before.[150]

The proportion of state-budgeted funds for capital construction to be devoted to agriculture, which had averaged slightly more than 10 percent from 1966-78,[151] increased from 10.7 percent (1978) to 14 percent (1979)[152] and is scheduled to rise to 18 percent (1980-82).[153] Operating expenses for agriculture and state outlay of aid to communes, brigades, and teams will rise from 6.9 percent (1978) and 6.3 percent (1979)[154] of the state's annual expenditures to 8 percent (1980-82).[155] Long-term low interest loans to rural people's communes from the Agricultural Bank of China and the rural credit cooperatives rose from 13 billion yuan (1978) to 17 billion yuan (1979). The total sum that will be made available in 1980 has been announced as 20 billion yuan, and the volume by 1985 is supposed to be "more than double" the 1978 level.[156] Finally, the terms of trade between agricultural and industrial products have again been addressed and in 1979 were less unfavorable to agriculture and rural areas than in any previous year.[157] The estimated gross financial transfer to the countryside brought about by the changes in state purchase prices of farm goods and sales prices of industrial goods, together with reduction and remission of rural taxes, was estimated at 9 billion yuan.[158] By way of comparison, state aid to rural units and for agricultural operating expenses came to 7.05 billion yuan, whereas state rural capital construction was 7.80 billion yuan in 1979.[159]

The sufficiency of the commitment is more difficult to ascertain. In the 1950s China reaped relatively inexpensive agricultural gains without major commitments of scarce resources. In the 1960s the areas emphasized were those most nearly capable of establishing all the necessary conditions for auspicious introduction of high-yielding varieties. In the 1970s the gains were more costly. It might by hypothesized that the extent of central government commitment to foodgrains output expansion, resulting in only a 2.5-2.6 percent growth rate (1952-78), was never sufficient and that more resources should have been devoted to agriculture throughout the period. Alternatively, it might be supposed that China is simply approaching the biological limits of her output capability, given small fixed quantities of often unsuitable land.

Given the available evidence, it seems more likely that investment in China's agriculture was chronically inadequate for making large strides in output.[160] "Agriculture first" seems to have been a slogan indicating at best a policy of concentration relative to a previous period rather than relative to other sectors. If China's top leadership failed to furnish "agriculture first" with enough teeth to succeed, in terms of crucial allocation of scarce financial, industrial, foreign exchange, and administrative resources at the national level, the understanding and acceptance of the concept was far less keen within certain lower leadership echelons.[161]

The results of this chain of events were dramatic. By the mid-1970s the reports of production units that had increased output but had reaped little or no gain in per capita income were numerous. Among those particularly hard hit were units that had acceded to government pressure and concentrated all available resources on crop production, especially that of grain and cotton.[162] The blame was placed on the large increase in input requirements (particularly fertilizers, water supply facilities, insecticides, and machinery) and on the quantity of labor applied per unit increase in output, as well as on insufficient cuts in prices of industrial inputs to agriculture and inadequate boosts in state procurement prices.[163]

The results of an extensive 1978 survey[164] in Hebei province are particularly telling in this regard. Hebei is a major agricultural province in North China. It produced 5.4 percent of the nation's grain and 19.2 percent of its cotton in 1957[165] and has benefited considerably from tubewell construction since that date (see Table 5). Among surveyed localities the cost of producing 100 jin (50 kilograms) of wheat (excluding labor) rose from 13 yuan in 1965 to 15 yuan in 1976 for a loss of 1.17 yuan per mu (1/15 hectare). For cotton the business cost increase for 100 jin was from 64 yuan (1965) to 112 yuan (1976) for a loss of 7 yuan per mu. Agricultural income rose 46 percent (1965-77), but production expenses rose 190 percent. The percentage of the latter in total product price rose from 26.5 percent (1965) to 40.2 percent (1977). Labor application per mu also rose (wheat: from 19.1 units in 1965 to 33 units in 1976; cotton: from 42.6 units

Table 5—Farm area irrigated per pump well in China: provincial and regional averages of selected periods between 1949 and 1979

Province or Region	Period	Number of New Wells	Increase of Irrigated Area[a]	Irrigated Area Per Well	Date and Page of Published Figure[b]
			(1,000 hectares)	(hectares)	
Anhui	1979	25,900	87.3	3.37	June 28, 1979, p. 04
Gansu	1975	19,200	77.3	4.03	January 7, 1976, p. M1
	1972-5	50,000	200.0	4.00	December 30, 1975, p. M1
Hebei	1949-70	>200,000	2,600.0	<13.0	January 13, 1971, p. F2
	1974	93,000			January 5, 1976, p. K1
	1975	121,000	266.0	2.20	January 5, 1976, p. K1
Heilongjiang	1979	10,513	66.7	6.34	February 20, 1980, p. S11
Jilin	1970	2,500	85.0	34.00[c]	January 4, 1971, p. G6
Liaoning (Central)	Spring 1979	6,370			March 14, 1979, p. E14
Liaoning (Total)	Spring 1979	10,000			March 14, 1979, p. E14
Nei Menggu	1973	>25,000	56.0	<2.24	January 10, 1974, p. F8
	1974	9,300	41.3	4.44	January 8, 1975, p. K6
Shandong	1949-79	540,000	2,260.0[d]	4.19	April 15, 1980, p. 06
	1949-72	<226,800			April 15, 1980, p. 06
	1972-79	>313,200			April 15, 1980, p. 06
	1979	30,000			April 15, 1980, p. 06
Xinjiang	1966-76	10,620	200.0	18.83	January 14, 1977, p. M2
North China	October 1971-September 1972	>175,000			December 26, 1973, pp. B3–B4
	October 1972-September 1973	>300,000	1,400.0	<4.67	December 26, 1973, pp. B3–B4
	1979	250,000	1,000.0[e]	4.00	February 21, 1980, p. 67

Source: U.S. Foreign Broadcast Information Service, *People's Republic of China: Daily Report*, various issues.

[a] These figures were converted from mu to hectares by dividing the original figures by 15.

[b] These are the dates and page numbers of the issues of FBIS, *PRC* in which these data appeared.

[c] Ten large reservoirs and 2,790 medium and small water conservancy projects were also completed. Irrigated area increases are more closely linked to pump well construction alone in other province data.

[d] The actual increase in irrigated area was 4,415,000 hectares (FBIS, *PRC*, September 20, 1979, p. 03), but only 2,260,000 hectares were irrigated by pump wells (FBIS, *PRC*, April 15, 1980, p. 06). It was also indicated that each pump well can irrigate 30 to 60 hectares of farmland, but the averages computed here are much lower.

[e] This figure includes increases in irrigated acreage from all sources for all of China, but 1979 press reports indicate that these increases result primarily from the completion of irrigation facilities built as auxiliaries to existing pump wells.

in 1965 to 49.8 units in 1976). The situation was particularly severe in 1976-77 when the supply of industrial goods faltered and their prices rose. For 1976 the average net profit rate in Hebei's surveyed localities (no doubt including a labor valuation) was 1.1 percent for grain, while cotton production registered a loss of 15.1 percent. Against these figures the profit rate was 26.3 percent on oil crops and 12.7 percent for live hogs. The average tax on industrial inputs involved was estimated at around 20 percent.[166]

Despite the rather severe rural circumstances that have existed throughout the last two decades, in each period of recommitment to agriculture, resources applied have been sufficient to sustain a period of comparatively rapid growth, given the context of China's large and mature agrarian system. In view of the destruction in rural real capital during the Great Leap Forward (that is, to irrigation systems, soil quality, and cultivable acreage), one might argue that even 1962 is an appropriate base year. But whether one chooses 1962 or a later year, the period ending in 1967 was one of better-than-average growth.[167] The same may be said to a lesser extent of the recommitment to agriculture in the early 1970s[168] as well as of the recent reemphasis that resulted in foodgrain output growth of 7-8 percent in 1978 despite poor weather, and a further increase of 9.0 percent in 1979.[169] In each case the stumbling blocks were overprocurement, overdirection, and setbacks in rural investment and input proliferation, resulting more or less directly in rural impoverishment, political unrest, and farm output decline.

Barring a repetition of that scenario, there appears to be no strong reason why China cannot maintain a growth rate of 3.0-3.5 percent[170] or even a shade over that in the immediate six-year period, given the state's aggressive plans for rural investment and for production and purchase financing of industrial inputs to agriculture. Of course, in any one or two given years poor weather could result in stagnation without seriously affecting the medium-term trend.[171] The principal justification (though not the only one) for the prognosis of higher-than-average growth rates in Chinese agriculture in general and foodgrain production in particular can be found through examination of trends in application of inputs to the agricultural production process and their long-term, quantitative impact on output.

Trends in Input Use: Quantity and Quality

Tractorization

China's long-term increase in current inputs has been estimated at about 7 percent a year,[172] which averages to roughly 22 percent over a three-year period. Excluding the 1950s, when growth rates were large due to extremely small base figures, and beginning with the "agriculture first" policy formulations in 1962, the average annual growth rate of China's tractor stock was 14 percent. It peaked in the early 1970s, declined in the stagnant agricultural years of the mid-1970s, and rebounded in 1977 or 1978.[173] The decline seems to have been the result of disturbances stalling the industrial sector and of rural financing difficulties (1974-76). 1977 production seems to have recovered quickly, and by contrast the 1980 targets call for an average annual large- and medium-sized tractor-use growth rate of 20 percent.[174]

The actual level of tractor production in 1978-79 is somewhat less encouraging than the targets for tractors in use. Production of large- and medium-sized tractors rose 14.3 percent in 1978 and a further 9.3 percent in 1979, whereas that of garden tractors rose only 1.2 percent in 1978 and declined 4.9 percent in 1979[175] These figures are, of course, well below the 1966-77 average rates of increase of 20.3 percent per year for large- and medium-sized tractors and of 46.4 percent per year for hand tractors.[176] But there are several ameliorating circumstances. To begin with, the absolute production level has increased so that high growth rates are much more difficult and somewhat less important to maintain.

Second, one of the main problems in Chinese agricultural mechanization has been an imbalance, and in many cases, chronic shortages, in production and deployment of types of implements and machinery other than tractors.[177] In 1978, 1.7 million horsepower of large- and medium-sized tractors and 1.1 million horsepower of garden tractors were produced for a total of 12.3 percent of all horsepower of internal combustion engines for agriculture (23 million horsepower)—a much lower percentage than in previous years.[178] In 1979 the figures were 1.9 million horsepower (large- and medium-sized tractors) and 1.1 million horsepower (garden tractors) for a total of 9.8 percent of the total (29.9 million horsepower). Thus total production of internal combustion engines for agriculture increased more than 30 percent in 1979. A total of 129,000 machine-drawn plows, harrows, and transplanters, or more than two such implements for each large- or medium-sized tractor, were produced.[179] This was about the ratio of all machine-drawn implements to tractor stock in 1959.[180]

Finally, it appears that deploying tractors has been a greater problem than producing them. Several times over China's tractorization history, production has stabilized while demand (or the ability to finance purchases) has caught up to production. In a number of instances, then, advances in "tractors in use" continued during periods of stable production, while inventories of unsold equipment were drawn down.[181]

This is exactly what seems to be happening now. The increasing burden on rural finances of the greater flow of industrial inputs to agriculture at the still adverse terms of trade prevalent in the mid-1970s severely discouraged purchases of agricultural machinery. The rural stock of all tractors grew 14 percent per year between 1962 and 1977, but only about 8 percent per year between 1975 and 1977. By contrast stock increased 21.5 percent in 1978 [182] with the expansion of state mechanization financing in that year, which breaks down to a 19.3 percent increase in large- and medium-sized tractors and a 25.7 percent increase for garden tractors, despite the stabilization of production of the latter.[183]

Mechanization of Irrigation and Rural Electrification

The planned increase in stock of powered irrigation equipment of 11 percent per year from 1978 to 1980 [184] may not represent an increase over the rate of 1976 and 1977 and is certainly lower than that of the previous 13 years (16-24 percent for 1963-75 depending upon the series used). The actual 1978 increase of 9.2 percent was smaller still.[185] Once again the absolute magnitudes are much larger so growth rates are of necessity somewhat smaller. But more persuasively, the increase in stock may underestimate the increase in usage of such equipment. As will be discussed shortly, the quality and actual completion of ancillary irrigation projects and the operability of existing irrigation equipment have been worse than usual in recent years.

Although the statistics are not completely clear, there is a strong indication that the quantity of electricity supplied for agricultural purposes in 1978 and 1979 was substantially greater than in previous years. Regardless of the series used, power consumption "in rural areas" rose in the neighborhood of 17-19 percent per year between 1963 and 1975. No official statistics or statements about this indicator were available for 1976 and 1977, although it was made abundantly clear that power was in extremely short supply: even coal mines and large fertilizer plants were running below capacity owing to failures in electrical supply. In 1978, however, despite continued shortage of electricity across the economy, the amount supplied to agriculture was more than double the highest "rural usage" estimate for 1975.[186] In 1979 an increase of 10.6 percent over the 1978 level was registered. This topped the percentage increase in total electrical output.[187]

The sudden apparent jump in rural power supply cannot be attributed to the development of small hydroelectric power plants, which grew in number at a rate of about 12 percent per year (1974-78). This last statistic may underestimate capacity expansion of small plants since the 1979 increase in numbers was only 8.2 percent compared with a 19.9 percent increase in small plant capacity, but these plants still only account for about 40 percent of agricultural consumption.[188] The remainder comes from various regional power grids.

