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FOOD PRODUCTION IN THE PEOPLE'S REPUBLIC OF CHINA

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FOREWORD

In 1977 the International Food Policy Research Institute published projections to 1990 of the production and consumption of basic food staples. The People's Republic of China was not included in those projections because of the difficulty of using the data on China in a manner comparable to the way the data for other Third World countries was used. However, China's nearly 1 billion people and more than a quarter of a billion tons of grain seems an excessive omission. According to a recent statement from the People's Republic of China, there are in China some 200 million people with inadequate food intake. Thus the size of the food problem in China requires attention because it has direct implications for the welfare of large numbers of people and because it has indirect effects on the food and food production input availabilities for other countries. Even small imbalances in domestic supply and demand in China are magnified into substantial effects elsewhere in the world.

Because of the paucity of hard data and the controversial nature of the political system, there are considerable differences of opinion about food trends in China among analysts in noncommunist countries. IFPRI provides in this Research Report two contributions to thought in these areas. Each author began his analysis with different perceptions. Each author offers the data with which he has worked as the basis for alternative analyses and conclusions.

The first piece by Anthony Tang is a broad analysis of trends and projections for food and agriculture in China. In particular, Tang does what is necessary to understand agricultural development in any developing country. He places agricultural policy in the context of the broad set of objectives for the economy. He then examines the past record in detail and presents projections. In the process he provides an immense amount of carefully worked and analyzed data. His lucid and candid presentation is refreshing, stimulating, and important.

Bruce Stone concentrates on the foodgrain production targets for 1985 as stated by the government of the People's Republic of China, makes judgments about the potential for meeting those targets, and analyzes their consistency with various assumptions about demand. Stone's initial perceptions, the data he uses, and his view of the data differ from Tang's, but his major conclusions are strikingly similar.

The main papers by Tang and Stone have been the subject of three seminars held at the International Food Policy Research Institute during the past year. One seminar came at an early stage of Tang's paper and included a wide range of people concerned with development topics. Later a set of China specialists convened to discuss the data and analysis in detail. Finally, a small group discussed both the Tang and Stone papers from the point of view of their implications to development policy as well as to China. This last group included T. W. Schultz, Vernon Ruttan, Thomas Wiens, Radha Sinha, and members of the IFPRI staff. The papers reflect the comments made at these discussions.

In addition, Bruce Stone has developed an important set of tables on aspects of China's agriculture. These include many estimates illustrating the difficulties of selecting appropriate data and providing the range of what is available. His commentaries serve as a careful guide in appraising, selecting, and judging this data. This work is to be published as IFPRI Research Report No. 16.

At the risk of adding even a further set of numbers, I attempt in the following paragraphs to distill general conclusions.

China's post-1950 history of agriculture seems to divide into three periods. The first is the period of recovery from the incredible disruption of the decades before 1950. From then until 1957 reconstruction efforts caused agricultural production to return to earlier levels of productivity. Growth was rapid, but gradually declined. It averaged 5.8 percent for the period 1950 to 1957.

The second period is best measured from 1957 to 1971, which were both average years for weather and without major political disruption. In the years between, major disruptions resulted in short periods of fast growth, slow growth, and even declines of production. Attention was generally focused on industrial growth. There was little opportunity to expand cultivated area, although irrigated acreage grew moderately rapidly and the base of modern inputs was too small to allow even rapid

growth rates to affect overall output growth rates very much. The effect was a growth rate of about 2 percent. This just kept pace with population growth.

In the third period the production growth rate appears to have accelerated significantly for the comparable weather years of 1970 and 1975, when the growth rate is calculated to be 3¼ percent. Both years were good crop years, with the edge to 1975, and the spread of five years adds some credibility to the calculated rate. This high rate was achieved despite some apparent slowing of the growth rate of inorganic fertilizer availability and either slowing of or no increase in the growth rate for irrigated areas. But both were operating off much larger bases than before. Although it is not clear from such a short period the extent to which the accelerated growth is due to short-term factors or changed incentives, it would not be inconsistent with the information at hand to expect the growth rate to accelerate beyond 3 percent.

Looking ahead to 1985, it seems possible but not likely that the growth target will be reached. This conclusion is made partly on the assumption that 1975, the base year for the 10-year plan, was a normal year (and therefore an appropriate base for projections); that the effort to achieve growth was consistent from 1975 (growth in fertilizer availability is consistent with that view); that the three years following 1975 were poor weather years, thereby reducing growth below the long-term trend in the first years of the 10-year period; and hence that the appropriate growth rate implicit in the target is the 3½ percent needed to increase the output of foodgrains in 1975 to the target level in 1985. It should be recognized, of course, that the required rate is 50 percent higher than the long-term rate of the 1957-71 period.

The planned acceleration in growth of grain supplies is large enough to require significant coordination with demand. The difference between a 3 and a 3½ percent growth rate between 1975 and 1985 is 15 million metric tons. If the lower income people are to benefit, provisions must be made to increase their real incomes. If the benefit is to be through livestock, then provision must be made to expand the livestock industry in the appropriate time and place. The latter may prove difficult in both the traditional sector and the large-scale hog and poultry farms.

Two caveats are in order. First, weather or major political disruption can affect production by as much as the difference between the 3 and 3½ percent growth rates spread over 10 years. Second, changes in trade can have an effect equal to a large part of such a difference.

For the longer run the picture is more difficult to estimate. It is obvious that the growth rate of the 1957-71 period is inadequate to meet the needs of the new economic policies. However, Tang's median projection for the increase of demand, 3 percent per year, is based on assumptions that appear to give a political position consistent with the past. In keeping with the preceding analysis, it seems feasible to match that with a sustained 3 percent growth rate in foodgrains production. It is notable that Tang's median output growth rate for foodgrains (which would be higher if he worked on the 1975 base rather than the 1977 base) is essentially the same as the demand growth rate. His estimate is based on the planned input levels and a reasonable, arbitrarily derived assumption about increases of factor productivity.

The inferences that follow about trade in foodgrains are that the gaps are so small that their existence depends on short-term weather and short-term and long-term political factors. If demand grows at about a 3½ percent rate and raises the real income of the lower fifth of the income distribution and of the more prosperous urban classes, and if production growth does not rise above 3 percent, then imports could grow an additional 15 million tons a year. That, however, seems unlikely. If the production increases to a 3½ percent rate, and the growth of livestock or urban income follows, then imports could halt. Right now it seems that these forces will push more toward maintaining net imports or increasing them modestly.

It is notable that Tang's approach relates the assumptions for demand and supply and that his high growth rate assumption for production assumes even greater acceleration in consumption, and hence, higher imports. That is consistent with a position which I mention for India and set forth in *The New Economics of Growth: A Strategy for India and the Developing World* (Ithaca, N.Y.: Cornell University Press, 1976).

Tang makes a major contribution in his discussion of the relation of agricultural policy to overall development strategy. The similarity of his discussion to my own writing on India, particularly with respect to

the Mahalanobis model, is striking. Tang approaches political questions that are inextricable from questions of development strategy. There are important lessons for other countries in these broader economic and political relationships.

Stone's analysis tries to develop the essence of what needs to be done if China's food targets are to be met and indicates how difficult and perhaps unlikely meeting them will be. His joint treatment of supply and demand forces demonstrates a great deal of value about the processes of agricultural development.

We at IFPRI hope these two different, careful analyses will settle a number of controversial questions and provide considerable light on some important development issues.

John W. Mellor

Washington, D. C.
May 1980

FOOD AND AGRICULTURE IN CHINA: TRENDS AND PROJECTIONS, 1952-77 and 2000

Anthony M. Tang

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PREFACE

In 1967-68 I had the considerable pleasure of visiting the Chinese University of Hong Kong on a Rockefeller Overseas Professorship from Vanderbilt University. One of my responsibilities was to direct a commodity projection study for Hong Kong for 1970 to 1980. Hong Kong was the closest thing to a classical laissez-faire economy to be found anywhere. It had been booming at the Japanese rate of growth, though temporarily slowed by the spillover effects of the Cultural Revolution then in full swing on the Chinese mainland a few miles away. The Government of Hong Kong has seldom collected statistics. There were no economic planners to demand it; nor has the economy suffered any apparent ill effect from a lack of it. Like the People's Republic of China, Hong Kong has had but one census, a modest demographic census in 1961. To make projections it was first necessary to "estimate" from data fragments a time series for Hong Kong's GDP. The present study is reminiscent of that exercise.

The unprecedented surge of 1969-73 (unforeseen in the somber days of 1967-68) and the subsequent "stagflation" following the oil embargo and price quintupling have made the Hong Kong projections less than prophetic. It is our hope that this effort will fare better.

The basic work in data collection and estimation for the agriculture of China for 1952-77 was done at the University of Michigan, where I visited two years ago. It builds on my earlier work for 1952 to 1965. Many of the ideas expressed in this study on the leadership of China during the transition period of 1975-78 are distilled from the reflections and insights of my Michigan days. These have benefited from the stimulation of colleagues and students at the Center for Chinese Studies whose research support from the Mellon Foundation via the Chinese Economic Studies Project is gratefully acknowledged. To Alexander Eckstein, director of the project, whose death during my visit grieved every China scholar, I owe a very personal debt of gratitude in memoriam, expressed here with respect and fondness. Mr. Thomas R. Gottschang, my invaluable and able research assistant at Michigan, has my thanks, the magnitude of which he alone can fathom in full. His contribution was such as to earn him the role of a coinvestigator. I wish him well as he joins the ranks of scholars and analysts of China.

I also express my appreciation to the International Food Policy Research Institute for encouraging this study and to Dr. Leonardo A. Paulino for the opportunity to work with him. I have benefited from comments by Paulino and Bruce Stone on an earlier draft of the work presented at a seminar at the Institute in December 1978. Dr. John W. Mellor, director of the Institute, and two anonymous reviewers have commented on the revised version of the study. The views and findings presented in this study are, of course, mine and need not represent those of the Institute. Maria Maia assisted ably with computations at Vanderbilt.

To Theodore W. Schultz and Vernon W. Ruttan I owe the intellectual stimulation of their presence at the seminar this June when the revised version was presented. To Schultz and his penetrating insights, both at the seminar and as set out with care in the margins of the manuscript pages, I acknowledge a special debt—a very special debt accumulated over the years by a grateful recipient of his unfailing encouragement and unstinting help.

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SUMMARY

Projections of Chinese agriculture to the year 2000 point to increased production and consumption of agricultural products, but major breakthroughs in productivity do not appear likely. Under conditions considered most plausible, rates of increase would exceed those of 1952-57 but would fall short of the Ten-Year Plan goals.

Three sets of projections are presented using different assumptions as to population growth and development strategy. The medium, or most probable, projection assumes that the Chinese leadership will continue to follow the moderate and pragmatic policies that have characterized the post-Mao period. Market restrictions would be gradually relaxed, and prices would be relatively stable. However, China would not abandon the command system of centralized economic controls or its goal of becoming a leading world power by the end of the century.

The high projection assumes a dramatic swing toward social and political liberalization and market economics. The low is based on a return to policies that relied on normative appeals and coercive pressure rather than material incentives to induce greater productivity.

Chinese agriculture has managed to meet the essential food needs of an expanding population that comprises nearly a fourth of mankind. Grain production rose 75 percent from 1952 to 1977, but the average annual increase of 2.3 percent barely exceeded the 2.1 percent rate for population growth. The increases in output were achieved by a massive injection of resources since the Great Leap Forward of 1958-60, particularly inputs originating outside agriculture.

The gross value of agricultural output rose 97 percent in 1952-77, whereas inputs were up 131 percent with the largest increases in power equipment and machinery, chemical fertilizer, and chemicals for insect and disease control. As a result, agricultural productivity, as measured by the index of total factor productivity, declined at an average rate of 0.65 percent. This is in sharp contrast to the productivity gains recorded by Japan, South Korea, and Taiwan.

Much of the relative slowness of agricultural development can be attributed to development policies that emphasized the heavy industrial sector and allocated key economic resources administratively rather than by prices and markets. These policies have tended to weaken the incentives of workers and producers, discourage cost-reducing innovations, distort economic signals, and reduce willingness to accept risks. Bureaucratic control has encouraged irresponsiveness, rigidity, and delays.

Planners had difficulty in coping with dynamic changes in comparative advantage among regions. Development was hampered by policies of self-reliance which limited specialization, the relatively fixed boundaries of collective farms, the government-enforced immobility of labor, and transportation bottlenecks.

More rapid increases in agricultural production are called for in the Ten-Year Plan unveiled in 1978. Grain output in 1985 would be 43 percent above 1977, which would require a growth rate twice that of 1952-77. Increases of 4 to 5 percent a year in the gross value of agricultural output are envisioned.

On the demand side, the Plan calls for population growth to be reduced to less than 1 percent a year within three years, increased consumer incomes, and higher consumption of nonstaple foods. On the supply side, the Plan aims at increased fertilizer output, greater mechanization, "commercial-type" animal husbandry, and land development.

The medium projection developed in this study results in an approximate equilibrium for demand and supply of agricultural products by the end of the century. Population would grow 1.5 percent a year, faster than in the Ten-Year Plan, while household income would rise 2.5 percent a year. This would yield a 3 percent annual increase in demand for all agricultural products.

Direct demand for foodgrains is projected to rise 2.1 percent annually, but indirect demand for foodgrains would grow three

times as fast, reflecting increased livestock production.

The medium aggregate supply projection is based on the assumption that current inputs will continue to increase at about the 1952-77 annual rate of 7 percent. Reflecting further mechanization and growth in livestock, farm capital would rise 6 percent a year. The farm labor force would grow 1 percent a year, below the 1952-77 rate of 1.8 percent. The annual increase in sown area would be 0.9 percent.

The decline in agricultural productivity would be reversed under the medium projection to an increase of 0.5 percent a year. Grain output would go up to 2.9 percent a year for a total increase of 92 percent by 2000.

2

INTRODUCTION

Forecasting, a risky calling under the best circumstances, is especially hazardous when applied to the People's Republic of China. Since 1949 it has witnessed some of the most dramatic shifts in leadership and policy among major world powers. China is now emerging from its most recent political upheaval under a new leadership of moderate and pragmatic economic persuasion. In order to develop a feel for its future, it is necessary first to analyze economic policy changes and disputes in the context of Chinese economic development strategy.

Development Strategy

The values and goals of the leadership of the Chinese Communist Party (CCP) are aptly summarized in the aphorism attributed to A. Bergson: "To the Communist Party leadership, bread is only an intermediate product; steel is the final good."[1] Such values are apparent in the aspiration of party leaders, present and past, to turn China into a modern, front-ranking power by the end of the century.

This goal dictates a "maximum-speed selective growth" development strategy and requires a command economic system for implementation. Main emphasis is placed on growth of the modern heavy industrial sector, whose absolute size is the preponderant determinant of power. The command system in important ways allocates key economic resources administratively rather than by markets and prices. A liberal democracy also is apt to embrace a command system in times of crisis, as was done by the United States and the United Kingdom in World War II.

The role of agriculture in such a system is to support priority (selective) industrialization with resource transfers in the form of food (the principal wage good), labor, raw materials, and exportable farm products. When agriculture fails to meet the full resource transfers required by the priority industrial sector for maximum growth, the agricultural sector becomes a drag on industrialization. Such was the case in the People's Republic even during the relative economic heyday of 1952-58.[2]

With agriculture limiting industrial growth, the two sectors were no longer separable for operational planning. To develop industry it was necessary to develop agriculture. Fostering development in agriculture while extracting the maximum surplus from it proved a difficult policy problem. In passing, we note that Russia, during its comparable development phase under Stalin, faced a much simpler task, thanks to its large initial agricultural surplus.[3] The Chinese problem was dramatized by the slogan "agriculture is the foundation" in the early 1960s following the disastrous Great Leap Forward (1958-60). This was not a complete policy reversal as is often argued by China watchers. The Chinese policy had never been "industry only," and the renewed emphasis on agriculture was not a reordering of priorities in a value-goal context but was concerned with ways to develop the sector. The strenuous development efforts for agriculture in the 1950s were limited primarily to bootstrap operations utilizing the sector's own indigenous resources of low or no opportunity cost. The 1960s saw the beginnings by the state of large-scale commitments of scarce resources to the production and import of modern inputs for agriculture. The current Chinese official view is that both the First Five-Year Plan period (1953-57) and the readjustment period of 1962-65 were comparable periods, noted for their "fairly well-coordinated relations between agriculture, light industry, and heavy industry."[4]

Much has happened in China since then. Books will be written on the Cultural Revolution and the massive leadership shakeup that followed. The radical phase which came to a head with the deaths of Zhou Enlai and Mao Zedong and the Gang of Four episode was followed by the counter-revolution. Deng Xiaoping, who once was sacked for holding the view that "it matters not whether the cat is white or black as long as it catches mice," is now being praised for

it in and outside the country. China analysts have generally been inclined to view the struggle over economic growth between Mao and his associates and those of moderate, pragmatical persuasion as involving value-and-goal disputes. A common notion is that with the start of the Cultural Revolution in 1966 Mao and followers tempered the growth objective with liberal doses of nonmaterial, ideologically appealing values, for example, distributional equity, self-reliance, antielitism, and work ethic for service as opposed to material incentive.[5] The present leadership is seen as returning (selective) economic growth to its earlier position of primacy and as freely adopting pragmatic methods to achieve it.

It seems more plausible that the contending leadership factions have shared common values and goals but have differed over methods. Clearly Deng was not condemned by his detractors for his "cat and mouse" statement because of the end but because of the means he advocated. Moreover, the quarrel over the means was concerned not so much with ideological or nationalistic considerations as with their economic efficacy. If this were not so, how can one explain Mao's unfailing willingness to tolerate (indeed, to insist on) the continuance of Hong Kong and Macao as Western colonies—an anomaly not many other independent nations would be likely to accept without duress. We know that Portugal tried to return Macao to China but was refused. The Chinese attitude can only be explained by the fact that the two colonies earn for Peking more than two billion dollars a year in (hard currency) net foreign exchange earnings. This speaks to the centrality of the economic growth goal and to Peking's inclination to wink at what must be a most unpleasant means to an end.[6]

Consumption was seen by Peking's leaders as an intermediate process rather than as the final act of an economic system. Consequently they tended to think of efficiency in consumption more in relation to workers' productivity than in relation to utility. Here is the clue to much of the policy dispute. It turns on what constitutes the right mix between material incentive and nonmaterial (normative) substitutes. Mao and associates inclined toward the nonmaterial substitutes. Their periodic attempts to impose their view were checked by real world intractability, giving rise to the well-known policy cycles in China.[7] Each time Mao retreated from his "high tide," material incentive would regain lost ground in the wage-consumption policy debate.

Even so, Mao's dominant power and personality, together with China's thin cushion of agricultural surplus, have largely determined wage-consumption policy during the past 20 years. The level of consumption for the masses was adequate but strictly without frills. Virtually no improvement occurred. Differences among income classes were kept small. To this end, Peking rationed the basic necessities—grains and cooking oil, cotton cloth, and housing, the latter through government allocation. Convenience and luxury goods were priced extremely high to absorb income not spent on necessities. This policy background provides a perspective for viewing the salient features of economic development. As a rough, perhaps generous, statement of magnitude, China's real domestic product may be said to have increased at an average rate of perhaps 5 percent a year between 1952 and 1977, whereas per capita product rose 3 percent. If one takes as plausible an income elasticity of demand for all food of 0.8 for countries like China and a Chinese population growth rate of 2 percent a year, the expected annual increase in demand for food in China would have been on the order of 4.4 percent (0.8 × 3 percent + 2 percent). Yet the People's Republic managed with a food output growth that did little more than keep pace with population growth, and without massive imports or food crises. It is clear that much of the rise in per capita output was kept by policy from reaching the households, farm and nonfarm, through higher personal incomes.[8] Where some trickling down materialized, continuing rationing helped maintain the basic food balance.

The new leaders in Peking have set out in earnest to "de-Maoify" the Chinese economy. Higher worker incomes are displacing normative appeals and coercive pressures as ways of inducing greater effort and productivity. The first significant wage increase since the 1950s was granted in the fall of 1977 to a broad segment of nonsupervisory, noncadre workers.[9] Deng and his followers are certain that this is the surer and quicker way to the power goal set for the year 2000. Note that the worth of the new policy turns on its ability to raise manager and worker productivity enough to more

salaries. How this evolves depends critically on the new regime's ability to expand consumption opportunities.

While Peking will no doubt continue to rely on high pricing (to soak up purchasing power) of sewing machines, bicycles, watches, cameras, and, most recently, television sets, it is difficult to see how it can avoid providing more agricultural products. Moreover, since direct grain consumption is already adequate, especially in cities and farm areas with relatively high incomes, increased food consumption will consist primarily of meats, fruits, and what the Chinese call subsidiary foods—all of which use much more land than grains for equivalent caloric production. Shigeru Ishikawa estimates that for China the resource cost in terms of scarce land required for equivalent production is 3.3 times higher for meats than for foodgrains and 10 times higher for vegetable oils.[10] Thus the prospects of solving the supply side of the equation under the new economic policy are not reassuring because of the scarcity of land. Furthermore, the collective form of organization and the Chinese system of farming are better suited for grain production. The problem is further aggravated by rural-urban differences in consumption. Urban areas, according to Ishikawa's estimates, consume 20 percent less grain per capita but two to three times more meats and oils. If Deng's liberalization means an end to the coercive "send down" program and a return to city-oriented industrialization and migration, as seems to be the case, further demand pressure will fall on the grain-centered Chinese agriculture.[11]

Peking's new production goals in the Ten-Year Plan (1976-85) unveiled before the Fifth National People's Congress on February 26, 1978 are ambitious in light of China's production record since 1952 when recovery from 1937-49 wartime dislocations was largely completed.[12] Grain output is to reach 400 million tons by 1985 (43 percent above 1977 or a rise of 4.5 percent a year). Gross value of agricultural output (GVAO) is to increase 4 to 5 percent a year between 1978 and 1985. The grain output target would require growth twice the 1952-77 rate and the value output target a rate of growth 45 to 80 percent higher than the historical average. The targeted increases for grain output apparently reflect a large increase in use of grain for livestock feed. Although China will likely continue to export rice, probably in increasing quantities, in exchange for wheat and coarse grain imports, it is inconceivable that the country will import feedgrain on a scale proportional to Japan or Taiwan during the Plan period. This need not rule out (in absolute terms) large feedgrain imports from the United States in the 1980s.

It is reasonable to suppose that the People's Republic, because of its size and development strategy, must depend on domestic production for its basic food balance and can turn to foreign trade for marginal adjustments only. Therefore the production targets for 1985 probably take into account the demand implications of the unfolding wage and consumption policy. In the later sections on projections, these demand implications serve as an alternative set of demand projections.

It has been widely reported that several major readjustments in prices received and paid by farmers have been put into effect by the government since the 1950s. These are said to correct the longstanding imbalance against agriculture. As such it was taken to be an incomes policy. These assumptions were checked by calculating the value added ratio and per-worker figure in current prices, deflating them by a general consumer price index, and comparing them to the constant-price magnitudes. This indicated that the changes of terms of trade made by Peking since the 1950s apparently did little more than to maintain the meager incomes of the farm people in China. These alternative price-value calculations, which are being made for a study of the People's Republic agricultural historical record, are still tentative. However, the falling value-added per farm worker in constant prices is clear from Table 1. The decline would be sharper if noncurrent nonfarm-supplied cost items, such as depreciation of tractors, were deducted in arriving at value-added totals.

The pragmatic appraisal by the present leadership of the role of science, technology, and laws of economics in nation building has been received with widespread approval in and outside China. The new course is seen as foretelling the emergence of a progressive, responsible, and stable China with a clear understanding of the advantages of peaceful, mutually beneficial economic, scientific, and technological interchange with the world community. The road ahead, however, may be neither straight

Table 1—Value of agricultural output and value added by agriculture, 1952 to 1977

Year	Value of Livestock Produced, Grain, Soybeans, and Cotton[a]	Gross Value of Agricultural Output: Pre-1957 Coverage[b]	Post-1957 Coverage[c]	Adjusted Post-1957 Coverage[d]	Insecticides and Miscellaneous Inputs[e]	Chemical Fertilizers[f]	Cake Fertilizers[g]	Value Added by Agriculture[h]
	(billion 1952 yuan)							
1952	27.47	48.39	40.05	37.76	0.070	0.169	0.690	36.83
1953	27.78	49.91	41.31	38.93	0.088	0.253	0.719	37.87
1954	27.86	51.57	42.69	40.26	0.191	0.354	0.659	39.06
1955	29.82	55.54	45.97	43.54	0.313	0.519	0.662	42.05
1956	31.37	58.29	48.25	45.71	0.742	0.659	0.741	43.57
1957	33.06	60.35	49.95	47.21	0.695	0.892	0.728	45.07
1958	36.32	67.27	55.68	52.86	1.148	1.041	0.761	49.91
1959	29.82	54.29	44.94	42.32	1.521	1.219	0.833	38.75
1960	25.72	46.11	38.17	35.76	1.890	1.197	0.595	32.08
1961	26.92	48.50	40.14	37.83	1.195	1.288	0.573	34.77
1962	29.62	53.89	44.61	42.21	1.321	1.650	0.558	38.68
1963	32.15	58.94	48.79	46.22	1.456	2.211	0.511	42.04
1964	34.73	64.09	53.05	50.34	1.610	3.043	0.503	45.18
1965	36.72	68.06	56.34	53.42	1.773	3.854	0.496	47.30
1966	38.88	72.38	59.91	56.92	1.960	4.616	0.493	49.85
1967	41.07	76.75	63.53	60.49	2.165	5.206	0.505	52.61
1968	38.83	72.28	59.83	56.82	2.389	5.773	0.471	48.19
1969	39.52	73.65	60.96	57.91	2.637	6.698	0.450	48.17
1970	43.39	81.47	67.44	54.32	2.912	7.742	0.500	53.17
1971	45.55	82.81	68.54	65.27	3.215	8.928	0.573	52.55
1972	46.02	86.63	71.71	68.26	3.551	10.248	0.631	53.83
1973	46.59	91.25	75.53	72.17	4.009	10.942	0.725	56.49
1974	49.55	93.68	77.54	74.04	4.527	11.646	0.688	57.18
1975	50.61	95.79	79.29	75.67	5.110	12.208	0.725	57.63
1976	50.71	95.99	79.45	75.77	5.768	11.895	0.653	57.45
1977	50.33	95.23	78.82	75.09	6.510	15.555	0.690	52.33

Note: Additional notes on this table appear in Appendix 2.

[a] Includes items for which complete series have been estimated. The values of livestock products are from Appendix 1, Table 15. The values for grains, soybeans, and cotton are from Table 3.

[b] These estimates were made by adjusting China figures to single price scales and uniform coverage, determining the relationship between the adjusted figures and the figures in column 1, then using this relationship to obtain missing values.

[c] These are the pre-1957 coverage figures multiplied by the 1957-52 link index to convert them to 1957 prices and post-1957 coverage, then divided by a price ratio of 1.075 to convert them to 1952 prices.

[d] These figures were calculated by subtracting the value of feed and seed from the post-1957 coverage figures.

[e] These figures are based on estimates in Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965).

[f] These figures are the quantity series from Appendix 1, Table 12 multiplied by prices taken from Alexander Eckstein, *The National Income of Communist China* (New York: Free Press, 1962).

[g] These figures were obtained by multiplying the oilcake quantity series from Appendix 1, Table 17 by a price from Eckstein, *The National Income of Communist China*.

[h] These figures are the adjusted gross value of agricultural output minus the sum value of insecticides and other inputs, chemical fertilizers, and cake fertilizers.

nor smooth. The cost of a crash, outward-oriented modernization program may turn out to be higher than Deng has allowed. And the results may not meet the high expectations. Such a combination of outcomes could again set in motion the familiar pattern of policy reversal and leadership change. Derek Davies of the Hong Kong-based *Far Eastern Economic Review* characterized Deng's "New Deal" as "a gamble of enormous proportions."[13]

There are many reasons for uncertainty about Deng's approach, particularly in agriculture. The targets of the Ten-Year Plan for

1985 (until recently revised downward) are 400 million metric tons of grain and 60 million metric tons of steel. Although the agricultural target calls for a smaller percentage growth, official Peking considers it the more difficult.[14] Under Mao's policy, China was effectively shielded from comparison with the accomplishments of other countries or from competing ideas and thoughts that might have cast doubt on the CCP's design for nation building. Considering those circumstances, it is not surprising that the past accomplishments, now seen as slow and disappointing, generated a strong sense of pride and dignity among the Chinese people. When the author visited China in January 1973, after an absence of 30 years, he found an insular, self-satisfied, proud, and confident people. The new open policy will call these attitudes into question. It will bring hordes of foreign visitors and residents and send thousands of Chinese abroad on missions and for training. These changes cannot but benefit China and the world in the long term, but in the shorter term the story may be quite different, particularly in relation to the specific goals of Peking.

Modernization, the centerpiece of the new policy, is in itself destabilizing. If recklessly carried out at the expense of the old policy of "walking on two legs," it may slow rather than hasten growth. Thoughtlessly implemented, it may become equated with change for the sake of change. The elementary fact that the technology that makes economic sense in other countries may not be suitable for China could be overlooked. This is all the more likely since decisions to adopt technology in China are not based on local profitability tests but tend to be made administratively from the center.

The material-incentive component of the new economic policy also will add to Deng's burden. The raises in income beginning in late 1977 without commensurate increases in consumer goods supply have increased inflationary pressure. Use of the material incentive to induce greater productivity inevitably means increased economic disparity in income and consumption because of the unequal capacity of people to respond. The presence of an affluent class and the desire to join it will weaken the inhibitions against corruption and crimes fostered by the egalitarianism and pervasive social control of the recent past.

To the student of economic development, the opening up of an insular society, the demonstration effects, modernization, and the play of new economic incentives are all positive and necessary ingredients for change and progress. Although the process is not costless, no one has seriously argued against it. But the Chinese leaders are primarily interested in making China a superpower no later than the year 2000. As Derek Davies's assessment clearly implies, the verdict is far from being in as to the efficacy of the new policy in this regard. It is also useful to remember that in a command economy the question of corruption and ossification of a massive bureaucracy looms much larger than in more decentralized systems. And an unresponsive, self-centered bureaucracy can make the best-laid plans go astray.

The people's perception of the system will be a key to the success or failure of the new policy. Their perception in turn will depend on the relationship of performance to expectations. The new announced goals for 1985 and for the end of the century, the new openness, the "four modernization" campaign, and the reintroduction of material incentive all tend to raise the expectations of the people and to lower their estimate of China's achievements. This may be compounded by cynicism resulting from past reversals in government policy of which Deng Xiaoping, the twice-resurrected new architect is a living reminder. In time, prudence, skepticism, and formal compliance (known as simulation in the Soviet Union and Eastern Europe) could replace enthusiasm and commitment as dominant attitudes.

Recent Developments

Since this study was first drafted, several major developments have occurred. To accommodate the modernization plan, China adopted measures never before attempted: tourism, direct foreign investment and joint ventures, and symbolic acts such as the return of Coca Cola, banned since 1949. To provide incentive for increased productivity, plans were made to resume payment of bonuses to workers and managers, to return confiscated personal properties, and to resume payment of equity earnings (or lump-sum compensation) to former owners (or their families) of shares in enterprises that have been long nationalized. There also was

a renaissance of the "one hundred flowers" and "democracy wall" for posters expressing opinions. Other developments tended to discredit or to sidetrack the modernization scheme and the decision to open up the country to the West; for example, the military incursion into Vietnam which has escalated military demands on the budget and the incongruous fashion show staged in Peking by Parisian designer Pierre Cardin.

The future course of the post-Mao Chinese leadership was still not clear in the spring of 1979. However, events since then suggest that Deng is proceeding with renewed confidence. Recent appointments of close associates to positions of power attest to this. More telling still is the just-announced appointment of Rong Yiren, a 63-year-old former Shanghai capitalist, as chairman of the new China International Trust and Investment Corporation, an agency that reports directly to the State Council. Two other former Shanghai capitalists assist as vice-presidents, whereas industrialists and businessmen from Hong Kong and Macao serve as directors. The corporation, with a capital of 200 million yuan, has broad authority in administering direct foreign investment, joint ventures, and transfer of Western technologies.[15] Indications are that the new path will bear many more of Deng's marks than of Mao's.

To many observers the Ten-Year Plan targets for 1985 and the power goals for 2000 now seem to err on the ambitious side. However, the power of a country depends more on the absolute size of its modern heavy industrial sector than on its level of living. This suggests that the power goal for 2000 may not be beyond China's reach.

Greater awareness of China's structural bottlenecks has forced retreat from some Plan targets. Two of these were described in a Peking article last summer on transport and energy.[16] "Owing to the shortage of electric power, about 20 per cent of the nation's productive capacity has not been tapped....In communications and transportation, the capacity in some weak sectors on the trunk railway lines can only meet 50 to 70 percent requirements; loading capacity at the harbors is highly inadequate." Theodore W. Schultz has reminded us that these bottlenecks will reduce the availability of modern nonfarm inputs that are critical if agriculture is to move forward at a vigorous and sustained pace.[17]

Modernization and liberalization for agriculture need not mean an end to scarcity if the Soviet experience is any guide. Despite local reorganization, liberalization, and decentralization, the major decisions affecting agriculture are centrally conceived and directed by a vast bureaucracy. Thus the efficacy of price will depend on decisions of central planners.

The values and goals that have served the CCP since the framing of its First Five-Year Plan are not likely to undergo major changes in the years ahead. Consequently agriculture will remain in difficult circumstances. Its role will resemble that exhibited by the familiar two-sector model of the Lewis-Fei-Ranis type, but exacerbated by the CCP's commitment to the "Principle of Maximum-Speed Selective Growth under Austerity."[18]

If the material incentive provided by the new economic policy is to be effective, supplies of consumer goods must be increased. Otherwise higher wages and salaries can only lead to inflation and the frustration of queues and depleted ration coupon books. Since much of the increase in supplies must be filled by agriculture, it is reassuring that the new agricultural growth targets were both prominent and explicit in the Party's economic message to the Fifth National People's Congress in February 1978. As was suggested earlier, the 1985 targets may be plausibly taken to indicate the food demand implications of the new economic policy that the new Ten-Year Plan (1976-85) is to satisfy.

FOOTNOTES

[1] Bergson referred to the Stalinist strategy of economic development that was embraced by Peking's leaders. For a fuller development of the model, see my earlier writings: "Policy and Performance in Agriculture," in Walter Galenson, Ta-Chung Liu, and Alexander Eckstein eds., *Economic Trends in Communist China* (Chicago: Aldine, 1968), pp. 459-509; "Agriculture in the Industrialization of Communist China and the Soviet Union," *Journal of Farm Economics* (December 1967): 1118-34; and "Organization and Performance in Chinese Agriculture," a paper presented at the joint session of the AEA, AAEA, and ACES on the Economic Organization of Socialist Agriculture at the annual meetings of Allied Social Science Associations, Dallas, Texas, December 29, 1975, pp. 1-21.

[2] See Tang, "Policy and Performance in Agriculture," pp. 459-509. For a Chinese statement on the agricultural bottleneck, see "Second Shanghai Talk on Mao's Major Relationships," February 25, 1977, Foreign Broadcast Information Service, *People's Republic of China: Daily Report*, p. E6. Recent statements from Peking remind us how dependent China's industrialization is on agriculture. In a special feature article in *Beijing Review*, June 29, 1979, p. 15 on disproportions in the national economy, Shi Zhengwen pointed out that agriculture contributes about 85 percent of the people's means of subsistence, 70 percent of the raw materials needed by the light industry, 40 percent of raw materials needed by all industry, and "a considerably large part of our financial revenue."

[3] Tang, "Policy and Performance in Agriculture," pp. 466-80.

[4] *Beijing Review*, August 3, 1979, p. 10.

[5] A more radical but perhaps the best articulated version is by John G. Gurley. See his *China's Economy and the Maoist Strategy* (New York: Monthly Review Press, 1976).

[6] See Tang, "Policy and Performance in Agriculture," pp. 466-80; Tang, "Agriculture in the Industrialization"; and Tang, "Organization and Performance."

[7] For seminal writings on the Chinese policy cycle, see G. William Skinner and Edwin A. Winckler, "Compliance Succession in Rural Communist China: A Cyclical Theory," in *A Sociological Reader on Complex Organizations*, 2nd ed., ed. Amitai Etzioni (New York: Holt, Rinehart and Winston, 1969), pp. 410-38; and Alexander Eckstein, *China's Economic Development* (Ann Arbor: University of Michigan Press, 1975), pp. 311-22 and 332-38. Eckstein's excellent work on China is particularly sensitive to the clashes between planner and household, between resource mobilization and economic efficiency (incentive) and, in his language, between the Communist Man and the Economic Man. These clashes create policy dilemmas and policy cycles.

[8] See below for Peking's 1979 release of per capita income.

[9] This is being followed by other income adjustments, planned or already implemented, through further wage-price reform and reinstatement of bonus payment. Vice-Premier Yu Qiuli revealed (*Beijing Review*, June 29, 1979, p. 11) that the average annual wages of workers and staff in state enterprises rose from 602 yuan in 1977 to 644 yuan last year, while peasant collective income rose 13.7 percent. Planned increases in wages and incomes for 1979 are 7 billion yuan for urban families and 13 billion for rural families (the latter amount reflecting not only an improved price relationship but anticipated increases in farm output).

[10] See Shigeru Ishikawa, "China's Food and Agriculture: A Turning Point," *Food Policy* 2 (May 1977): 94.

[11] Ibid.

[12] Pre-1937 norms suggest that in 1952, output and the stocks of the means of production were still 6 percent lower than they would have been had the war not hampered development.

[13] See Derek Davies, "Putting People in the Picture," *Far Eastern Economic Review*, July 6, 1979, p. 13. Also see his fuller analysis in "China: Rebirth of the Individual," *Far Eastern Economic Review*, August 17, 1979, pp. 51-6.

[14] *Peking Review*, October 20, 1978, p. 8.

[15] *Beijing Review*, October 19, 1979, pp. 4-5.

[16] Shi Zhengwen, "Readjusting the National Economy: Why and How?" Special Feature, *Beijing Review*, June 29, 1979, p. 14.

[17] Comments at a seminar on this study.

[18] For a theoretical exposition of the general principle of maximum-speed development (without selectivity which was our adaptation to fit the Chinese strategy), see John C. H. Fei and Alpha C. Chiang, "Maximum-Speed Development Through Austerity," and Anthony M. Tang, "Comment," in *The Theory and Design of Economic Development*, ed. Irma Adelman and Erik Thorbecke (Baltimore: The Johns Hopkins University Press, 1966), pp. 67-99.

3

THE DATA

The input-output time series for 1952-77 are pieced together from Chinese official sources. Except for 1952-58, official data exist only in widely scattered fragments. These have been collected and pieced together by several U.S. government agencies: the Central Intelligence Agency (CIA), the Department of Agriculture (USDA), and the Department of Commerce (DOC). These series are fully documented as to sources and methods of estimation. A number of China scholars have also published data series with full documentation. Where available and appropriate these data series were adopted (sometimes after modification) in this study with full acknowledgment and complete reference.

The Food and Agriculture Organization of the United Nations (FAO) publishes annual estimates not supplied by Peking on both the output and input. China scholars agree that the FAO estimates leave much to be desired mainly because of lack of documentation of sources, methods of estimation, and assumptions made. We share these views and have in general not used FAO estimates.

All of the time series, except those for grain and population, are incomplete or nonexistent. The basic work in gap filling for the 1952-75 period was done by Thomas R. Gottschang. The basic methodology guiding data generation and analysis is related to the aggregate production function and factor productivity decomposition based on the residual method. These techniques were developed for the People's Republic by the writer in connection with earlier studies of Chinese agriculture.[19] The techniques employed in filling information gaps ranged from simple arbitrary, but hopefully plausible, assumptions to interpolations and extrapolations, regressions on available related series, and the Moorsteen-Kaplan procedure (see Appendix 1, Table 14) familiar to students of the Soviet Union. These details and complete source documentation appear in the notes to the tables.

The complete grain and population series are the more controversial, because of their importance in any empirical study of China. The grain series is taken from USDA figures. It excludes soybeans and includes potatoes in grain-equivalent weight based on a ratio of four to one. The USDA estimates are based on official data fragments since 1958 and the compilations of the State Statistical Bureau for 1952-57.[20] Questions recently have arisen about whether changes have been made on the potato-grain conversion ratio and the treatment of soybeans in grain output reports. Evidence seems to indicate that changes have taken place, but their timing is unknown. Field and Kilpatrick recently recalculated a consistent "official grain series" based on plausible guesses about the dates of the changes.[21] The last word is far from being in, however. In a special statistical release on the 30th anniversary of the People's Republic, Peking revealed that its recent grain output figures included soybeans and the grain equivalent of potatoes at the old four-to-one ratio.[22]

The long-term output trend will be little affected by the changes. The corrections suggested by Field and Kilpatrick are to an extent compensating, lowering the official figures for the earlier years when their new five-to-one potato-grain conversion ratio is applied and raising the same figures for the early years when soybeans are included. Thus the average compound rate of grain output growth calculated from the USDA series is 2.3 percent per year; the rate from the Field-Kilpatrick (CIA) series comes to 2.2 percent. The exponential growth curve remains relatively stable even though the USDA estimates for 1976 and 1977 are probably understated by perhaps 5 million metric tons. It is not considered worthwhile to recalculate the grain series and several others related to it. However, to reduce the effect of an understated benchmark year figure on projections for 2000, the trend value for 1977 has been used instead of the "reported" grain output. (For the handling of the newly released official data, see Table 2.)

The size of China's population, its growth rate, and the growth deceleration likely in the future remain major points of contention. Of the several population estimates available, those of John S. Aird

Table 2—Comparison of Tang estimates and official 1979 releases

Source	Stock Items									Flow Items							
	Population[a]	Cultivated Land	Tractors: All	Tractors: Large and Medium	Tractors: Hand	Power Drainage and Irrigation Equipment	Pigs	Sheep	Large Animals	Grains[b]	Cotton	Oil-bearing Crops	Aquatic Products	Insecticides	Chemical Fertilizers	Energy Consumption[c]	Gross Value of Agricultural Output[d]
	(millions)	(million hectares)	(million 15 horse power units)			(million horse power)	(millions)			(million metric tons)							(billion yuan)
Tang 1977 estimates	973	107	1.3			47	274	161	110	280	2.2	3.7[e]	1.7[e]	1.4[e]	8.5	..[e]	79
State Statistical Bureau																	
1977	946	100	1.557	0.467	0.577	60	292	161	94	283	2.1	4.0	4.7	0.5	7.2	36	134
1978	958	100	1.927	1.090	1.370	66	301	170	94	305	2.2	4.6	4.7	0.5	8.7	40	146

Sources: People's Republic of China, State Statistical Bureau, "Communique of China's 1978 National Economic Plan," *Beijing Review*, July 6, 1979, pp. 37-41; and Ye Jianying, "Speech in Celebration of the 30th Anniversary of the Founding of the PRC," *Beijing Review*, October 5, 1979, pp. 7-16.

Notes: The discrepancies between the Tang estimates of inputs and official statistics are usually modest and offset one another. The stock figures are for the end of the year. Additional notes on this table appear in Appendix 2.

[a] These figures exclude Taiwan.

[b] Grains include potatoes at one-fourth their weight and soybeans.

[c] The Tang estimate includes domestic production plus imports. The official figures include only domestic production.

[d] The Tang estimate is in 1952 yuan; the official estimates are in current yuan.

[e] These are 1952 figures; the 1977 estimates are not available. The coverage of oil crops may not be strictly comparable over time.

have been selected (see notes to Appendix I, Table 11). Aird and some other Western demographers may have underestimated the efficacy of the Chinese population control measures. On the other hand, the post-Mao relaxation policy is likely to mean some increase in fertility rates. Labor reward in the collective sector of agriculture continues to encourage more labor units per family. In short, because the Chinese have not had a census since 1953, Aird's medium projections continue to be accepted. Official Peking may be equally in the dark concerning the country's demographic dimensions.

FOOTNOTES

[19] Anthony M. Tang, "Policy and Performance in Agriculture," pp. 459-509; and "Input-Output Relations in the Agriculture of Communist China," in W. A. Douglas Jackson, *Agrarian Policies and Problems in Communist and Non-Communist Countries* (Seattle: University of Washington Press, 1971), pp. 259-302.

[20] Students of China agree that Peking does not keep two sets of books: one for the leaders and planners themselves and another (with inflated figures) for external consumption. Official releases represent the government's own best estimates. There is a second type of government release, mainly for the Chinese public, whose purpose is to promote numerous campaigns of "emulation and exultation." Unfortunately, the releases are not labeled for distinction, and it takes sensitivity on the part of the investigator to make the separation.

[21] Robert Michael Field and James A. Kilpatrick, "Chinese Grain Production: An Interpretation of the Data," *China Quarterly* 74 (June 1978), 369-84.

[22] *Beijing Review*, October 5, 1979, p. 13 shows grain output of 304.5 million metric tons in 1978 and 163.9 million metric tons in 1952. The 1952 figure includes soybeans and values potatoes at 1/4 their natural weight, as is shown in People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Languages Press, 1960, reprinted as Occasional Paper No. 5, Program in East Asian Studies, Western Washington State College, Bellingham, Wash., 1974).

4

THE 1952-77 RECORD

Starting with an output of 154.5 million metric tons in 1952, total grain output in the People's Republic of China reached 270 million metric tons in 1977, an increase of 75 percent (Table 3). The average annual rate of increase of 2.3 percent exceeded the average population growth rate of 2.1 percent.[23]

Gross value of agricultural output (GVAO) rose from 40.05 billion yuan (in constant 1952 prices) to 78.82 during 1952-77, a jump of 97 percent or 2.9 percent per year (Table 1). Unlike other agricultures characterized by dynamic technological and productivity advances, growth in inputs outpaced growth in output, rising 131 percent (Table 4). As a consequence total factor productivity dropped 15 percent or 0.6 percent a year (Table 5). The increase in resource use was particularly noteworthy for inputs purchased from outside agriculture: power equipment and machinery, and modern current inputs such as fuel and electric power, chemical fertilizers, and chemicals for disease and insect control. (See Tables 4 and 5 and Appendix 1, Tables 11, 12, 14, 15, and 17.) Modernization in this context refers not only to the provision of inputs from the outside that are qualitatively new and different from the traditional varieties, but also the transfer of traditional agricultural activities and processes of an intermediate character from agriculture to the outside. Thus mechanical power not only replaced draft animals, but the feed (or equivalent farm output) saved became an end product of the sector, either directly or indirectly when used to produce livestock products. Under the Chinese-Soviet definition of gross output value, grain imports when embodied in livestock product also add to gross value of agricultural output. Because of this double counting, the Chinese-Soviet-type GVAO becomes increasingly misleading if taken as a measure of the sector's contribution to the national economy. Part of the difference between the higher growth rates for GVAO and for grain output is attributable to double counting.

This is not to minimize the critical importance of modern nonfarm-supplied inputs in agricultural development. Two aspects may be noted. First, modern inputs underpin the generation of new, low-cost income streams in agriculture. Second, they ease the two principal constraints operating in agriculture—time and space as imposed by nature—by permitting transfers of agricultural activities to an industry not so constrained.[24] In other words, the final output of the sector is the joint product of internal and external inputs. As such the problem does not lend itself to neat accounting solutions.

With this caveat in mind, the value added by agriculture (VABA) as an indicator of the sector's contribution to the gross domestic product of the People's Republic is used. VABA, as defined here, is gross of depreciation charges on farm machinery, equipment, and service buildings. VABA increased by only 42 percent as compared with 97 percent for GVAO, or by an annual rate of 1.7 percent (Table 1). In net terms (not attempted in this study), the pace of increase in sector contribution to the Chinese national economy would be slower still. The modest rate of increase in agriculture's contribution has meant a stagnant or declining value added per worker (Table 5). Value added is traceable to the employment of so-called primary factors of production: labor, land, and capital. These factors as an aggregate rose by 62 percent during 1952-77, as compared to a 42 percent increase in VABA, leading to a primary factor productivity decline of 12 percent (Table 5).

The Chinese productivity under the CCP was none too impressive. Nor was the sector's capacity to generate value added. Agriculture managed to deliver end products in quantities large enough and rising fast enough to meet the elemental needs of China's expanding population, not through finesse, but by a massive injection of resources, particularly those of external origin. This record contrasts sharply with the agricultural productivity gains of Japan, South Korea, and Taiwan.[25]

Grains as a group showed an average annual output growth rate of 2.3 percent during 1952-57 compared with the GVAO

Table 3—Quantity and value of output of grains, soybeans, and cotton, 1952 to 1977

Year	Rice	Wheat	Coarse Grains[a]	Potatoes (Grain Equivalent)[b]	Total Grain		Soybeans		Cotton	
					Quantity[c]	Value[d]	Quantity	Value[d]	Quantity	Value[d]
			(million metric tons)			(billion yuan)	(million metric tons)	(billion yuan)	(million metric tons)	(billion yuan)
1952	68.45	18.10	51.50	16.35	154.40	18.95	9.52	1.33	1.30	2.21
1953	71.25	18.30	50.70	16.65	156.90	19.23	9.93	1.39	1.17	1.99
1954	70.85	23.35	49.25	17.00	160.45	19.88	9.08	1.27	1.06	1.81
1955	78.00	22.95	54.95	18.90	174.80	21.56	9.12	1.28	1.52	2.58
1956	82.45	24.80	53.40	21.85	182.50	22.61	10.23	1.43	1.44	2.45
1957	86.80	23.65	52.65	21.90	185.00	22.81	10.04	1.41	1.64	2.78
1958	93.00	25.00	52.00	30.00	200.00	24.70	10.50	1.47	1.60	2.72
1959	79.00	24.00	41.00	21.00	165.00	20.34	11.50	1.61	1.35	2.29
1960	73.00	21.00	36.00	20.00	150.00	18.50	8.20	1.15	0.90	1.53
1961	78.00	16.00	44.00	24.00	162.00	19.97	7.90	1.11	0.89	1.51
1962	78.00	20.00	53.00	23.00	174.00	21.45	7.70	1.08	1.00	1.70
1963	80.00	22.00	56.00	25.00	193.00	22.56	7.04	0.99	1.10	1.87
1964	90.00	25.00	59.00	26.00	200.00	24.66	6.94	0.97	1.50	2.55
1965	90.00	25.00	60.00	25.00	200.00	24.66	6.84	0.96	1.65	2.80
1966	96.00	28.00	66.00	25.00	215.00	26.51	6.80	0.95	1.81	3.07
1967	100.00	28.00	76.00	26.00	230.00	28.36	6.95	0.97	1.94	3.29
1968	95.00	25.00	70.00	25.00	215.00	26.51	6.48	0.91	1.81	3.07
1969	99.00	27.00	69.00	25.00	220.00	27.13	6.20	0.87	1.77	3.01
1970	110.00	31.00	75.00	24.00	240.00	29.59	6.90	0.97	2.00	3.40
1971	117.00	31.00	75.00	23.00	246.00	30.33	7.90	1.11	2.32	3.77
1972	112.00	36.00	69.00	23.00	240.00	29.59	8.70	1.21	2.13	3.62
1973	118.00	35.00	73.00	24.00	250.00	30.82	10.00	1.40	2.55	4.33
1974	127.50	38.00	74.50	25.00	265.00	32.67	9.50	1.33	2.50	4.24
1975	126.50	41.00	77.50	25.00	270.00	33.29	10.00	1.40	2.40	4.08
1976	125.50	45.00	76.50	25.00	272.00	33.54	9.00	1.26	2.35	3.[illegible]
1977	126.50	40.50	76.50	26.50	270.00	33.29	9.50	1.33	2.20	3.74

Sources: The 1952-57 figures for all categories except soybeans were taken from the People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Languages Press, 1960); the 1958-77 figures are from U. S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *People's Republic of China Agricultural Situation: Review of 1977 and Outlook for 1978* (Washington, D. C.: USDA, 1978). The 1952-77 figures for soybeans are from People's Republic of China, Ministry of Agriculture, Bureau of Planning, *A Collection of Statistical Data on Agricultural Production of China and Other Major Countries* (Peking: Agricultural Publishing House, 1958); the 1958 figures are from State Statistical Bureau, *Ten Great Years*; the 1959 figures are from *Jen-min Jih-pao*, January 22, 1960.

Notes: Values are in constant 1952 yuan. Additional notes on this table appear in Appendix 2.

[a] Coarse grains include millet, corn, kaoliang, barley, buckwheat, oats, proso-millet, small beans, green beans, broad beans, and peas.

[b] Potatoes were converted at a ratio of four metric tons of potatoes to one metric ton of grain.

[c] Total grain does not include soybeans.

[d] The 1952-57 figures were calculated with 1952 prices developed in Ta-Chung Liu and Kung-Chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965). Aggregate prices for 1958-77 were calculated as sums of the prices of each type of grain, weighted by its average proportion in total output between 1951 and 1957.

annual rate of increase of 2.9 percent. Rice output increased 2.5 percent; potatoes, 1.3 percent; coarse grains, 2.3 percent; but soybeans decreased 0.5 percent. Wheat output grew 3.0 percent per year. (All growth rates here and elsewhere in this study are estimated from the exponential growth function.)

Cotton production rose by 3.2 percent a year. The highest nongrain output increase is registered, not surprisingly, by livestock products, with the annual rate standing at 4.2 percent.

In the base year 1952, grain output of 154.4 million metric tons was valued at 18.95 billion yuan (in 1952 prices), and accounted for 47.3 percent of a total GVAO of 40.5 billion yuan.[26] Livestock products contributed 12.4 percent, soybeans, 3.3 percent, and cotton, 5.5 percent. The re-

Table 4—The aggregate input index, 1952 to 1977

Year	Agricultural Labor Force[a]	Labor Input Index[b]	Sown Area Adjusted for Irrigation and Multiple Cropping[c]	Land Input Index[d]	Value of Farm Capital[e]	Capital Input Index[f]	Current Input Index[g]	Aggregate Input Index[h]
	(million)		(million hectares)		(billion 1952 yuan)			
1952	168.677	100.0	130.7	100.0	11.292	100.0	100	100
1953	169.940	100.7	132.6	101.5	12.024	106.5	107	102
1954	171.575	101.7	135.5	103.7	12.166	107.7	118	105
1955	174.134	103.2	137.9	105.5	11.885	105.3	128	108
1956	176.396	104.6	145.1	111.0	12.430	110.1	161	115
1957	177.267	105.1	145.0	110.9	13.084	115.9	164	116
1958	178.193	105.6	142.7	109.2	15.532	137.5	204	124
1959	179.688	106.5	139.5	106.7	14.014	124.1	220	125
1960	180.925	107.3	136.7	104.6	12.455	110.3	235	126
1961	182.544	108.2	134.0	102.5	11.887	105.3	186	118
1962	185.017	109.7	136.0	104.1	12.604	111.6	198	122
1963	188.107	111.5	138.3	105.8	14.132	125.1	220	128
1964	192.005	113.8	139.9	107.0	15.308	135.6	244	134
1965	196.471	116.5	142.2	108.8	17.103	151.5	271	141
1966	201.265	119.3	142.7	109.2	18.106	160.3	290	146
1967	205.476	121.8	143.1	109.5	18.542	164.2	306	151
1968	210.076	124.5	143.5	109.8	18.399	162.9	321	154
1969	214.946	127.4	144.0	110.2	18.519	164.0	341	159
1970	220.702	130.8	144.7	110.7	19.893	176.2	367	166
1971	226.582	134.3	146.1	111.8	21.468	190.1	400	174
1972	232.388	137.8	146.9	112.4	23.697	209.9	435	183
1973	238.274	141.3	148.4	113.5	23.280	206.2	464	189
1974	244.111	144.7	149.8	114.6	25.317	224.2	506	199
1975	250.010	148.2	151.7	116.1	26.703	236.5	552	209
1976	255.956	151.7	152.6	116.8	27.669	245.0	596	219
1977	262.052	155.4	153.5	117.4	28.371	251.2	659	231

Notes: For all indexes, 1952 = 100. Additional notes on this table appear in Appendix 2.

[a] This column is taken from Appendix 1, Table 11.

[b] This index was derived by dividing the agricultural labor force by 168.677.

[c] These figures are from Appendix 1, Table 14.

[d] These figures are from Appendix 1, Table 14.

[e] Includes the value of livestock holdings from Appendix 1, Table 15, the value of poultry (value of livestock holdings times 0.0385) and the value of machinery, estimated by multiplying total horsepower of tractors and irrigation power equipment from Appendix 1, Table 18, by the weighted average of 1952 draft animal prices from Appendix 1, Table 15.

[f] This index was derived by dividing the value of farm capital by 11.292.

[g] This column is from Appendix 1, Table 14.

[h] This index is the weighted average of the other four input indexes in this table. The weights are 50 percent for labor, 25 percent for land, 10 percent for capital inputs, and 15 percent for current inputs.

maining 30 percent was contributed by vegetables, fruits, pulses, nuts, and miscellaneous products.[27]

As measured by the aggregate input index, real resources cost (in 1952 prices) required to generate output growth rose by 131 percent between 1952 and 1977 (Table 4). In production function analog, the aggregate input index is also a theoretical index of output in the absence of any technical change (and under certain assumptions about the markets and technical properties of the function).[28] The CVAO index, as seen earlier, rose by only 97 percent (Table 5). Technically, there have been downward shifts in the aggregate agricultural production function in the People's Republic. This suggests the conclusion that the Chinese output growth has been realized at high resource cost, especially when compared with other East Asian nations.

It is our belief that the command economic system and the Chinese development strategy tend to undermine producer-worker

Table 5—Factor productivity index, total and primary, and value added per worker, 1952 to 1977

Year	Gross Value of Agricultural Output Index		Aggregate Input Index[c]	Total Factor Productivity Index[d]		Value-Added Index[e]	Primary Input Index[f]	Primary Factor Productivity Index[g]	Value Added Per Worker[h]
	Un-adjusted[a]	Adjusted[b]		Un-adjusted	Adjusted				
									(1952 yuan)
1952	100	100	100	100	100	100	100	100	218.3
1953	103	101	102	101	99	102	103	99	222.8
1954	106	103	105	101	98	106	104	102	227.6
1955	115	110	108	106	102	114	105	109	241.5
1956	120	113	115	104	98	118	108	109	247.0
1957	125	118	116	108	102	122	110	111	254.2
1958	139	131	124	112	106	135	113	119	280.1
1959	112	106	125	90	85	105	111	94	215.6
1960	95	90	126	75	71	87	108	80	177.3
1961	100	94	118	85	80	94	107	88	190.5
1962	111	105	122	91	86	105	109	96	209.1
1963	122	115	128	95	90	114	114	100	223.5
1964	132	125	134	99	93	123	118	104	235.3
1965	141	133	141	100	94	128	123	104	240.7
1966	150	141	146	103	96	135	126	107	247.7
1967	159	150	151	105	99	143	128	112	256.0
1968	149	140	154	97	91	131	129	101	229.4
1969	152	143	159	95	90	131	131	100	224.1
1970	168	158	166	101	95	144	134	107	240.9
1971	171	161	174	98	93	143	139	103	231.6
1972	179	169	183	98	92	146	144	101	231.6
1973	189	178	189	100	94	153	146	105	237.1
1974	194	183	199	97	92	155	151	103	234.2
1975	198	187	209	95	89	156	155	101	230.5
1976	198	187	219	90	85	156	159	98	224.4
1977	197	186	231	85	81	142	162	88	199.7

Note: Additional notes on this table appear in Appendix 2.

[a] This index was computed from Table 1.

[b] In this column, 6 percent underrecovery is assumed for 1952. This is reduced 1.5 percent a year until 1956.

[c] This column is from Table 4.

[d] These columns were derived by dividing the gross value of agricultural output index (unadjusted or adjusted) by the aggregate input index.

[e] This column was calculated from Table 1. The output value underlying this index is not adjusted for underrecovery.

[f] This index includes land, labor, capital, and nonpurchased fertilizer, the last from Appendix 1, Table 17.

[g] This index was derived by dividing the value-added index by the primary input index.

[h] This column was derived by dividing the value added by agriculture (from Table 1) by the agricultural labor force (from Table 4).

incentive, discourage cost-reducing innovations, distort economic signals, and exaggerate aversions toward risk. The bureaucratic controls needed to insure compliance with the central design mean irresponsiveness, rigidity, and delay. In the larger (power-oriented) Communist context, decentralization cannot be total. When attempted as a localized partial scheme giving local responsibility without commensurate power to command resources or to alter mixes for greater efficiency, it often destabilizes the system. Decentralization and recentralization and other forms of experimentation come and go in Soviet-type economies without notable success. This is not to say that such a system is about to break down. In fact, the central virtue of the system from the standpoint of Communist leadership values and goals is its ability to bring about larger savings ratios than are generally attainable in market economies and to con-

centrate resources thus mobilized for the central purposes of the state. Given high savings ratios, growth is going to be vigorous despite difficulty in resource allocation and management. It will be especially so in high-priority heavy industries where output is more standardized and workers and management are more easily monitored. Difficulties are much greater in consumer goods industries where the problems of a bureaucracy mediating between millions of consumers and thousands of state enterprises become intractable. And the more affluent the consumers, the greater are the difficulties for the planners, as quality, diversity, assortment, and after-sales service become increasingly more critical.[29]

The planner's problems are compounded in agriculture. The producers are more numereus, the spatial dimension looms large, and parameters are location-specific. The human factor takes on singular importance at the local level. Organizational and incentive issues require a delicate balancing between private and collective activities, compulsory and free marketing, and agricultural and nonagricultural production.

In farming the basic clash between the household and the planner tends to be at its sharpest. The fact that the Chinese household has seen little increase in income and consumption since the 1950s does not make the planner's task any easier. The Chinese worker, in or out of agriculture, rates low in effort compared with his East Asian counterparts. The Chinese enterprise manager does not perform any better. These problems have been generally observed in all the Marxist-socialist economies modeled after the Soviet command system.[30] Against this background, caution may be well advised in projecting the efficacy of China's post-Mao policies under Deng.

The new policy, by elevating the role of material incentives, should help on the cost or productivity side. This has been taken into account in making projections to the year 2000. It is, however, unlikely that major breakthroughs will take place in the future as long as the command system remains in place, which is expected.

Turning to the components of resource cost, our estimate of effective sown acreage adjusted for irrigation and multiple cropping shows an annual rate of increase of 0.5 percent (Appendix 1, Table 14). The agricultural labor force grew at 1.8 percent a year, whereas farm capital (livestock and equipment) increased at 3.8 percent annually (Appendix 1, Tables 11 and 16). The primary input index rose 62 percent over the 25-year period, or at an annual rate of 2 percent (Table 5). Livestock inventories grew 3 percent a year, whereas tractors and power irrigation equipment (in horsepower units) showed an average annual growth of 22.8 percent each (Appendix 1, Tables 15 and 18). Cultivated land area is estimated at 107 million hectares for the entire period, although some increases may have occurred in the first plan period. The multiple-cropping index rose at a moderate rate of 0.6 percent a year, reaching 158 percent in 1977 (Appendix 1, Table 14).

Current inputs as a whole increased by 560 percent during 1952-77, or at an annual rate of 6.9 percent. All fertilizers (in nutrient terms) registered an annual increase of 4.4 percent with organic fertilizer rising at 3.2 percent and chemical fertilizer at 17.2 percent. Total nutrients amounted to 31.49 million metric tons in 1977 compared to 10.23 million metric tons in 1952. In the latter year they consisted of 22.99 million metric tons of organic nutrients and 8.50 million metric tons of chemical-based nutrients (Appendix 1, Table 12). The 1977 application rate was 186 kilograms of total nutrients per hectare of sown land with chemical fertilizers accounting for only 50 kilograms. The latter rate is low by East Asian standards, amounting to about one-tenth the Japanese rate of chemical fertilizer application and one-fifth the Taiwanese rate. Although the total nutrient application rate is much higher by international standards and Chinese crop yields per unit of sown land area are roughly commensurate with total fertilization, there is scope for further increases in both. It is useful to remember that there are qualitative differences between organic and chemical fertilizers in release and absorption properties. There is also much scope for qualitative improvement of chemical fertilizers with expected future decline in the relative importance of low-quality nitrogen fertilizer produced in small-scale rural plants using locally available coal as the base. The payoff will depend on concurrent development of new high-response seed varieties.

The State Statistical Bureau (SSB) recently published, for the first time since 1958, statistics in a systematic compendium form. The releases are on a limited scale and without notes and explanations. *Beijing*

Review, July 6, 1979, pages 37-41, published SSB output data for 1977 and 1978 on major industrial and agricultural products, along with gross value aggregates, year-end population, and current natural rates of increase. The issue, October 5, 1979, honoring the 30th birthday of the People's Republic carried shorter comparative statistics from 1949 and 1952 data published earlier. It also resolved the mystery about the treatment of soybeans and the potato-grain conversion rate in official data fragments that filtered out of the People's Republic during the "information blackout period." It is now clear that these grain statistics included soybeans but continued to use the four-to-one ratio in converting potatoes into grains (contrary to CIA's long-standing assumption).

A comparison of these estimates with the new official data is summarized in Table 2. Because the differences will make only marginal changes (as discussed in the notes to the table in Appendix 2) to the historical growth rates, which were estimated from the fitted exponential functions, the present estimates are kept. Also, in the interest of completing the study for early circulation, 1978 was not included in the time series. It was also felt that because of the length of the series, the historical growth rates would be little affected by the inclusion of one more year. It should be noted that insofar as 1977 was used as the base year for the later projections for 2000, the trend values for 1977 rather than the actual values as estimated in our series were employed as benchmarks. Trend values for 1977 would be virtually unchanged if the 1977 estimates were modified in light of the new official releases.

With no information on stock changes, it is difficult to estimate China's grain consumption. The grain consumption and stock change estimates in Table 6 are strictly for heuristic purposes. These crude estimates show a present Chinese strategic food reserve of just under 50 million metric tons, a figure roughly equivalent to total net grain import over the period. Total grain consumption rose 81 percent or 2.4 percent a year between 1952 and 1977. Grain consumption per capita showed only a negligible rise, from 270 kilograms to 289 kilograms.

The estimation procedure assumes that the planner determines consumption for the current year on the basis of current supply availability (output plus net import or minus net export) while abstracting from supply fluctuations. Operationally, it is assumed that the planner uses the average of the supplies of the current year and the two preceding years. The adjusted moving average is centered on the year immediately preceding. In the presence of a trend, it is necessary to recenter it on the current year by applying the trend factor as an adjustment. The trend factor is the average long-term grain output growth rate of 2.35 percent. In other words, the moving average is multiplied by 1.0235. The moving average method is a plausible way to approximate planner actions for consumption and thus stocks.

The simple moving-average method is applied to the 1950s when, because of the relative food security afforded by a friendly Soviet Union, stock operations in China were assumed to be not for strategic buildup but for smoothing out supply fluctuations only. The same assumption applies to the early post-Leap years because of the country's inability to mount a reserve stock program during the food crisis following the Great Leap Forward. However, because of the large percentage increase in current supplies in those years, estimated stock changes resulted in some accumulations. Beginning with 1965 an annual set-aside of 0.5 percent of the current supply is assumed for the reserve stock buildup. The calculation involves multiplying the moving average adjusted for the trend by a factor of 0.995 (Table 6). This procedure yields an accumulated strategic reserve of 48 million metric tons by 1977, which is consistent with the 40 million metric ton figure for the mid-1970s announced by Zhou Enlai on several occasions. The long-term target stated by Li Xiannian is a reserve of 80 million metric tons.

Gauging Household Income Growth Rise Through GVAO Estimates, 1952-77

Although the procedure may raise more questions than it answers, it is tempting to estimate the probable magnitude of the historical rise in real per capita income in the hands of the Chinese household.

Evidence abounds suggesting that the income growth that filtered down to the

Table 6—Estimated consumption of grains, excluding soybeans, 1952 to 1977

Year	Output	Exports	Imports	Current Supply[a]	Estimated Consumption[b] Total	Estimated Consumption[b] Per Capita[c]	Estimated National Stock Change[d]
				(million metric tons)		(kilograms)	(million metric tons)
1952	154.40	0.65	...	153.7	153.7	270	0.0
1953	156.90	0.76	...	156.1	156.1	268	0.0
1954	160.45	0.88	...	159.6	159.6	268	0.0
1955	174.80	1.13	...	173.7	166.9	274	+6.8
1956	182.50	1.18	...	181.3	175.5	281	+5.8
1957	185.00	1.15	...	183.8	183.8	287	0.0
1958	200.00	1.16	...	198.8	192.4	294	+6.4
1959	165.00	1.17	...	163.8	173.8	260	-10.0
1960	150.00	1.18	...	148.8	157.8	231	-9.0
1961	162.00	0.37	6.2	167.8	163.9	236	+3.9
1962	174.00	0.56	5.3	178.7	169.0	240	+9.7
1963	183.00	0.66	5.7	188.0	182.4	254	+5.6
1964	200.00	0.70	6.8	206.1	195.4	266	+10.7
1965	200.00	0.70	5.7	205.0	203.4	271	+1.6
1966	215.00	0.87	5.6	219.7	214.1	279	+5.6
1967	230.00	0.68	4.1	233.4	223.4	285	+10.0
1968	215.00	0.74	4.4	218.7	228.1	284	-9.4
1969	220.00	0.80	3.9	223.1	229.2	279	-6.1
1970	240.00	0.86	4.6	243.7	232.7	277	+11.0
1971	246.00	0.92	3.1	248.2	242.7	282	+5.5
1972	240.00	0.90	4.6	243.7	249.6	284	-5.9
1973	250.00	2.14	7.6	255.5	253.6	282	+1.9
1974	265.00	1.98	6.8	269.8	261.1	285	+8.7
1975	270.00	1.44	3.5	272.1	270.7	290	+1.4
1976	272.00	0.90	2.1	273.2	276.7	291	-3.5
1977	270.00	0.70	6.9	276.2	278.8	289	-2.6
Total		25.18	86.9				+48.1

Sources: The grain output figures are from Table 3. The 1952-57 grain export figures are from Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China* (Chicago: Aldine, 1967); the 1958-59 figures are interpolations; the 1960-67 figures were pieced together from USDA sources by Feng-Hwa Ma in *The Foreign Trade of Mainland China* (Chicago: Aldine, 1971), p. 23; the 1968-70 figures are linear interpolations; and the 1971-77 figures are from U. S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *People's Republic of China Agricultural Situation: Review of 1977 and Outlook for 1978* (Washington, D. C.: USDA, 1978), p. 23, and U. S. Central Intelligence Agency, Office of Economic Research, "China: Agriculture in 1978," ER79-10206, Washington, D. C., April 1979, p. 6. Grain import figures for 1961-70 were assembled from various CIA studies and Alexander Eckstein, *China's Economic Revolution* (Cambridge: Cambridge University Press, 1977); the 1970-77 figures are from the same sources as the grain export figures for the period.

Note: Additional notes on this table appear in Appendix 2.

[a] These figures are the difference between exports and imports added to output. They represent total domestic availability without regard to changes in stocks.

[b] The 1952-64 figures are averages of current supply. The 1965-77 figures take stock changes into account.

[c] These figures are the results of dividing total estimated consumption by the population estimates from Appendix 1, Table 16.

[d] These figures are the difference between current supply and estimated total consumption.

households has been a small part of the total annual gain in national production. There have been virtually no pay raises in China since the 1950s, and meager improvement of the observable general level of living attests to that. Household income gains that have been realized were largely the result of fuller employment and increased labor force participation.

As already suggested, if household income gains had kept pace with real GDP growth and food had not been rationed, a 5 percent Chinese annual GNP growth would have generated an annual increase of some 4.4 percent in total food consumption. The latter figure (Δ d/d) is the sum of population

growth rate ($\Delta p/p$ 2.1 percent) and per capita GNP growth ($\Delta y/y$ 2.9 percent) times the income elasticity of demand for food (plausibly e 0.08 for China). Food production and consumption did not rise by 4.4 percent per year in China. Rationing, which lowered income elasticity by denying its full expression, and the partial filtering down of the GNP gains explain how the People's Republic has been able to get by with an overall agricultural output growth of only 2.9 percent a year.

With $\Delta d/d$ 2.9 percent as given by the historical average rate of growth of GVAO, $\Delta p/p$ 2.1 percent and e put at 0.6 to reflect food market restrictions, the magnitude of $\Delta y/y$ can be inferred. In these terms Chinese household incomes (or technically, per capita disposable income, which is the same as personal income in China) by inference have risen at a rate of 1.33 percent a year during 1952-77.

Chen Muohua, one of China's Vice-Premiers, in a major policy article in the *People's Daily* (August 11, 1979, page 2), on "four modernizations," elaborated on the country's retardation against an unusual backdrop of comparative incomes drawn from the United States and Japan. He highlighted the need for modernization. He used the figure U.S. $139 (in current prices presumably) as the 1976 "national income per capita." This was compared with $7,028 for the United States and $4,193 for Japan. It is reasonable to suppose that the Vice-Premier had made use of comparable statistics for consistent international comparisons. In these terms, it would seem clear from the magnitude of the U.S. and Japanese per capita figures cited in the article that "national income" referred to personal income.

Vice-Premier Chen also gave per-capita incomes for some earlier years, all in U.S. dollars. Without usable Chinese price indexes, it is difficult to obtain growth rates from them. Taking the year 1965 to mark off the period to 1976 and using the lowest rate of consumer price increase among the socialist countries (that is the Soviet Union's 16 percent increase over the period) to apply to China, Chen's 1965 per capita figure of $78, translated into 195 (1965) yuan or 226 (1976) yuan. The 1976 per capita income of $139 converts to 268 (1976) yuan using the same source for the exchange rate. An increase from 226 yuan to 268 over 11 years yields an average rate of growth of 1.5 percent compared to the 1.33 percent inferred above from food consumption estimates. The comparison supports the study's estimates of agricultural output, income, and demand in the People's Republic during the historical period under review.[31]

FOOTNOTES

[23] Average growth rates presented in this study are all compounded rates estimated from the standard exponential function in natural logarithmic transformation fitted to the time series shown in the tables above. The population series by Aird is in Appendix 1, Table 16.

[24] For a fascinating discussion of the differences between agriculture and industry, see Nicholas Georgescu-Roegen, "Process in Farming Versus Process in Manufacturing," in *Economic Problems of Agriculture in Industrial Societies Proceedings of the International Economic Association, Rome, 1965*, ed. Ugo Papi and Charles Nunn (London: Macmillan, 1969), pp. 497-528.