One of the principal agricultural areas requiring powered irrigation is the northeast, where drought has adversely affected water supplies and electrical generation alike in recent years (1976-78). In 1979 production over the northeast power grid doubled that of the previous year,[189] but the biggest jump in supply of electricity to agriculture seems to have occurred earlier, suggesting that the primary difference has been a shift in allocational priorities. Electrical power consumption in agricultural production is targeted to increase at 10 percent per year through 1985, while gasoline allocations are to grow at the annual rate of 10.4 percent.[190]

Irrigation and Acreage Expansion

Our understanding of the history of irrigation in the People's Republic is particularly poor. One of the principal difficulties is insufficient knowledge about the timing and extent of various changes in the quality of irrigation. Available series for irrigated area almost certainly fail to incorporate and reflect this phenomenon.[191] A look at the numbers, however, shows that the same historical trend documented for other indicators is accentuated for irrigated area expansion. If 1965 is used as a base (irrigated area had then recovered to the 1957 level after a decline during the early 1960s), irrigated acreage rose 3.2-5.0 percent per year on average through 1974. Then, if the statistical categories are comparable, the growth rate declined to no more than one-third of a percent per year through 1978.[192] By contrast, in 1979 irrigated acreage rose 2.1 percent and the 1985 target implies an annual increase of 3.6 percent per year. The area of farmland capable of producing high and stable yields is expected to grow even faster.[193]

The input to the agricultural production process that has grown at the slowest rate is undoubtedly cultivated acreage. According to official statistics, farmed area increased at the rate of less than 1.7 percent per year (1949-57), although at least 14 percent of the claimed increase was merely statistical, and some of the remainder may have represented recovery from wartime decline. Nevertheless, it was the period of greatest real growth in this category in China's history. The official figures for 1958 dropped to 107.8 million hectares from the claimed 111.8 million hectares of 1957. Throughout most of the 1960s and 1970s, the usual reference was 107 million hectares, but 100 million hectares or a little less was regularly quoted in 1978 and a figure less than 107 million was certainly relevant at least one year earlier.[194]

By contrast reclamation plans call for a gross increase of 8 million hectares (1979-85).[195] Yields on this land will be low and partially offset by retirement of marginal farmlands, but the planned acreage expansion is clearly the most ambitious since the 1950s.

Utilization of Farm Chemicals and Chemical Fertilizers

Reliable official statements about the supply of chemical pesticides indicate that it grew from an extremely low base in 1949 to 149 thousand metric tons (gross weight) by 1957, then increased more than 330 percent by 1965, and more than doubled again in the early 1970s with the recommitment to agriculture. The exact growth rate of pesticides supplied to rural areas cannot be documented for recent years, owing to a shift in statistical reporting from gross weights to weights of active ingredients, but the state plan went unfulfilled for 1974-76. The current renewal of interest in agriculture has brought on another period of accelerated growth in the supply of this input (in 1978, 22.4 percent in gross weight terms; 16.6 percent in terms of active ingredient).[196]

Chemical fertilizer presents a similar picture:[197] a 1962-77 long-term average growth rate in nutrients applied of 17 percent; a period of stagnation in 1974-76 of around 5 percent per year due to industrial slowdowns and import reductions, ending with a recovery and rapid expansion in 1977 and 1978. The targets for annual production of chemical fertilizer in 1980 called for a 53 percent increase in gross weight over the 1977 level,[198] whereas the 1985 target is almost double the 1978 level.[199] This suggests an annual growth rate of about 10 percent per year at substantially higher absolute delivery levels than those of the 1960s and early 1970s.

So far performance seems to be exceeding the trend required to achieve these targets. In 1978 domestic production in gross weight terms was reported to have increased more than 26 percent.[200] In nutrient weight the 1978 output increased 20 percent,[201] while 1979 output has been reported to have increased 22.5-23.5 percent over 1978.[202] Meanwhile, by 1977 imports of fertilizers had recovered the peak levels of 1970-73. 1978 imports have been estimated to have risen about 64 percent above the previous record set in 1972, and to be almost 30 percent of domestic nutrient production.[203] This combined effort brought about an increase in chemical fertilizer nutrients applied per cropped hectare from 64 kilograms in 1977 to 89 kilograms in 1978, and 109 kilograms in 1979.[204]

Campaign to Raise Input Quality

Improvement of input quality is once again a major plank of the new agricultural policy. (Policies aimed at increasing the quality of labor application are briefly addressed below.) Large discrepancies exist between reconstructed official figures for tractors produced and increments in tractors in use, indicating either a lack of financial ability to purchase tractors, a high rate of mechanical and repair failure, or both. 1979 statements confirm that in recent years the operability rate of tractors and irrigation and drainage machinery has been only about 70 percent. Raising this proportion to 80 percent has become an important immediate target in agricultural mechanization.[205] While the quality of operation of the nation's 2,400 county-level repair and manufacturing enterprises[206] will not be improved so quickly, it appears that rapid strides are being made in standardization and quality control of original production in state-assigned enterprises. Late 1979 statistics for 531 kinds of farm machinery produced in 22 provinces indicate that output of 508 of these was up to standard. Spot checks of complete farm machinery assemblies and of major accessories and subassemblies showed that 96 percent and 93 percent, respectively, were up to standard.[207]

Current increments in chemical fertilizer production are now dominated by the output of new centralized plants constructed by American, European, and Japanese corporations, after almost two decades in which the share of output derived from small and medium-sized domestic plants was rising. Fertilizer from these plants, though farther from the location of use, will be of higher and more dependable nutrient content (suggesting higher effectiveness per unit of gross weight, thereby easing some transportation and labor bottlenecks) and less volatile than the output from the small plants. Even the products of small plants have been improving, on average, since 1978 under threat of closure. Particularly inefficient plants in a number of provinces have been forced to terminate production, while the efficiency, profitability, and product quality of remaining plants, especially in several of the leading provinces and municipal areas, have significantly improved.[208]

Forty percent of installed tubewells in a major grain province were evidently inoperative in the mid-1970s, and the reinforcement of dams to prevent collapse had become, by 1978, one of the highest priority tasks of capital construction work in rural areas. Another major grain producer in the northeast, Jilin, indicated that existing irrigation projects are utilized only to 50 percent of design capacity, while for Shaanxi and Yunnan, among others, full utilization became the major capital construction task in 1978-79.[209]

As suggested earlier, it seems likely that the technical requirements for qualifying as "irrigated acreage" have been raised at least twice since the early 1960s and possibly more. To date, however, there is no unequivocal confirmation of this allegation. On the other hand, it is clear that if there has not been a definitional change in recent years, there has been a correction of current and previous statistics to reduce overestimates resulting from incorporation of lands in which the irrigation facilities were not actually completed. Moreover, the quality of irrigation has unquestionably improved, not only because of the greater stocks of operating tubewells, irrigation and drainage machinery, and higher fuel and power allocations to operate them, but because of the design of the irrigation network itself.[210]

In the 1950s and 1960s, most so-called "irrigated lands" were equipped with facilities able to apply only plot-to-plot irrigation methods. The amount of water supplied by these facilities was not sufficient to cope with a long period of drought, so attempts to intensify land use beyond the traditional cropping system were risky. In the 1970s, as land use intensification became more urgent, the emphasis of the project design was placed increasingly on the assurance of controlled and sufficient water supply and drainage for individual plots (a "ditch-to-plot" method). In describing infrastructural construction targets and accomplishments, "the area of land guaranteeing good harvests irrespective of drought or flood" increasingly replaced the terminology "area of land under irrigation." For lands on which the introduction of highly intensive cropping systems was planned, a far more sophisticated infrastructure began to appear. In these "lands with yield of a ton (per mu)," the land was completely levelled and subdivided into uniform plots surrounded by irrigation and drainage ditches, while access roads suitable to accommodate tractors and power tillers were constructed.[211]

Low electrical power consumption in rural areas has clearly constrained irrigation and fertilizer production efforts until recently. It seems to have been the result not only of insufficient total capacity and a low priority for agricultural uses in allocation of power-grid supply (despite a central official policy of "agriculture first"), but also of low capacity utilization and inopportune failures in the electric power industry—coal mines in China have been shut down recently for lack of power, while generators remained idle for lack of coal. The sector is focusing considerable attention on improving efficiency and increasing the capacity utilization, especially in the critical northeast power grid.[212]

Discussion of input quality in the Chinese press seems to go in cycles. Rural stock increases are occasionally reported as if the problem was nonexistent: as if all goods produced were up to standard and depreciation did not occur. At other times there seem to be campaigns of criticism: reports issued at these times draw a general picture that may possibly be overly pessimistic. Therefore, estimates of the degree of progress immediately attainable in this area in a massive developing country such as China should be conservative. But it should not be difficult to improve on the extreme situation outlined above, now that it has been placed at the forefront of bureaucratic and popular attention and has received priority from central organs. The last time such strident criticisms of inefficiency and poor quality control were registered was in the early 1960s,[213] just before the period of rapid agricultural growth that ended during the first phase of the Cultural Revolution.

Potential Contribution to Foodgrain Output

Until recently few foreign analysts believed China's increase in input application alone would sustain the growth rate required to achieve the 1985 foodgrains production goal. Yet this increase may enable China to achieve faster than average growth over the next seven years if the input targets for 1980 published early in 1978, the Central Committee Decisions adopted in December 1978, and the draft 1979 National Economic Plan released in June 1979, [214] are indicative of the commitment to the agricultural sector over the entire period.

A 1979 paper by Sarma and Roy suggests that the effects of other agricultural production inputs on Indian agriculture are subsumed in the regression coefficients for increases in acreage under foodgrains, increases in irrigated area, and increases in chemical fertilizer nutrients supplied, and that these composite coefficients are additive.[215] Full input-output analysis or econometric study of the determinants of foodgrain growth in China is beyond the scope of this paper.[216] Moreover, it seems quite possible that in China other production inputs, notably improvements in the quality of irrigation, would be seen to have independent effects were appropriate statistics available. Nevertheless, it may be useful to look at the impact on grain production of changes in the amounts of the key inputs identified by Sarma and Roy as well as the prospects for changes in the supply of these inputs.

Yields in the most productive major reclamation areas are about one-and-a-quarter tons per hectare. Yields in other areas are often three-quarters of a ton.[217] Even ignoring the acreage shifts out of foodgrains, especially into oil crops and fibers, and the planned reconversion of large tracts of marginal land to pastures and forests,[218] no more than 5 million metric tons should be expected from gross additions to foodgrain-sown area.

The other two categories will receive slightly more extensive treatment. For each, two questions will be explored. Are the input expansion targets for 1985 consistent with production of 90 million metric tons of additional foodgrains (400 million metric tons minus 1978 output, minus the 5 million metric tons expected from net additions to foodgrain acreage)? What are the prospects that these input expansion targets will be fulfilled? Examination of the first question requires an estimate of the expected impact on foodgrain production of changes in the amounts of inputs applied. Because of the limitations of available data, because only two inputs are considered, and because Tang conducts an extensive input/output analysis in the accompanying paper, a simpler and less ambitious approach will be adopted. Historical changes in the level of application of these inputs will be matched with changes in foodgrain production levels for various periods to obtain hypothetical "coefficients of consistency." These coefficients are nothing more than lagged and unlagged changes in foodgrain output per unit change in input application. The coefficient that seems least likely to be biased and most applicable to the 1979-85 period will be adopted to determine whether the 1985 input expansion targets in the two categories are consistent, on the basis of the historical record, with the production of an additional 90 million metric tons of grain.

Consistency and Attainability of Irrigated Area Targets

Table 6 presents lagged and unlagged ratios of change in foodgrain output per unit of change in irrigated acreage for three periods. The irrigated area changes involved were not based on statistics derived from single year citations and compilations by Western analysts, but were given more or less directly in the Chinese press. Consequently, possible changes in the definition of "irrigated area" suggested earlier are not as likely to present a problem as they would if other materials had been used.

Table 6 shows that the ratios between the changes in foodgrain output and the changes in irrigated area are rather consistent no matter how many years the change in grain output was lagged behind the change in irrigated area. In general, weather conditions in the initial and final years were dissimilar, thereby explaining a large part of the variations between the calculated ratios. Only in the initial and final years for the unlagged 1965-75 coefficient were weather conditions similar. Although 1978 has been identified as a poor weather year by American and Soviet intelligence services and the Chinese press, the increase in foodgrain output over the poor weather years 1976 and 1977 was so great that it is tempting to accept it as an average year. This would make weather conditions for the three-year-lag figures for 1965-75 (and 1970-75) match up. But the official figures for change in irrigated area for 1957-78 and 1970-75 are still ambiguous. Moreover, there has been some indication that the 1977 and 1978 output figures, unlike those for 1957 (and possibly 1970), excluded some portion of soybean production, introducing a downward bias in the ratios calculated for periods terminating with these years.