[25] For empirical evidence on productivity growth in these countries, see Vernon W. Ruttan and Yujiro Hayami, eds., *Agricultural Growth in Japan, Taiwan, Korea, and the Philippines* (Honolulu: University of Hawaii Press, 1979); and Anthony M. Tang, "Research and Education in Japanese Agricultural Development," *Riron Keizai Gaku* [Economic Studies Quarterly] February 1963, pp. 27-41, May 1963, pp. 91-99.

[26] From Table 1. The table presents two GVAO estimates based upon different definitions of agricultural output. The definition used for the pre-1957 figures is broader and includes the value of fishery, processing, and side-occupation activities in the countryside. For a precise definition, see Appendix 2, Table 1. The definition used for the post-1957 figures, standard in current usage, comes close to what is generally understood to cover agricultural production. The GVAO reference in the text above uses the post-1957 definition.

[27] Growth rates in this section are calculated from Tables 1, 3, and 15.

[28] For those who feel uncomfortable with the production function analog because of the difficulties with the required assumptions in the Chinese context, the straightforward quantity index approach might be preferred. The productivity analysis in this study stands in either case.

[29] The literature on the strong and weak points of the Soviet-type command economies is vast. A good, concise introduction is Robert W. Campbell's *The Soviet-type Economies: Performance and Evolution*, 3rd ed. (Boston: Houghton-Mifflin, 1974). For an authoritative summary on conditions tending to reduce efficiency of centralized planning, see Béla Balassa, "Proposals for Economic Planning in Portugal," *Economia* 43 (May 1976): 117-24. Balassa discusses the need for simple, overriding goals for effective centralized planning and the difficulties created by rising affluence, by increasing sophistication of the economy, and by the mixture of ownership and control of the means of production as is found in Chinese agriculture (pp. 119-23).

[30] Balassa's recent work ("Proposals for Economic Planning") sheds considerable light, consistent with this generalization, on comparative growth performance between socialist and nonsocialist economies classified by level of development.

[31] In passing we note that against a per capita personal income of $139, the CIA estimate of Chinese GNP per capita of $379 (U.S. Central Intelligence Agency, "Handbook of Economic Statistics, 1979," ER79-10274, Washington, D.C., August 1979, pp. 22 and 50) for 1976 is too high even for a country whose overriding concern is growth. A Chinese private consumption ratio of about 37 percent is clearly too low when compared with the Soviet ratio of 56 percent in 1976 (CIA, "Handbook," 1979, p. 62), even though the latter includes government outlays for education and health.

5

THE PROJECTIONS

Hua Guofeng, in unveiling the new 1976-85 Ten-Year Plan, gave the following specific targets: population growth to be lowered to less than 1 percent a year in three years; grain output to increase 48.0 percent between 1977 and 1985, or at an average rate of 4.5 percent a year; gross value of agricultural output to grow at 4 to 5 percent a year; increased wages to be awarded step by step; and consumption of nonstaple foods to be stepped up.

By adopting an average population growth rate of 1 percent, an income elasticity of demand for food of 0.8 percent, and a growth rate of 4.5 percent for all agricultural output, one can determine the rate of increase of real per capita disposable (or personal) income implied by the Plan. The scenario envisions the Chinese achieving food balance without significant internal constraints on food consumption so that income elasticities will operate. By means of the ordinary time-rate relative change equation derived from a standard log-linear demand function, we have the following relationship:

$$\frac{\Delta d}{d} = \frac{\Delta P}{P} + e\ \frac{\Delta y}{y}$$

where the ratios refer respectively to the rate of demand increase per year, population growth rate per year, and per capita (disposable) income growth per year. The coefficient e stands for income elasticity of demand for all food taken collectively. Solving for the unknown income growth rate, implicit in the Plan targets under the assumed scenario $\Delta y/y$ yields 4.4 percent [(4.5 percent – 1.0 percent) – 0.8]. This rate is compared to the historical rate of household income rise, crudely estimated in the preceding section at 1.3 percent for 1952-77.

Aggregate Demand Projections

In the following projections, future increases of 4 percent per year in real per capita disposable income are to be the highest level consistent with the new income-consumption policy. A higher figure would be difficult to reconcile with the development strategy discussed earlier, especially if the overall GNP growth rate is taken to be around 6 percent per year.

For all scenarios presented in Table 7, stable relative price structure is assumed. The high estimates presume unsuccessful population control, a relatively relaxed income-consumption policy for the people (against an implicitly assumed overall GNP growth rate of about 6 percent a year), and an average income elasticity (0.8) that assumes gradual relaxation of market restrictions. Gradual relaxation would raise e beyond what it would be if $\Delta y/y$ alone were operative. It is recognized that e falls as households enjoy long-term income improvement. In other words, the constant elasticity consumption function employed shifts as development proceeds. The assumed value of e is thus an average for the period.

The low projection assumes effective population control, a nominal income-consumption improvement policy for the masses, and continued tight rationing of basic foods as well as queuing. To stretch the raw farm supply, special effort will be made to absorb the "food yuan" in the hands of relatively affluent households by inflating the value added through fancy packaging, canning, and labor service embodied in processing and food service. The government also resorts to high-priced nonagricultural consumer goods to help soak up the consumers' purchasing power and to hold disincentive for work in check. Such developments are likely in any future scenario, but would be accentuated if austerity is the official posture.

The medium or probable projections assume an intermediate scenario. The present trend toward more moderate, pragmatic economic policies and programs would continue. For these policies to produce planned growth in productivity and output, an annual 2.5 percent increase in household income accompanied by freer expenditures on food would be required.

Table 7—Projections of demand for all agricultural output, 1977 to 2000

Projections	ΔP/p	Δy/y	e	Percent Increase in Demand for GVAO (Δd/d) Per Year	Total for Period	Projected GVAO 2000[a]
	(percent)			(percent)		(billion 1952 yuan)
High	2.0	4.0	0.8	5.2	221	257.4
Low	1.0	1.5	0.4	1.6	46	117.1
Probable	1.5	2.5	0.6	3.0	97	158.0

Note: GVAO stands for gross value of agricultural output.

[a] Projections obtained by multiplying the 1977 GVAO trend value (80.2 billion yuan) by one plus the percent increase from 1977 to 2000.

This points to an income elasticity of 0.6. Moderate policies would bring less social control. They would mean more housing, shortage of which has been a key restraint on family formation. Meanwhile rural economics would still favor large families with many labor units. In short, this projection assumes a population growth rate of 1.5 percent a year, placing it higher than that of Peking's planners. The medium projections place the annual demand increase for all agricultural output at 3 percent, compared with 5.2 and 1.6 percent for high and low projections.

The grain demand projections distinguish between direct demand for foodgrains and indirect demand for feedgrains. From this perspective, the loss in calories that results when grains are converted into meats and other livestock products becomes an important consideration. Recent Chinese estimates put the output value of animal husbandry at 13.9 percent of "total agricultural production value."[32] This figure is close to the study's estimates, which for 1977 place the value of livestock product at 11.97 billion yuan, about 15 percent of the gross value of agricultural output. Shigeru Ishikawa states that livestock production requires 4.3 times as much land as production of an equivalent amount of grains.[33] This is in line with commonly accepted calorie-equivalent grain-meat conversion rates of two to one for poultry, four to one for pork, and six to one for beef. China will continue to rely heavily on field and household wastes as a feed supplement, but future incremental meat production will have to rely increasingly on grains.

The medium projections of Table 8 are considered the more probable magnitudes for 2000. Direct demand for foodgrains is projected to rise slowly at 2.1 percent a year, but indirect demand for feedgrains is expected to grow at more than three times that rate. Such a growth rate, 6.5 percent, would be in line with the experiences of Japan and Taiwan (see Table 8, footnote c). The increase in indirect demand derived from the high-income elasticity of livestock product demand helps explain the grain import explosion of Japan and Taiwan, which occurred as income levels soared, domestic grain output rose, and the Engel curves for (direct) grains leveled off and then fell. The future indirect demand estimated here takes into account future displacement of work animals by machines in addition to population growth, income change, and other standard factors.

All grain demand is projected to increase at 3 percent a year. Total demand over the 23-year period is expected to grow 97 percent to 538 million metric tons. In the benchmark year 1977, domestic grain output (trend value) was 273 million metric tons and total grain consumption 278.8 million metric tons.[34]

Aggregate Supply Projections

One of the main resource provisions of the Ten-Year Plan for agriculture appears to be to increase chemical fertilizer output in 1980 by 58 percent over 1977.[35] This is slightly higher than the historical annual growth of 18 percent. The Plan also mentions a goal of one "large chemical fertilizer plant" in each province by 1985, and continued encouragement for construction

Table 8—Projections of direct and indirect grain demand, 1977 to 2000

Projections	$\Delta P/P$	$\Delta Y/Y$	Income Elasticity[a]			Projected $\Delta d/d$				Total Grain Demand in 2000[d]
						Per Year			Total Increase For Period[c]	
			Direct Demand	Indirect Demand	All Demand[b]	Direct Demand	Indirect Demand	All Demand		
	(percent)						(percent)		(percent)	(million metric tons)
High	2.0	4.0	0.30	2.5	0.74	3.2	12.0	4.96	204	831
Low	1.0	1.5	0.20	1.0	0.36	1.5	3.5	1.54	42	368
Medium	1.5	2.5	0.25	2.0	0.60	2.1	6.5	3.00	97	538

Note: Additional notes on this table appear in Appendix 2.

[a] Estimated income elasticities of demand for grain are averages for the period. They are considered plausible for China in relation to international statistical estimates. They are also more or less consistent with the elasticity estimates for China of the Food and Agriculture Organization of the United Nations.

[b] These figures are weighted averages of direct (0.8) and indirect (0.2) demand. Indirect demand is derived from consumer demand for livestock products.

[c] The total increase was calculated by compounding the yearly rates of increase (r) of all demand over the 23-year period using this formula: $(1+r)^{23}-1$.

[d] This column was calculated by multiplying the 1977 trend value for grain output (273 million metric tons, excluding soybeans) by one plus the rates of increases of all demand in decimal form.

of local plants. The general thrust suggests probable continuation of the 1952-77 annual expansion rate of 7 percent for all current inputs (from Appendix 1, Table 12). In this study the 7 percent figure is used for the remainder of the century.

Another major provision deals with achieving 85 percent "basic mechanization" by 1985; improving quality; promoting standardization of parts; doubling some machine numbers in eight years; raising the utilization rate of available machines to over 80 percent; and reducing by 20 percent the price of farm machines by 1980. Perhaps the most meaningful single target is the planned increase of gasoline allocation to agriculture of 1.2 times (or a yearly increase of 10.4 percent) between 1977 and 1985. Taking this as an indication of total mechanization, a farm capital growth rate for 1977-2000 of 6 percent was projected.

This takes into account the slower—but higher than the historical—growth of the other main capital component, livestock. The Plan gives prominent mention to setting up mechanized and semimechanized livestock farms and to increasing nonstaple food consumption. Household raising of pigs, long the mainstay of China's livestock program, is not given much attention. Emphasis seems to be on "commercial-type" animal husbandry that is also consistent with limited possibilities for further expansion of household livestock-raising based on household and field wastes and with the inordinately large planned grain output target. The 1952-77 average annual growth rates are 23 percent for farm machinery and 3 percent for livestock holdings. Because the 1952-57 weights were highly skewed against machinery, the overall farm capital growth rate was 4 percent per year (Table 4 and Appendix 1, Tables 15 and 18). Our 6 percent for projected capital growth rate indicates the increased emphasis on mechanization.

Another aim of the Plan is to bring population growth down to less than 1 percent in three years. As noted earlier, this study projects a 1.5 percent growth rate. But lower growth rates for farm population and farm labor force are plausible, especially under the new moderate policy that implies freer future rural-urban migration. Therefore, this report adopts a 1 percent annual growth rate for farm labor force for 1977-2000, compared with the historical rate of 1.8 percent (from Appendix 1, Table 11).

The Plan also calls for enough farmland capital construction to provide every 15 members of the rural population with one hectare of farmland "guaranteed" to produce stable high yields irrespective of the weather. This involves nearly half of the country's total acreage. The scheme is to be backed by state-budgeted investment for capital construction for the next 8 years equal to the total for the past 28. There are also provisions for large-scale development of grassland and opening up of 13 million hectares of wasteland for cultivation in the Northeast and Northwest by 1985. A more determined drive toward mechanization for relaxing labor-time bottlenecks in peak seasons may be expected to raise the utilization rate of land under cultivation. This study uses 0.9 percent (almost twice the historical rate) for annual increase in effective (sown) land area (from Appendix 1, Table 14).

In making alternative sets of supply projections, it is assumed that the equal growth targets for GVAO and total grains, increasing shares of which will be used as feed, will be achieved though not necessarily reaching planned rates of 4.5 percent a year.

It is also expected that the annual rate of increase for each of the four input categories for 1977-2000 essentially will be as subjectively inferred from the Plan and as adopted. For low supply projections, the total factor productivity index (TFPI) is assumed to continue to decline at its 1952-77 rate of 0.65 percent per year. For medium or probable projections, an annual increase of +0.5 percent per year is used. For the high projections, the implications of the Plan are accepted, recognizing that the contents of the Plan are still a matter of conjecture. In other words, it is supposed that factor productivity will rise markedly so that the input-output relationship will come out as planned. This was done as follows:

$$\text{Planned GVAO (1985/1977)} = 1.48 \times \text{TFPI}\ (0.5 \times \overset{\text{Labor}}{1.01^8} + 0.25 \times \overset{\text{Land}}{1.009^8} + 0.1 \times \overset{\text{Capital}}{1.06^8} + 0.15 \times \overset{\text{Current Inputs}}{1.07^8}).$$

The sum of the terms inside the brackets is the aggregate input index (AII, with 1977 = 100 percent) for 1985. The weights are the factor income share weights used elsewhere in developing the Chinese historical series.[36] The rates of input increases adopted earlier appear as 1 + (the rate) compounded over eight years to produce the component input index for 1985 (1977 = 100 percent). This sum comes to 1.228. TFPI (1.48/1.228) is thus 1.2; that is, the 1985 total factor productivity needs to be 20 percent higher than in 1977 if the 1985 output target is to be achieved on the basis of what we inferred to be planned resource commitments. The annual increase in TFPI adopted for the high projections is thus 2.3 percent.

For the high aggregate supply projections for 2000, the annual rates of increase for each of the four categories of inputs are those worked out for the shorter Ten-Year Plan period. The TFPI improves at 2.3 percent a year. The low and the medium (or probable) differ from each other and from the high only by the annual change in TFPI: 0.5 percent (the 1952-77 rate rounded upward from 0.65 percent) for low projections and -0.5 percent for medium projections. The latter rate is purely judgmental. However, it is consistent with the Soviet experience in which total factor productivity changed from declines in the 1930s to moderate gains in the post-Stalin period. It is also consistent with China's move to relax restrictions on income and consumption for the farm households. Considerations discussed in Chapter 2 discourage the adoption of higher TFPI growth rates for the probable projections.

The aggregate supply projections are presented in Table 9. The medium projections anticipate a 92 percent increase in grain output between 1977 and 2000, to a total of 524 million metric tons. The annual rate of increase is 2.9 percent. GVAO is expected to reach 154 billion yuan in 2000 as compared to the 1977 trend value of 80.15 billion (all in 1952 prices). Further comment on supply projections appears in the consolidated demand and supply analysis below. If a reader wishes to infer stock and consumption changes from the consolidated statement, it is useful to recall Li Xiannian's announced long-term reserve stock target of 80 million metric tons and compare it to the estimated reserve of about 50 million metric tons in 1977 (Table 6).

Table 9—Domestic supply projections to 2000

Projections	Projected Indexes (1977 = 100 percent): Total Factor Productivity Index[a]	Aggregate Input Index[b]	Output Index[c]	Projected Grain Output[d]	Projected Gross Value of Agricultural Output[e]
		(percent)		(million metric tons)	(billion 1952 yuan)
High	168.7	172.5	287	785	230
Low	89.1	172.5	154	420	123
Medium	112.1	172.5	192	524	154

Note: For the indexes, 1977 = 1.00

[a] The total factor productivity index for high projections was obtained by compounding the annual rate of productivity increase of 2.3 percent, as inferred from the 1976-85 Ten-Year Plan, over the 23-year future period. For low projections, the compounding was based on the historical rate of annual productivity decline of 0.5 percent. Medium projections assume a modest annual rate of productivity increase of 0.5 percent as discussed and adopted in the text.

[b] A common index, as inferred from the Ten-Year Plan applies to all three sets of projections. The aggregate annual increase of 2.4 percent was first calculated as the weighted average of the following annual rates of increase: labor, 1 percent; land, 0.9 percent; capital, 6 percent; and current inputs, 7 percent. This aggregate rate is then compounded to the year 2000 to obtain the above index.

[c] These figures were derived by multiplying the total factor productivity index for 2000 by the aggregate input index for 2000.

[d] These figures were derived by multiplying the output index by the 1977 trend output (273 million metric tons).

[e] These figures were derived by multiplying the output index by the 1977 trend gross value of agricultural output (80.15 billion yuan).

FOOTNOTES

[32] See Ching Hua, "How to Speed Up China's Agricultural Development," *Peking Review*, October 1978, p. 12.

[33] Ishikawa, "China's Food and Agriculture."

[34] See Table 8 for projections based on alternative consumption and output benchmarks. The differences among alternative projections are small.

[35] Some of the details below are from Ching Hua, "How to Speed up China's Agriculture," pp. 8-12. The article attempted to flesh out the Plan's blueprint.

[36] For sources and methods, see notes to Tables 1, 4, and 5.

6

SUPPLY AND DEMAND PROJECTIONS CONSOLIDATED

Considering their rather tenuous base, the projections for supply and demand are remarkably close. The high estimates produce a projected demand in 2000 for agricultural products (GVAO) of 257 billion yuan (in 1952 prices), compared to 230 billion yuan for the projected aggregate gross output (Tables 7 and 9). For reasons stated earlier, we do not regard this scenario as probable because it would involve a dramatic swing toward social and political liberalization and toward market economics. The low estimates, which assume a return to Maoist policy, would yield a projected demand for GVAO of 117 billion yuan and a supply of 123 billion yuan. This scenario also is considered unlikely in light of the policies of the post-Mao leadership.

The medium projections are near equilibrium. If the present regime continues on its moderate and pragmatic course without abandoning the command system and the fundamental development strategy, this is the most plausible scenario for the future. It would be likely to bring some improvement in economic performance in agriculture but no breakthroughs. The projected GVAO demand for 2000 is 158 billion yuan, only 4 billion yuan or 2 percent over the projected aggregate supply. Such a gap could be easily met by net grain imports not much larger than the current level of food imports.

A rough balance between supply and demand also is projected for grains. The medium projections call for total direct and indirect demand for grains to reach 538 million metric tons in 2000, compared with total grain output (soybeans excluded and potatoes included at a four-to-one weight ratio) of 524 million metric tons. The deficit of 14 million metric tons would be only about double the current net grain import tonnage and clearly manageable.

The low projections would produce a surplus of 32 million metric tons and the high projections a deficit of 46 million metric tons.

Table 10 presents the 1952-77 rates of supply increase based on exponential growth trends fitted to the estimated data. The supply projections are obtained by simple mechanical extension of the trends to 2000. For demand projections, 1.5 percent for annual population increase and 2.5 percent for annual per capita disposable income growth was used. Income elasticities for commodities are from FAO's recent estimates on the People's Republic (5th run, April 15, 1978). The 1985 and 1990 elasticities were averaged to obtain 0.195 for wheat, 0.265 for

Table 10—Commodity trends and projections by trend extrapolation, to 2000

Commodity	Trend Rate Per Year 1952-77	Supply Projections: Index (1952 = 100)	Supply Projections: Amount	Demand Projections: Annual Increase	Demand Projections: Index (1977 = 100)	Demand Projections: Amount[a]
	(percent)		(million metric tons)	(percent)		(million metric tons)
All grains	2.35	304	471	3.00[b]	197[b]	538[b]
Rice	2.47	322	221	2.16	163	205
Wheat	3.00	413	75	1.98	157	74
Coarse grains	2.28	295	152	2.00	158	120
Tubers	1.30	186	30	1.25	133	35
Pulses	0.04	98	11	1.97	157	19

[a] These figures were calculated by multiplying the index in the preceding column by 1977 output adjusted for exports or imports.

[b] These figures were taken from medium estimates in Table 8.

rice, 0.200 for coarse grains (corn, millet, sorghum), 0.100 for tubers, and 0.19 for pulses. Such mechanically extrapolated values have little intrinsic worth; they are presented without comment for possible inclusion in IFPRI's global projections.

A study on the scale attempted here obviously cannot answer adequately many questions that will affect development of Chinese agriculture. What is the state of Chinese research in plant and animal breeding? How effective are the personnel, organization, and structure for research and development? What are the water prospects in northern China where moisture is a chronic limiting factor? How do we evaluate the massive scheme to channel the waters of the Yangtse northward? Can the projected 7 percent annual increase in current inputs be realized? Are there enough fertilizer plants in place and in process to meet the implicit chemical fertilizer requirement? How about energy and transport? How are the rice transplanters coming along? How are the water control and farmland capital construction programs going to fare? What are the prospects for fertility rates dipping below 1 percent? The list could be extended indefinitely.

Although the answers to such specific questions are most important to the future, an understanding of the larger picture may be just as useful for long-term forecasting of critical national aggregates. The problem is similar to the distinction between partial and general equilibrium analysis. To study details in isolation is one thing, to evaluate the whole in which all parts interact is quite another.

There is no better summarizer of the whole than the historical record. The Chinese agricultural record for 1952-77 has been documented more completely in this study than ever before. For the first time there is a reasonably complete quantitative record of contemporary Chinese agriculture. That record shows that Chinese agriculture has been able to meet the essential food needs of the Chinese population, nearly one-fourth of mankind, whose annual increment almost equals the entire population of Canada, but at a high cost in resources. The historical record is undoubtedly useful for making projections for the People's Republic because the post-Mao leadership is expected to retain the command economic system and the principles of nation building that the CCP introduced with the First Five-Year Plan. The projections in this study rest on that historical record modified by the implications of the moderate post-Mao policy direction. Some elements of the latter are drawn from the general outline of the new Ten-Year Plan, 1976-85. The projections are based mainly on broad sweeps and tendencies rather than on specifics and details.

Theodore W. Schultz is noted for his special feel for what matters. In a capsule form, his message over the years has read: give the farmer the world over new profitable production possibilities and sufficient incentive, and he will turn sand into gold. The large and growing disparities in income and productivity in world agriculture he attributes not so much to unequal resource endowment as to technological disequilibria among nations. China is a victim of the latter. It has much to gain from a vast technological backlog. All backward, low-income agricultures do. But to utilize it a national government must get on with adaptive research and development, investment in the human agent, and provision of an environment conducive to producer incentive. The problem of control versus incentive comes to the forefront. In China, with its 150 million households in agriculture, 5 million production teams, 500,000 brigades, and 50,000communes, details have to take care of themselves if Peking is to manage.

This projection study is conditioned by the larger picture. The historical record shows that Chinese agricultural productivity has been declining even though rapidly increasing quantities of modern inputs have been injected since the early 1960s. In this connection, two problems related to the command system should be noted. The first is the difficulty of central planners in coping with dynamic changes in comparative advantage among regions. This has been compounded by transport bottlenecks. During the latter years of Mao's rule, extreme emphasis on self-reliance required localities to further reduce the limited specialization that remained. The Chinese cropping pattern became increasingly different from what it was when commercial orientation was stronger under private farming. The second problem concerns the inflexibility of the boundaries of the collective farms and the government-enforced immobility of farm labor in China. The combination causes unsound resource allocation. As the more

prosperous farms and farm areas forge ahead, thanks to accumulation and through it technical advancement, the poor ones fall further behind, and the twin problems of resource misallocation and weak income distribution worsen. The principle of self-reliance applied to resource supply and employment creation compounds the problem. Transfer of accounting and income distribution from the commune to the team, although conducive to greater incentive on the lower collective level, adds another dimension to the problem.

Although a fuller understanding of falling Chinese agricultural productivity awaits further investigation, there is little doubt that problems arising from the command system had something—perhaps a great deal—to do with it. To this add the negative impact of bottlenecks and disparities in the Chinese economy, afflictions that Peking's present leaders attribute to the Gang of Four.

Expectation of relaxation of the restrictions and increased incentives are the basis for projecting an annual increase in total factor productivity of 0.5 percent, a rise of one percentage point over the historical record. The projected rise was limited by other problems associated with the command system, the bottlenecks in transport and energy, and the loss of skills resulting from missed schooling opportunities during 1966-76. The magnitude of the bottleneck problem was illustrated in the *Beijing Review*, June 29, 1979, page 14, which states that "the capacity of some weak sectors on the trunk railway lines can meet only 50 to 70 percent of requirements" and that "owing to the shortage of electric power, about 20 percent of the nation's productive capacity has not been tapped." Such "disproportionalities," which the article says pervade the entire national economy (in fact, involving all of Mao's "ten major relationships"), have had a negative impact on resource productivity in agriculture in the past. Such impact has also tended to become more pronounced as agriculture's interdependence vis-à-vis the rest of the economy broadened while it modernized. The latter fact in turn places a new burden on the planner in his role as the interindustry resource coordinator. The correction of the existing disproportionalities will require a major effort (and time) by Peking, as government articles on the readjustment theme have amply suggested in recent months.

APPENDIX 1

SUPPLEMENTARY TABLES

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

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

SOURCES AND NOTES TO TABLE 11

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

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

of urban youth and greater participation of women increase the agricultural labor force, while growing primary education and rural industry reduce it.

Total Population

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

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

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

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

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

Urban Population

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

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

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

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

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

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

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

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

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

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

Rural Population

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

Rural Proportion of Total Population

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

15-64 Age Group

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

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

Rural Labor Force

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

Agricultural Labor Force

This column was derived by multiplying the rural labor force figures by 0.7731. This ratio was developed by Anthony Tang,

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

SOURCES AND NOTES TO TABLE 12

Feed

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

Table 12—Current inputs, 1952 to 1977

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

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

Seed

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

Insecticide

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

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

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

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

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

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

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

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

Chemical Fertilizer, Gross Weight

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

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

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

Chemical Fertilizer, Nutrients

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

Organic Fertilizer Nutrients

This series is from Table 17.

Total Fertilizer Nutrients

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

Table 13—Current input indexes, 1952 to 1977

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

SOURCES AND NOTES TO TABLE 13

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

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

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

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

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

Table 14—Land input, 1952 to 1977

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

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

SOURCES AND NOTES TO TABLE 14

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

Cultivated Area

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

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

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

Irrigated Area

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

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

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

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

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

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

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

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

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

Figures for the years for which information on irrigated area is not available (1958-62) were interpolated as shown below, using the method developed by Norman M. Kaplan

and Richard H. Moorsteen, *Indexes of Soviet Industrial Output* (Santa Monica, Cal.: Rand Corp., 1960), pp. 61-8.[38]

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

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

Cultivated Area Adjusted for Irrigation

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

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

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

Sown Area

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

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

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

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

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

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

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

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

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

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

Multiple-Cropping Index (MCI)

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

Sown Area Adjusted for Irrigation

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

Modified Multiple-Cropping Index (MMCI)

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

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

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

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

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

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

Effective Sown Area Adjusted for Irrigation and Multiple-Cropping Bias

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

Land Input Index

For this index, 1952 is equal to 100.

SOURCES AND NOTES TO TABLE 15

Detailed information on livestock holdings is available only for 1952-58. Scattered statements relating holdings in years after 1949 have appeared in the 1970s. Holdings in the intervening years were estimated by a least square regression analysis of the relationships between the livestock series and the complete series available for livestock exports and grain production. The regressions were run using the grain output series estimated or pieced together in U.S. Central Intelligence Agency (CIA), National Foreign Assessment Center, "People's Republic of China: Handbook of Economic Indicators," ER76-10540, Washington, D.C., August 1976, p. 11. The CIA has since developed a new series (see Table 17). Elsewhere in this work, the grain series (and the aggregate value output estimates based on it) is adapted from 1978 USDA estimates (U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *People's Republic of China Agricultural Situation: Review of 1977 and Outlook for 1978* (Washington, D.C.: USDA, 1978), pp. 30-2). It is not considered worthwhile to rerun the regressions and make new estimates of animal numbers that will differ only marginally from the estimates already made. New grain output estimates for 1974-77 are substituted for the old estimates in the regressions. The "Total Value" column gives the value of the stock of animals in constant prices, while the "Value of Production" column presents the flow value of livestock produced or consumed. All figures are for the end of the year. Data presented directly by the PRC, or derived on the basis of official statements include:

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

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

1952-58

Peoples's Republic of China, Ministry of Agriculture, Bureau of Planning, *A Collection of Statistical Data on Agricultural Production of China and Other Major Countries* (Peking: Agricultural Publishing House, 1958) pp. 65-78,

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

The 1958 figures are from People's Republic of China, State Statistical Bureau, *Communique on the Development of the National Economy in 1958* (Peking: Tung-chi Ch'u-pan-she, 1959), p. 21. (See Chen, *Chinese Statistics*, p. 340.) They are given as year-end figures.

1961, 1962, 1965, 1971, 1972

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

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

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

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

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

Estimates for Regression Analysis

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

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

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

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

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

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

$$\text{Hogs}_t = -149.68 + 0.44764\,(\text{Grain}_t) + 1.1292\,(\text{Grain}_{t-1});$$
(standard errors) (37.309) (0.84337) (0.75261)
(t statistics) (-4.0119) (0.53077) (1.5004)

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

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

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

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

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

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

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

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

model and a concurrent adjustment of the constant term, as follows:

$$Hogs_t = -145.975 + 0.78715\,(Grain_t) + 0.76095(Grain_{t-1}),$$

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

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

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

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

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

Value

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

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

Weighted average = 77.3 yuan

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

$$\text{Value of livestock utilized} = \text{(million 1952 yuan)}$$
$$0.138 \times (\text{draft animals}_{t-1}) \times 77.3 \text{ yuan} + 0.8 \times \text{hogs}_{t-1} \times 46 \text{ yuan} + 0.4 \times (\text{sheep and goats}_{t-1}) \times 8 \text{ yuan.}$$

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

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

Weighted average = 0.138

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

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

SOURCES AND NOTES TO TABLE 16

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

SOURCES AND NOTES TO TABLE 17

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

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

Night Soil

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

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

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

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

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

Night soil utilized = 0.5 × (rural pop.)

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

× (urban utilization rate).

Hog Manure

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

Hog manure utilized =

2 × (hog holdings)

× (rural utilization rate).

Draft Animal Manure

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

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

Weighted average = 7.7 metric tons

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

Draft animal manure utilized =

(draft animal holdings)

× (rural utilization rate).

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

Green Manure

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

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

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

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

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

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

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

Oil Cake

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

Compost

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

River and Pond Mud and Other

In the words of Chao (*Agricultural Production*, p. 312), "This item is meant to contain all the unimportant types of natural fertilizer that have only marginal contributions." Using an analysis of cropping areas and the location of suitable bodies of water, along with the probable effect of government directives, Dawson derives an estimate of river and pond mud available for use as

fertilizer in 1956 of 144 million metric tons, ("Fertilizer Supply," pp. 138, 140). He estimates the amount of "other" minor natural fertilizers available at 8.12 million metric tons. The total for 1956, then, is 152.12 million metric tons. This is assumed to be one-third greater than the amount used in 1952 (Kilpatrick, "Role of Chemical Fertilizer"). Estimates for 1953-55 are interpolated using the average annual rate of growth implied by the 1952-56 increase. The quantity used is assumed to have remained constant after 1956 (Kilpatrick, "Role of Chemical Fertilizer").

Total Gross Weight

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

Total Nutrient Content

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

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

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

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

SOURCES AND NOTES TO TABLE 18

Tractors

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

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

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

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

Table 18—Farm machinery, 1952 to 1977

Year	Inventory of Tractors: Number	Inventory of Tractors: Horsepower	Inventory of Powered Irrigation Equipment	Total Horsepower
	(1,000 15 horsepower units)	(1,000)	(1,000 horsepower)	
1952	2.0	30	153	183
1953	2.7	40	200	240
1954	5.1	77	260	337
1955	8.1	121	338	459
1956	19.4	291	508	799
1957	24.6	369	560	929
1958	45.3	680	1,280	1,960
1959	59.0	885	2,535	3,420
1960	79.0	735	4,145	4,880
1961	95.0	1,425	4,845	6,270
1962	103.0	1,545	5,800	7,345
1963	115.0	1,725	6,440	8,165
1964	123.0	1,845	7,300	9,145
1965	134.4	2,016	8,450	10,466
1966	153.6	2,304	9,980	12,284
1967	178.1	2,671	10,695	13,366
1968	195.4	2,931	12,742	15,673
1969	216.1	3,242	14,790	18,032
1970	293.0	4,395	16,911	21,306
1971	352.7	5,290	20,000	25,290
1972	484.1	7,262	24,016	31,278
1973	639.5	9,592	30,000	39,592
1974	836.2	12,543	36,000	48,543
1975	971.8	14,577	40,000	54,577
1976	1,187.3	17,810	43,500	61,310
1977	1,300.0	19,500	47,000	66,500

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

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

Powered Irrigation Equipment

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

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

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

SOURCES AND NOTES TO TABLE 19

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

Deflator

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

Constant 1963 Value Terms

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

SOURCES AND NOTES TO TABLE 20

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

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

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

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

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

The weights for Panajachel are from T.W.

Table 20—Relative input weights of selected countries and China

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

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

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

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

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

FOOTNOTES

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

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

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

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

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

APPENDIX 2:

EXPANDED NOTES ON TEXT TABLES

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

TABLE 1

Gross Value of Agricultural Output (GVAO)

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

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

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

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

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

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

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

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

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

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

1971 Industry and agriculture = (billion 1957 yuan)

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

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

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

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

1973 GVAO = (billion 1957 yuan)

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

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

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

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

GVAO =
(standard errors)

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

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

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

considering, again, the importance—both direct and indirect— he partial GVAO products for total farm output.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\frac{C_{52}}{Y_{52}} \left[\frac{1}{1+i} + \frac{1+r}{1+i} + \left(\frac{1+r}{1+i}\right)^2 + \ldots + \left(\frac{1+r}{1+i}\right)^7 \right]_6^1 = 0.009.$$

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

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

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

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

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

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

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

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

The cake fertilizer value series is calcu-

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

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

TABLE 2

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

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

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

TABLE 3

Potatoes

A recent reinterpretation of the grain data, Robert Michael Field and James A. Kilpatrick, "Chinese Grain Production: An Interpretation of the Data," *China Quarterly* 74 (June 1978): 369-84, argues that since 1970 the official data fragments included potatoes in grain equivalent weight at the ratio of five to one. The reconstructed grain series (which also assumed that soybeans have been included in "official" grain figures

since 1964) is best regarded as tentative until new evidence becomes available. As the series now stands, it raises more questions than it answers. An authoritative Chinese source which official Washington is not yet prepared to identify has indicated a different date for the introduction of the five-to-one potato-grain conversion rate than Field and Kilpatrick assume.

Total Grain

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

Total Grain Value

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

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

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

Weighted average = 123.3 yuan per metric ton

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

Value of Soybeans

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

Value of Cotton

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

TABLE 4

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

The value of machinery is crudely estimated by multiplying the total horsepower of tractors and irrigation power equipment (from Table 18) by the weighted average of 1952 draft animal prices (of 77.3 yuan from the notes to Table 7). This is probably a low estimate of the cost of farm machinery per horsepower. The U.S. Central Intelligence Agency, using scattered Chinese sources,

placed the 1958 price of a 2.1 horsepower motor and pump set for irrigation at 211.83 yuan and the 1957 price of a standard 15 horsepower tractor at 10,371 yuan (U.S. Central Intelligence Agency, "Prices of Machinery and Equipment in the PRC," AER75-76, Washington, D.C., May 1975, pp. 15-6). Actual 1952 machinery prices are preferable, but consistent, detailed data are not available.

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

TABLE 5

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

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

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

TABLE 6

Estimated Consumption

It is assumed that no well-articulated national stock policy was in operation before 1955 when "unified purchase and supply" of grains was introduced throughout the country. For 1955-59 it is assumed that

because of the relative food security that a friendly Soviet Union was expected to provide in a national emergency and because of the need to amortize the Soviet loan (repaid partly with shipments of soybeans and other agricultural products), stock changes in China were to smooth out short-term weather-associated supply fluctuations and not to build up a strategic reserve. Hence, estimated consumption in year t is the average of supply in t, t 1, and t 2. As a moving average it is centered on year t 1. To "recenter" it on year t, the average is inflated by 2.35 percent, the long-term exponential growth rate from the fitted trend to the grain output series (1952-77). For 1960-64 it is assumed that Peking saw the need for a strategic food reserve but the food crisis growing out of the Great Leap Forward and a run of adverse weather caused short-term subsistence to override longer-term strategic reserve considerations. Hence, for this period also the estimation procedure for grain consumption for 1955-59 is applied. The moving average method resulted in 22.6 million metric tons for 1959 and 25.7 million metric tons for 1960 as stock changes. Subjecting the draw down to the accumulated 1958 total stock of 19 million metric tons as a limit, we arbitrarily assign 10.0 and 9.0 as stock withdrawals for 1959 and 1960.