It appears, then, that the most appropriate coefficient may be the unlagged 1965-75 figure. In defense of such a high ratio, the reader should be reminded that this is a "consistency coefficient" and not an input-output or multivariate regression coefficient since the contribution of other inputs was not considered; the quality of irrigation, as defined for the 1965-75 statistics, was substantially higher than in the 1950s and 1960s; and average foodgrain yields in China are the results of aggregating extremely high-yielding land, especially land with a guaranteed water supply, and much lower-yielding land, especially unirrigated land. Foodgrain yields over the entire province of Zhejiang averaged 10 tons per hectare in 1979. For several of the hinterland provinces, the average is close to 1 ton per hectare. The latter provinces have large tracts of unirrigated land that yield even less.[219]

Applying the selected coefficient to the target of 13.3 million hectares for the increase in irrigated acreage by 1985 results in exactly 90 million metric tons, suggesting that the ratio may approximate the benchmark figure used by the Chinese. Two questions remain, however. Can 13.3 million hectares be delivered by 1985? What if a more conservative coefficient is adopted?

Only one of the major surface irrigation schemes (the Han River diversion, affecting some 4 2/3 million hectares) is likely to affect yields in the 1980s, [220] but two other lines of attack are being pursued: pumpwell construction and the completion of auxiliary projects on existing irrigation works. The latter is expected to add some 8 million hectares to irrigated acreage.[221] This total plus the Han diversion acreage would come close to fulfilling the 1985 target, but what about pumpwells? In 1979 irrigation facilities for 250,000 pumpwells in North China were completed, and irrigated area rose 1 million hectares. But the impact of much of this work may be included in the 8-million-hectare figure cited above. New tubewells were sunk at the average rate of over 150,000 per year between 1965 and 1974 and over 200,000 per year between 1975 and 1978. Although the exact number of new wells constructed in 1979 cannot be deduced from currently available information, scattered provincial reports during the spring of 1979 indicated that work was proceeding at the pace of 1975-78. This suggests that

Table 6—The relationship between changes in foodgrain output and changes in irrigated area, 1957-78, 1965-75, and 1970-75

Period/ Amount of Lag	Change in Irrigated Area	Change in Foodgrain Output	Weather Conditions: First Year	Weather Conditions: Last Year	Change in Output from Irrigated Area
	(million hectares)	(million tons)			(tons/hectare)
1957-78[a]					
No lag	20.8	120	good	bad	5.8
No lag	17.5	120	good	bad	6.9
1965-75					
No lag	13.3	89–91	average	average	6.7–6.8
1 year	13.3	66	bad	bad	5.0
2 years	13.3	50–52	good	bad	3.8–3.9
3 years	13.3	90	average	bad	6.8
1970-75[b]					
No lag	8.00	40–42	good	average	5.0–5.3
	6.65	40–42	good	average	6.0–6.3
1 year	8.00	40	average	bad	5.0
	6.65	40	average	bad	6.0
2 years	8.00	43	bad	bad	5.4
	6.65	43	bad	bad	6.5
3 years	8.00	39–44	average	bad	4.9–5.5
	6.65	39–44	average	bad	5.9–6.6

Sources: For changes in irrigated area, the 1957-78 figures are based on a quote from U.S. Foreign Broadcast Information Service, *People's Republic of China: Daily Report*, January 26, 1979, p. E10 (see note a). The figures for 1965-75 are based on the statement "irrigated area was extended each year (1965-75) by an average of 1.33 million hectares," from "A Decade of Rapid Economic Development," *Peking Review*, October 8, 1976, p. 47. The 8.00 million hectare figure for 1970-75 is based on the statement that "the average annual increase over the previous five years was 1.6 million hectares" (FBIS, *PRC*, January 5, 1976, p. E2) and "in each of the recent few years an average of 1.6 million hectares were added to the irrigated area" (Chiang Hua-nong, "How China Became Self-Sufficient in Grain," in Chang Chung-wang and Chiang Hua-nong, *How China Became Self-Sufficient in Grain* [Beijing: Foreign Languages Press, 1977], p. 10). The 6.65 million hectare figure is from FBIS, *PRC*, February 19, 1976, pp. E10, E11.

All data for the changes in foodgrain output and for weather conditions are from Table 1, Series B. 215 million tons has been used as an estimate for 1968, consistent with Series B assumptions.

[a] The figures for this period depend upon a January 1979 official statement that irrigated area rose 60 percent between 1957 and 1978. 20.8 million hectares was derived by using the official 1957 figure (published in 1959) for 1957 (34.7 million hectares) and 1.6 times that figure for 1978. 17.5 million hectares was derived by using the 1978 official figure (46.6 million hectares, published midyear 1979) and 1957 figure derived by dividing the 1978 value by 1.6. Therefore, taken literally, the first set of figures assumes that all changes in definition of irrigated acreage (1959-79) occurred between January and June 1979. The second set assumes that all such changes occurred between 1959 and January 1979. It seems very likely that the definition was changed at least twice between 1959 and 1979, lending credence to the second set of figures, but it is possible that another change was made within the first six months of 1979 as definitional changes were clearly made in other statistical categories during that period.

[b] The first figure for the changed irrigated area (8.00 million hectares) was published in early January 1976. The second figure (6.65 million hectares) was published in mid-February 1976. This suggests that the second is a revised figure or that a change in definition occurred in this brief period. In either case, the second figure is more appropriate for our purposes, but it may represent merely a halving of the 1965-75 difference. Moreover, an official pamphlet published in 1977 claimed that "in each of the recent few years (ending in 1975) an average of 1.6 million hectares of land has been added to the irrigated area." This value may be gross rather than net, but otherwise seems more consistent with the first figure.

completion of auxiliary facilities may have been the more serious constraint.[222]

The average area of farmland irrigated by a single pumpwell is best approached on a more disaggregated basis. But data presented in Table 5 suggest that three to four hectares per well might be a reasonable aggregate estimate. In view of past history, it seems quite likely that the rate of tubewell construction can be maintained, which would indicate overall irrigated area consistent with the 1985 foodgrain output target even if a lower coefficient from Table 6 is used, five tons per hectare, for example.

Several caveats should, of course, be mentioned. The full potential of previous irrigated area increases may not yet be realized. If it has been realized but a lag is required after future irrigation efforts in order to achieve full potential, immediate output increases from this source may suffer from the apparently slow irrigation expansion in the 1975-78 period. This discussion ignores not only the question of the supply of other yield-increasing inputs, but also the significant shift in rural policy in 1978-79. To a certain extent, soil to be irrigated is inferior to the soil in areas already irrigated.[223] Eventually, the quantity of "high-and-stable-yield land" or "land with a yield of a ton (per mou)" will be more reliable output indicators than the quantity of irrigated acreage.

It should also be noted that while China's current proportion of irrigated area (almost 50 percent) exceeds that of most developing nations, the growth rate implied by the 1985 target[224] surpasses the 1975-90 projected growth rates of almost all developing countries with the exception of Nepal, Afghanistan, and several nations with proportions of arable area irrigated falling below 5 percent.[225] The rate appears less ambitious when compared with historical rates of expansion in the People's Republic. It exceeds the 1972-78 rate but falls below the rapid expansion of the 1950s (even after recovery of prewar levels) and the 1964-72 period.[226]

The Contribution of Planned Increases in Fertilizer Application

Some scholars have maintained that the rates of China's yield response to incremental application of chemical fertilizer nutrients have declined. The principal proponent of this view is Kang Chao, who found that the incremental yield of grain fell from between 10 and 30 kilograms for each additional kilogram of nitrogen applied between 1959 and 1963 to 7.2 tons of grain for each ton of nutrients applied between 1971 and 1973.[227] Chao concludes that if returns continue to decline at such a rapid rate, China will soon cease to benefit from increased applications of fertilizers.[228]

If Chao's analysis is correct, it would be crucial to determine what causes the decline, whether it is likely to continue, and how current policies might affect it. Fortunately, however, other research [229] has indicated that the historical evidence does not support Chao's contention. A number of problems with the methodology and data series used in Chao's study have been dealt with extensively in another work. A more recent study by Benedict Stavis[230] suggests that the productivity of fertilizer may actually be rising in China. The series Stavis uses corresponds somewhat more closely with the information now available on production of grain and fertilizer, but still suffers from some methodological problems.[231]

Tables 7, 8, and 9 contain national aggregate rates of response of grain output to incremental applications of various fertilizers. Table 7 contains the expected rates of response published by the Chinese in the 1950s and early 1960s. There are problems in comparing these figures with the coefficients in Table 8 (see the notes to Tables 7 and 8 and Appendix 2).

Table 10 provides the response rates derived from field tests in specific localities made during the 1950s and early 1960s. It is probably even more risky to compare these figures with the figures in Table 8. Moreover, there is no suggestion that the lands on

Table 7—Expected response rates of foodgrain output to chemical fertilizers applied

Fertilizer	Rice	Wheat
	(kilogram of foodgrain/ kilogram of nutrient)	
Ammonium sulfate, 1950s		
Nitrogen applied	14.6–24.4	9.8–19.5
Nitrogen absorbed	29.3–48.8	18.5–39.0
Ammonium sulfate, early 1960s		
Nitrogen applied	19.5–29.3	14.6–24.4
Nitrogen absorbed	39.0–58.5	29.3–48.8
Ammonium nitrate, 1950s		
Nitrogen applied	14.4	9.4
Nitrogen absorbed	28.8	18.8
Superphosphate, 1950s		
P_2O_5 Applied	11.8	7.6

Notes: To get these figures, yield increments per unit of gross weight were converted to nutrient weight rates by dividing through by 0.205 (for ammonium sulfate), 0.34 (for ammonium nitrate) and 0.17 (for superphosphate). It was assumed that only about half of the nitrogen applied was absorbed by plants. This assumption is based on a study by the Fujian Soil and Fertilizer Research Institute (appearing in U.S. Foreign Broadcast Information Service, *People's Republic of China, Daily Report*, April 30, 1979, pp. L13–L14).

Table 7—(Continued)

The statistics for expected yield per unit of gross weight from which these figures were derived appear in a table misleadingly labelled "The Average Yield Increment in 1959 and 1962-63," appearing in Jung-Chao Liu, *China's Fertilizer Economy* (Chicago: Aldine, 1970), p. 110. Liu cites these data as if they were national averages for 1959 and 1962-63. Yet the 1950s data were not based on 1959 results alone—they appear in publications as early as 1954 and as late as 1962. Similarly, the data for the early 1960s appeared in February 1962 and in February and March 1963, so the earliest results must have been from no later than 1961.

The figures were used in several Chinese articles to predict the improvement of yields that would result if more fertilizer were applied. But it is not actually known whether these figures are broadly-based national averages or aggregations of a few experimental results; what actual levels of fertilizer application were involved; whether base amounts of natural fertilizers were also used; or whether increments were calculated for different years on the same parcel of land or for neighboring parcels during the same year.

which these local studies were conducted were representative of the national norm. Even so, the range of response is illuminating. It must also be noticed that the incremental yield response in most experiments dropped off sharply after a point, since increases in other complementary inputs were absent. In the only cited experiment investigating the impact of widely variable application levels of nitrogen and phosphorus combined, however, the rate of response was high and relatively stable over a broad range of comparatively intensive application.

The response rates may have risen or fallen between the 1950s and 1978, but scrutiny of the data, including the data examined by Chao and Stavis, reveals no justification for concluding that they did. This is partly because the data are not easily compared and partly because the calculated coefficients are similar after controlling for various extraneous features such as weather fluctuations and poor data for certain years. This similarity can be seen among the coefficients in Table 8. These coefficients must not be interpreted as the number of additional weight units of grain that will be produced when an extra weight unit of nutrient is applied or absorbed and the other input levels held constant. It can only be said that within our period of scrutiny the incremental production of grain was consistent with the absorption or application of nitrogen (N) or a combination of nitrogen, phosphorus, and potassium (NPK) according to the given rates. Therefore, if these rates are used to predict the amount of fertilizer required to produce an increment of grain, there is an implicit assumption that something approximating constant returns to scale may be obtained from the base period through the period of prediction and that the amounts of other inputs to the production process will be as large in relation to increased fertilizer supply as in the past.

Though the amount of cultivated land was relatively fixed in the process, cultivated area has actually declined since the 1950s and will rise somewhat in the prediction period. But although there was no evidence of decline in long-term aggregate rates of response to fertilizer within the period scrutinized compared with the 1950s, it is not at all impossible that the rate will decline between 1979 and 1985 if the growth rates of fertilizer nutrient application and absorption increase much faster than those of the supplies of other yield-increasing inputs.

The state's aggressive chemical fertilizer supply plans for 1979-85 and the extent to which they seem likely to be fulfilled make this a real possibility. Fortunately, nutrient application and absorption appear likely to be so high that even a large decline of the response rate may be accommodated without jeopardizing the foodgrain output target, unless there is a critical failure in the current plans for supplying other inputs.