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

TABLE 8

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

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

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

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

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CHINA'S 1985 FOODGRAIN PROJECTION TARGET: ISSUES AND PROSPECTS

Bruce Stone

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1

SUMMARY

China's production target of 400 million metric tons of foodgrains by 1985 called for a growth rate of 3.5 percent per year for 1976-85, well above the 1952-78 average of 2.5 percent. Because of stagnation in 1976 and 1977, the prospects of reaching the target seemed remote, but recovery and rapid growth in 1978 and 1979 have restored the prospect of target fulfillment.

Emphasis on the technological transformation of agriculture has waxed and waned over the last two decades, reflecting major policy changes. China's coordinated and consistent commitment to technological change in agriculture began in 1962. Before then development strategy had centered on the expansion of the industrial producers' goods sector, national security, and organizational reform of rural and urban areas. In the early 1960s production and delivery of inputs to agriculture increased rapidly but stagnated in the closing years of the decade.

Renewed commitments to agriculture were made in the early 1970s and again in 1978. In particular, the latest recommitment features significantly more favorable terms of trade for agricultural producers, increased production of industrial inputs to the farm sector, greater investment in rural infrastructure, and higher incentives for local areas. State funds budgeted for agriculture were increased from about one-tenth of the total in 1966-78 to 14 percent in 1979 and are scheduled to increase to 18 percent for 1980-82. If this planned allocation and the input supply program are carried out, China should be able to maintain a growth rate of 3.0-3.5 percent in foodgrain production over the 1979-85 period. When weather conditions in 1978, a number of technical developments, and the implications of various 1979 policy changes for resource allocation, allocative efficiency, distribution, and incentives are considered, a mean rate closer to 3.5 percent or more appears quite possible. This would provide enough grain for both quantitative and qualitative improvements in the diet.

Direct consumption of foodgrains by the Chinese is among the highest in the world, but per capita total caloric consumption is no more than average among developing countries. Despite increased grain production, however, average grain consumption per capita in 1977 was about the same as in 1957 as the population grew by 300-350 million, and grain feeding of livestock increased.

Although strong efforts are being made to reduce population growth, about 43 million tons will be required by 1985 to maintain consumption at recent levels. Even if population control is successful, the large number of children who will become adults by 1985 will increase requirements.

Per capita consumption rates vary considerably by income group, with the lower 20 percent consuming far less than higher-income groups. In some areas consumption is little above subsistence levels. Current policy indicates that an additional 7-8 million tons will be made available more or less directly to those in the two lowest income quintiles, but perhaps 20-33 million would be needed to bring their consumption up to the national average level.

Livestock targets adopted in December 1978 call for 30 percent increases in numbers of cattle, sheep, and pigs, and a doubling of meat output by 1985. In 1977 per capita consumption of meat, mostly pork, was estimated to be 7.5 kilograms per year. The government plans to increase the small herd of dairy cattle and to utilize northern grassland for beef. But the target for cattle may be either of minor quantitative importance or quite difficult to achieve, depending on the current definition of cattle. The sheep and goat target, on the other hand, will probably be exceeded. But most of the targeted increase in meat must come from hogs. Hog stock in the People's Republic has been fed unusually large amounts of nongrain feed in the past, but the present trend is toward higher grain/feed ratios.

Conditions in early 1980 suggest that no less than an additional 5 million metric tons of grain would have to be supplied—mostly to hogs—to meet the livestock targets. This is likely to be met. Achieving the meat target, however, would require 6-19 million

metric tons more.

In addition to the grain needed for population growth (43 million metric tons), direct distribution to lower-income groups (7 million), and the minimum for increased livestock (5 million) in 1985, current policy indicates that stockpiling requirements will be up 2 million metric tons, while industrial use, food processing, and brewing may use an extra 6 million. The total of 63 million metric tons is well below the 95-million-metric-ton increase called for by the 1985 target and seems likely to be attained.

For the most part, additional supply will be divided between more direct human consumption and more feed for heavier animals, since there remains active unsatisfied demand for both meat and grain. Wealthier provinces seem to have reached a point at which much smaller proportions of increments in production are devoted to direct consumption. But at the national average level of around 200 kilograms per capita of processed grain, there is no evidence of slackening direct demand.

The People's Republic has long been important in international grain trade, with regular rice exports since the mid-1950s and large wheat imports since the early 1960s. The late 1970s marked a major increase in the latter. Further growth is possible, but a measured decline seems more likely. The probability of a large rise seems quite small.

Imports allow China to leave more grain in rural areas, particularly in the north where adverse weather has resulted in more erratic output. Imports allow urban stocks to be larger and make feed available for the new suburban hog and poultry farms. China is also in the market for soybean imports to meet increased demands for food, vegetable oils, and possibly animal feed.

Improving the quality and quantity of industrial inputs to agriculture is a major plank of the current agricultural policy. Standardization and quality control are being emphasized for manufacture and repair of machinery. The new fertilizer plants built by American, Japanese, and European firms are turning out higher quality products, and the operation of local plants is also being improved. The power industry is stressing increased efficiency and higher utilization of capacity.

The growth rates of supply of various nonlabor inputs to farm production have been revived to levels equalling or surpassing those of the rapid-growth period for grain output in the first half of the 1970s. The prospects for effective nutrient delivery seem particularly good, not only because of large increases in the amounts of fertilizers with higher nutrient content, but because these fertilizers are more stable. Present utilization rates of organic manures are unknown, but may be declining owing to the large labor requirements involved. Hog manure is the most important and effective natural fertilizer. Its availability (as opposed to the rate of utilization) is likely to increase more rapidly than during the 1970s. The quality of conditions on China's irrigated lands has improved substantially during the past 20 years, injecting ambiguity into any constructed "irrigated acreage" series. Planned increases call for a growth rate of 3.6 percent per year, which is high but not unprecedented in the People's Republic. The plans for growth of both irrigated area and chemical fertilizer supply seem to be consistent with production of 400 million metric tons of grain by 1985. The extent to which these plans are likely to be fulfilled is also apt to be consistent with that target.

The effects on the trend of foodgrain production growth of influences other than the supply of the nonlabor agricultural input stream are more difficult to assess. An exception is weather. 1978 was still a poor weather year, though production soared over that of even worse 1977. Yet average weather, in spite of China's improved facility for dealing with weather changes, might have resulted in an increase of as much as 10 million metric tons.

It may be concluded that changes in policy emphasis affecting prices, budget allocation, and the manner of rural administration should bring about an increase in work and investment incentives by sharply altering immediate and long-term returns in the farm sector and providing greater peasant participation in decisionmaking. It is far from clear that the bulk of additional effort so generated will be devoted to foodgrain production, but there are a number of reasons for suspecting that net impact on the latter will not be negative.

For nonlabor inputs the policy changes should improve the efficiency of resource allocation both among and within collective units in a manner that favors grain production. Considering the quality and quantity of land retired from grain production in 1979, it does not appear that the negative impact on output was large. Even if such

changes represented a trend, the resultant production loss through 1985 will probably be covered by reclamation. A measured retrenchment in cropping intensity is also implied. But so far such changes are still hotly debated, and in some instances the retrenchment will have a positive impact on output as well as on profits.

"Commandism," as unpopular as it may have been, represented a means of easing key infrastructural problems that constrained growth. Despite state and provincial assistance to poorer brigades at an unprecedented level and revision of oppressive policies contributing to their impoverishment, the net effect of the current policy changes will particularly favor the areas that have grown rapidly in the 1970s.

The incentive to expand production thereby provided is no doubt crucial, but it should be recalled that distributional issues are intense political topics in China and have often been near the heart of growth-stalling popular turmoil. The causes of the disturbances have been complex. Broad current participation in income growth may ensure against an immediate outbreak, but future difficulties cannot be ruled out. Also, the possibility of an eventual administrational shift back toward policies more closely associated with the Cultural Revolution cannot be discounted.

The prospects for growth of production caused by the available seed technology also seem reasonably good. The outlook for expansion by use of single-cross hybrid maize and semidwarf wheat still looks strong. Even the slow growth of rice production, which may have even accelerated in the 1970s, will be bolstered by the present proliferation of male-sterile hybrids as growth from conventional rice hybrids becomes exhausted in more and more regions. Toward the end of the current planning period, growth in stagnant tuber yields is likely to begin responding to increased emphasis on appropriate field management of this crop and to virus-free seed stock.

It appears that the seed technological prospects for expanding production in the first half of the 1980s are at least as favorable as they have been in the 1970s, although eventual exhaustion of growth from semidwarf wheat and hybrid maize will ultimately present a problem. The net impact of several other developments will favor farm production in the first half of the 1980s. What effect the purportedly greater peasant autonomy in production and the current administration's relative de-emphasis of grain will have on foodgrain output is unclear. The material gathered to date, however, suggests that it may even be positive or at least not significantly negative.

If the input supply plans (and the extent to which they seem likely to be fulfilled) suggest foodgrain output growth in the annual range (from a 1978 base) of 3.0-3.5 percent, then consideration of 1978 weather conditions, changes in allocational efficiency, incentives, and technological prospects would tend to argue for growth averaging in the upper end of that range or even above it. At the implied production level of 380-400 million tons, demand is likely to completely absorb available supply. Domestic consumption of such volumes will result in both a qualitative and quantitative improvement in Chinese diets. It should be noted, however, that expected growth of these rates through 1985 does not at all imply that such rates will be maintained in future periods. The present outlook for supply growth is particularly favorable. But rapid growth beyond 1985 may depend upon more problematic contingencies, such as continued allocational emphasis on agriculture and foodgrains, long-term water diversion plans, further breakthroughs in seed technology, resolution of economy-wide energy supply constraints, and preservation of political and social stability. A major shift in the composition of domestic demand for grain in China may also occur in the post-1985 decade. Important future research and data development would help ascertain the nature, timing, and extent of such a crucial shift.

2

ISSUES AND PROSPECTS

In 1975 China formulated a 1985 foodgrain[1] production target of 400 million metric tons. At the time it implied an ambitious but conceivable growth rate of 3.5 percent per year. Foodgrain production stalled at about the 1975 level for the following two years, and although 1978 registered a 7-8 percent increase (see Table 1), the implied growth rate for target fulfillment within the remaining seven years had risen to about 4 percent per year.[2] A preliminary 1979 figure of 315 million metric tons has been released.[3] This figure represents a healthy increase over a good 1978 harvest but falls somewhat short of the required rate for target attainment. It is quite possible, of course, that the preliminary figure is an underestimate.[4] But it would have to be a record underestimate, with the subsequent adjustment surpassing even 1978's upward revision of about 10 million metric tons, to bring the required growth rate for reaching 400 million metric tons by 1985 back to 3.5 percent per year. (According to the State Statistical Bureau final figure [332.115 million tons], the preliminary figure was in fact a record underestimate. The required growth rate for 1985 target fulfillment is now 3.2 percent. Fulfillment must now be considered a serious possibility, but would still represent a remarkable achievement.)

High sustained growth rates in output are far more difficult to attain in developing agriculture than in the industrial or service sectors. From the vantage of 1978's final estimate or 1979's preliminary figure, realization of the implied expansion rate would not only represent a truly significant achievement for the People's Republic, but for any major producer of grain.[5] During the spring and summer of 1979, there was little reference to the 1985 target, but it was not explicitly revised with the new wave of economic conservatism as were the steel target and a variety of capital construction projects. In late September 1979, Zhang Finghua[6] reaffirmed the target and went on to disclose that of Mainland China's 29 provinces, municipalities, and autonomous regions, 18 declared that they would be able to fulfill their individual 1985 targets, 3 indicated that they would have difficulty doing so, and 8 promised overfulfillment. It is therefore useful to investigate how close the Chinese might come to achieving the goal and how the additional 95 million metric tons of production would be allocated.

China's long-term foodgrain production growth rate averages 2.5-2.6 percent per year (1952-78) and is a good deal lower if the base year chosen is 1957, just before one of the worst nationwide agricultural failures in Chinese history. The rate can be made to appear higher by using 1949, the year of the Communist Party's ascension to power before full recovery from World War II and the Chinese Civil War; and the rate has clearly

Table 1 — Two approximations of a consistent "official" foodgrain output series, 1949-78

Date	Approximation A	Approximation B	Weather Conditions
1949	111	111	bad
1950	130	130	n.a.
1952	161	161	good
1953	164	164	average
1954	166	166	bad
1955	180	180	good
1956	188	188	bad
1957	191	191	average
1958	206	205 [a]	good
1959	171	184 [a]	average
1960	156	146	bad
1961	168	156 [b]	bad
1962	180	170	good
1963	190	183	average
1964	194	200	good
1965	194	194	average
1966	215	220	bad
1967	225	231-233	good
1968	210	[a]	average
1969	215	[a]	average
1970	243	243	good
1971	246	246	average
1972	240	240	bad
1973	266	261-266	average
1974	275	275	good
1975	284	283-285 [b]	average
1976	285	286 [c]	bad
1977	285	283 [c]	bad
1978		305 [c]	bad

Table 1—(Continued)

Sources: Approximation A: Robert Michael Field and James A. Kilpatrick, "Chinese Grain Production: An Interpretation of the Data," *China Quarterly*, June 1978, pp. 372-3.

Approximation B: Bruce Stone, *A Review of Chinese Agricultural Statistics*, Research Report 16 (Washington, D.C.: International Food Policy Research Institute, forthcoming).

Weather Conditions: Leo A. Orleans, "Soviet Perceptions of China's Economic Development," in U.S. Congress, Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C., U.S. Government Printing Office, 1978), p. 147; Edwin F. Jones, "The Emerging Pattern of China's Economic Revolution," in U.S. Congress, Joint Economic Committee, *An Economic Profile of Mainland China* (New York: Praeger, 1970), p. 93.

Notes: Approximation A was an attempt to compensate for changes in the official Chinese definition of foodgrains. It is based on the authors' conclusion that 1964 was the first year since 1955 that soybeans were included in foodgrain output statistics released by the Chinese government and that since 1970 tubers have been included at a fifth rather than a fourth of their natural weight. The series relies primarily on adjustments of figures appearing in Chinese publications, broadcast transcripts and oral statements by Chinese officials. They are supplemented by estimates prepared by the authors and other scholars.

Approximation B is based exclusively on Chinese materials and differs, principally in the 1960s, from those used to derive the Field and Kilpatrick series owing to the author's provisional adoption of the recent statement attributed to a Chinese government official that the definition of foodgrains and the grain equivalent weight of tubers were changed in, respectively, 1958 and 1963. Both series are presented since the dates need to be verified. Not only are these dates a source of some ambiguity, but there is now some question whether all soybeans or only those consumed directly are included. There is also a small chance that the tuber ratio has been changed back to one fourth of their natural weight (see note e). Finally, Chinese officials have told members of a Japanese delegation that whatever the aggregative conventions adopted by the government, definitions used by local units in reporting output varied between localities and were sometimes changed, suggesting that establishment of a truly consistent series will necessitate a recomputation of adjusted local reports. It will be complicated and difficult if not impossible to construct such a series.

Foodgrains include paddy rice, wheat, coarse grains, tubers (valued at one fifth of their natural weight), and soybeans; for coarse grain definition see footnote 1.

[d] The official figures for 1958 and 1959 are particularly unreliable. Popular consensus has it that massive overreporting on the part of local administrative cadres during those years vastly inflated compilations at the State Statistical Bureau. These compilations may not now be completely correctable, although various more conservative official series were published after the original estimates appeared. The figures included are based on the last of these more conservative series, although it is not a particularly reliable series for other years.

No official national aggregate figures have been published for 1968-69.

[b] Based on preliminary estimates; unambiguously final official estimates have not been made available.

[c] A definitional question has again arisen over the 1978 output figures first published by the State Statistical Bureau in June 1979. The 1977 figure may also be implicated since it appeared in the same State Statistical Bureau publication. The included 1976 figure, which was based on an increment over 1977 output appearing in a September 1979 publication, may be as well. An official news release in late September quoted the included 1978 figure along with figures for 1949 and 1952. But the latter two coincide with official foodgrain figures for those years, including all soybeans and tubers valued at one-fourth of their natural weight. In 1978 and 1979, however, the current definition (including all soybeans and tubers valued at a fifth of their natural weight) was reportedly confirmed by Chinese officials to at least two independent foreign delegations. Moreover, statements made to a Japanese delegation indicate that not all soybeans, but only those consumed directly, are included in official foodgrain statistics although an American delegation was reportedly told that all soybeans were included. The assumptions here are merely convenient ones: that the exclusion of soybeans used in oil and bean cake production is, at most, relatively recent (perhaps accounting for the difference between the final 1977 figure published in mid-1978 and the State Statistical Bureau figure published in mid-1979); and that the comparison with the 1949 and 1952 figures, which include all soybeans and value tubers at one-fourth their natural weight was one of expediency. Statistics may not be available for a recomputation of "foodgrain" soybeans or the Chinese may now accept that early official production figures were minor underestimates anyway, more or less offsetting the bias introduced by additional incongruity. Current figures may also be underreported, though no doubt to a lesser extent. If soybeans used to produce such things as cooking oil and bean cakes have indeed been excluded, then to establish rough consistency in Approximation B it is only necessary to add about 3 million metric tons to the included State Statistical Bureau estimates for 1977 and to the 1978 figure (though probably not 1976). But the question, unfortunately, remains open.

been higher for shorter periods, even if we are careful to take peak-to-peak (1971-75: 3.8 percent per year) or trough-to-trough (1968-77: 3.1-3.5 percent per year) readings. But the 1978-85 implied rate of growth has been exceeded no more than once in the last three decades for a period of comparable length (1960-68: 3.8-5.0 percent per year), and although this is a trough-to-trough reading, the 1960 trough was so low (production probably did not exceed the 1952 level) as to render comparison with 1978-85 quite spurious.[7]

In order to exceed historical average rates of growth in domestically produced foodgrain supply, China must do one or more of the following: increase the rate of growth of input application and absorption in foodgrain production; increase markedly the quality of these inputs; improve significantly the efficiency of allocation or manner of combining these inputs; or utilize technical innovations to effect a major upward shift in the production function. It can be demonstrated that China, owing to technical developments and policy adjustments, may be in a position to improve on past performance in each of these categories of change. Yet the changes themselves present problems which may eventually increase the risk of production stagnation. Although nonpolemicists must perhaps remain skeptical that the 1985 foodgrain production goal will be achieved, the Chinese are currently in a rather favorable position to put together several years of better-than-average agricultural growth in the face of declining rates of population increase.

The fact that China is supporting one-fifth to one-fourth of the world's population on 7-8 percent of the world's cultivated land suggests to many Westerners the pessimistic theories of Thomas Malthus and marginal labor products diminishing to zero. Yet over the last three decades as a whole, China has been able to increase foodgrain output, albeit by a slim margin, in excess of population growth and seems in a strong position to continue and even intensify this process, all within the context of a development plan that has emphasized agriculture to a far lesser extent than its press reports would indicate. Moreover, the chronic peak-period labor shortages of Chinese agriculture, documented as early as the 1920s by Buck,[8] have been accentuated, due in particular to overlapping peak demands of multiple cropping and China's labor-intensive agricultural strategy.[9]

Virtually no Western observers doubt that the People's Republic's immense population of over one billion[10] will be capable of absorbing 400 million metric tons of foodgrains in 1985, particularly when population growth is taken into consideration. But a closer examination of China's demand for grain may shed light on the extent and timing of changes in China's international purchase plans (should future production levels actually turn out to be unexpectedly high or low) and on prospects for demand progress beyond the 400-million-metric-ton mark.

FOOTNOTES

[1] Foodgrains include rice; wheat; coarse grains; green, yellow, and black soybeans (probably all soybeans but perhaps only those used directly for consumption); and tubers (valued at one-fifth their natural weight). Coarse grains include millet, sorghum, corn, barley, buckwheat, mung beans, oats, proso-millet, small beans, green beans, and broad beans.

[2] For output figures see the official series in Bruce Stone, "A Review of Chinese Agricultural Statistics," International Food Policy Research Institute, Washington, D.C. June 13, 1979, Table 2. See also two approximations of consistent series in Table 1 below.

[3] U.S., Foreign Broadcast Information Service (FBIS), *People's Republic of China Daily Report*, December 31, 1979, p. L12. "Rich Harvests," *Beijing Review*, January 14, 1980, p. 3. The State Statistical Bureau (SSB) final figure (332.115 million metric tons) is from Xinhua [New China] News Agency, news bulletin, April 30, 1980.

[4] Chinese economists share the belief that initial estimates are consistently below the true output figures because they are deliberately underestimated by local, county, and provincial governments. They also believe that the final estimates based upon state purchase information are underestimated, although not by as much. Conversation with Wu Chuan-chun, deputy director of the Institute of Geography, Academica Sinica, Beijing, January 25, 1979.

[5] This point was first made on the basis of a 1978 estimate of about 290 million metric tons with an implied growth rate of 4.8 percent per year by Robert F. Dernberger and David Fasenfest, "China's Post-Mao Economic Future," in U.S. Congress, Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 3-47.

[6] Xinhua, news bulletin, September 27, 1979, p. 19; FBIS, *PRC*, September 28, 1979, pp. L9-L15.

[7] These growth rates were calculated from Table 1.

[8] John Lossing Buck, *Chinese Farm Economy* (Chicago: University of Chicago Press, 1930).

[9] This argument is developed in Shigeru Ishikawa, "China's Food and Agriculture: A Turning Point," *Food Policy* 2 (May 1977): 98-9, where it is pointed out that the current labor utilization rate in Chinese model communes far exceeds that of China in earlier periods and concurrent rates in other Asian countries. However, this is due in part to the differences between the valuation of labor by the individual and by the state, which results in both overemployment and a neglect of collective activities in favor of private sideline and leisure activities (see Thomas B. Wiens, "The Evolution of Policy and Capabilities in China's Agricultural Technology," in U.S. Congress, Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C.: U.S. Government Printing Office, 1978) p. 674. Also see Ishikawa, "Prospects for the Chinese Economy in the 1980s," Tokyo, March 12, 1979. (Mimeographed.)

[10] A recent estimate by John Aird, the United States's foremost expert on the Chinese population, places the midyear 1979 figure at 1.017 billion (see Stone, "A Review of Statistics,"; Table 1). As of year-end 1979 even the Chinese were occasionally quoted as referring to their population as over a billion. (Xinhua quoted by the *Japan Times* [Tokyo], December 29, 1979).

3

COMPONENTS OF DEMAND

The Chinese revealed in the spring of 1979 that foodgrain consumption per capita in 1977 was no higher than it was in 1957.[11] But approximately 300 to 350 million more Chinese were averaging consumption at that level in 1977 than 20 years earlier, and a smaller proportion of production was devoted to direct human consumption (livestock feed accounted for much of the difference).[12] Then, too, 1977 was the second year of grain production stagnation, resulting in part from extremely dry weather, while 1957 and 1958 were at the apex of 1950s growth, not again surpassed until the mid-1960s.

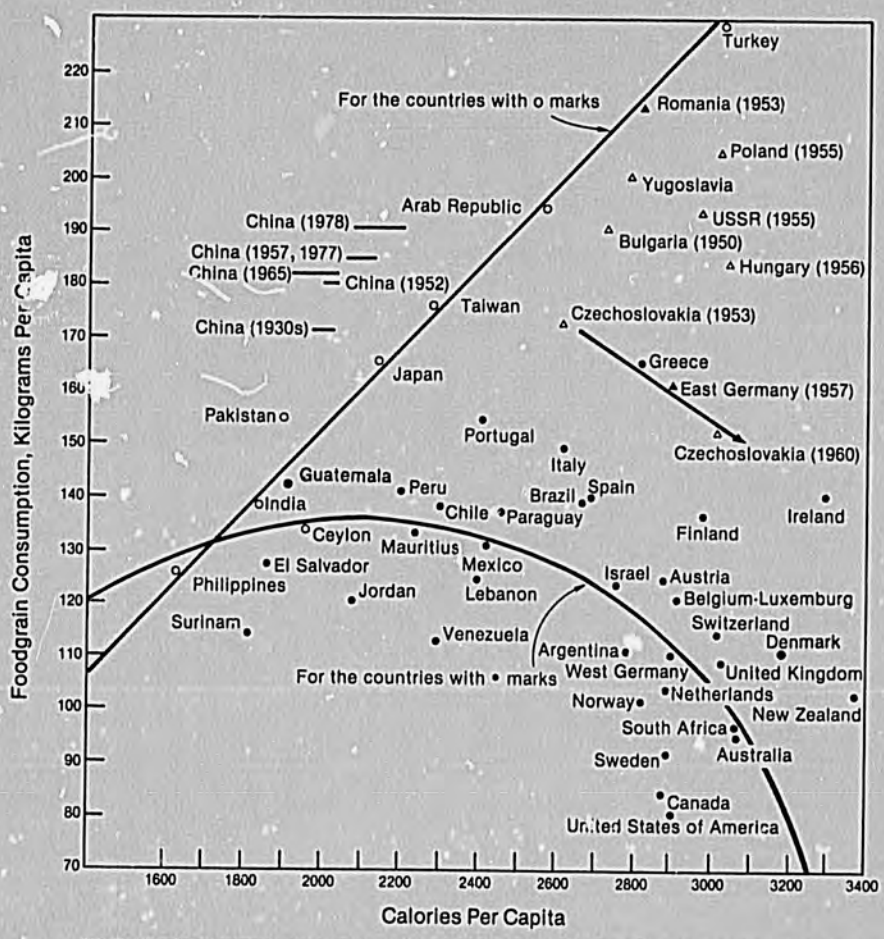
The principal point to keep in mind in comparing past and present Chinese consumption levels is that the average level in the 1930s was already very high by international standards and the 1978-79 average level ranks China among the highest in the world. There remains excess direct demand for grain in China, not because average per capita consumption is low, but because sizable segments of the population have been consuming well below the average and because even average supply of nongrain foodstuffs is low. Purchasing more foodgrains is the cheapest means for individuals to augment consumption and producing more foodgrains is the least land-consumptive means for economic planners to supply the extra demand for calories.

Figure 1, most of which is borrowed from a 1977 article by Ishikawa, is an international cross-section of average annual foodgrain consumption per capita plotted against average daily caloric consumption per capita from all food sources. Nations represented by triangles are Eastern European socialist countries. Those represented by circles along the rising trend line are Asian, and dots, along the falling trend line, represent all others. Among a variety of interesting observations drawn by Ishikawa, the figure makes clear that China's total caloric consumption is modest (about average among developing countries) but that its foodgrain consumption per capita ranks high. This observation suggests that improvements in the nonfoodgrain diet might be a much higher Chinese priority than further increments of foodgrains for direct consumption. But this ignores the tendency of socialist planners to prolong concentration on foodgrain output expansion, and high average foodgrain consumption levels in Asian countries generally, as well as the issue of distribution around the quoted mean levels.

Raising The Consumption Level of the Lowest 20 to 40 Percent of the Population

The redistributive nature of government policy and egalitarian nature of Chinese society can be easily exaggerated. The development process is normally associated with a widening of rural income differentials, and redistributive efforts have had to contend with this effect as well as the original maldistribution. Over and above the minimum guarantees of foodgrains, cloth, oils, shelter, basic medical treatment, rudimentary education, and so forth, the socialist principle of "each according to his work" has, in many respects, clearly triumphed over the communist principle of "each according to his need," and recent policy changes have effected an even greater compensation emphasis upon results achieved over effort expended in rural areas.[13] The land reform in the early 1950s, though clearly redistributive, by no means eradicated rural income differentials (see Table 2), and it appears quite possible that the subsequent collectivization movement and other redistributive activities were even less effective in reducing the remaining differences, except to the extent that they provided greater security against drastic temporary and trend degeneration of welfare.[14] Although China's rural income distribution is one of the most egalitarian in the world today, average per capita incomes vary considerably among administrative and productive units. In 1977, for example, average foodgrain distribution in Jiangsu was 44 percent greater

Figure 1—International cross-section relationship between per capita grain consumption per year, and per capita calorie intake per day of all food



Note: The figures for per capita foodgrain consumption are calculated as the sum of the weight of processed foodgrains consumed directly by humans and one fourth of the weight of tubers. To conform with other international data, the entries for China omit soybean consumption, which is normally included in the Chinese definition of foodgrains.

Sources: Shigeru Ishikawa, "China's Food and Agriculture: A Turning Point," *Food Policy* 2 (May 1977): 93. The idea for the graph and all entries except those for China are from Ishikawa. He used data for socialist countries for the dates indicated; where the date is not given, figures are from Food and Agriculture Organization of the U.N., *1965 FAO Production Yearbook*, vol. 19 (Rome: FAO, 1966). For China the data was derived as follows: the figures for the 1930s, 1952, and 1957 are recomputations of data appearing, for the most part, in Thomas G. Wiens, "Agricultural Statistics in the People's Republic of China," in *Quantitative Measures of China's Economic Output*, ed. Alexander Eckstein (Ann Arbor: University of Michigan Press, forthcoming), Table II-9. For the 1930s following Wiens' suggestion, the "low" figure for rice and the "high" figures for other grains were used, omitting soybeans. Population figures are, for the 1930s, from Ta-chung Liu and Kung-chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* (Princeton: Princeton University Press, 1965), p. 178; the figures for other years are May 1979 midyear estimates by John Aird appearing in U.S. Central Intelligence Agency, National Foreign Assessment Center, "China: A Statistical Compendium," ER79-10374, Washington, D.C., July 1979, p. 5. Estimates of foodgrain percentage in total calorie consumption range from 85 percent (soybeans excluded) to 90 percent (soybeans included) (see Stone, "A Review of Chinese Agricultural Statistics," International Food Policy Research Institute, Washington, D.C., June 13, 1979, Table 5). These figures determine the range of the estimates. The 1977 foodgrain output figures by crop are from Table 11 (tubers reconverted to one-fourth of their natural weight, soybeans excluded). Net foodgrain imports are from Stone, "A Review of Statistics," Table 6. The figures for processing loss by crop and calories per piculi (0.05 tons) are from Wiens, "Agricultural Statistics." The midyear population was estimated by Aird, in CIA, "China: A Statistical Compendium." The percentage used for direct human consumption was 79 percent (Stone, "A Review of Statistics," Table 4). The foodgrain percentage in total calories assumed the same range as above. There is no strong statistical basis for the assumption, but scattered reports of low output levels of nongrain foods suggest that this percentage has not fallen significantly.

The total output for 1965 is from Table 1. The sources of disaggregated figures are as follows: wheat, Wiens, "Agricultural Statistics," Table II-15; soybeans, the sown acreage from Wiens, "Agricultural Statistics," Table II-14, and the yield from Stone, "A Review of Statistics," Table 8; coarse grains and tubers (assumed to be the same as in 1957), Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China* (Chicago: Aldine, 1967), pp. 338-39; rice is a residual when tubers are converted to one-fifth of their natural weight. The percentage of foodgrains consumed directly is 82 percent (Stone, "A Review of Statistics," Table 4); all other figures are from same sources as for 1977.

The total output for 1978 is from Table 1 except that net foodgrain trade figures from Stone, "A Review of Statistics," Table 6 have been added, potatoes have been reconverted to one-fourth of their natural weight, and soybeans have been omitted. Output figures from 1977 were adopted for potatoes and soybeans; otherwise, wheat, coarse grains, and rice were estimated to increase in equal proportions to account for 1977-78 difference in domestic output. The midyear population is from Aird, in CIA, "China: A Statistical Compendium." All other parameters used are the same as for 1977 above, except that the percentage of foodgrains consumed direct[illegible] is assumed to have fallen from 79 percent to 75 percent and the proportion of foodgrain calories in total calorie consumption is assumed to have fallen from 85 percent to 83 percent (if soybeans are excluded from foodgrains) and from 90 percent to 89 percent (if they are included). The justification for these hypothesized declines may be found in the text and in Stone, "A Review of Statistics," Tables 4 and [illegible]. If the 1977 proportions are assumed, the 1978 coordinate would be just above 200 kilograms and slightly to the left of the indicated 1978 coordinate (though still to the right of 1977). Since soybean consumption per capita has probably declined by at least 30 percent since 1957, the higher end of the total calorie consumption ranges for 1977 and 1978 (based on the "without soybean" calculation) are suggested.

Table 2—Changes in the distribution of per capita income produced, 1930s to 1952

Percentile	Share of Farm Income			Share of Total Income		
	1930s	1952	Change in Share	1930s	1952	Change in Share
	(percent)			(percent)		
Top 10	26.0	21.6	-4.4	24.4	21.6	-2.8
Top 20	42.7	35.1	-7.6	42.0	35.0	-7.0
2nd 20	23.8	21.3	-2.5	23.9	21.3	-2.6
3rd 20	16.3	17.5	+1.2	14.9	17.4	+2.5
4th 20	11.4	14.8	+3.4	13.2	15.0	+1.8
Bottom 20	5.8	11.3	+5.5	6.0	11.3	+5.3
Bottom 20	1.8	5.1	+3.3	2.5	5.1	+2.6
Average per capita income (catties of grain)[a]	972	920	...	1,084	1,082	...

Sources: Table 6 and Robert C. Roll, "Incentives and Motivation in China: The 'Reality' of Rural Inequality," a paper presented at the annual meeting of the American Economic Association, Dallas, Tx., December 28, 1975, pp. 27, 49.

The distribution of incomes for the 1930s is derived from the sample survey data presented in John Lossing Buck, *Land Utilization in China*, 3 vols. (Nanking: University of Nanking Press and Chicago: University of Chicago Press, 1937), Statistics, in Roll, "Incentives and Motivation," Chapter 3.

[a] One catty equals 0.5 kilograms.

than that of Ningxia, while average distributed income per capita (excluding private plot and sideline income) in Shandong was over 77 percent higher than that of Ningxia (see Table 3). Turning to variations within provinces, in 1978 Zhejiang's 10 high-yield counties averaged 161 yuan of distributed income per capita, 57 percent above the provincial average of 102 yuan, whereas the four poorest counties averaged 40 yuan per capita.[15] Among communes, average per capita income levels may still vary on the order of 1:10, and differences within communes and even brigades remain substantial.[16] In 1979 Shanghai's 10 richest brigades averaged 325 yuan per capita, whereas the 10 poorest averaged 190 yuan per capita.[17] Thus, the available information on distribution would indicate that for the poorest members of the poorest communes, the margin of consumption of calories (and even of rationed foodgrains)[18] above a modest subsistence level may be very slight, despite average rates of foodgrain consumption ranking among the world's highest.

A formal foodgrain rationing system in both rural and urban areas was instituted in the mid-1950s. By 1956-57 the average urban ration had been raised from 125.8 to 134 kilograms of grain per capita (processed). These rations represented minimum guarantees; average consumption levels were purported to be significantly higher.[19] Although harvest fluctuations remain a problem in broad regions throughout China, resultant extreme losses in income documented by Buck[20] for earlier years are far less of a threat. Moreover, a variety of redistributive policies and activities of the Chinese government assist backward provinces and localities in maintaining subsistence and ensure all areas against extreme harvest loss.[21]

But there are indications that the rationing mechanism may break down in some of the areas most in need. Refugee-based research reveals cases of malnutrition in localities of several regions of China,[22] and Chinese press statements have indicated that 200 million peasants each consumed less than 150 kilograms of grain in 1978.[23] If this figure refers to unprocessed grain, then the processed figure would be around 124 kilograms,[24] well below the 1957 average urban ration. This suggests that some of the targeted increase in production might be devoted to raising the consumption standards of the bottom quintile of the population.

Although it is difficult to estimate how much positive distributional impact on China's lower income and consumption strata will result from the broad spectrum of recent policy changes to be discussed later in the paper, some direct measures have

Table 3—Average rural provincial foodgrain and income distribution

Province	Average Foodgrain Distribution Per Capita					Average Cash Distribution Per Capita from Collective Income		
	1976	1977	1978	1979	1957	1977	1978	1979
	(kilograms)					(yuan)		
Anhui							66.7	70.2
Beijing								8.7 greater than 1978
Gansu								20.8 greater than 1978
Guangdong			32 greater than 1977					
Heilongjiang						84.0	110.0	
Henan								7.8 greater than 1978
Hunan								13.5 percent greater than 1978
Jiangsu		219.5	249.5			67.0	85.0	
Jiangxi				300.0			73.0	89.0
Jilin		209.0	249.5			81.0	107.0	
Liaoning		205.5	220.0			77.0	87.6	
Ningxia		152.2	187.2			63.5	80.2	
Qinghai			25 greater than 1977					
Shandong			24 greater than 1977			112.6	112.4	
Sichuan	184.4	217.5	246.6	250.0		10 greater than 1976	8 greater than 1977	
Xinjiang		169.3	184.8	193.3		73.6	85.6	102.6
Xizang			37 greater than 1977			104.0	130.0	
Zhejiang			42.5 greater than 1977	285.0	57.5	64.5	102.5	120.0
Average			9 percent greater than 1977				13.7 percent greater than 1977[a]	

Sources: Average foodgrain distribution per capita: Stone, *A Review of Chinese Agricultural Statistics 1949-79*, Research Report 16 (Washington, D.C.: International Food Policy Research Institute, forthcoming), Table 4A.

Average income distribution per capita:

Anhui: FBIS, *PRC*, April 22, 1980, p. O4; and January 16, 1980, p. O4.
Beijing: FBIS, *PRC*, February 14, 1980, p. L1.
Heilongjiang: FBIS, *PRC*, July 3, 1979, p. S3.
Henan: FBIS, *PRC*, April 3, 1980, p. P1.
Hunan: FBIS, *PRC*, March 25, 1980, p. P6.
Jiangsu: FBIS, *PRC*, May 25, 1980, p. O3; May 30, 1980, p. O4.
Jiangxi: FBIS, *PRC*, April 24, 1980, p. O8.
Jilin: FBIS, *PRC*, May 1, 1979, p. S3; May 9, 1979, p. S4; "Rural Economy Looking Up," *Beijing Review*, May 11, 1979, p. 5.
Liaoning: FBIS, *PRC*, June 5, 1979, p. L9; June 8, 1979, p. S4.
Ningxia: FBIS, *PRC*, May 16, 1979, p. T1 (where the 1978 increase over 1977 was given as 26.3 percent); elsewhere it was given as 16.7 yuan.
Shandong: "up 9.8 yuan in 1978" FBIS, *PRC*, April 25, 1979, p. O5; "up 8.7 percent" FBIS, *PRC*, June 25, 1979, p. L18.
Sichuan: FBIS, *PRC*, April 4, 1979, p. Q1; May 14, 1979, p. Q4.
Xinjiang: FBIS, *PRC*, May 11, 1979, p. T1; April 10, 1980, p. T2.
Xizang: FBIS, *PRC*, June 25, 1979, p. Q2.
Zhejiang: "Average rural per capita income in the highest yield counties in 1978 was 161 yuan...57 percent greater than the provincial average" (FBIS, *PRC*, April 17, 1979, p. O4). Also see, FBIS, *PRC*, February 13, 1980, p. O4.

All provinces: FBIS, *PRC*, June 14, 1979, p. L9; Minister of Finance Zhang Jingfu "Report on the Final State Accounts [illegible]78 and the Draft State Budget for 1979" (delivered at the 2nd Session of the 5th National People's Congress on June 21, 1979), Xinhua [New China] news bulletin, June 29, 1979; FBIS, *PRC*, July 3, 1979, pp. L6-L7.

Note: Income and foodgrain distribution is shown, but not private plot and sideline income.

[a] 1979 per capita income distribution from the collectives increased more than 10 yuan over 1978 and 20 yuan over 1977, suggesting that the national average was less than 73 yuan in 1977 and less than 93 yuan in 1979.

been taken that should raise consumption standards of the poor localities over 1979 levels. Already in 1978 large increases in collective income and foodgrain distribution were registered in a majority of Chinese provinces. Except in two cases, all provinces, municipalities, and autonomous regions increased per capita collective distribution. The average provincial increase across China was 9 percent for foodgrains and 14 percent for per capita distribution of collective income (see Table 3). In 1979 the state reduced (compulsory) rural grain purchases by 2.5 million metric tons. From 1979 onward, wet rice areas with foodgrain rations of less than 200 kilograms (probably unprocessed) and nonstaple foodgrain areas with rations under 150 kilograms have been exempt from state purchases. Newly reclaimed land will be exempt from state purchases for the first five years of production.[25]

Agricultural taxes, which averaged a little over 5 percent of agricultural crop output in 1974 [26] and 3.35 percent of gross industrial and agricultural output value of rural areas in 1977, were further reduced or eliminated for poor communes. Rural processing enterprises operated by the people's communes are now tax exempt until the annual profit reaches 3,000 yuan (as opposed to 600 yuan before), while all new rural industrial enterprises (exclusive of tobacco factories, distilleries, wineries, and cotton mills) in financial difficulties can operate tax-free for two to three years. In frontier counties and national autonomous areas, the tax exemption is for five years. The Ministry of Finance estimates that these tax reductions alone will add 1 billion yuan to rural incomes.[27] The incidence of the tax reductions falls primarily on low-income areas.

There remains an estimated 25.4 billion yuan flowing to China's countryside in 1979 from the state[28] to be set against remaining direct and indirect rural taxes. Although social relief funds and aid to communes and brigades are included in this sum, the extent to which low-income groups will benefit from the programs financed thereby remains unclear.

If we made the very conservative assumption that income distribution in 1978 was no more egalitarian than it was at the end of the land reform in 1952 and that foodgrain distribution was identically correlated with income distribution, then the bottom income quintile of the Chinese population consumed an average of 113.6 kilograms of processed grain per capita in 1978 and the fourth quintile averaged 150.7 kilograms per capita.[29] Bringing the bottom quintile's consumption up to the estimated 1978 average level of 201 kilograms per capita would then require about 21.3 million metric tons (unprocessed grain); the fourth quintile's requirement would be about 12.2 million metric tons for a total of 33.5 million metric tons.[30] All things considered, however, it seems highly unlikely that the 1978 income distribution is as skewed as it was in 1952, whereas it is very likely indeed that the distribution of foodgrain consumption is significantly less skewed than is income, even considering flaws in the rationing system and upward leaks in the official distribution ceilings.[31]

Furthermore, ignoring the above-mentioned biases, if the 150-kilogram figure quoted by the Chinese press is in terms of processed grain, then the incremental foodgrain requirement to bring the consumption of the bottom two quintiles up to the average is more likely to be in the neighborhood of 20 million metric tons (unprocessed). Moreover, it is not at all clear that the Chinese government has the intention of increasing consumption levels of poor localities to anywhere near the current national average through unilateral state programs within the 1979-85 planning period. Under our more pessimistic assumptions about the 1978 mean level of per capita consumption of the bottom quintile of the population (113.6 kilograms per year), raising the average to 150 kilograms (123.75 kilograms processed) would require a little less than 2.5 million metric tons, which would be covered by the 1979-85 reduction in compulsory grain deliveries. In the eyes of the government, this sum would be enough to alleviate the most drastic insufficiencies among the Chinese population.[32]

If the sole beneficiaries of the one billion yuan to be transferred to rural areas through tax reductions were lower-income groups and this sum completely devoted to increased grain consumption (which may be perilously close to the truth), an estimate of 4.3-5.8 million metric tons of additional grain[33] would be available to the bottom quintiles for a total of 7-8 million metric tons.

The remaining 25.4 billion yuan flowing to rural areas in 1979 is an estimated gross sum, not an increase over 1978. Aid to rural

communes actually declined (from 7.695 billion yuan to 7.05 billion yuan) from 1978 to 1979.[34] Funds for capital construction, rural enterprises, and social relief rose from 4.8 billion yuan to 7.8 billion yuan, but of the increment, the extra share devoted to social relief was probably not large.[35] Loans to communes and brigades from rural banks and credit cooperatives rose from 10.03 billion yuan to 13.03 billion yuan, but the lion's share (11.6 billion yuan) was devoted to agricultural development and commune-run industries, and certainly not to consumption loans.[36] By far the largest increase in the rural package derives from an estimated 8 billion yuan for increases in state purchase prices for agricultural products.[37] But, as will be discussed in subsequent sections, the primary incidence of this increase will more likely be in high-income and fast-growing rural areas.

In summary, although the lowest two quintiles of the Chinese population may require 20-33 million metric tons per year of additional foodgrains to achieve the 1978 national average for per capita consumption, direct financial arrangements may make possible increases of around 7-8 million metric tons if the 1979 policy changes extend through 1985. Further improvement for those poor areas appears to be dependent on production increases and population control, both of which may continue to be difficult tasks despite policy changes which facilitate the former, especially in well-organized and wealthier areas.

Maintaining Per Capita Consumption Levels

The next question to be addressed is that of how much foodgrain will be required to maintain the status quo: that is, to feed the 1985 population at the sufficiency level achieved for the 1978 population. The important thing to note is that incremental demand in this regard will not be generated so much from numerical growth in population as from chronological growth. In estimating how much additional grain must be supplied to satisfy all of China's citizens in 1985 to an extent equal to that enjoyed in 1978, one must first recognize that an identical per capita ration will not be sufficient owing to the changing age distribution of the Chinese population. Although there appears to be no one inside or outside China who has a highly detailed and accurate knowledge of the Chinese population, John Aird, of the Foreign Demographic Analysis Division of the U.S. Department of Commerce, appears to produce the most comprehensive and authoritative materials readily available on the subject. If his figures[38] are even generally correct, something on the order of 40 percent of China's population in 1978 were children under 15 years of age. The results of a recent sample survey conducted by Song Jian and three other Chinese scientists seem to confirm Aird's data, suggesting a figure of 38.6 percent. This means that the numerical mean ration based upon the entire population (approximately 201 kilograms per year processed, aside from stock contributions) is substantially below the average adult ration (which may be as high as 269 or more kilograms).[39] Thus, even if birth and death rates were zero over 1979-85, a sizable amount of grain would be required to supply the new adults with adult rations, and adolescents with increases commensurate with their quantitatively greater nutritional requirements in 1985.

Appendix I attempts to incorporate this phenomenon into a rough estimate of incremental foodgrain requirements for supplying the 1985 population with rations equal to those available to members of a similar age group in 1978. In the absence of relevant Chinese data, people 15 years old and older have been assigned 100 percent of an adult ration indiscriminate of age and sex. The weighting then proceeds: 14 years (90 percent), 13 (80 percent), 12 (70 percent), 11 (60 percent), 10 (50 percent), 9 (45 percent), 8 (40 percent), 7 (35 percent), 0-6 (an average of 15 percent) of an adult's ration.

There is no doubt that these weights are highly arbitrary, but it is quite likely that they represent some improvement over the assumption that all newborn children are immediately adult consumers and that changes in the age distribution of the population have no impact on the degree of adequacy of foodgrain supplies. Since there is no data available for age distribution of deaths, all deaths (1979-85) are assumed to be of adults, which gives a systematic downward bias to the estimates; but child deaths have been greatly reduced in China in the past 30 years, so the size of the error, in view of the relatively low hypothesized

death rates, may not be too large. Furthermore, the bias should be partially counterbalanced by the absence of an estimate for the reduction in consumption requirements for aged Chinese over the 1979-85 period.

The results of this exercise show that a large quantity of grain—about 42-46 million metric tons per year—will be required by 1985 over and above the 1978 level just to hold the line on consumption per person relative to age. China's fulfillment or failure to fulfill 1980 and 1985 target rates of natural increase is fairly immaterial to the estimates. As Appendix 1, Table 12 shows, the Official A estimates use the official 1978 vital rates (including the lower of the two given death rates) and assume a 1 percent rate of natural increase during 1980-85. The Official B estimates use the official 1978 rates (including the higher of the two death rates) and assume rates of natural increase of 1 percent in 1980 declining to 0.7 percent in 1985. Aird's estimates, based on his projected rates, are actually the lowest owing to his higher hypothesized death rates. The three estimates are all relatively close since they all depend heavily on Aird's population estimates for 1963-78, which have been selected as those most likely to be accurate among series readily available. Even official population estimates are now drawing very close to Aird's.[40]

Grain Stockpiling, Food Processing, Brewing, and Other Industrial Uses

China's national grain stockpile, which was probably quite depleted by the early 1960s, was as high as 40 million metric tons in the early 1970s and is apt to be no lower in 1979 despite two recent years of output stagnation. It has therefore been accumulating at an average rate of 1-2 percent of yearly output. A 1.5 percent figure would allow China by 1985 to surpass its long-range stockpiling target formulated in the early 1970s; a lower figure is more likely in view of greater administrational emphasis since 1978 on leaving more grain in rural areas.[41] But even the 1.5 percent figure would only take 6 million metric tons from a hypothetical 400-million-metric-ton 1985 production figure and less than 1.5 million metric tons of the 95-million-metric-ton increment.

These figures probably do not include local and provincial stocks, of which very little quantitatively is known. Although visitors' reports confirm the existence of stocks at several local levels, the slight information available indicates that they may not be comparable in the aggregate to the national stockpiles.[42]

Ishikawa has estimated that the proportion of grain used in industry and for food processing and brewing in 1952, 1956/57, and 1965 were 2 percent, 3 percent, and 2 percent, respectively.[43] His foodgrain balance calculations in a recent article suggest that the proportion may only have risen to 3 percent again by 1974.[44] If this is so, then it seems likely to have declined again in 1976/77 when foodgrain production per capita dipped back toward the levels of the 1950s and 1960s, exacerbated by larger feedstock requirements.[45] The proportion should have recovered to 3 percent in 1978, and with prospective grain production increases running well ahead of population growth, it can be expected to rise slowly over the 1980s. A proportion of more than 6 percent (6 million metric tons) for the hypothesized increment of 95 million metric tons (not the average for 400 million metric tons) would not be surprising in view of a renewed flurry of activity[46] in such industries and more favorable tax and financing schemes available from 1979.[47] This would bring the average proportion for the entire 400 million metric tons toward 4 percent by 1985.

If 7-8 million metric tons for immediate increased direct consumption levels of the lowest quintiles, 1-2 million metric tons for stocking, 6 million metric tons for industrial use, food processing, and brewing, and 42-46 million metric tons for population growth are added, it would still leave 33-39 million metric tons of the targeted increase unaccounted for.

Past and Future Trends For Livestock Feed

A large portion of the remainder, particularly in view of the relatively low probability of actual target fulfillment by 1985, is likely to be devoted to improvements in diet quality (as opposed to quantity). Aside from illustrations of China's unusually high foodgrain consumption per capita figure, Figure

1 also indicates the relatively modest position with respect to nongrain caloric intake per capita. For nonrationed items such as fruit and animal products,[48] the skewness of distribution far exceeds that of foodgrains. With average consumption at very modest levels, and greater skewness, it is clear that the bottom brackets enjoy very little of these commodities.[49]

The most important food in this respect is undoubtedly pork. The Chinese have focused on increasing the pig population because of its fecundity and early maturity, its omnivorous and hence less immediately competitive consumption habits, its importance in traditional Chinese diets, and its efficiency as a fertilizer producer. The hog population has quintupled since 1949[50] despite major setbacks due to pricing inconsistencies and excessive compulsory grain deliveries in the mid-1950s (and very possibly the mid-1970s),[51] as well as an intermediate decline due to the agricultural failures of 1959-61.

The average annual peasant consumption of pork in 1952, 1955, and 1956 was 4.95 kilograms, 3.3 kilograms, and 3.85 kilograms, respectively, with worker and employee consumption in 1955 at 5.90 kilograms.[52] Chinese figures place 1977 consumption of all meats (dominated by pork) at 7.5 kilograms per year,[53] somewhat lower than recent Western estimates,[54] and there are current plans to further increase these levels to deal with active unsatisfied demand. Although rural private and collective pigs are fed a substantial amount of nonfeedgrain, low-opportunity-cost materials, Western analysts suggest that further increases in hog stocks will require a commitment to increase the percentage of feedgrain consumption.[55]

In any event, the planned improvement in diet quality[56] will be a more land-consumptive means of furnishing calories. Ishikawa estimates the cultivated land requirements for supplying meat and vegetable oils at, respectively, 3.3 and 10 times that of furnishing foodgrains directly.[57] Public pledges by party and government officials and reports of pent-up demand for meats and oils are entirely consistent with China's high relative proportion of foodgrains in total calories consumed (see Figure 1), rising disposable income per capita in both rural and urban areas,[58] recent policy changes that immediately raise rural and urban money income,[59] and high-income elasticities of demand for such products relative to foodgrains.[60]

The proportion of foodgrain production used for livestock feed in the 1930s has been estimated at about 12.5 percent[61] and was roughly the same in the 1950s. About one-fifth of this was fed to hogs.[62] The share for all animals may have been as high as 14 percent in 1965[63] and 14-17 percent in 1974,[64] if fine-feed (concentrate) consumption rates per head of livestock were allowed to drift up with increases in per capita grain supplies for nonseed purposes as hypothesized by Ishikawa. A rough calculation on 1978 livestock figures[65] indicates that if rates of concentrate use per head of livestock and the ratio of whole grain to millings were kept at the low 1957 levels, only about 10.7 percent of total 1977 foodgrain production (or 9.9 percent of 1978 production) was consumed by pigs and large animals, although almost 40 percent of the total was hog feed.[66]

These last figures may be a closer approximation of current reality since even model pig-raising units in the late 1970s were feeding their animals an average of only 10.8 percent more grain per head than in 1957.[67] Even if the latter were representative of pig raising generally, it would require less than an additional 1 percent (for a total of 11 percent) of total grain supplies.

But current policy is moving away from grain-saving techniques.[68] If the entire nutritional requirements of the 1978 Chinese hog stock were supplied by grains and millings, it would necessitate the allocation of an additional 30 million metric tons. This, of course, will not occur, but present policies could bring about a 15 percent increase in the long-term hog population growth rate through 1985 (from 3.5 percent to 4 percent). Some of the increment over the old rate could result from planned and current development of suburban pig farms requiring high rates of concentrate use. But development of these farms would have to occur at several times the current rate to utilize as much as a million tons of foodgrain by 1985.

Assuming essentially no growth in absolute quantities consumed by the stagnant large animal population,[69] adding 95 million pigs to the 1978 stocks would mean an extra 4 million metric tons of feedgrains. This includes the high concentrate diets of hogs reared on present and planned suburban pig farms, but not any further upward drift in the fine-feed consumption rates of private

and collective sideline pigs. If concentrate consumption by all pigs were allowed to drift up by a second 11 percent over 1957 levels (to the average level of state procured pigs in the first six months of 1979), an extra 2 million metric tons would be needed.

The target adopted by the Central Committee in December 1978 called for a 30 percent increase in cattle, sheep, and pigs and for the annual quantity of meat products to double by 1985.[70] This would mean an additional 90 million hogs, 51 million sheep, and 3 million cattle above December 1978 stocks, and an extra 7.5 million metric tons of meat products.[71] Assuming the higher of our previous fine-grain consumption rates for hogs, the 1957 rate for large animals, and the 1957 ratio of grain to millings in concentrate synthesis for all stock (45:55), then the targeted increments would call for 3.8 million tons and 1.2 million tons of additional unprocessed grain for pigs and cattle, respectively. It should be noted that to say that cattle herds will increase by 30 percent does not imply a 30 percent increase in China's 84 million other large animals (including horses, donkeys, mules, camels, yaks, and breeds of oxen excluded from cattle statistics).[72]

Large Animals

In 1957 water buffalo accounted for 13.127 million (15.7 percent) of China's 83.457 million large animals, whereas all varieties of oxen numbered 50.485 million (60.5 percent).[73] By 1978 large animals had only reached 93.89 million with "cattle" accounting for about 10 million (10.7 percent) of the total.[74] Cattle here include water buffalo (about 20 percent of the total) and dairy cattle, but possibly only the common (yellow) ox from among a number of varieties,[75] or only those raised specifically for beef as opposed to those used as draft animals. If it includes all oxen, then numbers of other draft animals believed to be in decline must have increased over the 1957-78 period, while cattle numbers alone dropped drastically. This contradicts both Western analysts and the implications of official reports. Even if the 10 million figure does not include most oxen, it is clear that most of those that are included, as well as the stocks of water buffalo, have declined since 1957. This conclusion seems to be borne out by scattered reports from both agricultural and herding provinces.[76]

The government has aggressive plans to increase China's inadequate herd of 500,000 dairy cattle and is developing long-range schemes to utilize the northern grasslands for beef cattle.[77] But the plans are still too small in scale and the transformation of the grasslands too distant to reach the required numbers by 1985, let alone the figure for meat increase. In the collective economy of major growing areas, cattle raising cannot be expected to compete economically with pig raising, and calving rates are too low to generate the required increases.

The most auspicious opportunity is probably presented by major herding provinces such as Qinghai, which accommodated 16 million cattle in 1956,[78] as opposed to 5 million in 1979.[79] Restoration of reclaimed farmland to pasture and elimination of government limitations on private stock, as well as technical progress in breeding and varietal improvement, should facilitate the process of recovery and expansion, provided the decimation through soil erosion of former pasture is not critically extensive.

The additional yield of meat from an extra 3 million head is likely to be only about 40,000-140,000 kilograms [80] due to the unavoidable low slaughter rate of large animals. It is not impossible that the stock increment (1979-85) will exceed the given figure,[81] but the additional feedgrain required is not apt to surpass the estimated 1.2 million metric tons since the largest stock increases are likely to occur in pastoral provinces such as Qinghai and Xinjiang, where cattle will feed primarily on grasses.

As for other large animals (except perhaps camels, yaks, and highland horses), it is reasonable to assume that stock increases in herding provinces and middle-income localities better able to afford draft animals will be largely offset by continued stock declines in the poorest agricultural localities (owing to more direct competition with humans and with the more economical meat-and fertilizer-producing hogs) as well as in richer areas where more extensive and effective mechanization will continue to displace draft animals.

Sheep and Goats

Sheep and goat numbers have already

responded well to pastoral policy reform and will be quite capable of reaching and even surpassing their target. Following 15 years of growth at slightly over 2 percent per year (1962-77), herds expanded 5.3 percent between December 1977 and December 1978, 7.3 percent between July 1978 and July 1979, and 4.1 percent between December 1978 and December 1979.

Less than 4 percent per year (1978-85) would be required to increase numbers by 30 percent over the December 1978 stock of 170 million.[82] But at current slaughter rates (about 40 percent), the targeted increment of 51 million head would only provide 300-500 thousand tons of lamb and mutton.[83] The herd growth rate may indeed be higher than the hypothesized 4 percent per year. A high rate is indicated not only by the 1978-79 performance, but by a new slaughtering regimen which should take the maximum number of animals in the fourth quarter for more efficient fodder utilization and maximum herd growth.[84] But even considering the auspicious signs, the meat contribution of the increment to the sheep and goat population is not likely to be more than a million tons.

Fortunately, although both the late 1950s and mid-1970s were periods in which pastoral lands were viewed as prime targets for expansion of grain acreage,[85] the current period rejects such a view. Herders have been released from grain production duties to a considerable extent, and herding is no longer regarded as a retardant of progress in grain production.[86] Because the vast majority of China's sheep and goats are raised in predominantly herding areas where the animals graze for most of the year and winter for two to three months on cut grasses,[87] no estimate has been made to account for extra feedgrain consumption of these animals.

Poultry

No mention of poultry has been attempted thus far. Unfortunately, national statistics on absolute poultry numbers are unavailable, probably even to Chinese officials. Therefore, increments to feedgrain demand from this source have been ignored. By means of justifying the omission, an "order of magnitude" estimate of poultry numbers in 1979 has been made on the basis of the quantity of chicken eggs purchased by the state during the first half of the year.[88] Although the results of this exercise must be regarded as an extremely loose approximation, they suggest that poultry numbers (including chickens, ducks, and geese) may have been on the general order of a billion birds at midyear 1979, about three times the estimated figure for 1956,[89] implying a growth rate of about 4.7 percent per year.

If this rate were extrapolated or even doubled through 1985, additional grain demand generated by the increment over 1978 stocks would be well within the most optimistic standard of error for our estimate of aggregate incremental demand for foodgrains between 1979 and 1985. This is especially true because the amount of grain the average Chinese bird is allowed to consume has been kept low. New suburban facilities for poultry and egg production accommodate about 200,000 birds, while new commune-level facilities average about 7,000 birds.[90] Development of the former, although contributing to increased feedgrain demand, is still in the initial stages (the first large center was opened in 1978),[91] whereas commune facilities are of a size that allows substantial substitution of low-opportunity-cost materials for feedgrains.

Hogs: Greater Numbers Versus Heavier Stocks

Unless poultry is counted as meat, the bulk of the targeted meat product increase of 7.5 million metric tons must come from hogs. But how much meat can be expected from an increment of 90 million hogs? Using parameters from the mid-1950s, the quantity of pork available from the increment would be 2.3-3.1 million metric tons,[92] which together with increased mutton and beef could reach the neighborhood of 4 million metric tons of extra meat. Increased consumption of large species principally identified as draft animals has not been included (the most important omission is probably that of yaks). Inclusion of dead draft animals and yaks raised for meat might add an absolute maximum of about 2 million metric tons to 1978 total meat consumption figures,[93] but surely a much smaller figure (at least an order of magnitude lower) is appropriate for the probable 1985 increment over that level.

If fulfillment of the target for increased meat is seriously intended (which cannot be taken for granted), the solution to the problem may lie in attempting to drive the hog stock growth rate beyond 4 percent per year; attempting to increase the average weight of hogs; or a combination of both approaches. Boosting the rate of stock increase has the disadvantages of requiring lower slaughter rates early in the period and requiring large and sudden, rather than gradual, increases in grain-consuming stock held over the winter—just at a time when it appears the leadership has finally come to believe that it is quite important to bring about some clear and immediate improvements in popular living standards, especially in rural areas.

Increasing the average weight per pig, however, would seem to require even more fine feed for each additional kilogram of pork. If the remaining 3.5 million metric tons of targeted meat production were to be attained entirely from increased hog numbers, the 1985 stocks would have to be some 76 percent above the year-end 1978 level. A further increment of 5.5 million metric tons of unprocessed grain plus additional millings would also be required.[94] If the same result were to be achieved by increasing the weight of the planned 1985 stock of 392 million hogs (1978 stocks plus 30 percent), the required weight increase might be over 22 kilograms (for a total of about 90 kilograms per hog at slaughter time if the 1957 average was relevant for 1978).[95] According to previously well-accepted parameters in the 1930s, this would necessitate the allocation of an additional 18.2 million metric tons of feedgrains.[96]

Chinese officials until recently have evidently maintained a policy of pushing low concentrate use in feed schedules to an uneconomical extent.[97] The result of a typical 1974 official study[98] implied that as much as 20-23 million metric tons would be needed to add an average of 22.4 kilograms to the weight of 329 million hogs (making sure that it would appear quite foolhardy not to slaughter after a relatively brief and concentrate-scarce period for fattening weaned shoats). But calculations based upon a recomputation by Wiens of a 1957 Chinese study (the original results of which may have been altered to conform with official concentrate conservation policy)[99] indicate that the feedgrain requirement for an extra 22.4 kilograms per hog would be, on the contrary, in the range of 11-15 million metric tons, depending upon the quantity and mix of supplementary feed used. This range is even below the figure of 18.2 million metric tons derived by assuming 4 kilograms of concentrate (grain and millings) per kilogram of incremental hog weight, widely used as the rule of thumb in China in the 1930s.

Requirements and Availability of Millings

All estimates made so far have been based on a 1957 grain proportion of 44.7 percent of total concentrate weight. Most of the remaining weight has typically been supplied by millings. The larger estimate (5 million metric tons of grain for increased numbers and 18.2 million metric tons for increased weight) would also require 28.7 million metric tons of additional millings or other fine feed. At the 1977 average processing loss of 17.5 percent,[100] no more than 19.6 million metric tons of millings could be provided from the targeted increment of 95 million metric tons of unprocessed grain. In 1978 a maximum of 36.7 million metric tons (or about 66.7 percent) of millings out of a potential 55.3 million metric tons available in 1978 were used for animal feed (excluding poultry). Thus under the more pessimistic assumptions, if about 88 percent of all millings available in 1985 can be allocated to livestock feed, relatively tractable quantities of other concentrates will be required. If not, the slack will have to be made up by more rapid growth of the availability of other fine feeds (such as wine dregs or oil cakes from soybean, cotton, rape, sesame, or peanuts, after the oil has been extracted), or from additional grain.

The Outlook for Grain Demand From Livestock in 1985

On balance, then, where does all this conditional figure manipulation lead us? It would be absurd to pretend to give a definitive answer. But there are a few things that can be said without sinking into complete ambiguity in view of the rough picture of Chinese planning, popular responses, and current conditions available in January 1980. At least 5 million metric tons of extra unprocessed grain must be supplied to

livestock by 1985 in order to satisfy the basic stock expansion plans formulated in 1978; it seems quite likely that these plans can in fact be fulfilled. If the target for domestic supply of meat products is also to be achieved, somewhere between 6 and 19 million metric tons of additional grain must be supplied (primarily to hogs, although additional demand for poultry feed could probably also be included).

The actual figure within the range of 6-19 million metric tons depends on whether the means of increasing the meat supply focuses more on increasing weight per hog or on increasing the numbers of stock. This in turn depends primarily upon: the amount of grain available and its redistribution (the more available and less redistributed, the more grain-intensive will be the means of meat increase); the availability of nongrain feedstuffs; and the extent to which the state believes that peasants can or should be persuaded to forgo higher current incomes and standards of living now to increase national income later.

If current signs are any indication, the supply of nongrain feedstuffs is a bit of an obstacle to continued hog stock increase by means of the methods officially recommended over the last two and a half decades (although temporary removal of this constraint is not out of the question).[101] Feedgrains will be increasingly available and will be left in the hands of those that produced it to a greater extent than before. The state, at least for the time being, appears to feel, more than in the past, that the most effective means of rural enrichment and the solution to the agricultural problem lie in allowing peasants to enrich themselves within permissible latitudes of action. The bonds restraining peasant economic activities have not been and will not be eliminated. But the range of permissible activity has unquestionably been widened.

All this would suggest that a more grain-intensive means of supplying additional pork products will be followed above and beyond what can be gained from a moderate upturn in the growth rate of hog numbers.

What little can be ascertained from the record of the first year or so of policy changes suggests that this prediction may be correct. The July 1979 official stock figure is about 4 percent above that of July 1978, a tidy but unextravagant increase over the long-term rate of 3.5 percent. But the December-to-December increase was only 2.7 percent.[102] Meanwhile, it has been reported that in the first four months of 1979 the average weight of marketed pigs rose by 8 kilograms in Shanghai municipality and by 4 kilograms in Guizhou province. The national average increase for pigs sold to the state over the first half of 1979 has been given as 5.3 kilograms (from 76.5 to 81.8 kilograms) over the corresponding 1978 period.[103] Pigs sold to the state may indeed be heavier than those appearing in rural fairs and retained for home consumption. But the average for the first six months of 1979 marks a 13.8 kilogram increase over the average 1957 level for state-marketed hogs.

The appearance of the average-weight-increase statistical category itself is indicative of an official attitude encouraging weight increase as opposed to previous government efforts to promote concentrate conservation and early slaughter. Furthermore, the purchase price of pigs (by kilogram) as well as of beef and sheep has been raised.[104] It also appears that hogs brought for state sale have, if anything, exceeded government expectations and occasionally, facilities for storage.[105] Still, it is not at all clear that the meat-products target will be fulfilled. Even if it is, the additional supply will derive from increases of stocks as well as of weight. And the percentage of meat per kilogram of live weight should increase with the latter. Therefore, if forced to quote a number, 10 million metric tons for additional feedgrain by 1985 seems a reasonable estimate, with a probable maximum of 15 million metric tons. The millings complement of even the latter figure could be supplied out of the 95 million metric tons of hypothesized incremental grain production.

Increased Direct Consumption Among the Top Three Quintiles

Current rural policies notwithstanding, however, it is not completely clear whether Chinese authorities will allow livestock to consume as much as 15 million metric tons of grain so soon. One very important issue has so far been avoided: aside from feeding the 1985 population at the 1978 level, aside from raising the standard of the bottom 20 percent or even 40 percent of the population, aside from increased supplies for livestock and stockpiles, how much additional food-

grain can the average Chinese absorb? How much would he choose to consume? To what extent is this level actually dependent upon any realistic supply of nonfoodgrain items to the average Chinese citizen by 1985? These are questions about which we are not only uninformed but profoundly ignorant.

It might be suspected from Figure 1 that the middle-income Chinese would now want more nongrain foods rather than additional foodgrains. It has also been noted that he probably wants, first and foremost, more calories, and that the cheapest way for him to acquire them and the most economical and secure way for the state to supply them is to encourage more foodgrain production and consumption. But how long is this process likely to continue?

One Chinese agricultural economist[106] suggests that foodgrain output can be expected to grow 3 percent per year (0.5-1.0 percent below our forecast) but not much more over the 1979-85 period, and livestock feed will comprise only 10 percent of total additions to supply (slightly below our basic estimate). A growth rate of 3 percent per year in foodgrain production (1980-85) with 10 percent of the increment supplied to hogs and cattle would allow 7.14 million metric tons of additional livestock feed over that available in 1978. After 5 million metric tons are deducted to feed the planned additions to livestock at the 1978 feeding rate, the remaining grain would only cover a weight increase of 3 or 4 kilograms for each hog slaughtered. If the 400-million-metric-ton target were reached, 10 percent of the increment going to feeds would mean 9.5 million metric tons and would allow 7 kilograms of extra weight per hog.[107]

If our ranges for other uses are correct (for stocking, industrial use, and so forth, and population growth) this would leave a mean value of 34 million metric tons for improved direct consumption in the event of 1985 foodgrain production target fulfillment. This is probably more than enough to raise the average consumption of the bottom two quintiles to 201 kilograms per year of processed grain or 269 kilograms per adult equivalent, should the recent and future policy changes result in such a distributional pattern. But as has been noted above, only about 7 or 8 million metric tons of additional deliveries to the lower-income peasants seems assured. How then are the remaining 27 million metric tons likely to be divided among the categories of increased direct consumption and increased indirect consumption?

Despite the expectation, through international comparison, that further increases in income among middle- and upper-income peasants might lead to a modest interest in increased grain consumption, it is possible that this notion is seriously in error. Recent nutritional studies note rising foodgrain requirements of consumers who have consistently derived high percentages of caloric intake from foodgrains.[108] Refugee studies have also turned up evidence of high foodgrain demand in particular localities,[109] although such demand must be taken in the context of particularly low caloric availability from nongrain sources compared with that of the average Chinese peasant. Ultimately it may turn out that the elasticity of demand for foodgrains among even the top three quintiles of Chinese consumers is much greater than expected from examination of world-wide data.

In 1978 grain distribution per capita was 249.5 kilograms (probably of unprocessed grain) in Jiangsu and Jilin, two of China's relatively more affluent provinces within their respective regions. In 1979 Sichuan's per capita distribution was 250 kilograms while Zhejiang's was reported as 285 kilograms. Although official figures are not available for all provinces, those included are clearly in the upper range of foodgrain distribution[110] Jilin's value of animal products, however, is only 11 percent of the total provincial gross value of agricultural output (GVAO)[111]—even less than the low national average of 13.7 percent[112]—and Sichuan's animal stocks have only just started to grow again after recovering from a severe decline in grain distribution (reaching a low of 184.4 kilograms per capita in 1976).[113] Liaoning, which distributed 220 kilograms per capita in 1978,[114] registered a value increase of 35 percent in pork supplies between January and July 1979 relative to the same period in 1978.[115] But the March 1979 rise in purchase price of pigs alone,[116] which may have been included in the pork value calculations, could cover most of the increase. Although too fragmentary to constitute proof, these data indicate no discernible decline in the rate of direct consumption increase, at least until the approximate level of the national average is reached (201 kilograms of processed grain; about 244 kilograms of unprocessed grain).

In 1954, when children comprised about 40 percent of the population (as they did in 1978),[117] a survey was conducted covering over 16,000 peasant households in 25 provinces.[118] "Poor" peasant families with an average income of 116.7 yuan per family member consumed a mean of 176.5 kilograms of processed foodgrains per capita (or about 1.5 kilograms per yuan of income). "Middle" peasants with an average income of 154.9 yuan per family member consumed 189 kilograms each (0.32 kilograms per yuan of income over that of a poor family member). Curiously, the marginal propensity to consume foodgrains did not drop off significantly among "rich" peasants: at 216.2 yuan per family member, they consumed 206.5 kilograms per family member, 0.29 kilograms per yuan of incremental income over that of "middle" peasant family members (see Table 4). When converted to monetary terms, the marginal propensity to consume yuan of foodgrains per extra yuan of income merely dropped from 6.1 percent to 5.3 percent. If anything the figures may overestimate the decline since richer peasants may consume foodgrains of higher quality and price. One may assume that a rich peasant in 1954 was able to consume substantially more nongrain foodstuffs than was a poor peasant.

Unfortunately a full range of variations of the marginal propensity to consume was not obtainable since the peasant categories were defined along class rather than economic lines and therefore mask much more substantial regional variation in income[119] (and probably consumption). Nevertheless, even on the basis of this abbreviated information, it should be observed that the figure of 206.5 kilograms of processed grain would be about 5 kilograms per capita above the 1978 national average, below Zhejiang's 1979 average distribution (when converted to processed terms); but about equal to the 1978 figures for even the more relatively well-off provinces, such as Jilin and Jiangsu. All this suggests that even the middle quintile is likely to have unsatisfied demand for foodgrains. How far such demand may extend into the top 40 percent of peasant incomes and among urban dwellers is unknown, as is the point at which Chinese consumers are likely to begin eating less rather than more grain with increased incomes.

There is some indication, however, that a major point of inflection may finally be within sight. Zhejiang province has historically allocated about 2 percent of total grain production to hogs.[120] In 1979, however, when distribution per capita reached 285 kilograms per capita (223 kilograms processed [121] or about 22 kilograms above the national mean), and grain production increased by 1 million hog numbers rose to 15 million—7 million above the previous record. This would indicate that about 20 percent of incremental grain production was allocated to hogs alone.[122]

To summarize the breakdown of estimates for grain demand increases, about 43 million metric tons will be required to maintain 1978 standards of direct consumption for the older and numerically larger population. About 2 million metric tons will probably be reserved for national, provincial, and local stocks and 6 million metric tons for industrial use, processed food, brewing, and so forth; 5 million metric tons will be required as a minimum grain provision for planned increases in livestock, and 7 million metric tons will be transferred more or less directly to lower-income groups. These components sum to 63 million metric tons, which would be covered by an annual growth in foodgrain supply of 2.7 percent—a reasonably safe goal given the period under question. The remaining 32 million metric tons supplied if the 1985 target is reached will be divided principally among increased livestock feed (at least an additional 5-10 million metric tons would be required to approximate the 1985 target for provision of meat products) and increased direct consumption among all categories. Considered thus far, however, have been demand increases over and above the level supplied in 1978, which included 6.4 million metric tons of net foodgrain imports.