One such failure could be of the supply of organic fertilizers. If the "chemical fertilizers only" coefficients are used to predict consistency, there is an implicit assumption that appropriate increases in organic nutrient supply will also be made. Table 9 also presents consistency coefficients which incorporate the "response" to both chemical and organic fertilizers combined. These rates are of course much lower. But they are also conservative because the organic series employed for their computation has been generous. (It assumes that the high rates of animal manure and night soil utilization of the mid-1960s continued through the 1970s and that the 1950s quantities of other organic materials [mid-1960s quantities for green manure and oil cakes] continued to be supplied despite the increasing opportunity costs of providing most of these components.) It is also not clear that sufficient account

Table 8—National aggregate response rates of foodgrain output to all fertilizers applied, late 1960s to 1970s

Years Fertilizer Applied		Years Foodgrains Harvested		Chemical Fertilizers Only				Chemical and Natural Fertilizers			
Base Period	Terminal Period	Base Period	Terminal Period	NPK Nutrients Applied	N Absorbed P K Applied	N Nutrients Applied	N Nutrients Absorbed	NPK Nutrients Applied	N Absorbed P K Applied	N Nutrients Applied	N Nutrients Absorbed
				(kilograms of foodgrain output/kilograms of nutrient)							
Lagged rates of response											
1963-65	1971-74	1964-66	1972-75	21.4–22.0	36.5–37.6	31.0–31.9	76.8–79.1	6.9–7.1	11.3–11.6	15.9–16.4	48.4–49.8
1963-65	1972-75	1964-66	1973-76	21.2–21.7	37.6–38.5	29.7–30.4	76.4–78.2	8.3–8.5	12.5–12.8	16.6–16.9	50.6–51.8
1964-66	1971-74	1965-67	1972-75	21.4–22.5	36.6–38.4	31.7–33.3	81.5–85.5	7.5–7.9	11.1–11.7	15.9–16.7	50.3–52.8
1964-66	1972-75	1965-67	1973-76	21.1–22.0	37.8–39.3	30.0–31.2	80.0–83.1	8.3–8.6	11.4–11.8	16.7–17.3	52.7–54.8
Unlagged rates of response											
1964-66	1971-75	1964-66	1971-75	21.7–22.2	38.7–39.6	30.9–31.7	81.9–84.0	8.2–8.4	12.4–12.7	16.7–17.1	52.8–54.1
1964-66	1971-74	1964-66	1971-74	22.2–22.7	37.9–38.8	32.9–33.7	84.4–86.5	7.8–8.0	11.5–11.8	16.5–16.9	52.1–53.4
1964-66	1972-75	1964-66	1972-75	21.0–21.6	37.5–38.5	29.8–30.6	79.3–81.6	8.2–8.5	12.5–12.9	16.5–17.0	52.3–53.8

Sources: For the grain production data, the Stone approximations in Table 1. For the fertilizer data, 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. Also see Bruce Stone, *A Review of Chinese Agricultural Statistics, 1949-78*, Research Report 16 (Washington, D.C.: International Food Policy Research Institute, forthcoming), Tables 15–17.

Notes: N stands for nitrogen, P for phosphorus, and K for potassium. When the calculated response rate is expressed as a range, that range is entirely dependent upon the range of grain output figures cited in Approximation B in Table 1.

The response rates (RR) in this table have been calculated by the following formula:

$$RR = \left(\frac{\sum_{i=0}^{n} Q_{t+T+i}}{n} - \frac{\sum_{j=0}^{2} Q_{t+j}}{3} \right) \Bigg/ \left(\frac{\sum_{i=0}^{n} F_{t+T-r+i}}{n} - \frac{\sum_{j=0}^{2} F_{t-r+j}}{3} \right)$$

where:

Q_t = China's national output of foodgrains in year t;
F_t = 90 percent of NPK chemical fertilizer nutrients produced and imported (or which may be absorbed from nutrients produced and imported) in year t. It includes natural fertilizer nutrients where designated. (It was assumed that 10 percent of all fertilizers were applied to nongrain crops, based on the calculation for 1965 in Kang Chao, *Agricultural Production in Communist China, 1949-65* [Madison: University of Wisconsin Press, 1970], pp. 160-2.);
n = the number of consecutive years averaged in the terminal period (3, 4, or 5);
r = the lag between grain output data and fertilizer production and import data (0 or 1 year);
T = the number of years separating the first years of the base and terminal periods (2–12 years).

Table 8—(Continued)

There is no guarantee that any of these rates are comparable to the rates cited in Table 7 for the 1950s and early 1960s. Even if they were, the material presented here and in Tables 9 and 19 does not support the contention that the national aggregate response rates have declined. In attempting to prove the contrary, Chao (in *Agricultural Production*) uses only the ammonium sulfate rates for the 1950s and early 1960s. He also uses a different data series for grain and fertilizer for the 1970s and ignores the volatility of chemical fertilizer and the differences in weather of the base and final years. He does use a similar, though cruder formula for estimating yield response than the one above:

$$RR = Q_{1973} + Q_{1971} - 2Q_{1970} \Big/ F_{1973} + F_{1971} - 2F_{1970}$$

The estimates used for natural fertilizer are of doubtful accuracy. No allowance has been made for declining rates of utilization since the mid-1960s despite indications that a decline has occurred. The series for natural NPK fertilizers applied may be particularly misleading since no allowance is made for nutrient loss during drying, storing, and the preparation of manures and feces cakes. The loss was much greater if the cakes were stored out of cover. See James Cameron Scott, *Health and Agriculture in China* (London: Faber and Faber, 1942), pp. 133-47.

Table 9—Lagged averages of national aggregate response rates of foodgrain output to chemical fertilizers applied, 1960s to 1970s

Years Fertilizers Applied		Years Grain Harvested					
		Base Period		Terminal Period			
Base Period	Terminal Period	Years	Weather	Years	Weather	NPK Applied	N Absorbed
						(kilograms of foodgrain/kilograms of nutrient)	
1963-65	1971-73	1964-66	good, average, good	1972-74	bad, average, good	21.1	72.4
1963-65	1972-74	1964-66	good, average, good	1973-75	average, good, average	22.7	82.1
1963-65	1973-75	1964-66	good, average, good	1974-76	good, average, bad	21.0	77.6
1963-65	1974-76	1964-66	good, average, good	1975-77	average, bad, bad	20.3	75.5
1963-65	1975-77	1964-66	good, average, good	1976-78	bad, bad, bad	17.7	62.2
1964-66	1971-73	1965-67	average, bad, good	1972-74	bad, average, good	21.1	75.9
1964-66	1972-74	1965-67	average, bad, good	1973-75	average, good, average	22.9	87.6
1964-66	1973-75	1965-67	average, bad, good	1974-76	good, average, bad	21.0	81.2
1964-66	1974-76	1965-67	average, bad, good	1975-77	average, bad, bad	20.2	78.4
1964-66	1975-77	1965-67	average, bad, good	1976-78	bad, bad, bad	17.3	62.3
1971-73	1972-74	1972-74	bad, average, good	1973-75	average, good, average	24.8	129.6
1971-73	1973-75	1972-74	bad, average, good	1974-76	good, average, bad	16.8	94.1
1971-73	1974-76	1972-74	bad, average, good	1975-77	average, bad, bad	16.9	83.3
1971-73	1975-77	1972-74	bad, average, good	1976-78	bad, bad, bad	13.9	50.0

Sources: The grain production data is from Approximation B in Table 1. The fertilizer data is from 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, revised May 1980; also see Bruce Stone, *A Review of Chinese Agricultural Statistics, 1949-79*, Research Report 16 (Washington, D.C.: International Food Policy Research Institute, forthcoming), Tables 15, 16. For the weather conditions, see Table 1.

Notes: The response rates (RR) in this table have been calculated by the following formula:

$$RR = \left(\sum_{i=0}^{2} Q_{t+T+i} - \sum_{j=0}^{2} Q_{t+j} \right) \Big/ \left(\sum_{i=0}^{2} F_{t+T-r+i} - \sum_{j=0}^{2} F_{t-r+j} \right)$$

where: Q_t = China's national output of foodgrains in year t;

F_t = 90 percent of NPK chemical fertilizer nutrients produced and imported (or which may be absorbed from nutrients produced and imported) in year t. It includes natural fertilizer nutrients where designated. (It was assumed that 10 percent of all fertilizers were applied to nongrain crops, based on the calculation for 1965 in Kang Chao, *Agricultural Production in Communist China, 1949-65* [Madison: University of Wisconsin Press, 1970], pp. 160-2);

r = the lag between grain output data and fertilizer production and import data (0 or 1 year);

T = the number of years separating the first years of the base and terminal periods (2–12 years).

Table 10—Responses of foodgrain yields to incremental applications of chemical fertilizers in experiments, 1947-65

Nutrient Applied	Crop	Year	Yield Without Chemical Fertilizer	Kilograms of Nutrient Applied Per Hectare (0, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150)
			(tons/hectare)	(average kilograms of incremental output/kilogram of nutrient applied)
Nitrogen	Rice	1947-51	3.390	←24→←12→←11.5→←8.5→
Nitrogen	Rice	1955	3.390	←18→
				←14.8→
				←12.7→
				←11.7→
				←10.4→
				←10→
Nitrogen	Rice	1955	3.840	←8.7→
Nitrogen	Rice	1956	3.345	←16.5→
Nitrogen	Rice	1956	4.230	←29.5→
Nitrogen	Rice	1963	4.635	←7.5→
Nitrogen	Rice	1965	6.276[a]	←9.3→←2.6→
Phosphorus	Rice	1955	3.340	←34.4→
Phosphorus	Rice	1955	5.487	←3.8→
Phosphorus	Rice	1963	4.464	21.5→
Phosphorus	Rice	1963	1.334	27.7→
Phosphorus	Rice	1963	3.555	49.5→
Phosphorus	Rice	1963	4.635	←30.4→
Phosphorus	Rice	1963	2.526	←36.6→
Phosphorus[b]	Rice	1963	2.715	←20.7→←30→←7.5→←5.1→←37.8→
				←25.3→
				←14.5→
				15.2
				←19.7→
				←11.4→
				←13.4→
				←19.5→
				←5.1→
				←16→
				←27.6→
Phosphorus	Rice	1963	1.190	←22.8→
Phosphorus	Rice	1963	1.827	←19.4→
Phosphorus	Rice	1963	1.238	←13.6→
Phosphorus	Rice	1965	2.265	←31.2→←5.5→←5.1→
				←19.1→
				←14.9→
				←10→

Nitrogen & Phosphorus[c]	Rice	1955	3.840	16.7
Nitrogen & Phosphorus[c]	Rice	1955	3.338	11.1
Nitrogen	Wheat	1956-57	2.145	17.2 -.8 5.6
				9
				7.9
				3.2
Nitrogen	Wheat	1957	0.488	22.5
Nitrogen	Wheat	1962-63	0.600	1
Nitrogen	Wheat	1964	0.655	2.6
Nitrogen	Wheat	1964	2.167	36.2 19.1
				27.7
Phosphorus	Wheat	1955	1.362	16.2
Phosphorus	Wheat	1962-63	0.600	7.5
Phosphorus	Wheat	1964	0.655	14
Nitrogen & Phosphorus[c]	Wheat	1958	2.325[d]	29.5 26.7 26.3
				28.1
				27.5
				26.5
Nitrogen & Phosphorus[c]	Wheat	1962-63	0.600	31.3
Nitrogen & Phosphorus[c]	Wheat	1964	0.655	18.8

Source: All figures are based upon yield data associated with various levels of fertilizer application, and have been calculated from material appearing in Jung-Chao Liu, *China's Fertilizer Economy* (Chicago: Aldine, 1970), Tables c7, c8, and c9.

[a] This refers to the yield of rice when 15 kilograms of nitrogen per hectare were applied.

[b] The results of this experiment are anomalous. Liu suggests that the yield figure on which the negative value was based (for 75 kilograms) was a misprint in his source. Omission or adjustment of this figure alone, however, would not eliminate the peculiar pattern exhibited.

[c] A combination of nitrogen and phosphorus fertilizers were applied.

[d] This refers to the yield of wheat when 60 kilograms of N and P_2O_5 were applied per hectare.

has been taken of nutrients lost while drying and storing manures; such losses must still have been large in the 1960s and 1970s.

But even if the conservative "chemical and natural fertilizer" coefficients are used and continued high rates of manure utilization assumed, the levels of all fertilizer nutrients likely to be applied by 1985 are consistent with the production of an additional 90 million metric tons of foodgrains (see below). Hog manure and night soil dominate the presumed increases in organic manure supply. By far the greater of the two is hog manure. If supply to agriculture of the latter rises collinearly with hog numbers, the 1979-85 period should see faster growth of this component than occurred in the 1970s. Together, night soil and hog manure would provide some 3.3 million tons of nutrients by 1985 over and above 1978 levels and perhaps as much as 4.8 million metric tons over 1977 levels (equally relevant for 1978 grain output).[232]

An important question remains: regardless whether utilization rates have been constant or have declined from the high levels of the mid-1960s, will they fall in the present period? Peasant autonomy over allocative decisions involving both their own labor and other resources (such as family night soil and excrement from privately owned pigs) has increased. So there must be a strong supposition that these rates will decline, at least as they concern application to grain crops, most of which are grown on collective lands, not private plots.