International Foodgrain Trade

In the immediate future, trade will almost surely play an augmented role (although still a relatively subsidiary one) in helping China meet its foodgrain demands. The importation of wheat in exchange for rice began, on a major scale, in 1961, following the agricultural failures of the period, although large rice exports began in the mid-1950s.[123] This kind of trade can be expected to expand. In spite of recent progress in wheat yields, China's production matrix and

Table 4—Average income and foodgrain consumption per person, and the average and marginal propensity to consume foodgrains in 1954

Category of Household	Percent of All Peasant Households	Average Income Per Household	Average Number Per Household	Average Income Per Person	Foodgrain Consumption Per Person		Average Propensity to Consume Foodgrains		Marginal Propensity to Consume Foodgrains	
					Amount	Cost				
		(yuan)		(yuan)	(kilograms)	(yuan)	(kg/yuan)	(yuan/yuan)	(kg/yuan)	(yuan/yuan)
Poor peasant	29.0	488.7	4.2	116.36	176.5	31.59	1.52	0.27	...	...
Middle peasant	62.2	774.4	5.0	154.88	189.0	33.83	1.22	0.22	0.325	0.061
Rich peasant	2.1	1,297.0	6.0	217.17	206.5	36.96	0.95	0.17	0.281	0.053
Former landlords	2.5	497.2	4.2	118.38	180.5	32.31	1.52	0.27	...	...
Members of Agricultural Cooperatives	4.2	704.6	5.1	138.16	195.5	34.99	1.42	0.25	...	...

Sources: The average income per household and the average number of persons per household are from a sample survey of 16,000 peasant households in 25 provinces. A summary of results appears in People's Republic of China, State Statistical Bureau, "A Brief Summary of Data on the Income and Expenditure of Peasant Households in 1954," *Tongji gongzuo* [Statistical Work] May 29, 1957, pp. 31-3; translated in Nai-Ruenn Chen, *Chinese Economic Statistics. A Handbook for Mainland China* (Chicago: Aldine, 1967), pp. 430-1. Chen gives the year of reference as 1955; it is actually 1954.

Foodgrain consumption per person. The amounts were calculated from information given in the State Statistical Bureau sample survey in Chen, *Chinese Economic Statistics*. They appear in jin in this source and have been converted at the rate of 2 jin per kilogram.

The cost of foodgrain consumption per person was calculated at the rate of 0.179 yuan per kilogram. The relevant price for peasants is not the retail price but the opportunity cost of eating the grains they produce—the average rural purchase price. The price used is derived from a 1950 average foodgrain price of 0.111 yuan per kilogram and an index number of 130.3 for 1954 derived as a weighted average of the average wheat and unhulled rice indexes for 1954 (1950=100). The weights are derived from the relationship between the wheat, rice, and average foodgrain price indexes for 1952. This yields a price figure for unprocessed grain of 0.145 yuan per kilogram. But since consumption was given in processed units, 0.145 yuan has been divided by an average processing loss figure (0.809) to obtain a suitable price for the processed grain (0.179 yuan). This average grain price was used for all average propensity calculations. The price data are from Stone, *A Review of Chinese Agricultural Statistics, 1949-79*, Research Report 16 (Washington, D.C.: International Food Policy Research Institute, forthcoming)

Average propensity to consume foodgrains. This is calculated from the average cost of foodgrain consumption per person, the average foodgrain consumption per person, and the average income per person.

Marginal propensity to consume foodgrains. This is calculated from the average income per person and the foodgrain consumption per person. The price used to compute the yuan of extra foodgrain consumption per extra yuan of income is an estimate of the over-quota purchase price, which ran generally 20-30 percent above the compulsory procurement price of the 1950s. The compulsory procurement price was used for 23-34 percent of all grain production between 1953 and 1956; the over-quota purchase price is relevant for the remainder. On the basis of this information, the within-quota price was estimated at 0.122 yuan per kilogram. The over-quota price was 0.153 yuan per kilogram of unprocessed grain or 0.189 yuan per kilogram of processed grain. The marginal values for middle peasants were computed using poor peasant income and consumption as a base. The marginal values for rich peasants were computed using middle peasant income and consumption as a base.

dietary habits still make it a rice-surplus, wheat-deficit economy, and the probable pattern of yield increase over the immediate future may well accentuate this characteristic. The world foodgrain price structure also argues in favor of this kind of trade, and recent econometric work indicates that the world rice price is a strong determinant of China's level of rice exports.[124] A more detailed explanation shows that wheat and coarse-grain imports are related to the two previous years' production of these crops and the previous year's trade balance (which, among other things, is influenced by the relative prices of wheat imports and rice exports). Rice exports are, of course, also related to per capita rice production and foreign exchange requirements.[125] Imports of wheat are loosely related to the procurement of grain in the North China Plain surrounding the major urban centers of Beijing and Tianjin where much of the imported grain has been consumed.[126]

Even the recent grain import contract commitments (11-13 million metric tons per year through 1981)[127] cannot be seen as altering significantly the per capita consumption of foodgrains in China as a whole. Nor does it appear that land being shifted out of foodgrain production is large relative to reclamation plans, much less total cultivated acreage.[128] The imports can clearly be seen as part of a coordinated program of investment in peasant incentives: allowing more grain to be left in rural areas, particularly in North China where output is erratic owing to drought, while easing bottlenecks in transport facilities; increasing urban foodgrain stocks (especially in Beijing, Tianjin, and other waterports); and supplying the new suburban hog and poultry farms.

In this last connection, feedgrains and feedgrain products may represent a growing trade opportunity. China has recently built a farm for raising up to 10,000 hogs and another for raising 200,000 laying hens;[129] Chinese leaders are reportedly considering the installation of seven new large-scale integrated hog-raising and processing plant facilities, with an annual capacity of 90,000 hogs, primarily to serve northeastern industrial centers. Large-scale poultry operations have also been discussed.[130] This stock will be fed a substantially higher proportion of fine feed than the average levels throughout China, and authorities may very well not require contiguous rural areas to cover the additional demand, presenting an opportunity for trade. But it should not be overlooked that state purchases in most provinces appear to be rising. Moreover, the vast majority of Chinese livestock will remain on private plots and in small unconcentrated collective units throughout China and will continue to subsist on substantially nonfeedgrain materials.

China was once one of the world's leading producers of soybeans with a large export market, but production may have actually declined somewhat since the late 1950s.[131] Soybean acreage was probably squeezed out in the early and mid-1960s by other, higher-yielding food crops and in the 1970s was primarily intercropped and planted at the edges of fields, though total output may well have recovered to around the 1957 level. Soybeans were previously counted on a weight-equivalent basis with cereals for purposes of quota fulfillment. The ratio has recently been changed to 2:1 in favor of soybeans[132] but is probably still low in view of their protein content, low per hectare yield, and value on the world market. Some provinces have already taken additional measures.[133] Despite a renewed government interest in soybean production, current diet-improvement policies may lead Chinese authorities to import soybean products[134] over and above increases in domestic output. This would be due to the value of soybeans as a protein source, their prominent role in traditional Chinese diets, the aforementioned feedgrain requirements, and both the pent-up demand for vegetable oils and high costs in cultivated land for producing them domestically.

The new import contract commitments are at levels two to three times the 1961-77 average.[135] These commitments seem to have been made principally because rural policy, urban consumption, and stockpiling plans could not be left to the vagaries of weather during the critical period of transition to new leadership. Per capita consumption, both urban and rural, is increasing at a reasonable rate, however, and it is unlikely that imports above the annual level of those committed to will be necessary.

While it is quite possible that around 10 million metric tons or a bit more will continue to be imported through 1985 (reduced within-quota procurements are guaranteed "from 1979 onward"),[136] it would not be too surprising if the level were cut back somewhat after 1981 if the initiative to further develop marketable grain bases progresses

well. It should be noted that despite the reduction in within-quota purchases, total state procurements in 1979 rose substantially over 1978.[137] In view of the probable extension of current grain purchase prices, the trend is likely to continue, provided grain production expands as required within agriculture as a whole. This issue is the subject of the remaining sections, but it should be noted that it appears improbable that China would radically increase net foodgrain exports within the 1980-85 period except to partially defray grain import costs. Even in the unlikely event that 400 million metric tons of domestic production is reached by 1985, the possibility of a massive increase in grain exports is quite remote: increased consumption is too important a plank in the administration's current rural and urban platform; and unsatisfied demand for grain, both direct and indirect, is too apparent. On the other hand, the Chinese have lived with unsatisfied demand since well before the establishment of the People's Republic of China. Therefore, although state policy must now address that demand, it need not be eliminated at once: evidence of clear, steady progress is probably sufficient.

FOOTNOTES

[11] See Stone, "A Review of Statistics," Table 4, discussion.

[12] Ibid., Tables 1 and 4. The Chinese put the population increase figure at 300 million. "Decisions of the CCP Central Committee on Some Problems in Accelerating Agricultural Development" (adopted by the 3rd Plenary Session of the 11th Chinese Communist Party [CCP] Central Committee on December 22, 1978), printed in *Zhanwang* (Hong Kong) June 16, 1979, pp. 21-4; July 1, 1979, pp. 23-5; and in FBIS, *PRC*, August, 31, 1979, pp. L22-L37. John Aird's "best" estimates indicate that the increase was 345 million (Stone, "A Review of Statistics," Table 1).

[13] See for example, "Discussion of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, p. L26. The recommended bases of distribution of commune members' food rations are 30-40 percent of work points and 60-70 percent of basic food rations, but commune members may use any method approved by the majority. This limits differences in food rations within communes, but not among communes. National upper limits on foodgrain distribution were abolished in 1979. The impact of the new rural incentive program upon income distribution will be discussed later in the paper.

[14] Dwight Perkins, "Radical Land Reform—The Experience of China," a paper presented at the Symposium on Institutional Innovation and Reform: The Ladejinsky Legacy, Kyoto, October 1977.

[15] FBIS, *PRC*, April 30, 1979, p.O5.

[16] C. Robert Roll, "Incentives and Motivation in China: The 'Reality' of Rural Inequality," a paper presented at the annual meeting of the American Economic Association, Dallas, Tx., December 28, 1975, p. 35, indicates that about 75 percent of the differences in crop income in the 1950s were caused by differences between regions. The remainder were attributed to differences within regions. Roll concludes, however, that the dispersion of rural income in China is one of the lowest in the world today. The 1.10 figure indicates that per capita income is 10 times larger in the richest 10 percent of all communes than in the poorest 10 percent of communes.

[17] "Investigation Report by the Shanghai Municipal Agricultural Office," FBIS, *PRC*, August 16, 1979, p. O6.

[18] Other rationed commodities include cloth, oil, sugar, and occasionally pork.

[19] Stone, "A Review of Statistics," Table 4, discussion.

[20] Especially those resulting in famine. See Buck, *Chinese Farm Economy*, and John Lossing Buck, *Land Utilization in China*, 3 vols. (Nanking: University of Nanking Press and Chicago: University of Chicago Press, 1937). The latter presents compilations of county records demonstrating that the surveyed localities suffered an average of from 2.5 (in the rice region) to 3.6 (in the wheat region) extreme famines between 1850 and 1932, which resulted not merely in malnutrition, but in migration, starvation, and cannibalism.

A summary of harvest losses not resulting in famine is given in Bruce Stone, "Agricultural Purchase Price Policy in the People's Republic of China," a paper presented at the International Food Policy Research Institute, Washington, D.C., January 10, 16, 1979. Stone uses Buck's figures to calculate step probability density functions to delineate the risk of varying degrees of harvest loss in the wheat and rice regions between 1904 and 1929.

Buck's figures include data for 64 localities in the wheat region over a 25-year period. They had a double-cropping index of 127 (Buck, *Land Utilization*, Study, p. 274). Their average yield, E(X), was equal to 76 percent of normal yield (Buck, *Land Utilization*, Statistics, p. 208). Normal yield, yield when no major natural calamities occur, is

equal to 1.31578 E(X). In the table below, 1−[X/1.31578 E(X)] is the percent of the normal harvest lost because of a natural calamity; j is a reference number given to each of the percentages in the table. The probability of sustaining a harvest loss of the percentage indicated by 1−[X/1.31578 E(X)] is indicated by p. The percentage harvest loss itself is indicated by x. It is shown in the table as the probable number of harvests with the harvest loss indicated. It was calculated by dividing the number of entries with crop losses of Z percent by the number of localities, then multiplying by the number of years multiplied by the double-cropping index.

j	1	2	3	4	5	6	7
1−[X/1.31578 E(X)]	80−100 (avg. 88.5)	70	60	50	40	30	20−0 (avg. 5.9)
p	1.0	1.8	4.5	3.8	17.0	16.6	50.3

Similarly, Buck's figures include data for 96 localities in the rice region over a 25-year period. Their double-cropping index was 166. E(X) was equal to 79 percent of normal yield, which equalled 1.26582 E(X).

j	1	2	3	4	5	6	7	8
1−[X/1.26582 E(X)]	85−100 (avg. 93.4)	80	70	60	50	40	30	20−0 (avg. 8.5)
p	1.1	3.3	3.6	3.1	6.7	3.9	6.2	72.1

The average percentage loss (x_n) in the wheat region when j equals 7 and in the rice region when j equals 8 was computed as follows:

$$x_n = \bar{x} - \sum_{j=1}^{n-1} p_j x_j \Big/ p_n$$

where $\bar{x}$ = E(X)/ normal harvest = average harvest loss;
p_j = the probabilities or frequencies associated with x_j;
x_j = the percentages of normal harvests lost;
$\sum_{j=1}^{n} p_j x_j$ = $\bar{x}$; and
p_n = $1 - \sum_{j=1}^{n-1} p_j$

Finally, the figures included in these tables exclude less frequent calamities that result in famines. These would add an extra 3.4 percent for the wheat region and 1.8 percent for the rice region to the tails of the distributions.

[21] Nicholas Lardy, *Economic Growth and Distribution in China* (Cambridge: Cambridge University Press, 1978).

[22] Miriam and Ivan London, "Hunger in China: The 'Norm of Truth'," *World View*, 22 (March 1979): 14-6; "Hunger in China: The Failure of a System?" 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.

[23] Stone, "A Review of Statistics."

[24] The composite grain processing reduction factor 0.825 is taken from Stone, "A Review of Statistics," Table 4.

[25] "Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, p. L27.

[26] *Peking Review*, January 3, 1975, pp. 10-1.

[27] "Tax Reduction in Rural Areas," *Beijing Review*, March 16, 1979, p. 12; see also Xinhua, news bulletin, December 27, 1979; FBIS, *PRC*, December 27, 1979, p. 13.

[28] Zhang Jingfu, "Report on the Final State Accounts of 1978 and the Draft State Budget for 1979," (delivered at the 2nd Session of the 5th National People's Congress on June 21, 1979), appearing in Xinhua, news bulletin, June 29, 1979; FBIS, *PRC*, July 3, 1979, pp. L6-L17. The relevant section here is on p. L13. In this report the total estimated sum was 24.4 billion yuan; the estimated component for financial transfer to rural areas owing to tax reductions and the rise in agricultural purchase prices was 7 billion yuan. The final estimate for the latter, however, was 9 million yuan (Xinhua, news bulletin, December 27, 1979; FBIS, *PRC*, January 3, 1980, p. L18). The 25 billion yuan appearing in the text is derived by adding 2 billion yuan to the original 24 billion yuan estimate, then deducting the 1 billion yuan for tax reduction already discussed.

[29] These figures were calculated using an average consumption per capita figure of 201 kilograms per year (207 kilograms available for consumption after deductions for feed, seed, industrial and food processing, brewing, net international trade, and processing loss have been made, minus 2 percent of the original production figure [304.75 million metric tons] for national, provincial, and local stockpiling; this is Stone's (best) estimate in Stone, "A Review of Statistics," Table 4), Aird's midyear 1978 population figure of 1,002.437 million, and Roll's 1952 income share percentages (see Tables 2 and 4).

[30] Stone's estimate is 201 kilograms per capita (Stone, "A Review of Statistics"); population is Aird's midyear 1978 figure from Table 5; the composite processing reduction coefficient used is 0.825 (Stone, "A Review of Statistics"), derived from Wien's processing loss figures for individual crops and Stone's estimated 1977 crop distribution (see Table 8 in this paper).

[31] Stone, "A Review of Statistics," notes to Table 4. See Table 3 below.

[32] *Cheng Ming* referred to the condition of the 200 million peasants consuming below the 150 kilogram mark as a "state of semi-starvation" (FBIS, *PRC*, May 10, 1979, p. U5). Although 1978 figures for steel were mentioned in the article, it is not clear whether the foodgrain reference is for 1977 or 1978. In "Decisions of the CCP Central Committee," FBIS, *PRC*, p. L22, it was stated that in 1977 "somewhat more than 100 million peasants had inadequate foodgrain supplies." Despite population and livestock increases, per capita direct consumption should have been significantly higher in 1978 than in 1977.

[33] Since the reform includes reductions of rural taxes other than the agricultural tax, the appropriate price for such a calculation is not immediately clear. The 1979 average compulsory purchase price of rice was about 0.230 yuan per kilogram. In 1978 it was 0.192 yuan per kilogram. See Stone, "A Review of Statistics," Table 20B; and Zhang Jingfu, "Report," FBIS, *PRC*, p. L10. The average compulsory purchase price is the lowest relevant price because agricultural tax reductions of grain retained in rural areas would be evaluated at this rate. For the highest price relevant to the purchased grain, the retail price of 0.32 yuan per kilogram may be used. This is the mean of 1975 national average prices of Grade B rice (286 yuan per kilogram) and medium grade wheat flour (0.360 yuan per kilogram) from Peng Kuang-hsi, *Why China Has No Inflation* (Peking: Foreign Languages Press, 1976), p. 7. One billion yuan at the average retail price would purchase about 3.1 million metric tons of processed grain (5.75 million tons in unprocessed equivalent). At the within-quota price the sum would purchase 4.34 million metric tons of unprocessed grain.

[34] Zhang Jingfu, "Report," FBIS, *PRC*, July 3, 1979, p. L8, L13. The 1977 figure was 5.069 billion yuan.

[35] The 1979 figure is from Zhang Jingfu, "Report," FBIS, *PRC*, p. L13. The total sum for capital construction (39.5 billion yuan) plus those parts of regular reserve funds and other standby financial resources earmarked for capital construction in local budgets came to 45.192 billion yuan in 1978, a large increase over 30.088 billion yuan in 1977 (p. L8). Agriculture's share in 1978 was 10.7 percent (Xinhua, news bulletin, December 27, 1979; FBIS, *PRC*, January 3, 1980, p. L18), or 4.836 billion yuan.

[36] "Rural Bank Loans and Savings Increase," *Beijing Review*, November 16, 1978, pp. 6-7. If loans emanating directly from the newly established Agricultural Bank of China are included, the totals are, for 1978, 13.178 billion yuan; for 1979, 17 billion yuan; and for 1980, 20 billion yuan (Xinhua, news bulletin, January 23, 1980; FBIS, *PRC*, January 23, 1980, p. L3).

[37] Purchase price increases and tax reductions accounted for 9 billion yuan in 1979 (as opposed to 7 billion yuan estimated a year earlier—see footnote 28). Of this sum, an estimated billion yuan were from tax reductions (see footnote 27).

[38] Calculated from Aird's May 1979 midyear China population series in U.S. Central Intelligence Agency, National Foreign Assessment Center, "China: A Statistical Compendium," ER79-10374 Washington, D.C., July 1979, p. 5. The 40 percent figure assumes that child deaths were zero over the 15-year period 1964-78. The Chinese sample survey was quoted in Xinhua, news bulletin, February 13, 1980; FBIS, *PRC*, February 15, 1980, pp. L11-L13.

[39] Stone's 1978 estimate is 201 kilograms per year (see footnote 29). The 269 kilogram figure is derived in Appendix 2 of this paper.

[40] See footnotes 10 and 38. New official targets for the rate of natural increase were published in February 1980: less than 1 percent for 1980, 0.8 percent for 1981, and 0.5 percent for 1985. (*Renmin Ribao* [People's Daily], February 11, 1980, p. 1; FBIS, *PRC*, February 15, 1980, p. L15)

[41] Stone, "A Review of Statistics," Tables 4 and 4A. The early 1970s figure and long-range target were given by Vice Premier Li Hsien-nien, cited in Ishikawa, "China's Food and Agriculture," p. 90. The report of a 1975 study mission to China put the figure at 40-60 metric tons. Food and Agriculture Organization of the United Nations, Study Mission, "Learning From China: A Report on Agriculture and the Chinese People's Communes," FAO, Regional Office for Asia and the Far East, Bangkok, 1977, p. 19.

[42] In 1978 when the province's output rose 27 percent over 1977, a dry year, Jilin's grain reserve increased 13.5 percent to 295,425 tons. FBIS, *PRC*, May 1, 1979, p. S1. Jilin is a major grain-producing province in the Northeast with average per capita consumption greater than the national mean in 1979 (202 kilograms per capita of processed grain).

[43] Shigeru Ishikawa, "Factors Affecting China's Agriculture in the Coming Decade," Institute of Asian Economic Affairs, Tokyo, 1967, Table 3 and Appendix 1. (Mimeographed.)

[44] Shigeru Ishikawa, "China's Food and Agriculture," p. 91.

[45] Stone, "A Review of Statistics," Tables 1-4; see also U.S. Central Intelligence Agency, "A Preliminary Reconciliation of Official and CIA National Product Data," ERM79-10690, Washington, D.C., December 1979, p. 4.

[46] Ma Hung-yun and Liu Yun-ch'ien, "Train More Experts of Economic Management of Agriculture," *Kwang-ming Jih-pao*, November 18, 1978; translated in U.S., Joint Publications Research Service, *PRC Agriculture* 23 (JPRS 072,921), pp. 14-6; "Proposal for Changing Dietary Habits," *Peking Review*, December 1, 1978, pp. 18-9; Benedict Stavis, "Turning Point in China's Agricultural Policy," Working Paper No. 1, Rural Development Series, Michigan State University, East Lansing, Mich., May 1979, p. 43.

[47] See above.

[48] Pork is strictly rationed in many urban areas.

[49] An exception to this observation appears to be vegetable consumption in areas where urban supply is relatively high (0.5 kilograms per capita per day, gross weight) and fairly well insulated against seasonal fluctuations (varying less than 20 percent in either direction of the yearly average), though there appears to be considerable pent-up demand for the gradually progressing program of varietal increase. See Thomas B. Wiens, "The Economics of

Municipal Vegetable Supply in the People's Republic of China," a paper prepared for the Vegetable Farming Systems Delegation, National Academy of Sciences, Washington, D.C., December 1977. (Mimeographed.) Lower-income people would probably enjoy fewer vegetables in those rural areas with short natural growing systems and incomes too low to afford vinyl technology. Although in the 1950s the average consumption of vegetables by peasants was greater than in the cities, current urban consumption per caoita is 125 percent above consumption in 1955 (this calculation is based on official data found in Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China* [Chicago: Aldine, 1967], p. 438). It should again be noted that average statistics conceal large variations at the extremes of the distribution. In the major municipal area of Tianjin, vegetable consumption per capita averages 1 jin 1 tael in the busy season and 1.7 tael in the slack season (about an eighth of busy season consumption). The facilities for busy season storage still do not even out the seasonal variation, so rotting is extensive. Tianjin also has a varietal problem: a surfeit of leafy vegetables and a lack of yellow vegetables. One of the apparent causes is inflexible management of prices by officials who do not take the problem of rotting into consideration and insulate the producers from corrective market signals. Neither free nor market administrative adjustments have solved this problem (*Tianjin Ribao* [Tianjin Daily] in FBIS, *PRC*, July 4, 1979, p. R3).

[50] Stone, "A Review of Statistics," Table 3. The use of 1949 as a base year is less misleading in this instance as hog numbers, unlike many other farm output indicators, were already above their prewar levels (see Ta-chung Liu and Kung-chia Yeh, *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-59* [Princeton: Princeton University Press, 1965], p. 135). The numbers of other livestock, especially large animals, have grown less rapidly.

[51] At the end of 1975 or midyear 1976, the hog stock was as low as 180 million head, although in 1974 stocks were probably between 260 and 290 million (Stone, "A Review of Statistics," Table 3). This sudden decline has yet to be clearly explained.

[52] Chen, *Chinese Statistics*, p. 438.

[53] "Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, p. L29, gives the total quantity of meat products as 15 billion jin (7.5 million metric tons). It is possible that the figure refers to 1978.

[54] A figure of 9.6 kilograms per capita can be calculated from Henry J. Groen and James A. Kilpatrick, "Chinese Agricultural Production," in U.S. Congress, Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C.: U.S. Government Printing Office, 1978), p. 645.

[55] Conversation with C. Peter Timmer, Harvard University, Cambridge, Mass., October 1978; C. Peter Timmer, Walter P. Falcon, and Gerald C. Nelson, "A Perspective on Food Policy in China," October 1978 (mimeographed); and Thomas B. Wiens, "Animal Husbandry in the People's Republic of China," August 1978. (Mimeographed). This is in part because of the increasing scarcity of even nonfeedgrain materials (conversation with Timmer, 1978, and Wiens," Animal Husbandry," p. 46), but also owing to a renewed emphasis of central policy on large collective pig farms for increasing urban supply rather than on collective sideline and private pig raising (Timmer, Falcon, and Nelson, "A Perspective on Policy", and Wiens, "Animal Husbandry").

[56] Refer to Zhou Enlai's statement in 1971 to a Japanese delegation, reported in *Nogyo to Keizai* [Agriculture and Economy] 38 (March 1972), p. 20, cited in Ishikawa, "China's Food and Agriculture," p. 94. Also see more recent statements by Chairman Hua Guofeng.

[57] Shigeru Ishikawa, "Factors Affecting China's Agriculture in the Coming Decade," pp. 23-8; and Ishikawa, "China's Food and Agriculture," p. 94.

[58] According to Christopher Howe, "Labor Organization and Incentives in Industry," in *Authority, Participation, and Cultural Change*, ed. Stuart Schram (Cambridge: Cambridge University Press, 1974), pp. 237-8, real urban wages grew about 6 percent per year from 1952-57, then essentially stagnated until 1971 and 1972, when wages were raised an average of 10 percent. A survey of 152 families of "typical" workers, salaried employees, and intellectuals in 10 districts of Shanghai (cited in Shigeru Ishikawa, "Prospects in the 1980s," p. 19), showed that per capita monthly earnings rose from an average of 26.78 yuan in 1966 to 33.43 yuan in 1973. But it appears that the increase was not so much the result of higher wages for an employed family member as of an increase in the number of members employed per family. Another article, "From the Household's Receipt and Expenditure Accounting Book of a Worker," *Jinmin Chugoku* [People's China], January 1974, pp. 24-7; cited in Ishikawa, "Prospects in the 1980s," Table 7, examining the accounts of a "typical" Shanghai worker, shows a similar effect. Ishikawa notes that the wage cited was approximately equivalent to the 1957 average wage from the other study. Lardy, *Economic Growth*, p. 175, shows that real wages of all workers rose 31 percent between 1952 and 1957, then declined to below the 1956 level by 1971. Despite the 1972 wage increases, real industrial wages were at the 1956 level in 1975.

In 1977, 46 percent of workers and government employees received a wage increase ("Increasing Wages," *Beijing Review*, November 19, 1979, p. 4). This actually amounted to a 10 percent raise for 60 percent of the industrial work force (*Beijing Review*, June 29, 1979, p. 11, and July 6, 1979, p. 40; FBIS, *PRC*, June 25, 1979, pp. L8, L9, and June 27, 1979, p. L17). In 1978 an additional 2 percent received an increase ("Increasing Wages"). But the amount of these raises did not counterbalance the March 1979 price rises when real earnings of staff and workers declined to below the 1965 level (*Cheng Ming*, FBIS, *PRC*, May 10, 1979, p. U4). To redress this situation, the average wages of 40 percent of workers and government employees were raised in November 1979 ("Increasing Wages") but retail prices of nonstaple food were also raised the same month by healthy margins ("Nonstaple Food Prices Raised," *Beijing Review*, November 19, 1979). To compensate for the rising prices (estimated to increase state revenue by 5 billion yuan) the government granted 5 yuan per month to each of 100 million workers and civil servants (including apprentices and retired), which transferred an estimated 6 billion yuan from the state back to consumers ("Nonstaple Food Prices Raised"). In summary it appears that inflation has just about cancelled nominal wage increases since the late 1950s, with real urban earnings in 1980 remaining very close to the 1957 level. Urban employment among legal residents has been reduced, however, lowering the dependency ratio per employed family member and bringing about

increases in per capita earnings. These should result in rising demand for nongrain foods.

The increases of peasant incomes are complex and are discussed in the text. But keep in mind that average peasant incomes in the late 1970s were rising and reached their highest levels in the history of the People's Republic, and some localities have consistently done well since 1949. See also Peter Schran, "China's Price Stability: Its Meaning and Distributive Consequences," 1976 (mimeographed); Alexander Eckstein, "The Chinese Development Model," in U.S. Congress, Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 80-114; *Beijing Review*, June 29, 1979, p. 11, and July 6, 1979, p. 40; FBIS, *PRC*, June 25, 1979, pp. L8-L9, June 27, 1979, p. L17, and December 27, 1979, p. L3.

[59] See footnote 58, Table 3, and the discussion of prices in the text.

[60] Some cited elasticities for other Asian countries, excluding the Middle East and Japan, are, for foodgrains: cereals, 0.5; starchy roots, 0.16; pulses and nuts, 0.3. For other food products they are: sugar, 1.3; vegetables and fruit, 0.9; fats and oils, 1.2; dairy products, 1.8; meat, 1.5; eggs, 2.0; and fish, 1.1 (1962 FAO figures cited in John W. Mellor, *The Economics of Agricultural Development* (Ithaca, N.Y.: Cornell University Press, 1966), p. 66.

[61] Japanese maternal cited in Wiens, "Animal Husbandry."

[62] Using Chinese data, Wiens gets 10-12 percent for 1954-57 (excluding millings and ignoring any fine feed devoted to sheep, goats, and poultry) and a high in 1957 of 21 percent (including millings in all nonseed grain use). See Wiens, "Animal Husbandry." Ishikawa derives figures for 1952 (12 percent) and 1956-57 (14 percent) from hypothesized stable correlations, based on Japanese experience, between per capita supply of foodgrains and per capita supply for all nonseed purposes. They are not strictly comparable with any of Wiens' figures. See Ishikawa, "Factors Affecting China's Agriculture," Table 3 and Appendix 1.

[63] Ishikawa, "Factors Affecting China's Agriculture."

[64] Ishikawa, "China's Food and Agriculture," p. 91.

[65] Based on methods and parameters quoted in Wiens, "Animal Husbandry," pp. 39-41. The concentrate required per fattened pig is 74 kilograms, only 44.7 percent of which is trade grain (which has been processed to 86 percent of its original weight). The remainder is millings.

[66] This is because the growth of the number of large animals (50 percent between 1949 and 1977, 15 percent between 1957 and 1977) was slow in relation to the growth in the number of hogs (400 percent between 1949 and 1977, about 100 percent between 1957 and 1977). See Stone, "A Review of Statistics," Table 5.

[67] Based on Chinese material quoted in Wiens, "Animal Husbandry," pp. 39 and 44.

[68] Ibid., pp. 44-7. This trend is partially confirmed by 1979 Chinese press reports that the average weight of hogs marketed in Shanghai has increased 8 kilograms over their weight in 1978 (FBIS, *PRC*, May 16, 1979, p. O6). In Guizhou the figure was 4 kilograms (FBIS, *PRC*, June 4, 1979, p. O3), while the national average of state-procured hogs seems to have risen from 76.5 kilograms in the first half of 1978 to 81.8 kilograms in the first half of 1979 (Xinhua, news bulletin, September 18, 1979, p. 12). The total number purchased (58.79 million), however, represents less than a fourth of the number likely to have been slaughtered in 1979.

[69] See Stone, "A Review of Statistics," Table 3, discussion.

[70] "Decision of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, p. L29.

[71] Calculation based on "Decision of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, and official figures in Stone, "A Review of Statistics," Table 3.

[72] For pigs, 82 kilograms of fine feed per fattened hog (footnote 68); all other parameters are cited in footnote 65; for cattle, 383 kilograms per large animal (a 1957 estimate from Wiens, "Animal Husbandry," pp. 40-1). The large animal stock estimate is a 1978 year-end figure minus 10 million "cattle" (from Stone, "A Review of Statistics," Table 3).

[73] Chen, *Chinese Statistics*, p. 340.

[74] State Statistical Bureau figures from sources listed in Stone, "A Review of Statistics," Table 3.

[75] Wiens suggests that water buffalo are included and that the remainder are mostly common (yellow) oxen (Wiens, "Animal Husbandry," p. 14). Its information ostensibly comes from People's Republic of China, Ministry of Agriculture and Forestry, Animal Husbandry Bureau, *Ta-li fa-chan Hsu-chu Shih-yeh* [Greatly Develop the Pig-Raising Profession] (Peking: Ministry of Agriculture and Forestry, 1974), and Chen, *Chinese Statistics*.

[76] According to *Nanfang Ribao*, FBIS, *PRC*, March 20, 1979, p. P3, cattle breeding in Guangdong declined over the 1970s; absolute numbers were about 4.34 million head in 1957 (Chen, *Chinese Statistics*, p. 359). A similar history has been noted for Anhui (FBIS, *PRC*, May 9, 1979, p. O1) and Xinjiang (March 13, 1979, p. M1), which maintained 22-23 million head of livestock in 1958 (Chen, *Chinese Statistics*, p. 349). According to "Expansion of Animal Husbandry," *Beijing Review*, January 28, 1980, p. 7, the number of cattle and horses began to rise in 1979 after declining steadily for several years.

[77] Stone, "A Review of Statistics," Table 3, discussion.

[78] Chen, *Chinese Statistics*, p. 348.

[79] FBIS, *PRC*, March 8, 1979, p. M2.

[80] The estimate is based on a slaughter rate of 12 percent (Liu and Yeh, *The Economy of the Chinese Mainland*, p. 311). Average live weight of an adult male animal varies among major breeds of oxen and water buffalo from 424 kilograms to 574 kilograms, or, omitting the heaviest and lightest breeds, 480-525 kilograms (Chinese sources in Wiens, "Animal Husbandry," p. 17). The estimate uses 500 kilograms. The 40,000-140,000 ton range then covers any realistic

parameter for meat yield per slaughtered animal and a reasonable margin of error. This estimate, however, should be supplemented by an equivalent figure for highland yak meat which has not been included. Yaks have a slaughter rate of about 20 percent, see Republic of China, Ministry of Agriculture and Forestry, *Nung-lin Tung-chi Shou-tse* [Handbook of Agriculture and Forestry Statistics] (Nanking, Republic of China, 1948), p. 59; Chang Chung-wang and Hwang Wei-yi, *Tsu-kuo Ti Hsu-mo Yu Hsu-chan Tzu-yuan* [Animal Husbandry and Animal Products of Our Fatherland] (Shanghai: Yung-Hsiang Book Co., 1953), p. 207; and Liu and Yeh, *The Economy of the Chinese Mainland*, p. 310. Qinghai grazed 4.6 million yaks in 1978, more than any other province. Yaks subsist on grasses growing on land generally unfit for grain cultivation. They have also been crossbred with oxen to produce an animal yielding more meat earlier and able to graze during the summer in high mountain areas (FBIS, *PRC*, June 28, 1979, pp. L14-L15). These animals may require feeding during some months of the year, but are probably included with oxen in cattle statistics.

If the figure of 10 million cattle in 1978 is correct, a higher slaughter rate is indicated, since over 1.3 million head were sold to the state in addition to the numbers slaughtered at home (calculated from "Expansion of Animal Husbandry," *Beijing Review*, January 28, 1980, p. 7). Most likely, the 10 million figure is an underestimate, but the difference should be covered by the wide range in meat yield allowed for when 'most probable' figures are used.

Camels number about 0.6 million (including 0.38 million in Nei Menggu). They are used for both draft and slaughter, supplying about 350 kilograms of meat per animal ("More Camels," *Beijing Review*, February 1980, p. 29). Slaughter rates are apt to be low—5 or at most 10 percent—suggesting meat yield of 10,000-20,000 tons per year.

[81] Xinjiang, which supported 22.23 million head of all kinds of livestock in 1958 but experienced stagnation and decline from at least 1967 to 1977 (see footnote 79), increased its livestock numbers by 575,000 head in 1978 (FBIS, *PRC*, March 13, 1979, p. M1). Cattle in Heilongjiang increased from 1.5 million head in 1977 to 1.6 million head in 1978 (FBIS, *PRC*, May 23, 1974, p. S3).

[82] The figures in this sentence and the preceding paragraph have been taken or are calculated from official figures in Stone, "A Review of Statistics," Table 3.