There is, however, a recent development which may counter-balance any decline in utilization rates. The appearance of manure storage tanks is hardly a recent phenomenon in rural China, but the massive proliferation of relatively high-quality, multipurpose storage facilities only began in the mid-1970s. In 1975 only 450,000 such units had been installed in China's countryside. By midyear 1979 the number had reached 7.1 million, and development is being accelerated in the Five-Year Plan. In addition to producing methane gas for home cooking and lighting and improving disease control, the tanks minimize nutrient loss in storage, which was 30-50 percent for nitrogen under even some of the better methods used in the 1930s. They also facilitate fermentation, which produces methane. The tanks provide fertilizers with 16 percent more nitrogen and 25 percent more phosphorus than the unfermented manures from which these nutrients are derived. By contrast, the nutrient gains of phosphorus and potassium through fermentation under the most efficient rural methods of the 1930s were lost in storage. The nutrient gains of more volatile nitrogen were completely swamped, especially when animal manures formed a large part of the organic material under study.[233]

In some areas there has been a secondary benefit of the tanks to the processes of soil preparation and nutrient supply. Crop stalks may be used in these processes as they are replaced as a household fuel source by methane produced in the tanks. Crop stalks from China's 1978 grain harvest may have weighed about 250 million metric tons.[234] Around 1 percent of the gross weight may be plant nutrients. Nitrogen and potassium each comprise about 40 percent of the total. Most of the remainder is phosphorus.[235] In crowded provinces such as Zhejiang as much as 70 percent of annual crop stalk production has been burned as fuel.[236] Household energy demand will rise with increased and convenient supply, but if even 10 percent of available crop stalks are diverted, then an additional quarter million tons of crop nutrients could be applied to fields.[237]

To summarize the argument with respect to organic nutrients, it is likely that the size of the natural fertilizer supply and its growth from the mid-1960s to the mid-1970s has been exaggerated. The amount of nutrients actually absorbed by plants and its growth rate during the same period has probably been exaggerated even more. This suggests that the coefficients appearing in Table 7 for "chemical plus natural fertilizers" are too low. Even abstracting from utilization, the growth of availability of natural fertilizers from 1978 to 1985 will certainly be much greater than it was over the previous eight years and will probably grow faster than it did between the mid-1960s and 1977. (This is based primarily on the assumptions that the prospects for the growth of the hog stock are good, that the numbers of large animals will continue to increase slowly, stagnate, or only gradually decline, and that the contribution of night soil has been overestimated by most researchers.)[238]

The natural fertilizer utilization rate may decline during the 1978-85 period, but the quantity of nutrients actually absorbed by plants seems likely to rise faster than the quantity originally collected for utilization because losses in storing and processing have been reduced and gains from fermentation have been increased. Even the hypothesized decline in utilization of some fertilizer components may be partly offset by increased utilization of others. Crop stalks may be diverted from household fuel use, and green manure acreage is being expanded. But these are trends suggested so far only by reports from a few provinces. These arguments suggest that fears of stagnation or decline in effective organic fertilizer use may be unfounded. Moreover, since the quantitative prospects for the effective use of these manures may be better in the current period than from the mid-1960s through the mid-1970s, the qualified use of "chemical fertilizers only" coefficients to predict for the present period may be justified.

What remains to be done is to use appropriate consistency coefficients to relate the foodgrain output targets with China's plans for nutrient supply.

In the past, imports have normally counterbalanced production shortfalls in particular categories.[239] It is likely that imports will continue to do this despite the sudden increase to unprecedented levels in 1978,[240] but domestic production may well continue the rapid expansion of 1977-79. By 1980 or 1981 the remaining synthetic ammonia/urea complexes built by foreign companies should be in operation. They will provide an additional 1.6 million metric tons of nitrogen annually.[241]

In addition, the central government plans to build a large plant in each province plus 10 more nationally (for a total of 39, including autonomous regions and the three major municipal districts).[242] If these plants are built from popular designs dating from around 1972, each is likely to produce no less than 110,000 tons gross weight per year of either superphosphate (45 percent phosphate) or urea (46 percent nitrogen).[243] This would add about 2 million metric tons to annual nutrient production capacity.[244]

But China's newest design for a large nitrogen complex can produce far more: 300,000 tons of synthetic ammonia. The first of these plants went into trial operation at the end of 1979. This complex includes urea production facilities with a capacity of 240,000 tons per year, which suggests that only half of the planned synthetic ammonia output will be used as raw material in the urea facility. This may not be a characteristic of future provincial complexes of this type. The plant in question is in the Shanghai municipal area,[245] where rapidly expanding demand by industry for synthetic ammonia and the high level of nitrogen application on local farmland may make it less important to devote all synthetic ammonia to agricultural uses.

If the 39 domestic plants planned for construction were all of the newer design, the capacity for additional annual nitrogen production would be 4.3 million metric tons (if the urea production capacity of the Shanghai plant is assumed) or as high as 8.7 million metric tons (assuming the plants are equipped to convert all synthetic ammonia output to urea). Even discarding the higher figure, it could be concluded that planned expansion of large plant capacity from both imported and domestically designed facilities would be between 3.6 and 5.9 million metric tons[246] of nutrients per year, depending upon the proportion of planned complexes that will be constructed according to the more recent design. If these plants were all completed by the end of 1985 and produced at full capacity in 1986, then the 1978 level of imports and capacity utilization in the older plants would be consistent with grain output of between 420 and 470 million metric tons by 1987 (using the NPK applied coefficient).[247]

But how many of the planned plants will be operating at full capacity on schedule, let alone in time to boost 1985 production? If it is assumed that full capacity of only the remaining foreign-contract plants and the Shanghai facility already completed will be added to 1978 production of nitrogen by 1984, then fertilizer output would be consistent with 1985 grain production of around 390 million metric tons using the NPK coefficient.[248] If the greater stability of the fertilizers produced in the newer plants is considered, however, and the "N-nutrients absorbed" coefficient is used, then the addition of these plants alone would be consistent with grain output well beyond the 400-million-metric-ton mark.[249] The result is the same if our tentative estimate for increases in organic fertilizer supply are included and the selected coefficient is for N-nutrients absorbed from chemical plus natural fertilizers.[250]

It does not appear, therefore, that fertilizer production capacity will be too small. In fact, capacity will probably far surpass what is required to fulfill the 1985 targets under any system of estimation. This is not only because net additions to large plant capacity (even after accounting for depreciation) will be greater than hypothesized above, but also because excess capacity exists in both large and small plants. Moreover, additions are being made to even small plant capacity in many areas. Communist party documents have maintained that excess capacity among large plants in 1978 exceeded the entire output of small plants. This must have been no less than 4 million metric tons (if the statement refers only to nitrogenous fertilizers produced in conjunction with small synthetic ammonia facilities).[251]

The important question is whether what caused capacity to be idle as late as 1978 will be even more limiting in the 1979-85 period. These causes should not be oversimplified. Limitations of weak rural buying power, mismanagement within the plants themselves, and fundamental unprofitability in some plants, including many of the smaller ones, must always be considered, but the principal problem seems to have been a failure to coordinate the physical delivery of raw materials.[252] Part of the problem may be seen in terms of agriculture's insufficient priority in many regions over the past three decades. But the crux of the failure has been a weakness in the basic infrastructure, especially in freight transport, in coal extraction and processing, and in electrical generation industries. Such difficulties are more intractable than problems with the construction of additional fertilizer plants.

Yet there are reasons for a qualified optimism that the limits on utilization will loosen. The greater priority for agriculture in the allocation of resources during this period seems to be more solidly backed up than before.[253] Government policy to concentrate more physical resources on key agricultural areas should simplify the transportation problem.[254] Development of rural infrastructure has received central attention, even under the more conservative revised capital construction budget.[255] Ultimately, China's abundant natural endowment of primary energy resources, especially coal, oil, and hydroelectric power, should not be a constraint in itself.[256] Current trends are to increase the utilization of existing mines, generators, and transport networks.[257] Utilization of existing capacity in China's large-scale chemical fertilizer plants has already increased during the last few years,[258] although there was considerable idle capacity in 1979, if the Party's statements were correct.

Two further developments should favorably affect the stability of nitrogenous fertilizers produced and their effectiveness in increasing grain yields. The Party has vowed to increase the utilization of large plant capacity at the expense of small plant output if necessary. The leadership argues that if the same resources used to operate the small plants were used to reduce idle capacity in large plants, a net increase of the quantity produced (presumably of nutrients) would result.[259] The Chinese material, however, does not discuss the major advantage of such a substitution: the far greater stability of large plant products such as urea and especially ammonium sulfate. The proportion of nutrient absorption by crops of urea may be twice (or more than twice) as great as for small plant products such as ammonium bicarbonate and aqueous ammonia.[260]

There are problems with realizing this potential gain, however. Large plant production will use the overburdened and inadequate transportation network more intensively and extensively. The absence of any modern facilities in outlying areas is also a problem. Of equal importance, the timing of transportation and the means of storage must be efficient enough to prevent gains in nutrient weight and stability from being cancelled by the necessity of applying nutrients at suboptimal times or by evaporation. As suggested above, however, this problem should be eased somewhat by the new policy concentrating grain production in "major grain bases" and "key front-runners" within these bases.

A more general difficulty with the scheme is the extent to which substitution is actually possible. Many inefficient small plants have already been closed down, and idle capacity in large plants has been reduced,[261] but the extent to which these events are related is less clear. The Party may not have the authority to close down small plants built on local initiative with local funds and primarily using locally produced materials. Since long-distance transmission of electricity from small hydroelectric facilities is impracticable, substitution would be limited to localities with access to power-grid supply which might somehow be conserved or reduced by plant closure. Many of the small coal plants have been designed to burn materials with few other uses such as brown coal, coal dust, or tailings that may be unsuitable or uneconomical to transport to large plants.

The threat is perhaps being used primarily to coerce the small plants to become more efficient. Many chronically unprofitable plants are responding.[262] Moreover, the small plants continue to be a temporary necessity in rural localities with insufficient transport links. Most provinces are still retrofitting existing plants for increased capacity. Some provinces are even stepping up new construction of small fertilizer plants.[263] China's small synthetic ammonia facilities increased production by 11 percent in 1979 while reportedly reducing costs.[264]

Ultimately, the closure of small plants may reduce the idle capacity of large plants less than other major developments, such as growth of raw material supply, a higher priority for industries serving agriculture, improved freight transport, or enterprise management reform. But new construction is shifting a higher proportion of nutrient production into large plants. This will increase the average stability and effectiveness of Chinese fertilizer supply, particularly within the major grain bases where inputs and planned yield progress will be concentrated.

Another development will eventually have a very important effect upon net nitrogen efficiency. It may also affect the speed of absorption of phosphorus and potassium, regardless of the variety of fertilizer applied. In China nutrients are most often applied to the surface of the soil, although mixing normally occurs before application. It is well known that pelletized fertilizer beneath the surface preserves nutrients from evaporation and leaching. In April 1979 the Fujian Soil and Fertilizer Research Institute announced the development of a pelletizer and a machine for deep application of pelletized fertilizer. The institute claimed that the equipment raises fertilizer efficiency by 20-30 percent and raised crop output in test localities by 10-15 percent. The machines are reportedly cheap and simple to construct and can be fabricated by agricultural machinery plants of counties and communes.[265]

It is unreasonable to expect to be able to discern the impact of the pelletizers on aggregate grain output in most of the period under study, particularly as it may be advisable to develop the equipment further and to investigate optimal utilization techniques and the timing for nutrient application. But in view of the extremely rapid deployment of garden tractors in the late 1960s and 1970s,[266] and the increase in buying power, particularly in high-yielding localities (see below) it would not be surprising to find some impact of the pelletizer in the major grain bases by 1985. In 1979 in Fujian it was already employed on 530,000 hectares, about half of the province's paddy fields.[267]

Another technical development will have important effects on crop yields and help offset the decline in applying other organic manures, especially in multiple-cropping regions. Blue-green algae have been used as nitrogen-fixing green manure on late rice crops in Hubei since 1976. Rice output has increased by an average of 17.2 percent on 87 test plots in 19 counties during the 1976-78 period. In 1978 the algae was used to grow late rice on 24,000 hectares. The province reportedly planned to double the acreage in 1979.[268] This technique, however, will probably not have as great an effect as the pelletizers during the current planning period since it is being used on a smaller scale and is being expanded more cautiously.

All things considered, it seems unlikely that the amount of nutrients applied and absorbed will prevent production of 400 million metric tons of foodgrain by 1985, though it may well have constrained production through much of the 1960s and 1970s. If it does limit foodgrain output, insufficient capacity is much less likely to be the cause than such difficulties as political problems in the plants themselves, a decline in agriculture's real importance to decisionmakers, or infrastructural problems involving, especially, the transportation network and the primary energy sectors. At present, however, the prognosis in even these areas is encouraging. The rate of increase of nutrient application and absorption should easily be greater than in the previous decade.

To summarize, net additions to cultivated acreage are likely to provide 0-5 million metric tons of additional foodgrains per year by 1985. In addition to whatever may be gained in this fashion, it is only possible to say that China's plans for irrigation and fertilizer production development are consistent with producing the remaining 90-95 million metric tons required over and above the 1978 output level to achieve the 400-million-metric-ton target by 1985. Moreover, while complete plan fulfillment in these categories is unlikely, fulfillment consistent with achievement of the foodgrain target appears within Chinese capabilities. It should be remembered, however, that driving the aggregate grain production growth rate of a large, diverse, mature agrarian system such as China's as high as 4 percent per year is a prodigious task requiring simultaneous successful development in a variety of quantifiable and nonquantifiable categories, in addition to successful delivery of irrigation systems and fertilizer. Ultimately, in fact, farm output expansion is not a function of physical inputs alone, but of resource allocation among and within collective units, labor incentives, political disturbances, and the future, not the historic, technological context. The remainder of the study will therefore be devoted to an exploration of these less easily quantifiable factors.

FOOTNOTES

[138]"It is necessary to mobilize and concentrate the strength of the whole Party and the whole nation in an active way to give agriculture and the collective economy of the people's communes every possible material, technical, and financial aid as well as aid in the field of leadership and personnel, and to bring about the technical transformation of agriculture stage by stage in a manner suited to local conditions." ("Communique of the 10th Plenary Session of the 8th Central Committee of the Chinese Communist Party," Xinhua, news bulletin, September 28, 1962, translated in U.S. Consulate, Hong Kong, *Current Background*, 691, p. 4; cited in Benedict Stavis, "Making Green Revolution: The Politics of Agricultural Development in China," Rural Development Monograph No. 1, Cornell University, Rural Development Committee, Ithaca, N.Y., 1974, p. 95.

[139]Although in decreasing amounts. See Shigeru Ishikawa, "Resource Flow Between Agriculture and Industry—The Chinese Experience," *The Developing Economies* 5 (March 1967): 3-49.

[140]Basic construction investment rose by over 240 percent between 1952 and 1956, while industry's share drifted up from 41.7 percent to 51.8 percent. Agriculture's figures are for 1952-56; water control figures are for 1952-55. Calculations are based on official material in Chen, *Chinese Statistics*, p. 165. If basic construction investment outside the state plan is included, the picture is the same: total investment rises 240 percent between 1952 and 1956, then falls in 1957 to 217 percent above the 1952 level; industry's share rises from 38.7 percent to 52.3 percent between 1952 and 1957; the share of agriculture, forestry, and meteorology falls from 4.4 to 3.3 percent in the same period; and the share of water conservation also falls, from 9.4 to 5.5 percent (Chen, *Chinese Statistics*, p. 159).

[141]In 1952, 87.5 percent; in 1956, 85.8 percent (Stone, "A Review of Statistics," Table 1).

[142]Housing is excluded. The figures are from Kang Chao, *Capital Formation in Mainland China, 1952-65* (Berkeley, Cal.: University of California Press, 1974), p. 112. With housing included the farm sector's share fell from 51.1 percent to 36.2 percent (calculated from Chao, *Capital Formation*, p. 11).

[143]Chao, *Capital Formation*, pp. 79 and 82. Chao actually estimates the 1962 value to be closer to the 1952 level of investment, but omits several categories included in the 1952 level for lack of data.

[144]See Stavis, "Making Green Revolution"; and Leslie T. C. Kuo, *The Technical Transformation of Agriculture in Communist China* (New York: Praeger, 1972).

[145]Chao, *Capital Formation*, pp. 63 and 69 estimates that the rates of gross fixed investment rose between 1962 and 1965, with agriculture's share increasing from 10.6 percent to 17.1 percent. However, he omits state investment in agriculture, forestry, and meteorology, investments in water conservation, and modern farm implements. State investment in agriculture and meteorology in those years must have been at least as much as it had been in 1956. The tractor stock increased from 0.9 to 2.24 times the 1956 level; the stock of irrigation equipment increased from 3.8 to 6.8 times the stock in 1956; and expenditures for repair and maintainence were easily from 10 to 20 times the requirements in 1956. This is to say nothing about water conservation infrastructural capital, which was in disrepair after the Great Leap. In 1964 over half the state's investment in the power industry was made to expand rural capacity (*Jen-min Jih-pao*, December 25, 1965; cited in Kuo, *Technical Transformation*, p. 211). All in all, the rural sector's share was easily double what Chao estimated it to be. From at least 2 billion yuan in 1962, it rose rapidly to at least 8 billion yuan by 1965 while gross fixed investment increased by about 150 percent. Meanwhile, the amount of chemical

fertilizer delivered in 1962 was double the amount of 1957. By 1965 it had sextupled. Electric power consumption in rural areas in 1962 was 15 times what it was in 1957, and it more than doubled again by 1965, reaching a value of 192 million yuan. This share of investments allocated by the center was not maintained, however. Agriculture's average share from 1965 to 1978 was a little over 10 percent ("On the Aim of Socialist Production," *Beijing Review*, December 21, 1979, p. 11). (The quantities cited in this note are from Stone, "A Review of Statistics," Tables 13, 14, 15, 16, and 18; fertilizer prices are a conservative ammonium sulfate transfer price of 184 yuan per ton from *Hua-hsueh Kung-yeh* [Chemical Industry, No. 11, 1957, cited in Jung-chao Liu, *China's Fertilizer Economy* (Chicago: Aldine, 1970), p. 32; the electricity price is a national average from *Tongji Gongzuo* [Statistical Work], No. 4, 1957, p. 7.

[146]This terminology is borrowed from Shigeru Ishikawa, "Prospects of the Chinese Economy in the 1980s," p. 5.

[147]The shift in motivational emphasis is discussed in Shigeru Ishikawa, "Prospects in the 1980s."

[148]See Ishikawa, "China's Food and Agriculture"; Nicholas R. Lardy, "Recent Chinese Economic Performance and Prospects for the Ten-Year Plan," in U.S. Congress, Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 48-62; FBIS, *PRC*, May 7, 1978, p. D16; February 17, 1978, pp. E12-E16; February 16, 1978, pp. H4, H5, and Xu Zhigang and Zhou Jinghua, "Economic Policies in Rural Areas," *Beijing Review*, April 20, 1979, pp. 15-26.

[149]Terms-of-trade indexes have been constructed and appear in Stone, "A Review of Statistics," Table 20. The idea that agricultural purchase prices have been chronically too low has now been openly acknowledged by the Chinese (see Xue Muqiao, "A Study in the Planned Management of the Socialist Economy," *Beijing Review*, October 26, 1979, pp. 14-20, and his recent book, *A Study in the Problems of China's Socialist Economy* (Beijing: Peoples Publishing House, 1980), see also Yao Jinguan, "Preliminary Discussions on Several Problems Concerning the Price Scissors Between Industrial and Agricultural Products," *Jingji Yanjiu* [Economic Research] December 1978, pp. 32-6.

[150]"Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979; Xu Zhigang, and Zhou Jinghua, "Economic Policies in Rural Areas," *Beijing Review*, April 20, 1979, pp. 15-26; David Bonavia, "A Revolution in the Communes," *Far Eastern Economic Review*, March 30, 1979, pp. 8-9; Bonavia, "At the Root of the Problem," *Far Eastern Economic Review*, pp. 49-50.

[151]"On the Aim of Socialist Production," p. 11.

[152]Vice-Premier and Minister in Charge of the State Planning Commission Yu Qiuli's "Report on the 1979 National Economic Plan at the Plenary Meeting of the 2nd Session of the 5th National People's Congress (June 21, 1979)," FBIS, *PRC*, June 25, 1979, pp. 6-7; excerpts are in "China's National Economy, 1978-79," *Beijing Review*, June 29, 1979, p. 9.

[153]"Accelerating Farm Production," *Beijing Review*, November 9, 1979, pp. 5-6.

[154]Calculated from Zhang Jingfu, "Report," FBIS, *PRC*, July 3, 1979, pp. L7, L8, L13. The 1979 figures are lower even in absolute amount: the 1979 figure is 7.05 billion yuan, the 1978 figure is 7.695 billion yuan. But the net transfer in 1979 is much larger owing to the agricultural purchase price increases and tax reductions.

[155]"Accelerating Farm Production," *Beijing Review*, November 9, 1979.

[156]Xinhua, news bulletin, January 23, 1980; FBIS, *PRC*, January 23, 1980, p. L3. The volume by 1985 is from "Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979.

[157]Stone, "A Review of Statistics," Table 20.

[158]Xinhua, news bulletin, December 27, 1979; FBIS, *PRC*, January 3, 1980, p. L18.

[159]Zhang Jingfu, "Report," FBIS, *PRC*, July 3, 1979, p. L13.

[160]In addition to evidence provided by the history of production input supply (discussed later in the text) and of the proportion of the capital construction budget devoted to agriculture, it may be useful to review some available information on the changing absolute size of rural construction investment and its distribution among agricultural localities.

As has been indicated above, the share of basic construction investment devoted to agriculture and water conservancy in the State Plan diminished during the 1950s and its absolute magnitudes were stagnant, though they reached a peak in 1956. (Official sources in Chen, *Chinese Statistics*, p. 165; Chao, *Capital Formation*, p. 112). Over the entire period 1953-71, the state spent 23.4 percent more on agriculture than it received from the agricultural tax (*Peking Review*, December 15, 1972, p.17), but this sum is not very large in absolute terms (between 6 and 12 percent of crop production). It would probably not have counterbalanced the implicit tax on rural areas embodied in the high (though declining) sale price for farm goods. See Li Cheng-jui, *Chung-hua Jen-min Kung-ho-guo Nung-yeh Shui Shih Kao* [Historical Report on the Agricultural Tax in the People's Republic of China] (Peking: Finance and Economic Press, 1962), p. 189; FBIS, *PRC*, October 24, 1973, p. B1; and Dwight Perkins, "Constraints Influencing China's Agricultural Performance," in U.S. Congress, Joint Economic Committee, *China: A Reassessment of the Economy* (Washington, D.C.: U.S. Government Printing Office, 1975), p. 363. This investment would have been concentrated in those areas that had most of the necessary conditions for increasing yields and that subsequently became more affluent.

In 1974 the state's capital allocation to agriculture was 50 percent greater than in 1965 (Tsai Cheng, "China's Financial and Monetary Achievements," *Peking Review*, April 17, 1974, pp. 4-6), but that still yielded a relatively small amount in view of the requirements of the vast long-term engineering projects undertaken in North China. Current plans call for total state budgeted investment for capital construction during 1978-85 to equal the entire budgeted sum for the first 28 years of the People's Republic (see the accompanying paper by Tang). This represents a sizable increase over previous periods but may not have much effect on output until, at the earliest, the end of the eight-year period.

Thus it can be tentatively concluded that state farmland capital construction investment has followed a pattern similar to that of the production and delivery of industrial inputs to agriculture—sizable increases over the average magnitudes of previous periods in the first half of the 1960s and again in the early 1970s, favorably affecting output. Nevertheless, they have been too small and selective to generate large nationwide increases in production. The present recommitment to agriculture involves another major increase in capital allocations to that sector and gives no cause for pessimism about long-term growth.

[161]From Ishikawa's material it can be shown that the point was admitted very frankly by Vice Chairmain Li Hsien-nien in his report to the National Conference on Basic Construction of Agricultural Land (held in July 1978). He charged that "at least a considerable number of officials were not very conscious of the policy of locating agriculture as the foundation of economic development" and "some of them were even completely ignorant of the policy" (*Renmin Ribao* [People's Daily], August 16, 1978; Ishikawa, "Prospects for the Chinese Economy," p. 31. In the same conference, the First Secretary of the CCP in Jiangsu Province disclosed the difficulties in actually attempting to use agriculture as the foundation of economic development (*Renmin Ribao*, July 31, 1978; Ishikawa, "Prospects for the Chinese Economy," p. 31).

[162]Ishikawa, "Prospects for the Chinese Economy," p. 32; Ishikawa, "China's Food and Agriculture," pp. 100-1; Yao Jinguan, "Preliminary Discussions on the Price Scissors," p. 34.

[163]Yao Jinguan, "Preliminary Discussions on the Price Scissors," pp. 33-4; "Diversified Economy is the Way Out," *Beijing Review*, February 11, 1980, pp. 21-2.

[164]Ibid., pp. 32-6.

[165]Calculated from Chen, *Chinese Statistics*, pp. 338-9 and p. 344.

[166]Yao Jinguan, "Preliminary Discussions on the Price Scissors," pp. 33-4.

[167]Growth averaged between 4.4 and 6.3 percent per year, depending on the base year and series used. See Stone, "A Review of Statistics," Table 2.

[168]Foodgrain output grew at 3.2 percent per year between 1970 and 1974, which were both good years, or 3.7 percent per year between 1971 and 1975, which had average harvests. See Table 1.

[169]Based on the SSB final foodgrain output estimate for 1979. See footnotes 3 and 4.

[170]For the justification of this range, see below.

[171]Serious or extended stretches of very poor weather, however, would adversely affect growth by reducing the total availability of grain. That would, in turn, reduce hog stock increases and the growth rates of organic manure supply.

[172]See the accompanying paper by Tang. At a discussion of this paper on June 13, 1979, Thomas Wiens suggested that the modern input weights selected by Tang for his "Current Input" series were too large relative to other constituent categories, resulting in an exaggeration in the estimates of "Current Input" growth. Tang did not agree.

[173]Stone, "A Review of Statistics," Table 18.