[83] Calculated from above figures and statistics from Jen Chi-chou et al., "Pastoral Production Process and the Seasonal Animal Husbandry," *Chung-kuo Nung-yeh K'o-hsueh* [Chinese Agricultural Science], no. 2, 1978, p. 91; cited in Wiens, "Animal Husbandry," p. 51. Furthermore, although an estimated 40 percent or so were slaughtered, only about 15 percent were sold to the state in 1979 (calculated from the above figures and 10.7 million sold to the state in 1979, "Expansion of Animal Husbandry," *Beijing Review*, January 24, 1980, p. 7).

[84] Jen Chi-chou et al., *Chung-kuo Nung-yeh K'o-hsueh*, p. 87; Wiens, "Animal Husbandry," p. 50.

[85] Wiens "Animal Husbandry," p. 35; Stone, "A Review of Statistics," Table 3, discussion.

[86] Stone "A Review of Statistics," Table 3, discussion.

[87] See the discussion of Xinjiang fine wool sheep in the Gansu highlands, in Jen Chi-chou et al., *Chung-kuo Nung-yeh K'o-hsueh*, pp. 87-91; Wiens, "Animal Husbandry," p. 48.

[88] Xinhua, news bulletin, September 19, 1979, p. 12.

[89] It is possible to calculate the poultry population only by making a large number of gross assumptions. The quantity of chicken eggs bought by the state during the first half of 1979 was 579,700 tons (579 million kilograms, Xinhua, news bulletin, September 19, 1979, p. 12) or 11.6 billion eggs at 20 eggs per kilogram. Yearly production may then be about twice that level, or 23.2 billion eggs. If we estimate 90 eggs per laying hen per year (Chinese sources in Liu and Yeh, *The Economy of the Chinese Mainland*, p. 313), then the total number of hens may be 257.6 million and the number of birds no greater than 515.3 million. Even if ducks and geese made up 18.4 percent of total fowl as in 1933 (Buck, *Land Utilization in China*, Study, p. 122), then total poultry would be about 631.5 million. This figure was based on the number of chicken eggs bought by the state and ignores eggs sold at rural fairs and retained for personal consumption. If it is assumed that state procurement is primarily for urban consumption, and if 1956 estimates constructed for the ratio of egg consumption per capita among urban and rural dwellers are adopted, then it may be concluded that although the rural population outnumbered urban dwellers 8:1 in 1978, total eggs consumed may have amounted to only about 1.7 times the procured level. This suggests that poultry stocks in 1978 were more than 1 billion birds or about 3 times the 1956 level. The estimate was made using Shanghai worker annual egg consumption per capita for 1956 (Chen, *Chinese Statistics*, p. 440), rural, urban, total and Shanghai year-end population figures for 1956 and 1957 (Chen, *Chinese Statistics*, p. 124, 127, and 129), estimates for the total number of poultry in 1953 and for the value of poultry in 1956 relative to 1933 (Liu and Yeh, *The Economy of the Chinese Mainland*, p. 250), estimates for the 1978 urban population (Stone, "A Review of Statistics," Table 1, official series) and for the total population (Stone, "A Review of Statistics," Table 1, Aird's best series), and other data cited above.

If the total 1979 state procurement figure of 825 million kilograms (Xinhua, news bulletin) was used in the above calculation, the procedure should yield an estimate of 0.8 billion birds. Wiens' estimate (Wiens, "Animal Husbandry," p. 3) based on constant ratios of poultry per capita, poultry per ton of grain produced, and poultry per pig, suggests figures of 0.85 billion for 1957 and 1.4 billion for 1978, but Wiens claims no great accuracy for these figures.

Moreover, laying rates of famous breeds such as the Peking duck (180 eggs per year) and the sparrow duck (200-250 eggs per year) are much higher than Liu and Yeh's 90 egg per year figure (W. R. Cockrill, "Report of a Visit to China, April/May 1974," Food and Agriculture Organization of the United Nations, Rome, 1974 [mimeographed], see Wiens, "Animal Husbandry," p. 21). But these figures cannot be generalized.

From the above evidence, it can only be suggested that poultry numbers in 1979 are at least 800 million. But they could be twice that.

[90] Vice-Minister of Agriculture Hou Cheng as related by Darwin Stolte, president of the U.S. Feedgrains Council, in an interview on March 30, 1979.

[91] "Mechanized Pig and Chicken Farms," *Peking Review*, October 20, 1978, p. 30.

[92] The slaughter rate used for this estimate was 80 percent (Chang and Hwang, *Tsu-Kuo Ti*). The percentage also appears to be used to derive the "number of hogs in the fattening process" from the "number of live hogs on July 1" (or vice versa) for the years 1953 to 1957 in *Chung-yang Ho-tso Tung-hsun* [Central Cooperative Bulletin] March 11, 1959, p. 31; Chen, *Chinese Statistics*, p. 404). The figure used for average live weight at slaughter was 68 kilograms, a mid-1957 average of hogs at sale (Liu Jui-lung, "Summary Report of the National Keypoint Pig-Raising Counties Discussion Meeting," *Chung-kuo Nung-pao* [Chinese Agricultural Journal], No. 11, 1957, p. 1; Wiens, "Animal Husbandry," pp. 43-44). The national average weight of state procured pigs during the first half of 1978 was 76.5 kilograms, and 81.8 kilograms in the first six months of 1979 (see footnote 63), but the average weight of pigs consumed was probably well below these figures. Wiens estimates the 1957 weight of pigs consumed by peasants to be close to 50 kilograms, despite the average sale weight of 68 kilograms. Therefore 68 kilograms may be a reasonable average to assume for 1978 hogs. If all hogs reach the 1978 state procurement average and the higher pork percentage per kilogram of live weight (see below) were used, additional meat supply would be almost 3.1 million metric tons for 90 million hogs. The range of the estimate in the text was derived from two differing percentage estimates of average weight per pig above and of meat yield per kilogram of live weight: 46.7 percent and 55.6 percent. Both percentages were based on average per capita pork consumption figures for 1955 appearing earlier in the paper (footnote 52), official 1955 yearly average population figures for rural and urban areas (Chen, *Chinese Statistics*, p. 127) and the "number of hogs in the fattening process" in 1955. The lower estimate assumes that in the official calculation the average weight of all slaughtered pigs was 68 kilograms. The higher estimate assumes that only "pigs purchased by the state" (*Chung-yang Ho-tso Tung-hsun*, March 11, 1959, p. 31) averaged 68 kilograms and that in the official calculations pigs sold in rural fairs and slaughtered for home peasant consumption averaged 50 kilograms (as assumed by Wiens, "Animal Husbandry," p. 44). The higher percentage is favored owing to the increase in average hog weight.

[93] Of a large animal stock of 94 million in 1978, 10 million cattle were considered above. Yak numbers are estimated at 10 million (a guess based on 4.6 million in Qinghai in 1978 and the historical stock relationship of that province to other highland provinces and autonomous regions). The yak slaughter rate adopted is 20 percent (Republic of China, *Nung-lin Tung-chi*, Chang and Hwang, *Tsu-kuo Ti*). The average weight per yak, 370 kilograms (Wiens, "Animal Husbandry," p. 17). Average kilograms of meat per kilogram of live weight, 0.5 (assumed to be the same as hogs). These figures suggest that the contribution of yak meat in 1978 was around 0.37 million metric tons. For the remaining 74 million large animals, it is assumed that the death rate is 10 percent (Liu and Yeh, *The Economy of the Chinese Mainland*, p. 341); the meat yield ratio is 0.5, and the average weight per animal is 350-500 kilograms. The 500 kilogram figure is assumed to be about the average for the various breeds of oxen in case most are not included in the cattle figures. The 350 kilograms figure is the modal breed average for Chinese horses (Wiens, "Animal Husbandry,"). These figures suggest a meat yield of 1.40-1.85 million metric tons, for a total (including yaks) of 1.8-2.2 million metric tons.

[94] 301.29 million in 1978 (Stone, "A Review of Statistics,"), 30 percent (90.387 million) computed previously, and 128.7 million additional. The last figure was derived by working backwards from 3.5 million metric tons of pork using the parameters cited in footnote 92.

[95] Stone, "A Review of Statistics," except that total stock (391.677 million), slaughter rate (80 percent) kilograms of meat per kilogram of live weight (0.5) and 3.5 million metric tons of meat required were used to derive the weight increment necessary (22.37 kilograms).

[96] All parameters in footnote 65, with the addition of the typical Chinese parameter of 4 kilograms of concentrate per kilogram of incremental live weight needed. This figure was so well accepted in the 1950s that the relationship between the price of meat and the price of grain was based on this requirement. See Chang Tsung-hui, *Chung-kuo Yang-chu-fa* [Chinese Methods of Pig Raising] (Nanking, 1957); Wiens, "Animal Husbandry," p. 39.

[97] Wiens, "Animal Husbandry," pp. 38-47.

[98] Based on a study in Wu Yun-Feng, ed., *Chien-ming Hsu-mu Shou-tse* [Simplified Animal Husbandry Handbook], pp. 73-4; Wiens, "Animal Husbandry," p. 43. Two methods are presented: one "for areas with adequate concentrate supplies" and the other (clearly the one intended to appear more efficient) "for areas deficient in concentrate supplies." For each method, daily concentrate feed for various growth stages up to 90 kilograms live weight have been calculated using material appearing in the cited table and the remaining parameters from footnote 65. Statistics for the concentrate-saving method do not even reach 90 kilograms, so the feeding regimen suggested for the first method has been added for an extra 26 days of weight gain after 75 kilograms have theoretically been reached under the second feed schedule. Aside from earlier slaughter (240 versus 260 days from weaning) the principal differences noticeable in the second (recommended) regimen are that prescribed concentrate and fodder are substantially lower for the middle growth period (between the dates at which the hog reaches 30 kilograms and 50 kilograms live weight, this period then, is 100 rather than about 70 days), partially compensated for by a high rate of forage feed (such as squashes and melons, the leaves of vegetables such as cabbage or beans and various trees) during the middle period and a lower rate in the final stage. Once the requirements for fattening 392 million hogs to 90 kilograms was calculated (38-41 million metric tons of unprocessed grain), 18 million metric tons were deducted as an estimate of requirements for 392 million hogs at 68 kilograms per hog (from footnotes 65 and 67 — 82 kilograms of concentrate per hog).

[99] Hsiung Te-hsiao, "How to Raise Pigs and Utilize Feed Economically and Effectively," *Nung-yeh Ko-hsueh Tung-hsun* [Agricultural Science Bulletin], no. 8, 1957, p. 422; Wiens, "Animal Husbandry," p. 45. Wiens found that Hsiung's computation contained many mathematical errors, some of which he suspects were deliberate in view of remarks Hsiung made to him. Other parameters required for the computation are found in footnote 65.

[100] The 44.7 percent figure is from footnote 65, the sources of computation for the milling rate are described in footnote 30.

[101]See footnote 55. A variety of means are being explored to improve the situation in provinces with large and growing stocks of hogs. In Zhejiang, crop stalks totalling 15.4 billion jin (7.7 million metric tons or about 70 percent of the total available) were burned as fuel annually in the mid-1970s. In recent years marsh gas digestors have become the main energy source for 31 communes and about 500 brigades, freeing a considerable volume of stalks to be used as a supplement to livestock roughage and as organic fertilizer. By mid-1979 Zhejiang had built 271,000 such fuel units. (FBIS, *PRC*, June 20, 1979, p. O7). For other methods of stretching the nutritional value of concentrate, see Scientific Cooperative Group, *Jen-kung Liu-wei Fa-hsiao Ts'u-liao* [Artificial Stomach Fermented Feed] (Peking: Scientific Cooperative Group, 1976); Kwangtung College of Agriculture and Forestry, Department of Animal Husbandry and Veterinary Medicine, "Isolation Selection of Cellulose Molds and Breeding of Induced Mutants," *Kuang-tung Nung-yeh K'o-hsueh* [Kwangtung Agricultural Science] no. 2, 1974, p. 24; both cited in Wiens, "Animal Husbandry," pp. 46-7. There are 1979 claims that the mixture of grain and nongrain feeds currently promoted by the government results in faster growth—an increase in weight of at least 30 percent is promised over an equivalent growing period. The exact proportions of this mixture are unknown, but it is likely to gain prevalence over 1980-85 and almost certainly incorporates higher percentages of fine feed. Zhao Zhiyang, "Study New Conditions and Implement the Principle of Readjustment in an All-Round Way," *Hongqi* [Red Flag], January 1980, pp. 15-20.

[102]Based on Stone, "A Review of Statistics," Table 3.

[103]See footnote 68.

[104]In March 1979 the purchase price of pigs was raised 26 percent. The national purchase prices of cattle and sheep for slaughter were raised by 20-50 percent. ("Higher Purchasing Prices Bring Good Results," *Beijing Review*, November 19, 1979). In Heilongjiang, prices rose 25 percent for pigs, 35 percent for cattle, and 33 percent for sheep (FBIS, *PRC*, April 24, 1979, p. S6). It appears that even before the increase relative feedgrain and hog purchase prices did not fully reflect the government policy of fine feed conservation. In actuality it was profitable to continue feeding more concentrate than was recommended. Also, see Zhao Zhiyang, "Study New Conditions."

[105]The state purchase of pigs over the first half of 1979 was 58.79 million head or 19.2 percent above the equivalent in 1978 (Xinhua, news bulletin, September 18, 1979, p. 12). The Hunan Provincial Commercial Department found it necessary to reduce the sale price of pork in urban areas (January 25—February 5, 1980) to prevent rotting, as the department's refrigeration warehouses could not store any more pigs (FBIS, *PRC*, January 29, 1980, p. P3). The problem was also experienced in April just after an April 1 price increase (FBIS, *PRC*, April 21, 1979, p. P4). At that time the doubling of pork supplies within a few days was ascribed to panic sale by peasants who believed the rise to be temporary. But the problem seems to be persistent.

[106]Wu Chuan-chun, Institute of Geography, Academica Sinica, Beijing, conversation, January 25, 1980.

[107]Figures for this calculation include a 1979 preliminary grain production estimate of 315 million metric tons (footnote 3), hog slaughter rate of 80 percent (footnote 92), the 5-million-metric-ton estimate for a 30 percent increase in hog and cattle stock (footnote 71), 86 percent milling factor for trade grain, 44.7 percent grain weight in total concentrate (footnote 65) and the rule of thumb from the 1930s of 4 kilograms of concentrate required to increase hog weight by 1 kilogram, which is probably high. The preliminary 1979 grain figure was used since it was the latest available at the time the 3 percent growth rate was quoted by Dr. Wu.

[108]It was first suggested that this idea be applied to Chinese grain sufficiency in Kenneth Walker, "Grain Self-Sufficiency in North China, 1952-75," *China Quarterly*, September 1977, pp. 581-2.

[109]London, "Hunger in China: Failure."

[110]All figures from Chinese sources in Stone, "A Review of Statistics," Table 4A. Also see Table 3 of this paper.

[111]FBIS, *PRC*, September 26, 1979, p. S2.

[112]FBIS, *PRC*, September 12, 1979, p. L14.

[113]Stone, "A Review of Statistics," Table 4A.

[114]Ibid.

[115]FBIS, *PRC*, September 20, 1979, p. S4. Xinhua, news bulletin, August 3, 1979 p. 5 gave the figure as 1/5.

[116]See footnote 104.

[117]The 40 percent figure for 1955 is based on computations using age-specific and total population figures for 1958 prepared by John Aird in May 1979 and found in CIA, "China: A Statistical Compendium," pp. 4-5; the 40 percent figure for 1978 was also based on Aird's population and birth rate estimates from the same publication and found in Appendix 2.

[118]A State Statistical Bureau study cited in Chen, *Chinese Economic Statistics*, pp. 430-1.

[119]The identification of the class position of each peasant was made according to People's Republic of China, Political Council, "Decision of the Political Council of the Central People's Government on the Classification of Rural Classes," *Collected Materials on Land Laws in the People's Republic of China*, ed. Peking Politics and Law College (Peking: Law Publishing Co., 1957), pp. 34-56; Shigeru Ishikawa, "Agrarian Reform and its Productivity Effect: Implications of the Chinese Pattern," in *The Structure and Development in Asian Economies*, Center Paper No. 10 (Tokyo: Japan Economic Research Center, 1968) p. 320. "Rich peasant" is defined as a peasant who is engaged in farm operation relying mainly on the exploitation of hired laborers. "Middle peasant" is a peasant who relies mostly on his own labor in farm operation, regardless whether he owns land or leases it. "Poor peasant" is a peasant who is exploited by others either through the payment of land rent or through the receipt of undervalued wages of labor.

A much wider range of income variation is exhibited in Table 2 and for example in Li Ch'eng-jui, *Chung-hua Jen-min Kung-he-kuo Nung-yeh-shui Shih-kao* [A Draft History of the Agricultural Tax in the People's Republic of China]

(Peking: Finance Publishing House, 1959), pp. 133-8; Roll, "Incentives and Motivation," Table 1, p. 11. Here average income varies widely between regions but no foodgrain consumption figures are presented.

[120]Zhejiang's hogs numbered 5.58 million in 1957 (Chen, *Chinese Statistics*, p. 354). Marketed hogs were fed an average of 74 kilograms of fine feed nationally in 1957, 44.7 percent of which was grain (see footnote 66), or 2.4 percent of the total provincial grain production of 7.793 million metric tons (Chen, *Chinese Statistics*). Most hogs were retained for home slaughter or breeding and probably consumed less grain per head.

[121]The processing loss figure (0.216) used for Zhejiang in this estimate was higher than the 1977 national average computed elsewhere (0.175, or 82.5 percent retained), owing to the higher proportion of rice in the province's grain output composition. The figure included is an average of 2 estimates: 77.4 percent based on 1957 crop composition from Chen, *Chinese Statistics*, and Wiens' figures for processing loss by crop (Stone, "A Review of Statistics," Table 4, notes); and 79.4 percent for 1979, estimated by assuming 6.55 million metric tons for early rice (FBIS, *PRC*, August 20, 1979, p. O5) represents total provincial rice production (biasing the estimate upwards) and assumes that nonrice production consisted entirely of wheat (biasing downward).

[122]The parameters are from footnotes 66 and 68; grain and hog figures are from "Changes in Zhejiang Countryside," *Beijing Review*, February 18, 1980, pp. 4-5. Output rose at an average annual rate of 13 percent in 1978 and 1979 (total 3 million metric tons, see Xinhua, news bulletin, December 18, 1979; FBIS, *PRC*, December 20, 1979, p. O12).

[123]See Stone, "A Review of Statistics," Table 6.

[124]From unpublished findings by Ammar Siamwalla, International Food Policy Research Institute, Washington, D.C.

[125]Frederic Surls, "China's Grain Trade," U.S. Joint Economic Committee, *Chinese Economy Post-Mao*, vol. 1 (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 663-6; Stavis, "A Turning Point in Policy," pp. 6-7.

[126]Stavis, "A Turning Point in Policy," pp. 6-7.

[127]Stone, "A Review of Statistics," Table 6.

[128]Ibid, Table 9A.

[129]"Mechanized Pig and Chicken Farms," *Peking Review*, October 20, 1978, p. 30.

[130]George Gunset, "China's Grain Push Could Alter Markets, *Chicago Tribune*, February 7, 1979.

[131]Production in 1957 was 10.045 million metric tons (official sources in Chen, *Chinese Statistics*, pp. 338-9). U.S. Department of Agriculture (USDA) figures show production rising from 6.2 million metric tons in 1969 to 10 million metric tons in 1973 and oscillating between 9 and 10 million metric tons thereafter (figures cited in Gunset, "China's Grain Push"). Wiens, however, gets an estimate of 7 million metric tons for 1977 (an unpublished estimate of Wiens, based on official sources). Recently a highly reliable official source is reported to have agreed that the current USDA estimate of around 10 million metric tons is "about right." The difference between the USDA and Wiens estimates (both of which are derived from official sources) may be "soybeans not consumed directly as foodgrain," which at least recently may have been excluded from official foodgrain statistics (Stone, "A Review of Statistics," Table 2, discussion).

[132]FBIS, *PRC*, February 23, 1978, p. E17.

[133]Hunnan province, for example, has a subsidy program encouraging production of all bast fiber and oil crops. (FBIS, *PRC*, March 3, 1980, p. P3).

[134]Stone, "A Review of Statistics." Table 6 gives 1977 soybean imports as 360,000 metric tons.

[135]Stone, "A Review of Statistics," Table 6.

[136]"Decisions of the CCP Central Committee," FBIS, *PRC*, August 31, 1979, p.L27.

[137]The state purchase period of a given year runs from April 1st of that year to March 31st of the succeeding year. By December 20, 1979 the state had purchased 50.144 million metric tons of grain, exceeding the 1979 plan by 2.04 percent and surpassing grain collected in 1978 by that date by 4.5 million metric tons (Xinhua, news bulletin, December 25, 1979; FBIS, *PRC*, January 4, 1980, p. L9). Jiangsu and Shandong had already registered increases over 1978 by December 5, 1979 (FBIS, *PRC*, December 20, 1979, p. O13). State purchases across China in calendar year 1979 exceeded those of 1978 by 5.15 million metric tons (Xinhua, news bulletin, February 27, 1980; FBIS, *PRC*, February 28, 1980, p. L5).

4

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 particu-

larly 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		Change in Output from Irrigated Area
			First Year	Last Year	
	(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	11.5-11.3	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:

$$RR = \frac{\frac{\sum_{i=0}^{n} Q_{t+T+i}}{n} - \frac{\sum_{j=0}^{2} Q_{t+j}}{3}}{\frac{\sum_{i=0}^{n} F_{t+T-r+i}}{n} - \frac{\sum_{j=0}^{2} F_{t-r+j}}{3}}$$

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:

$$RR = \left(Q_{1973} + Q_{1971} - 2Q_{1970} \right) / \left(F_{1973} + F_{1971} - 2F_{1970} \right)$$

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 frontrunners" 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 Repub' ,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 Chairman 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 7.5 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, 1966), 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.

5

THE EFFECTS OF OTHER POLICY CHANGES AND TECHNOLOGICAL DEVELOPMENTS

Thus far it may be concluded that on the basis of prospective input supply alone, China's population, which is growing older and more numerous, can be provided with a quantity of foodgrains equivalent to the amount consumed in 1978. Additional requirements for food processing, industrial use, brewing, and the like may also be accommodated, as can grain stockpiling plans, direct assistance to poor localities, and feed demands sufficient to underwrite the Party's livestock-increase targets. If the growth rate between 1980 and 1985 indeed falls within the range of 3.0-3.5 percent per year, then another 10-20 million tons of grain will also be available to be consumed directly (by those whose consumption is average or below) and to meet the meat supply target. Should the growth rate of supply exceed 3.5 percent per year, it is clear that unsatisfied direct and indirect demand will easily absorb the remainder, at least up to 400 million metric tons of production.

The justification for predicting growth in the 3.0-3.5 percent range rather than the long-term historical average of 2.5-2.6 percent is simply this: the current trends and future prospects for input supply in the target period are more reminiscent of those of China's rapid-growth periods in the mid-1960s (when output grew about 5 percent per year) and in the 1970s (when output grew 3.7 percent per year between 1971 and 1975) than of the slow-growth periods that followed the Great Leap Forward, the first phase of the Cultural Revolution, and the mid-1970s political disturbances. In each of these latter periods, politically ambitious policy shifts were undertaken while the input stream ebbed. After a year or so, output stagnated or declined.

In some ways input supply prospects are now even better than supply increases were in the two rapid-growth periods. The absolute levels of input supply are substantially higher. The growth rates are comparable. If the level of absorption of fertilizer nutrients has indeed been a major constraint, as suggested above, then the growth rate of absorption may very well exceed that required to generate a 3.5 percent-per-year average growth in output. But power and fuel supply is an immediate constraint throughout the economy, and growth continues to depend on major infrastructural efforts. If sheer comparative trends are any indication, the projected supply of irrigation and drainage machinery is suggestive of constraint although this may be temporarily alleviated by increased utilization of existing supply. Soil quality, which in certain areas has unquestionably deteriorated, must also be considered an input. Moreover, the two rapid-growth periods mentioned above did not continue without interruption over the eight-year period. Unfortunately, future periods of stagnation cannot be ruled out. For the immediate future, however, the prospects look very good.

In the remainder of the paper, it will be argued that the prospects for growth from other policy changes and technological developments also look good for the next few years, but that the risk of stagnation has not been eliminated. For convenience it may be assumed that output expansion resulting from these other considerations can be added independently to that resulting from growth in input supply.[269] This is a distortion, particularly in the case of changing technological circumstances, but perhaps one that is not too serious for present purposes.

Under conditions of dynamic technical change associated with "green revolution" developments, foodgrain output expansion is the result of an outward shift of agriculture's production function, as well as movement along that function. Hence potential for growth from technological change in the current period must be compared with growth from this source in past periods.

Recent changes in official policy emphasis are also apt to bring about output increases. The effects of such changes may be subdivided into those operating upon the efficiency of resource allocation within and among collective units and upon the structures for incentive and income

distribution. Although the influences of policy changes on foodgrain production are not limited to effects falling within these categories, the latter are certainly important considerations for China in the current period. Moreover, they are not mutually independent, and their orthogonal elements cannot be easily separated. Nevertheless, this section includes a separate attempt to describe the impact of each of these variables upon the prospective supply of foodgrains.

Before proceeding to these discussions, it should be noted that 1978 was still a bad weather year, although to a lesser extent than 1977. Therefore, it is quite probable that weather in 1985 will be more favorable than it was in 1978. The expected value of this consideration for prosepctive foodgrain output may be estimated without much trouble. In the process of estimation, it is sensible to weight 1970s fluctuations in weather and output much more heavily than previous variations since Chinese ability to mitigate adverse effect on output has improved significantly since the 1950s and 1960s. If this is done, and weather fluctuations are merely trichotomized as in Table 1, an expected increase in supply resulting from the expected difference in 1985 and 1978 weather conditions may still be as much as 10 million metric tons.[270]

The Effect of the 1978-79 Rural Policy Reform Upon Farm Labor and Local Savings Incentives

Three categories of recent policy changes by the central government should raise farm labor and local investment incentives and contribute to a higher effective labor input and savings in rural areas. Some changes increase the government's concentration on the agricultural sector in terms of its administrative priorities and budget allocations. These allocations help develop the agricultural infrastructure and industries with strong demand linkages to agriculture. Such priorities and allocations will expand the long-term rewards available to peasants for applying extra effort to agricultural development.

Other changes will raise the immediate rewards for extra productive effort in the rural sector. They include such measures as the 20 percent increase in the government purchase price of within-quota grain; the additional 50 percent price increase for delivery of surplus grain; the decision not to raise the quotas of grain that must be delivered at the lower, within-quota price, and the abolition of ceilings on collective grain distribution to commune members; the 10-15 percent decrease in the sales price of industrial inputs to agriculture,[271] and increased preferential input allocations to localities that increase output; and encouragement of rural fairs for interrural exchange and sale of produce from private plots and sideline production.[272]

Other changes are embodied in the government and party repudiation of "commandism"—a dictatorial tendency which often leads to the application of production team labor and savings, without team approval, to projects that benefit larger organizational units, or are otherwise unpopular. The frequent increase, contrary to national policy, of compulsory purchase quotas by ambitious local officials is also encompassed by this term. Commandism, of course, not only alienates peasants from expropriating and dictatorial authorities, but results in declines in labor productivity and in locally generated savings and investment. Repudiation of commandism should tend to reverse these declines as should the other incentive measures, although this policy shift may not be without drawbacks and limitations.

The essence of the grain procurement structure as an incentive mechanism is in the tax structure, relationships between the size of compulsory purchase quotas and output per capita, the changes in those quotas, the relationship between the compulsory quota price and the "surplus" delivery price, and the manner of determination and size of the planned "surplus" to be sold to the state.

In 1954, the year after a grain crisis that resulted in the establishment of the state purchasing monopoly, compulsory grain deliveries were introduced because state procurement organs had again been unable to secure enough grain for urban areas, grain-deficit areas, the army, and planned exports. Another crisis in 1955 led to the assignment of a standard production quota to each unit of land. A fixed portion of these quotas was to go to the state at a given low price. After meeting the grain needs of provinces for food, feed, and seed and

delivering the agricultural tax and compulsory quotas, 80-90 percent of all the "surplus" grain was to be sold to the state.[273] Production and fixed purchase quotas were to be set for the three-year period 1955-57 in "normal" years to avoid the powerful disincentive effect of increased output immediately resulting in higher quotas. After a fall in state procurement, an "abnormal" year was invoked, allowing compulsory sales to be increased beyond a legal restriction of 40 percent of extra output (over and above compulsory deliveries, tax, and "planned surplus") and subsequently, the elimination of the 40 percent limit. Pressure to produce more and deliver more grain to the state led to the abandonment of fixed quotas, but the system returned, even before 1962, during the agricultural disasters. Quotas were fixed for 5 years and in some areas, 10 years,[274] although there is evidence that the limitations on quota reassignment were sometimes transgressed.

The longer the declared period of a single fixed quota, the greater the incentive to exceed the quota, and the greater the reward to those who succeed. Compulsory quotas, the absolute quantity of agricultural tax, and the "planned surplus" percentage to be delivered to the state (varying from about 40-85 percent of total output after food and seed needs determined by provincial authorities have been met),[275] were set on the basis of land quality. The structure was progressive.[276] By fixing the tax as an absolute amount, however, an incentive was provided to increase production. This brought rewards to those who could do so and promoted income concentration. The greater the surplus price over the quota price, of course, the greater the incentive and the greater the financial ability of successful localities to purchase inputs, which made future success in exceeding the quotas easier.

Between 1953 and 1956 compulsory deliveries (the quota plus the "planned surplus") varied between 23 and 34 percent of annual output.[277] They appear to have dropped to an average of a little above 20 percent during the 1960s and early 1970s[278] and rose in the 1970s to an average of around 20-25 percent.[279] In calendar year 1978 total state grain procurement was 19.7 percent of output. In 1979 the figure rose to 20.6 percent despite a cutback in required deliveries.[280]

It is not yet possible to conclude that investment and labor applied to foodgrain production will increase above what they were before 1979. It is only being suggested here that there is an increased investment incentive to accumulate savings (complemented by a higher interest rate available on rural savings accounts) and that there is greater incentive to apply labor effectively to productive efforts. In making even this point, it is necessary to overcome any suspicion that coercive, or patriotically and socially inspired work levels might be superior to those more dependent on motivation through individual and small group self-interest.

Although it is quite possible that the former motivational elements, especially appeals to public-mindedness, at particular times and for particular purposes have yielded positive results, further dependence on such elements has encountered severe constraints. The relatively poor performance of rural policy overly dependent upon these elements in the recent past is one of the primary reasons for the 1978-79 policy changes. Leading Chinese economists and administrators have aggressively pointed out the relationship between substandard agricultural output and overprocurement and low profit rates for, especially, grain and cotton. This relationship has been singled out as a major obstacle to production increases in the mid-1970s.[281] It should also be kept in mind that duration of work, which is relatively easy to control, is only one element in effective labor application. Other elements, such as the quality and intensity of work, are much more difficult to preserve once the incentive structure is undermined and motivation begins to degenerate.[282]

Another idea that must be rejected is that necessity in recent lean years caused work levels to increase to those that can be expected in the current period. This is a complex matter that requires empirical investigation and more substantial treatment than it will receive here. It seems that millions of Chinese have been undernourished in recent years, perhaps chronically (see above). Nutritional studies indicate, however, that undernourishment inhibits effective labor application and that output rises as nourishment does.[283]

It must be admitted that many rural Chinese have incomes greater than the bottom quintile, and that the typical labor application curve has a backward-bending supply section at higher levels of compensation. It does not appear likely, however,

that most rural Chinese are operating on such a backward-bending section. If the 1979 response is any indication, the rural attitude is characterized more by a suspicion that current policy changes may be short-lived and by an eagerness to take advantage of favorable terms of trade through greater production and sales than by a desire for more leisure and less work.[284]

Given that the policy changes will probably generate, if anything, more rather than less effective labor, the above consideration may be cause for optimism that, in the short term, some proportion of incremental savings and effective labor will be applied to raising farm output. The Chinese authorities seem concerned that a dominant share of the large financial transfer embodied in the 1979 price changes will be devoted to upgrading rural housing and general living standards rather than to animal husbandry and agricultural investment. The likelihood of this seems to be borne out by recent experiences in Southeast Asian countries.[285] If the allocation of labor and savings has indeed become more discretionary, this kind of movement can be expected. This does not mean, however, that labor and savings devoted to increasing farm output is likely to fall absolutely as a result of the price changes.

The farm labor supply should be carefully monitored because of China's labor-intensive production methods. As it is more traditionally measured, a gross increase in the rural labor supply owing to population growth can be predicted (see Appendix 2). But net migration to the cities will probably increase between 1980 and 1985, as will the rural nonfarm work force. The size of these two effects is more difficult to predict. Forecasts depending on past trends, not exactly known to begin with, are probably poor measures of those factors, in view of liberal turns in policy and expanded rural opportunities both in and out of farming in the late 1970s. Unfortunately, it is still too early to estimate any short-term trend since then.

Effects of Changes in the Allocation of Resources

Thus far, the thrust of the supply-related arguments has been aimed at demonstrating that a greater rate of increase in the flows of productive resources to the farm sector is apt to occur in the 1980-85 period than before 1978, especially when compared with the slow-growth periods such as 1959-62, the late 1960s, and the years immediately before 1978. They may even compare favorably with the periods of rapid growth in the mid-1960s and the first half of the 1970s. But how much of these resources will be devoted to foodgrain production? And will the pattern of allocation increase or reduce efficiency in grain cultivation? If the repudiation of commandism is complete, might it not be reasonable to expect a large-scale reallocation of resources to more lucrative nongrain and peasant sideline production?

While commandism has been reduced, the limits of current initiatives to increase peasant autonomy should be recognized. On the whole, the 1978-79 rural policy changes were not taken to reduce planning in foodgrain production, but to make planning more effective while conserving expense.

In addition to the measures listed above, several shifts in policy emphasis may have significant effects on the pattern and efficiency of resource allocation. These include: an emphasis on reallocating agricultural land, devoting more to pastures, forests, and nonfoodgrain acreage; greater peasant autonomy over collective decisions and private plots, accompanied by the active encouragement of peasant sideline production; a focus of attention on "major grain bases" and, in particular, "key front runners" within that group which will receive preferential allocations of industrial inputs, investment, and credit in exchange for pledges to deliver large increases in marketed grain; and a focus of attention on the problems of backward localities and low-yield counties. Each of these shifts has affected grain production by influencing the quantity and location of acreage sown to particular crops. Acreage has been reallocated from foodgrain to, especially, sugar beets and cane, oil crops, bast fibers, and pulses. Some of this land has been of high quality. More marginal agricultural lands have been retired on a large scale, particularly for conversion to forest and pasture.

A sample of reported acreage conversions conducted in the spring of 1979 has been tabulated in another work[286] with the most recent foodgrain yield figures available for each area (usually on a provincial basis). The results suggest that foodgrain acreage

reductions as of 1979 were not a significant portion of total grain sown area even quantitatively and did not outweigh reclamation plans. When the quality of the retired lands is considered, the extremely low yields typical of these areas suggests even smaller gross reductions in grain output.

The policy of allowing greater peasant autonomy may indeed be in earnest, but it does not appear that it will result in major declines in foodgrain acreage on collectives except in some poor localities. Some provinces even announced that although they may reorganize foodgrain acreage on a county basis, the total area under grain cultivation will not be permitted to fall.

The private plots are a small proportion of acreage, and only a minor proportion was devoted to foodgrain production. The principal exceptions are in the areas where total foodgrain production per capita is very low—and even many of these areas may be unlikely to radically reduce foodgrain acreage for security motives, despite policy changes. All in all, the total reduction in foodgrain-cultivated area is not likely to be large, particularly when one considers policies to increase large state grain purchase prices and to open the lucrative rural markets to produce from private plots.[287]

The policy of allowing greater peasant autonomy will also reduce the pressure on local units to increase cropping intensity. This development coincides with growing administrational ambivalence over the ultimate value of maintaining even the 1978 level of multiple cropping in many regions. The combination seems likely to result in a decline in foodgrain-sown area in some provinces over and above any net reductions in foodgrain-cultivated land. The implications of this trend for aggregate grain production, however, are again apt to be much less serious than they first appear. In some provinces, most notably Sichuan, combined yields have actually increased when triple-cropped areas have reverted to double cropping or when unpopularly double-cropped land has again been single cropped.[288] In areas such as the lower Yangtse region,[289] triple cropping has coincided with gross increases in foodgrain production since the mid-1960s. But when greater seed requirements, lower milling rates of required varieties, and gains not attributable to increased cropping intensity are netted out, the improvement appears to be small. A shift back to double cropping may indeed occur since any increases in the profitability of net output are swamped by greater input requirements. But even a small reduction in output may be ameliorated by a judicious application of some portion of the difference between the current and mid-1960s input streams.