[174]"Farm Mechanization Targets for 1980," *Peking Review*, February 24, 1978, p. 10.

[175]The 1978 figures are from People's Republic of China, State Statistical Bureau, "Communique on Fulfillment of China's 1978 National Economic Plan," *Beijing Review*, July 6, 1979, p. 37; FBIS, *PRC*, June 27, 1979, p. L13. They are also in Zhang Jingfu, "Report," FBIS, *PRC*, July 3, 1977, p. L8. The 1979 figures are from Xinhua, news bulletin, January 13, 1980; FBIS, *PRC*, January 14, 1980, p. L5; "For More and Better Farm Machines," *Beijing Review*, February 4, 1980, p. 7.

[176]See Stone, "A Review of Statistics," Table 18, discussion.

[177]This was brought out, for example, in "Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, pp. L28, L29. See also Xinhua, news bulletin, November 28, 1979,;FBIS, *PRC*, December 5, 1979, pp. L12, L13. At a nationwide meeting called by the Ministry of Agricultural Machinery, it was decided that the number of major factories making machinery for livestock production be raised from 12 to 27 and the number making machinery for harvesters be increased. See also "For More and Better Farm Machines," *Beijing Review*, February 4, 1980, p. 7.

[178]These figures assume that the target for medium-sized tractor production is given in 15 horsepower standard units and that garden tractor production is given in physical units averaging 3.5 horsepower per tractor. The figure for other farm machines is from Zhang Jingfu, "Report" FBIS, *PRC*, July 3, 1979, p. L8.

[179]All figures appear in or are derived from those in Xinhua, news bulletin, January 13, 1980, FBIS, *PRC*, January 14, 1980, p. L5. "For More and Better Farm Machines," *Beijing Review*, February 4, 1980, p. 7.

[180]See Stone, "A Review of Statistics," Table 18, discussion.

[181]Ibid.

[182]Ibid., Table 18.

[183]People's Republic of China, State Statistical Bureau, "Communique on Fulfillment" p. 40; and FBIS, *PRC*, June 25, 1979, pp. L6-L7 and June 27, 1979, p. L17.

[184]"Farm Mechanization Targets for 1980," *Peking Review*, February 24, 1978, p. 10.

[185]See Stone, "A Review of Statistics," Table 13.

[186]Ibid., Table 14.

[187]There was an 8.4 percent increase in total production of electricity (1979 estimate from Xinhua, news bulletin, December 27, 1979; FBIS, *PRC*, December 28, 1939; FBIS, *PRC*, October 2, 1979, p. L15) and a 9.9 percent increase in generating capacity (FBIS, *PRC*, January 17, 1980, p. L5). The increase in 1979 usage for agriculture is from Xinhua, news bulletin, December 27, 1979; FBIS, *PRC*, December 28, 1979, p. L20; "Electricity—Over 270,000 Million Kilowatts," *Beijing Review*, February 4, 1980, p. 6. It is based on the first 9 months of 1979. There was an 8.7 percent increase in total production of electricity (1979 estimate from Xinhua, news bulletin, December 27, 1979; FBIS, *PRC*, December 28, 1979, p. L20; and "Electricity" *Beijing Review*, February 4, 1980, p. 6; see also FBIS, *PRC*, October 2, 1979, p. L15) and a 9.9 percent increase in generating capacity (FBIS, *PRC*, January 17, 1980, p. L5).

[188]Stone, "A Review of Statistics," Table 14A.

[189]Xinhua, news bulletin, September 6, 1979, p. 21.

[190]See the accompanying paper by Tang.

[191]Stone, "A Review of Statistics," Table 12, discussion.

[192]Ibid, Table 12.

[193]"Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1974, p. L27. There may also have been a downward revision in "high and stable yield" area statistics (or an increase in the requirements for qualification). The above source puts the 1978 figure at 33.3 million hectares, but *Renmin Ribao*, August 10, 1978, put the figure at less than a fourth of all cultivated acreage, which is about 100 million hectares. The 1975 figure was given in 1977 as "over 33 million hectares" (Chiang Hua-nong, "How China Became Self-Sufficient in Grain," in Chang Chung-wang and Chiang Hua-nong, *How China Became Self-Sufficient in Grain*, [Peking: Foreign Languages Press, 1977], p. 10). The 1978-85 planned increase is 13.3 million hectares ("Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979). The 1979 irrigated acreage figure (15 million mu) is from FBIS, *PRC*, February 21, 1980, p. L7.

[194]Stone, "A Review of Statistics," Table 10, discussion.

[195]The original figure was 13 million hectares (Jen Min, "Reclaiming Wasteland," *Peking Review*, June 30, 1978, pp. 10-2), but it seems to have been revised downward (or partially accomplished in 1978), according to "Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, p. L27.

[196]All these figures are from Stone, "A Review of Statistics," Table 19.

[197]Succeeding calculations based on ibid., Table 16.

[198]"Farm Mechanization Targets for 1980," *Peking Review*, February 24, 1978, p. 10.

[199]"Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, p. L28.

[200]"1978 Grain and Coal Output," *Beijing Review*, January 12, 1979, p. 8.

[201]People's Republic of China, State Statistical Bureau, "Communique on Fulfillment," FBIS, *PRC*, June 27, 1979, pp. L11-L19.

[202]Nutrient production in 1979 was given as 10.65 million metric tons (FBIS, *PRC*, January 15, 1980, p. L7) or 22.5 percent above the SSB figure cited in People's Republic of China, State Statistical Bureau, "Communique on Fulfillment," FBIS, *PRC*, June 27, 1979, pp. L11-L19. But the claimed percentage increase was 23.5 percent.

[203]CIA estimates supplied by James A. Kilpatrick in a letter, December 1979.

[204]The 1977 and 1978 figures are from People's Republic of China, State Statistical Bureau, "Communique on Fulfillment;" the 1979 figure is from Xinhua, news bulletin April 30, 1980; FBIS, *PRC*, April 30, 1980, p. L4.

[205]See Stone, "A Review of Statistics," Tables 13 and 18, discussion.

[206]Xinhua, news bulletin, November 28, 1979; FBIS, *PRC*, December 5, 1979, p. L12.

[207]Xinhua, news bulletin, January 13, 1980; FBIS, *PRC*, January 14, 1980, p. L5.

[208]See Stone, "A Review of Statistics," Tables 15 and 16, discussion.

[209]Ibid., Tables 12 and 13, discussion.

[210]Ibid.; and Thomas Wiens, "Chinese Agriculture: Continued Self-Reliance," *American Journal of Agricultural Economics* 11 (December 1978): 875.

[211]Ishikawa, "Prospects for the Chinese Economy," pp. 26-8. 15 mu = 1 hectare.

[212]This is attested to in various Chinese press statements issued during 1979. For information on the northeast power grid, see Xinhua, news bulletin, September 6, 1979, p. 21 and also FBIS, *PRC*, January 21, 1980, p. L7. According to the Xinhua bulletin, 1979 output through August 31, 1979 was double that of the preceding year, partly owing to better rainfall, but the grid's primary dependence is upon thermal stations unaffected by drought. According to the article in FBIS, only 145,000 kilowatts were added to generating capacity in 1979 and there will be fewer new units operating in 1980. The principal emphasis is upon more effectively tapping the potential within existing power plants.

[213]An overhaul of machinery carried out in 1962-63 showed that 25,000 standard tractors, or some 22.7 percent of the 1962 total were inoperable (*Renmin Ribao*, April 9, 1963). The rate of depreciation of irrigation and drainage machinery (1958-62) reached 29 percent of annual production. The official figure for 1962 of available machinery was revised downward in mid-1963 for this reason from 7 to 5.8 million horsepower (*Dagongbao* [Impartial Report], October 1, 1962; *Peking Review*, June 28, 1963, p. 20). For a discussion of mechanization developments and related

quality problems in the period, see Chin Szu-Kai and Choa Wing-fai, "The Mechanization of Agriculture," in E. Stuart Kirby, ed. *Contemporary China, 1962-64* (Hong Kong: Hong Kong University Press, 1968), pp. 1-10. For a discussion of inefficiencies in rural electrification and steps taken to reduce them in the same period, see Robert Carin, "Rural Electrification," in E. Stuart Kirby, ed. *Contemporary China, 1962-64* (Hong Kong: Hong Kong University Press, 1968), pp. 11-21. The most complete treatment of the People's Republic's early efforts in the electric power industry is Steve Schmeiser, "Growth and Development of the Electric Power Industry in the Peoples Republic of China, 1949-57," MATHTECH, Inc., Analytic Support Center, Bethesda, Md., June, 1977.

[214]"Farm Mechanization Targets for 1980."

[215]J. S. Sarma and Shyamal Roy, "Foodgrain Production and Consumption Behavior in India, 1960-77," in *Two Analyses of Indian Foodgrain Production and Consumption Data*, Research Report 12 (Washington, D.C.: International Food Policy Research Institute, 1979).

[216]See the accompanying paper by Tang.

[217]Jen Min, "Reclaiming Wasteland," pp. 10-2.

[218]Stone, "A Review of Statistics," Table 9A and Table 9, discussion.

[219]Stone, "A Review of Statistics," Table 9A and "Changes in Zhejiang Countryside," pp. 4-5.

[220]Stone, "A Review of Statistics," Table 12, discussion, and Kao Hsia, "A Project That Will Work: Yangtze Waters Diverted to North China," *Peking Review*, September 22, 1978, pp. 6-9.

[221]FBIS, *PRC*, August 21, 1978, p. E19.

[222]Stone, "A Review of Statistics," Table 13 and Table 12.

[223]The impact of this limitation should not be exaggerated in the current period. A large part of the land to be irrigated between 1979 and 1985 differs very little from that irrigated in the 1970s, but to a certain degree some of the ecologically more delicate red and yellow soils will be utilized. Similarly, although the Yellow River is not the principal source that will be tapped, to the extent that its highly silt laden water is used, yield increases will proceed slowly. It should be noted, however, that a number of counties irrigated with this type of water have achieved yields of 4.3 tons per hectare and more. *Xinhua*, news bulletin, February 21, 1980 and March 23, 1980; FBIS, *PRC*, February 22, 1980, p. L3 and March 26, 1980, p. L5.

[224]3.6 percent per year (see above).

[225]Stone, "A Review of Statistics," Table 12; Peter Oram, Juan Zapata, George Alibaruho, and Shyamal Roy, *Investment and Input Requirements for Accelerating Food Production by 1990 in Low-Income Countries*, Research Report 10 (Washington, D.C.: International Food Policy Research Institute, 1979), p. 40.

[226]Stone, "A Review of Statistics," Table 12.

[227]Kang Chao, "The Production and Application of Chemical Fertilizers in China," *China Quarterly*, December 1974, pp. 712-9.

[228]Ibid., p. 725.

[229]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.

[230]Benedict Stavis, "Turning Point in China's Policy," pp.13-4.

[231]The grain series is Approximation A, Table 1; the fertilizer nutrient series is from U.S. Central Intelligence Agency, National Foreign Assessment Center, "China: Economic Indicators," ER78-10750, Washington, D.C., December 1978. To his credit, Stavis chose years of comparison near the trend line in grain production, but the grain series should be lagged, and he paid no attention to the change in composition toward more volatile products.

[232]The 1977 and 1978 estimates are from Stone, "A Review of Statistics," Table 17 and Stone, "A Series of Nutrients." The 1985 figure adopts the methods and parameters used to produce the estimates cited above and a probably conservative prediction of 30 percent more hogs than in 1978. This was the target defined in "Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979. Fulfillment implies only a slight increase over China's long-term hog stock growth rate and will probably be achieved if not surpassed. The human population estimate is from John Aird's May 1979 projections in CIA, "China: A Statistical Compendium." It does not take into account the changing age distribution of the Chinese population. Changes in the supplies of other organic fertilizer components have been ignored in the 1985 figure.

The reason for the considerable discrepancy between the 1978 and tentative 1977 figures is a very recently released low figure for hog numbers in 1976 (180 million, see Stone, "A Review of Statistics," Table 3). The 1977 midyear figure used for estimating organic manure supply is an interpolation between the low 1976 figure and the year-end 1977 figure.

[233]For information on methane tank development, see Yu Qiuli, "Address to the National Methane Conference," FBIS, *PRC*, June 5, 1979, p. L7. For that and for Sichuan in particular, see June 18, 1979, p. L6; for Guangdong, see June 1, 1979, p.P4; for Zhejiang, see June 19, 1979, p. O7.

Experimental and survey data from the 1930s can be found in James Cameron Scott, *Health and Agriculture in China* (London: Faber and Faber, 1952). See especially Chapters 4, 5, and 9.

[234]Grain production in 1978 was 305 million metric tons (Table 1). In Zhejiang, grain production was around 13.6 million metric tons (computed from figures in Xinhua, news bulletin, December 18, 1974; FBIS, *PRC*, December 20,

1979, p. O12, and May 17, 1979, p. O4). Zhejiang produced about 11 million metric tons of crop stalks in 1978 from all crops (FBIS, *PRC*, June 19, 1979, p. O7). Assuming that the ratio of all crop stalks to grain production in Zhejiang is approximately the same for China as a whole, then about 250 million metric tons were produced in 1978. In *Renmin Ribao* [People's Daily], February 28, 1980, p.5, a Chinese estimate appeared of 300 million metric tons of stalks burned each year nationwide, suggesting that total production of stalks is even higher—perhaps 400 million metric tons or more. In Zhejiang 70 percent of crop stalks are burned as fuel (see footnote 236).

[235]Owen L. Dawson, "Fertilizer Supply and Food Requirements," in John Lossing Buck, Owen L. Dawson, and Yuan-li Wu, *Food and Agriculture in Communist China* (Stanford: Stanford University Press, 1960), pp. 138-40.

[236]FBIS, *PRC*, June 19, 1979, O7.

[237]Computed from figures appearing above.

[238]See Appendix 2 and Stone, "A Review of Statistics," Tables 2 and 17. Special thanks are extended to Radha Sinha for bringing attention to the night soil problem at a seminar on this paper. See Radha Sinha, "Chinese Agriculture: A Quantitative Look," *Journal of Development Studies*, 11 (April 1975): 208-9.

[239]Jung-chao Liu, *China's Fertilizer Economy* (Chicago: Aldine, 1970).

[240]According to a recent CIA estimate, 1978 nutrient imports were some 64 percent greater than in the previous record year, 1972 (letter from James A. Kilpatrick, December 26, 1979).

[241]FBIS, *PRC*, September 21, 1978, p. E14.

[242]FBIS, *PRC*, September 19, 1978, p. E11.

[243]Kang Chao, "The Production and Application of Fertilizers," p. 718.

[244]Calculated from figures above.

[245]FBIS, *PRC*, January 28, 1980, p. O7.

[246]All figures were calculated using estimates appearing above.

[247]NPK applied coefficient from Table 7. It is assumed that the 1976-78 average level of domestic fertilizer production plus imports (from Stone, "A Review of Statistics," Table 16) is most relevant for 1977-79 average grain production (from Table 1, Approximation B, plus the preliminary 1979 figure from footnote 3). The difference between the 1976-78 average and the 1978 figure has been added to the expected range of nutrient production capacity increase from the 39 new large plants. The sums have been deflated by 10 percent to allow for application to nongrain crops (see Table 7). They were then multiplied by the consistency coefficient (21.0) to arrive at a grain increment range consistent with the planned nutrient increment range. The range of grain increments was added to 1978 output, as was an estimated 5 million metric tons for the increment from net expansion of cultivated acreage.

[248]The same procedure outlined in footnote 247 was followed, except that the future increase in capacity over the 1978 level only included 1.6 million metric tons from the remaining foreign plants and 0.11 million metric tons from the Shanghai plant. In fact 1979 domestic capacity alone was reported to be 10.65 million metric tons (FBIS, *PRC*, January 15, 1980, p. L7). This is 1.957 million metric tons greater than the 1978 level reported in People's Republic of China, State Statistical Bureau, "Communique on Fulfillment." This abstracts from the resultant NPK imbalance, but output of nonnitrogenous fertilizers can easily be increased.

[249]For an example, assume that the 3.4 million metric tons of foreign plant urea-nutrient production capacity began being utilized after 1977 (actually some plants came on line before 1978) and that this increase plus the 0.11 million metric tons from the Shanghai plant are the only increases in nitrogen production capacity between 1977 and 1984 (certainly an underestimate). If 90 percent is applied to grain crops, and only 50 percent of that amount is absorbed by plants (see the notes to Tables 7 and 8), then the procedure used in footnote 247 can be used, but with the N-nutrients absorbed coefficient (72.4), this results in consistency with grain production of around 425 million metric tons, provided phosphates, potassium, and other input requirements are also supplied.

[250]See footnote 249 and Tables 7 and 8 for hypothesized increases in hog stock and human population over 1977 or 1978. Parameters may be found in Stone, "A Series of Chemical Nutrients." Also see Stone, "A Review of Statistics," Table 17.

[251]A *Cheng Ming* editorial on China's economic adjustments made in the spring of 1979 which can be found in FBIS, *PRC*, May 10, 1979, pp. U1-U9.

[252]A variety of articles have indicated that raw material supply is at the root of the idle capacity problem for both large and small plants, although small plants have also been troubled by widespread unprofitability. See FBIS, *PRC*, May 10, 1979, pp. U6-U7; June 7, 1979, p. O4; and Xinhua, news bulletin, September 8, 1979, pp. 6-7. In at least several provinces, coal and electrical efficiency targets for small plants were set by the government.

Of the 600 million metric tons of coal produced by China in 1978, only 180 million metric tons were effectively converted to thermal energy (about 20 percent below the world average rate). This was partly due to a lack of industrial recycling and irrational use patterns and partly to inefficient equipment (about 40-50 percent efficient whereas equipment in developed countries is 70-80 percent efficient; FBIS, *PRC*, May 29, 1979, p. L7). This problem has been exacerbated by a decline in the expansion of coal production in 1979. Growth in 1976 in other sectors was even slower. Coal output from 1949-79 is shown below.

	(million metric tons)
1949	32.4
1952	66.5
1957	130.7
1965	232.2
1970	327.4
1974	less than 428.0
1975	478.0
1976	483.0
1977	550.0
1978	618.0
1979	635.0

The figures for 1949, 1952, 1965, 1970, and 1978 are from *Beijing Review*, October 5, 1979, p. 10; the 1957 and 1975 figures are from CIA, "China: A Statistical Compendium," ER79-10374, p. 9; the 1974 figure is from FBIS, *PRC*, April 17, 1979, p. L11; the 1976 figure is from Hua Guofeng's speech to the 5th National People's Congress, printed in FBIS, *PRC*, June 21, 1979, pp. L5, L6; the 1977 figure is from People's Republic of China, State Statistical Bureau, "Communique on Fulfillment"; the 1978 figure is from People's Republic of China, State Statistical Bureau, "Communique on Fulfillment," Hua Guofeng's speech, and *Beijing Review*, October 5, 1979; the 1979 figure appeared in Xinhua, news bulletin, April 30,1980.

[253]See above.

[254]See below.

[255]Yu Qiuli, "Report," FBIS, *PRC*, June 25, 1979, pp. 6, 7. See also Hua Guofeng's speech at the same Congress, FBIS, *PRC*, June 21, 1979, pp. L5, L6. For several provinces the increase was dramatic. In Guangdong, for example, capital construction funds allocated for electrical generating capacity expansion rose 21.67 percent in 1979 (FBIS, *PRC*, March 3, 1980, p. P6).

[256]"China's Energy Policy," *Beijing Review*, December 14, 1979, pp. 5-6. China ranks 3rd in the world in known coal reserves (about 600 billion tons, 65 percent of which are in Shaanxi and Inner Mongolia); 1st in hydroelectric resources (580 million kilowatts, 3 percent of which are currently exploited); and 13th in workable oil reserves (about the same as the United States), but only a small portion has been opened up.

[257]For example, 1979 capacity expansion in the coal extraction subsector was about 14 million metric tons (9.5 million metric tons from the opening of 22 new coal mines and 4.49 million metric tons from enlargement of 10 existing mines—FBIS, *PRC*, January 22, 1980, p. L16). But output rose by about 17 million metric tons. In the first half of 1979, total production costs of major products were 1.2 percent lower than in the first half of 1978 (British Broadcasting Company, *Summary of World Broadcasts*, FE/W1046/A/2, August 21, 1979). In Jilin average coal consumption decreased 6 grams per kilowatt hour; generation and power transmission costs fell 5.7 percent (FBIS, *PRC*, March 13, 1980, p. S2). Across China total energy output increased by less than 1 percent in 1979 but satisfied the demands of an 8 percent increase due to conservation (Xinhua, news bulletin, January 5, 1980; FBIS, *PRC*, January 8, 1980, p. L1). In Guangdong 1 ton of synthetic ammonia required 203 kilograms less coal and 84 kilowatts less electricity in the first half of 1979 than in the first half of 1978. At that time 86 of Guangdong's 88 small nitrogen-producing facilities were still in operation (FBIS, *PRC*, August 15, 1979, p. P4). In Zhejiang coal consumption fell 19.7 percent and electrical demand dropped 13 percent in the province's 45 small nitrogen facilities, while output increased 71 percent over the first 9 months of 1979. See "Zhejiang Xiaotanfei Tiguan Wanchengnian Jihua" [Zhejiang Small Nitrogenous Fertilizer (Plants) Give Precedence to Fulfilling the Entire Year Plan], Xinhua, news bulletin, September 21, 1979. Dr. Shigeru Ishikawa supplied several articles to the author on Zhejiang's small fertilizer plants, including the last. In Fujian, coal consumption fell 14.3 percent and electricity by 8.5 percent from January 14 to November 17, while output was 25,000 tons greater than the total 1978 production (FBIS, *PRC*, December 20, 1979, p. O3). In turn, 1978 seems to have represented an improvement over 1977. In the first quarter, coal consumption per ton of fertilizer produced declined by 300 kilograms and electric power by 200 kilowatt hours compared with the first quarter of 1977 (FBIS, *PRC*, April 24, 1978, p. G7). For Anhui statistics see FBIS, *PRC*, July 21, 1978, p. G9; for Guangxi, see FBIS, *PRC*, July 21, 1978, p. H8.

[258]Increases in the domestic production of chemical fertilizer nutrients from 5.240 million metric tons in 1976 to 7.238 million metric tons in 1977, 8.693 million metric tons in 1978, and 10.654 million metric tons in 1979 have in each case surpassed reported increases in large plant capacity, even after expansion of small plant production has been deducted. See Stone, "A Review of Statistics," Tables 15 and 16; and Stone, "A Series of Nutrients."

[259]FBIS, *PRC*, May 10, 1979, pp. U6, U7.

[260]From Stone, "A Series of Nutrients," FBIS, *PRC*, April 30, 1979, pp. L13, L14; and John W. Mellor, International Food Policy Research Institute, conversation, Washington, D.C., June 15, 1979.

[261]For decreases in large plant idle capacity, see footnote 258. As for small plants, in Guangdong one-third of the province's 88 small nitrogen fertilizer plants were troubled by short supply of coal and electricity. Production was suspended in all plants, and output rose by 34 percent over the first 10 months of 1979 (FBIS, *PRC*, December 14, 1979, p. P6). It is not completely clear whether output from all plants or only small plants rose by 34 percent—probably the latter. From discussions in press reports on other provinces, it may be concluded that a sizable minority of small plants have been closed down across the country. In Fujian inefficient small fertilizer plants were "given six weeks to reform their backward methods" (FBIS, *PRC*, August 31, 1979, p. O9). For Tianjin see FBIS, *PRC*, June 26, 1979, p. Q4; for Hainan, see FBIS, *PRC*, April 21, 1979, p. P1. In spring 1979 only two-thirds of Hunnan's plants were operating (FBIS, *PRC*, May 14, 1979, pp. P6, P7.)

[262] In 1979 the purchase price of coal was raised, but the small synthetic ammonia plant deficit fell by 52.2 million yuan over the first 11 months. In 1979, 592 such plants began making a profit for the first time (FBIS, *PRC*, January 18, 1980, p. L15). In the first four months of 1979, Zhejiang plants made a profit of 5.58 million yuan while selling ammonium bicarbonate at a price around 20 percent lower than the national average (FBIS, *PRC*, May 24, 1979, p. L3). For other provincial information on increasing profitability, see articles listed in footnote 257.

[263] Technical innovations and expansion in 27 of Zhejiang's small nitrogen facilities are expected to raise synthetic ammonia production capacity by 100,000 tons per year (FBIS, *PRC*, May 24, 1979, p. L3). Also see "Zhejiang Xiaotanfei" and Xinhua, news bulletin, September 21, 1979. Technical change and expansion in Fujian is discussed in FBIS, *PRC*, March 7, 1979, pp. G1, G2. Of Fujian's 36 small nitrogen plants, seven will increase output of synthetic ammonia by 30,000 tons as a result of plant modifications. Meanwhile the province is building eight new small-scale plants with a total capacity of 26,000 tons (FBIS, *PRC*, August 31, 1979, p. O9). Ten new plants had been planned (FBIS, *PRC*, March 7, 1979, p. G1). Beijing's eight small nitrogen plants will increase capacity from 80,000 tons per year to 120,000 tons (FBIS, *PRC*, April 17, 1979, pp. L7, L8).

[264] Xinhua, news bulletin, January 14, 1980; FBIS, *PRC*, January 22, 1980, p. L16. The increase in Zhejiang, Jiangsu, Beijing, and Sichuan exceeded 22 percent in each case.

[265] FBIS, *PRC*, April 30, 1979, pp. L13, L14; Xinhua, news bulletin, July 21, 1979, p. 10.

[266] See Stone, "A Review of Statistics," Table 18A.

[267] Xinhua, news bulletin, July 21, 1979, p. 10. Although well-known outside of China, this method was reportedly developed by the Fujian Provincial Academy of Sciences in 1971. Much of the interim has been spent devising and putting into serial production, cheap and simple pelletizers and applicators that can be fabricated by county and commune farm implement factories.

[268] Xinhua, news bulletin, September 6, 1979, p. 9. For extensive details, a publication on China's azolla culture may be obtained from the Food and Agriculture Organization of the United Nations.