In the major grain bases, on the other hand, grain-cultivated area is likely to expand if it changes at all. Twelve such bases have been designated by the state, including the entire province of Heilongjiang, sections of Inner Mongolia and Ningxia that are irrigated by the Yellow River, the Gansu Corridor, the Tonting and Boyang Lake areas, the Yangtse Delta, the Songhua-Jiang and Liaohe basins of Jilin province, and the central plains of Liaoning.[290] Most are areas where production per capita is high, either because population density is low and land of modest yield is extensively machine cultivated, or because yields themselves are particularly high.[291] To the extent that grain acreage expansion occurs where yields are particularly high, the marginal impact on aggregate output will be large. Yields from the other land can benefit from the greater concentration of fertilizer, farm chemicals and machinery, capital construction investment, and preferential loans and subsidies that have been flowing to these bases since the spring of 1979.[292]

When all of the above are considered, it does not presently appear that foodgrain production is likely to seriously suffer from any net reductions in foodgrain-sown area. The aggregate effect may even be slightly positive. A number of other allocative considerations have net effects that are less ambiguous.

The zoning changes in several instances will make the spatial pattern of production more efficient if the risks of monoculture can be neutralized. For example, cotton yields in the southern and western sections of Liaoning are comparable, but grain yields are 3.7-4.0 tons per hectare in the south while only 0.75 tons per hectare in the west. It was therefore proposed that most cotton production be shifted to the west and grain to the south without significantly changing grain-sown area.[293] Heilongjiang province will concentrate production of wheat in the north, wheat and soybeans on the rich Songhuajiang and Nenjiang plains, maize and soybeans in the south, and maize and rice in the productive river valleys. It will relegate beets and oil crops to the compara-

tively saline and alkaline soils of the west.[294]

In addition to increasing allocative efficiency, such shifts in regional cropping patterns can bring ecological benefits, especially in the Yellow River watershed and in areas threatened by desertification. Ultimately, there may be some advantage to foodgrain production of the "green belt" now under construction in the northwest. This is seen as the answer to the problem of reducing silt content in the Yellow River, now used for irrigation with limited success.[295] Benefits to aggregate yields in the current period, however, will be negligible.

The sizeable boosts in the foodgrain purchase price mentioned above were made, of course, to provide rural localities with the means and incentive to make further input purchases required to raise production (or to maintain application levels within areas in which greater peasant autonomy would be apt to bring about cuts in those levels owing to perceived unprofitability at pre-1979 prices). The price increases could also improve the efficiency of resource allocation within collective units.

In general, acreage sown to foodgrains has been officially determined and impossible to disguise. Yet the purchase price of private and sideline products has been high relative to foodgrains, creating incentive not only for the individual to concentrate variable inputs like labor and fertilizer on his private plot, but also for the fairly successful collective unit to devote more resources to nonfoodgrain activity. The recent price change may be sufficient to turn the allocational decisions of collectives toward greater emphasis on foodgrain production. Since the old price structure would have resulted in a relatively land-abundant, and capital- or input-scarce foodgrain production mix, shifting units of capital and inputs could have a high marginal impact.

To be sure, there have also been large boosts in the purchase prices of nongrain farm products,[296] but for the most successful localities—those able to greatly exceed quota assignments—the surplus grain price must now compare much more favorably with prices of other agricultural products. The poorest localities, whose quota assignments have been reduced or cancelled, may also be motivated to produce more grain.

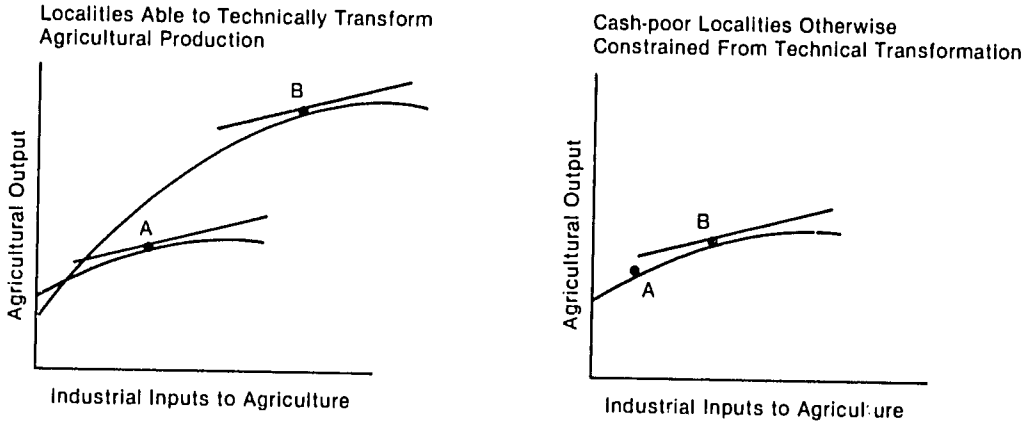
Foodgrain production in poor areas, however, may benefit more directly from the elimination of taxes and purchase quotas and from selective subsidy programs being implemented by the provinces. These measures may almost be prerequisites to obtaining more than nominal profit from the pricing changes in some poorer localities. They may be far more important than any increase in allocative efficiency within a collective.

For Chinese agriculture of the late 1950s, characterized by relatively high yields for a predominantly preindustrial production process and with little surplus land that could be easily converted to agricultural use, the most auspicious way to increase foodgrain output was the road of technical transformation.[297] A region able to put together a complete package of requisite inputs and field management patterns would be able to shift upward the production function of the agricultural sector, transforming its technical base. The region could increase output by large margins and to varying degrees, depending on the state-dictated terms of trade between agriculture and other sectors, justify the very sizable additional expense for the inputs purchased.

In general, those localities not able to put together such a package would suffer sharply diminishing returns when applying only part of the package. Thus, large-scale increases in, for example, chemical fertilizer application could easily be uneconomic for such localities even with favorable terms of trade. This observation conforms with results of research on Indian agriculture.[298] But even when the road of technical transformation is not open and the region is constrained to the existing production function, the path of making the most of available techniques may lead to some increased output, if the application of such inputs as farm chemicals and fertilizers has been at very low levels. The difference in potential between this type of region and one able to fully transform agricultural production is schematized in Figure 2.

While long-term aggregate growth rates in Chinese agriculture have been, on average, relatively modest and slightly above the rate of population growth, it can be documented that in many regions of the country, foodgrain output growth has, on the contrary, been very high.[299] This indicates that there are areas with essentially no growth or even negative growth in output per capita. It is in these localities that the better-off rural inhabitants have more incentive to separate themselves from poorer peasants and reject

Figure 2—Agricultural growth in two categories of localities



Notes: Point A on each figure is the initial position; point B is the final position. The slope of the straight tangent lines may be considered to be the ratio of the price of agricultural output to the price of the industrial inputs used in the agricultural sector. Or it may indicate the marginal product of the last unit of the available inputs when such inputs are allocated to maximize production.

collective behavior patterns. It is these areas that have probably been the centers of "reviving landlordism" and pressure for dissolution of the communes.[300] And these are also localities that may be chronic beneficiaries of the redistributive revenue policies of the state.[301] But although these policies include revenue sharing by the provinces, aid to many of the very poorest localities does not seem to have been oriented toward directly facilitating productive investment, but has generally taken the form of emergency grain aid, lowered agricultural taxes and procurement requirements, and, from time to time minor terms-of-trade advantages. Donnithorne has pointed out that counties and provinces that are designated "deficit areas" have had low priority in the competition for scarce inputs and allocations.[302]

The implicit policy described by Donnithorne may be reasonable for increasing allocative efficiency when distributing large quantities of industrial inputs to agriculture by region, but the rationality may break down somewhat at the local level. Many poor localities have had a long unbroken history of constrained growth. The fundamental constraint may be either deficiency in rural infrastructure and organizational support or the unavailability of an improved seed technology suitably adapted to local conditions. While these localities probably cannot, for example, efficiently use large additional applications of fertilizer, relatively modest increases may have a greater impact on production in some of these poorer locations than in those that are somewhat wealthier but are encountering new growth constraints. Judicious allocations in these poorer areas would also serve to ameliorate rapidly increasing income differentials between localities.

Available material suggests that areas with low rates of chemical fertilizer use also tend to have low rates of organic manure application.[303] Moreover, these areas are probably receiving little organizational support and have higher population growth rates. They are strongly subsistence oriented and higher state purchase prices have not appreciably increased cash income because quotas are of necessity set at very low levels. Grain, for the most part, has been eaten or paid as tax, not sold to the state. The larger constraint limiting rapid expansion in output is not merely a lack of fertilizer, but a more general discrimination by central authorities against poor areas, not only in distributing scarce physical inputs, but in allocating investment in infrastructural categories,[304] such as transportation, water control, and hydroelectric power. Owing to this more general constraint, and because these peasants are too cash poor and too risk averse to purchase or produce fertilizer, the most needy areas may not be disposed to finance even modest fertilizer applications, though

they might thereby bring about respectable additions to output.

In spring 1979 authorities in some provinces began a systematic attempt to supplement consumption assistance to poor counties and brigades with direct production assistance. In each case this was done selectively and the scope of such programs was limited. Surveys were conducted, and participating units were selected either according to their potential for expanding production or simply owing to their particularly low per capita income level. What few results are available on these programs seem to show some success and their expansion has been indicated.

A much larger number of provinces have announced assistance programs to poor brigades for 1980. Sometimes these programs are nothing more than agricultural tax exemptions or grain aid. Often they provide special organizational assistance and give encouragement and material aid to develop sideline production or cash crop cultivation. Occasionally, they include allocation of agricultural inputs or financial, technical, and organizational assistance to establish enterprises to produce inputs.[305]

How far such programs will eventually proceed is open to question. Grain production growth in these localities will be limited. But the programs represent a source of untapped potential and may mitigate the effect on aggregate grain production of acreage shifts out of foodgrains in poor localities.

Consideration of all the various adjustments of rural policy that may affect incentives and resource allocation suggests that the net incidence through these mechanisms on foodgrain production will be positive when compared with even 1978, although the magnitude of such influence is not possible to estimate at the present time. The most powerful reason for such a conclusion lies in the alleviation through terms-of-trade adjustment of the disincentive caused by the low, declining, and sometimes negative profit rates for foodgrain production. These rates were characteristic of important agricultural areas between 1966 and 1977, and more than occasionally brought about a fall in real income levels.[306] The most serious cause for pessimism is that this same experience, coupled with increased local peasant autonomy over farm decisionmaking, may result in widespread hesitancy to invest further in grain production expansion.

Rural Policy Changes, Income Distribution, and Political Unrest

A full discussion of the interaction among China's rural policies, the pattern of income distribution, and foodgrain production will not be attempted here. It would be remiss, however, not to offer a few basic observations of probable relevance to the future course of farm output in China: the 1979 shifts in rural policy will almost certainly have a profound effect upon the pattern of income distribution in China; distributional issues have been important historically in generating mass response to and participation in political upheavals; and periods of political unrest in the People's Republic have been associated with declines of agricultural output.

There should be little doubt that to the extent that policy measures of the kind embodied in the 1979 rural policy reform provide incentive to expand production, they will also widen the gap between fast-growing and slow-growing counties and brigades. An abolition of the ceiling for collective distribution to commune members and a freeze on quotas at their 1971-75 levels to be delivered at the lower compulsory purchase price will enable localities that are able to sell large and increasing shares of grain at the surplus price to generate large gains in incomes.

The inequality will be ameliorated by fewer bureaucratic restraints and active encouragement for all areas, (especially those relatively unsuccessful in generating income through grain production), to diversify into cash crops, animal husbandry, and farm subsidiary pursuits. But to a large extent, those best able to take greatest advantage of higher prices for these goods will be comparatively affluent localities. Poorer counties and brigades will be assisted by measures discussed above. But for the peasants in those localities to increase their income by as much as farmers in advanced and fast-growing areas, not to mention state industrial workers, the only alternatives may be migration, greater reliance on non-agricultural sources of income, or removal of some constraint barring technical transformation.

The latter two possibilities could require major capital transfers that the budgeting authorities may still not find justified. Even if such transfers were forthcoming in the current period, rapid growth in income

would at best be a long way off for many such localities.

Perkins and Myers argue that modest projects requiring a family or a few families have been pursued intensively by the Chinese for centuries.[307] More recently, several teams have gotten together to undertake more ambitious tasks. But there still remain projects that require more technology, working capital, or organization than a production team can manage. Such projects, coupled with indivisibilities in other capital investments too expensive for a team to handle, have created periodic pressures to shift the accounting unit from the team to the production brigade.

Yet, the brigade is generally too unwieldy for the link between effort and individual or family benefit to be clearly perceived. Ishikawa has shown that the social structure of Chinese rural society seems well designed for productive organization centered around the production team and incorporated into the looser framework of people's communes.[308] Within a production team of approximately 30 families, information flows freely and a certain community feeling prevails, contrasting sharply with mistrust of people outside the team and a sense of isolation from larger or neighboring organizational units. Ishikawa cites cases of production teams that have refused to surrender their collective savings to the brigade for the purchase of agricultural machinery.[309]

The National Agricultural Congress decided in 1975 that the investment funds for mechanization should be accumulated mainly from the surplus earned from production enterprises, which in turn should receive greater emphasis within brigades and communes. But this is not always an auspicious possibility and the result was often commandism, causing peasant resentment, low quality labor application, and occasionally output decline. Criticism of commandism similar to Liu Shaoqi's complaints about the Great Leap Forward,[310] may indicate an abandonment of active support for these collective projects and a disinclination to expropriate surpluses for machinery purchase and other development needs. As counterproductive as such actions can be, they may still be the only way to loosen key infrastructural constraints beyond the capacity of individual production teams in backward areas in the absence of larger capital and skilled manpower allocations from the central authorities.

Distributional themes in periods of political unrest and the use of distributional issues to mobilize the masses have been and, no doubt, will be the focus of much research. Howe discussed a variety of distributional issues in his investigation of groups most actively participating in the Cultural Revolution.[311] Donnithorne noted that five of the first six provinces to establish revolutionary committees at the start of that period were grain-deficit provinces.[312] Field, McGlynn, and Abnett developed a methodology for quantifying political stability and investigated its correlation with industrial output growth during the political conflicts of the mid-1970s.[313] They found that provinces of moderate or strong growth were stable and that, with one exception, politically unstable provinces experienced slow growth or even declines of output during the period. These effects were linked to a centrally administered program of phased discriminatory investment in industrial capital construction. Work cited by Dernberger indicates that "advanced-type counties" where significant yield increases were registered usually received preferential state assistance and tended to be high-yielding counties in traditional China.[314]

The exact nature of the distributional issues involved in each case and their exact relationship to the phases of the social upheavals that have been detrimental to production cannot be discussed here. It is enough to note that distributional issues have historically been of particular political significance in China. Popular consciousness of and sensitivity to changes in distribution have been heightened by the experience in recent decades under the CCP's leadership.

The association of political unrest with declines of output can be appreciated with a glance at Table 1. The Great Leap Forward (beginning 1958), the first phase of the Cultural Revolution (beginning 1966), and the mid-1970s political conflict (beginning 1974) all brought on periods of dislocation and unrest; all were followed, within a year or two of their advent, by stagnation or decline in agricultural production. It would be a serious distortion to overemphasize the similarity of the three periods. The causes of falling farm output have been varied and complex, but the declines were always at least exacerbated by stalls or drops in the rate of industrial input supply to agriculture and, to varying degrees, by direct rural participation in the upheavals. Problems

with the implicated industries have included instances of rural unwillingness or inability to finance demand, and political unrest within the industrial sector itself.

What do these considerations mean for the prospect of foodgrain output stalls caused by political unrest? First, since income and consumption increases are being widely distributed now after a recent period of upheaval and a decade or more of income stagnation for many localities, the hypothesized chain of causation seems unlikely to cause growth to stall in the next few years.

Secondly, it is unwise to assume that the current policy emphasis is in any sense final. Future administrations (or even the current one) are not at all incapable of attempting to shift China's development along lines more closely approximated by the social revolution as articulated by leading figures during the Great Leap and the Cultural Revolution.[315] Finally, even if there is no change in emphasis for the time being, popular participation in periods of political unrest, speaking simplistically, seems to have occurred when income distribution has been perceived as insufficiently egalitarian, as well as when it has been too egalitarian. If the current policies do provide incentives and materially reward the successful, they run the ultimate risk of being politically controversial once perceptions of growing inequalities supplant the euphoria from the initial broad-based income improvements.

The Suitability of Chinese Policy to Present Technological Developments

It is quite possible, then, that current trends, recent policy, and allocational changes may favorably affect output by increasing the growth rate of input and resource applications; improving the quality of inputs, especially labor inputs; and improving the efficiency of resource allocation. At the same time it does not appear likely that the gross allocational shifts away from foodgrain production and gross reversions toward less intensive cropping patterns that will inevitably accompany the developments described above will result in a large and negative influence on grain production once the amount and quality of lands involved and gross increases in grain acreage are considered. On the other hand, although the danger for the next several years does not seem great, these same policies will bring about profound and increasing changes in the pattern of income distribution in China. Put conservatively, such changes seem to have had an association with political disturbances that stall growth, although the causes of the latter are complex and not limited to distributional issues.

Thus far policy initiatives resulting in shifts in the patterns of resource allocation have been discussed as changes that may bring about a single absolute increase in output by increasing allocative efficiency under recent technological arrangements and gross input supply levels. Ultimately, however, the suitability of that pattern for fully exploiting the growth potential of the currently emerging technology and supply levels may be of dominant importance. In the past, instances have been reported in which input application in areas of newly constrained growth has proceeded not only beyond the point of profitability under the concurrent relative prices, but far beyond the zone in which quantities applied may be considered rational from the standpoint of sheer physical allocative efficiency.[316]

What then is the technological context that will be relevant for the remainder of the current plan? How will it gel with the current shifts in policy emphasis and resource allocation? One of the bright spots is a recent domestic breakthrough in rice production.[317] China's own male-sterile F1 rice hybrid was grown successfully in 1977 and 1978 on 5 percent (more than 2 million hectares) and 13 percent (4.3 million hectares) of China's rice acreage.[318] In 1977 it yielded about 20-30 percent more than conventional dwarf rice hybrids.[319] In 1978 nationwide increments over yields sown to conventional improved varieties averaged 700 kilograms per hectare.[320] The basic strain reportedly has a longer growing period than the varieties it replaces.[321] It is therefore suitable as a late or middle crop but discourages multiple cropping in some areas. Despite some indications that the new hybrid strains have not been an immediate success in certain areas, 1979 planting increased to over 5 million hectares, and yield increases reportedly averaged 750 to 1,125 kilograms per hectare.[322]

China is now actively participating in seed institute exchanges and hence will be exposed to a wider range of genetic variation,

with good potential for increasing disease and pest resistance.[323] It should be noted that many countries have been unable to realize that potential. But China's genetic stock has been particularly cloistered, and disease and pests have been an outstanding problem. This suggests that the short-range potential from the interchange for China is greater than for many other countries with a longer history of contact.

Finally, China has evolved a streamlined system permitting simultaneous stabilization, selection for local adaptability, evaluation, and seed multiplication, within about three or four years rather than the more customary eight to ten.[324] Hence as yet undeveloped varieties could further raise yields even during the current economic plan.

The FI hybrid is already beginning to noticeably augment aggregate yields and is especially suited to localities with histories of successful well-integrated development. Hence policy concentration on these areas may be advantageous to output growth.

Shaanxi's experience seems typical in this regard. In 1978 the FI hybrid yielded an average of 8.3 tons per hectare on 2,730 hectares (or about 2 percent of the province's rice acreage), whereas conventional hybrids were already yielding 6.1 tons per hectare. In 1979 Yangfengzao was planted on 38,630 hectares (or about 27 percent of provincial rice acreage).[325] As of 1979 the hybrid has been reported as being sown extensively in Hunan, Hubei, Jiangsu, Jiangxi, Shanghai, Zhejiang[326]—all with substantial proportions of high-yielding rice acreage prior to introduction of the hybrid.

FI may therefore make a major contribution to rice production growth, especially in the rice regions among China's grain bases such as the Yangtze Delta. But what about the evolving technological situation across the board? It should be recalled, for example, that the largest part of the major grain bases are most suitable for wheat, soybeans, corn and other coarse grains.

Recent work by Lardy[327] based upon incomplete provincial statistics indicates that yields during the 1960s and 1970s varied increasingly among provinces in the same major cropping region. Lardy's provisional conclusion is that the conditions underlying this variation suggest considerable growth potential.

The crux of the argument may be summarized as follows: in the 1950s variation between provinces in the pattern of growth (with few exceptions) seemed modest, suggesting the exhaustion of growth based on traditional technology. Growth in the 1967-75 period (more than 3 percent per annum) has been divergent—because of the limited pattern of diffusion of technological change in agriculture and because of inappropriate agricultural development policy. Broader geographic diffusion and the current reversal of poorly conceived agricultural policies of the past should help the rate of growth of foodgrain output accelerate.

It would be dangerous to accept such a thesis in gross statement or generalize from it. Nevertheless, it would be doing Lardy a disservice to presume that he is unaware of the cost efficiencies involved in increasing output through selective concentration and that he is ignorant of divergent growth patterns in countries at various stages in the process of "green revolution." The thesis must be taken, if it is taken at all, in a relative sense and with a particular reference to current circumstances in China.

Part of Lardy's optimism stems from his discovery that rice production growth may have accelerated in the 1970s, long after the introduction of conventional dwarf hybrids. This is contrary to popular supposition and suggests that a longer time lag than expected has been required to develop the full potential of these varieties. Although some of the well-publicized advanced areas seem to have exhausted this potential in the 1960s,[328] the process may still be continuing in several regions. An important implication for production in the current period is that the contributions of the newest seed technologies with their requisite input stream, and the contributions of the older type of improved seed technology which has now become common (when combined with better water control, more fertilizer, etc.) are to a certain extent additive at the present time in China, rather than the former being categorically a substitute for the latter.

Evidence that state plans will exploit this dual potential may be seen in China's capital construction efforts. As was discussed above, a small subset of high and stable yield lands are being converted to lands with yield of a ton per mu, and the major grain bases, almost half of which have high and stable yields, receive preferential financial assistance and input deliveries. Meanwhile, additional high and stable yield areas are now again being constructed. It may be useful to roughly sort out the possible

sources of growth among various crops and strains. (1957-77 growth disaggregated by crop is shown in Table 11.) Though it is somewhat illegitimate to do so, seed technical growth is discussed in isolation from the particular nature of the input stream that is normally required to increase yields from improved varieties, and in isolation from the input stream as a source of growth independent of seed technology changes.[329]

Conventional dwarf rice hybrids have accounted for slow but steady growth since 1964 when they were first distributed for full production. Yield growth between 1957 and 1976 was about 1.4 percent a year. Total production growth between 1957 and 1977 may have been about 2 percent a year. Provincial research indicates that rice production growth was accelerating rather than declining in the 1970s. The full potential of these varieties has probably not been realized, even though they were sown on 80 percent of all rice acreage in 1977.

It is claimed that yields from F1 male sterile rice hybrids are 20-30 percent greater than yields from conventional hybrids in areas where the full potential of the latter may have already been realized. Large-scale distribution did not begin until 1977, when they were sown on 5 percent of all rice acreage. These hybrids accounted for 13 percent of rice acreage in 1978 and over 15 percent in 1979.

Although wheat production has grown more than 3 percent a year since 1957, much of the increase is attributable to displacement of coarse grains and improved water control. Semi-dwarf varieties from more disease-resistant Chinese-Mexican crosses were introduced in 1973 and were widely disseminated by 1977. But peak growth rates from these varieties have yet to be realized.

In Shanxi, a number of hybrid wheat strains have been developed from a recently identified male-sterile strain which appeared through natural mutation and produces offspring, half of which are fertile. Thus one of the major stumbling blocks to male-sterile wheat development seems to have been overcome, although the usefulness of the hybrid to the current plan is still unproven.

Maize production growth has proceeded at 4.5 percent a year since 1957, benefiting from the displacement of coarse grains and improved water control. Double-cross maize occupied a large proportion of total maize acreage by the mid-1960s, but was susceptible

Table 11—Foodgrain production disaggregated by crop, 1957 and 1977

Grain	1957	1977
	(million metric tons)	
All foodgrains	195.05	286
Rice (unmilled)	86.80	129
Wheat	23.65	41
Coarse grains[a]	52.65	86
Corn	21.44	48
Tubers[b]	21.90	19
Soybeans[c]	10.05	10

Sources: All figures for 1957 are from People's Republic of China, State Statistical Bureau, *Ten Great Years* (Peking: Foreign Languages Press, 1960), p. 119. The figure for all foodgrains, however, is not the figure appearing on that page, but the sum of the figures for the categories included in the table.

For 1977 the figure for all foodgrains is from *Beijing Review*, January 12, 1979, p. 7. It is assumed that this figure includes soybean production and not merely soybeans directly consumed. The figures for rice, wheat, and corn are from Thomas B. Wiens, "Agriculture Among the Four Modernizations," 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, p. 20. Wiens based his figures on statements given by a Chinese official to a delegation in 1978. The figure for soybeans is from the U.S. Department of Agriculture, and was cited in George Gunset, "China's Grain Push Could Alter Markets," *Chicago Tribune*, February 7, 1979. The coarse grain figure was calculated as a residual.

According to Chinese sources in U.S. Foreign Broadcast Information Service (FBIS), *People's Republic of China: Daily Report*, September 10, 1979, p. T4, potato acreage rose from 20 million mu in 1949 to 80 million (5.3 million hectares) in 1979; yields increased from 700 to 1,300 jin per mu at that time. Irish potato acreage may have been about 20 million mu in 1949 as the figures for 1952-57 ranged from 25 to 32 million mu (Nai-Ruenn Chen, *Chinese Economic Statistics: A Handbook for Mainland China* [Chicago: Aldine, 1967], pp. 286-7). Chen cites official figures giving total tuber acreage in 1952-57 as 130-165 million mu and in 1949 as 105-159 million mu. It is therefore assumed that the sources found by FBIS refer only to Irish potatoes and that the tuber figures found in a news bulletin issued by Xinhua [New China News Agency], September 19, 1979, p. 5 (FBIS, *PRC*, September 26, 1979, p. 118) refer to sweet potatoes. Xinhua's figures are 4.6 million hectares sown with tubers, yielding 9 metric tons per hectare

Table 11—(Continued)

Adding Irish and sweet potato production gives the total tuber production figure for 1979, 93.348 million metric tons. This has been used as a proxy for the 1977 figure. Since the total foodgrain production figure and its components are used to derive an estimate of coarse grain output, the total tuber production figure has been divided by five as the Chinese have done since 1963 when aggregating foodgrain statistics. See Bruce Stone, *A Review of Chinese Agricultural Statistics, 1949-79* (Washington, D.C.: International Food Policy Research Institute, forthcoming), Table 2

[a] These include millet, corn, sorghum, barley, buckwheat, oats, proso-millet, small beans, small green beans, broad beans, and peas, and others.

[b] These include Irish, sweet, and other potatoes. Following official definitional conventions at the time, tubers in 1957 are valued at one-fourth of their natural weight; tubers in 1977 are valued at one-fifth of their natural weight.

[c] These include yellow soybeans, green soybeans, and black soybeans (or black beans). All soybean production is included although current official foodgrain definitions may only include the production of soybeans consumed directly as foodgrains, and exclude some 3–4 million metric tons of output devoted to edible oil and bean cake production.

to disease over broad areas in 1961 and 1966. Single-cross maize was distributed by the late 1960s. It occupied 40 percent of total maize acreage in 1973 and about 60 percent in 1978. Growth potential is still available from some displacement of other grains, continued displacement by the single-cross hybrids of other maize, and yield increases in current hybrid-maize areas.

Soybean production fell in the 1960s due to displacement by higher-yielding varieties of other foodcrops; recovery began in the late 1960s and early 1970s and may now be close to the 1957 level. Hybrid soybeans have recently become available, but their yield increment in ordinary farm situations has yet to be clearly documented. On the other hand, government incentive measures have been introduced to encourage increased acreage on collective lands and private-plot production. These seem to have had some effect, and further measures have been introduced by the provinces in 1979 and 1980. The growth rate of production of coarse grains other than maize since 1957 has been as low as 1 percent a year or less. Acreage displacement by higher-yielding and more valuable wheat and corn varieties and a general lack of concerted attention to coarse grains has worked against improvements in the input stream. Displacement is likely to continue, but a higher-yielding wheat-elytigia hybrid and drought-resistant hybrid sorghum and triticale varieties have been developed and are being disseminated.

The yields of potatoes since 1957 have probably increased less than 1 percent a year, and 1978 production may be little above the 1957 level. But potatoes have probably been valued at one-fifth rather than one-fourth their natural weight since 1963, which may have confused the yield computation. Potato yields seem to have stagnated owing to viral infections, but sharply divergent yields in contiguous areas confirm official reports that lack of coordinated emphasis on the dissemination of optimal field management practices is also at fault. The first virus-free potato farm was not established until 1975. By 1979 seven such farms and several potato institutes had developed 40 varieties. In 1978 seed potatoes were produced which are claimed to increase yields 150 percent on test farms. Dissemination should begin in the early 1980s but extensive adoption is still hampered by the small volume of seed currently produced. More suitable field management practices are also being promoted, notably in Fujian, Heilongjiang, and Inner Mongolia.

Producing 380-400 million metric tons of foodgrains by 1985 appears quite feasible from a seed-technology standpoint. On the basis of the kind of information given above, a sample distribution of an 80-million-metric-ton increment over 1978 production is offered.[330]

Thirty-five million metric tons could be rice, of which 13 million metric tons would come from acreage and especially yield increases of conventional dwarf hybrid and 22 million metric tons would come from adoption of the new F1 male-sterile dwarf in place of conventional hybrids. Thirteen million metric tons could be wheat. The increase would come primarily from yield improvements on existing semi-dwarf acreage, secondarily from acreage expansion of semi-dwarfs. No gain can yet be expected from male-sterile wheat hybrids. Seventeen million metric tons could be maize. This increase would come primarily from expansion of the acreage of single-cross hybrids and from yield improvements on existing hybrid acreage. Five million metric tons could come from coarse grains. Growth from an improved input stream would be almost

counterbalanced by acreage displacement; some increase could come from hybrid sorghum and triticale. Five million metric tons or more could come from potatoes. The increase would come from virus-free seed technology to be introduced in the 1980s and from improved field management. Less than 5 million metric tons would come from soybeans as a result of acreage increases and greater input application. No gain can presently be counted on from hybrid soybeans.

The point to be made here is not that the Chinese will produce 385 million metric tons by 1985. Whether they do will depend primarily on their success in fulfilling their plans for fabrication and delivery of requisite inputs to the localities that can most efficiently use them and their success in designing and administrating rural and urban policies to harness initiatives in both sectors and to avoid growth stalls due to political unrest and disaffections. With better than average marks in these areas, even the 400-million metric-ton target is not out of the question.

The rough crop distribution synopsis of possible production increases given above is designed to suggest that available seed technology provides potential for an average annual rate of growth of over 3.5 percent a year—an ambitious mark but not an unprecedented achievement—and to show that a large proportion of the potential increase over the current 10-year plan (perhaps 50 to 60 of the 80 million-metric-ton increment hypothesized) is dependent on the performance of China's relatively advanced agricultural regions. Hence, at least for the purpose of increasing aggregate output, a concentration on these regions may be well advised.

In the past China's ability to deliver requisite inputs to favored localities has been good, especially compared to other planned and developing economies. Its continued ability to do so should assure some acceleration of growth in the current period and foodgrain production levels well in excess of the 360 million metric tons the historic long-term rate implies. Whether they come close to the 1985 target of 400 million metric tons may depend on the Chinese being eclectic enough to supplement their efforts with a course of action that will tap the potential of less advanced and slow-growing localities without squandering resources—an approach that could also mitigate the threat of growth stalls from political disputes over maldistribution which may be risked by many of the new agricultural policies.

FOOTNOTES

[269]The supply relationship hypothesized and developed descriptively in this section may be formalized in a loose theoretical sense as follows.

Abstracting from the reflexive influence of demand upon foodgrain supply,

$$Q = f(I, P, T, W),$$

where P is policy, T is seed technology and the appropriate field management practices, and W is weather. I is the nonlabor input stream not embodied in T. Abstracting from the interrelationship among "independent" variables, it is assumed that the expected value of the change in foodgrain supply between 1978 and 1985, E(dQ), is of the form:

$$E(dQ) = E(dQ/dI) + E(dQ/dP) + E(dQ/dT) + E(dQ/dW)$$

It is also assumed that E(dQ/dI) can be written:

$$E(dQ/dI) = [1+E(g_{Q/I})]^6\, Q_{1978} - Q_{1978}$$

where $g_{Q/I}$ is the average annual foodgrain production growth rate from 1978 to 1985 that results from input supply increases alone. It has already been suggested that $g_{Q/I}$ is expected to be within the 3.0 to 3.5 percent range so that E(dQ/dI) is about 70 to 85 million metric tons, since Q_{1978} is 305 million metric tons.

As 1978 was a bad weather year, $E(dQ/dW) \geq 0$. It is briefly discussed in the text and the succeeding footnote.

In general, it can be suggested that E(dQ/dP) and E(dQ/dT) are not negative and that E(dQ/dP) is significantly different from zero. The components of the latter to be considered implicitly assume that E(dQ/dP) can be written

$$E(dQ/dP) = E(dQ/dR_1) + E(dQ/dR_2) + E(dQ/dS_1) + E(dQ/dS_2),$$

where R_1 is the effects of 1979 policy changes on resource allocations among communes and R_2 is those effects within communes; and where S_1 and S_2 are the effects on the labor and local savings incentive structure and upon the income distribution structure. A principal difficulty with the above equation and any attempt to discuss the included variables is that the latter are far from mutually independent and their orthogonal elements cannot be easily separated.

[270] Although weather fluctuations have resulted in drastic harvest variations within particular localities in China (see footnote 20), weather-related oscillations in national aggregate production of grain have for the most part been considerably damped. Moreover, China's improved ability to handle adverse weather has been one of, if not the most, important contributions to rural welfare. While sizable variations still occur in many localities, the 1976-78 period was one of the most severe stretches of extended bad weather in Chinese twentieth-century history. In the worst year, 1977, aggregate foodgrain output only fell by a few million tons (see Table 1). Similar periods of stagnation cannot be ruled out, unfortunately, as meteorological research suggests that the 1970s may mark the beginning of a period in which weather fluctuations are more drastic than they were in the last 30 years.

[271] "Decisions of the Central Committee," FBIS, *PRC*, August 31, 1979, p. L27, and March 5, 1979, pp. K2, K3.

[272] See, for example, the source listed in footnote 146.

[273] Audrey Donnithorne, *China's Grain: Output, Procurement, Transfers and Trade* (Hong Kong: Chinese University, Economic Research Centre, 1970).

[274] John C. Pelzel, "Economic Management of a Production Brigade," in *Economic Organization in Chinese Society*, ed. W. E. Willmott (Stanford: Stanford University Press, 1972), pp. 392-3, cited in Stavis, "Making Green Revolution."

[275] Stavis, "Making Green Revolution," p. 147.

[276] See ibid., and Lardy, *Economic Growth*.

[277] Donnithorne, *China's Grain*, and Audrey Donnithorne, "Economic Indicators for China," *US-China Business Review*, 1 (March-April 1974): 33, cited in Audrey Donnithorne, "Per Capita Grain Output in China and India," *Food Policy* 2 (February 1977): 60-6.

[278] Stavis, "Making Green Revolution."

[279] This is the result of a calculation by Thomas B. Wiens which he based on recent official material. None of the percentages quoted in the paragraph are highly reliable, but the trends observed are consistent with central policy toward the rural sector. Over the present 10-year plan, a fall might be expected from the 1978 figure, which is probably much lower than the 31 percent estimated by Ng for 1976-77. Ng finds an average of 31 percent among 22 counties in 15 provinces during 1976-77 (Ng Gek-boo, "The Incentive Policy in Chinese Agriculture: An Overview," International Labor Office, World Employment Program, Rural Employment Policies Branch Research Programme, 1978, p. 20). However, in a more recent publication, based on Food and Agriculture Organization of the United Nations, "Information Gathered on a Private Visit to China," W. K. 6874, FAO, Rome, 1976, p. 28, he gives 20-30 percent for the 1970s (Ng Gek-boo, "Incentive Policy in Chinese Collective Agriculture," *Food Policy* 4 [May 1979]: 75-86).

[280] Based on 1978 output of 304.75 million metric tons and the 1979 preliminary figures of 315 million metric tons.

[281] See, for example, Xue Muqiao, "How Can We Effect Planned Management on the National Economy," *Renmin Ribao* [People's Daily], June 15, 1979, and "A Study in the Planned Management of the Socialist Economy," *Beijing Review*, October 26, 1979, pp. 14-20. See also Yao Jingyuan, "Preliminary Discussion on Price Scissors."

[282] See Bruce Stone, "Industrial Incentive Structure in the People's Republic of China," Cornell University, Ithaca, N.Y., 1976; and G. William Skinner and Edwin A. Winckler, "Compliance Succession in Rural Communist China: A Cyclical Theory," in *A Sociological Reader on Complex Organizations*, 2nd ed., ed. Amitai Etzioni (New York: Holt, Rinehart and Winston, 1969), based on Etzioni's organization theory. For a discussion of the components in effective labor application, see Jaroslav Vanek, ed., *Self-Management: Economic Liberation of Man* (London: Penguin, 1975) and Jaroslav Vanek, *The General Theory of Labor Managed Market Economies* (Ithaca, N.Y.: Cornell University Press, 1970).

[283] Vanek, ed., *Self-Management*, and Mellor, *The Economics of Agricultural Development*, pp. 37-56.

[284] Several items have turned up in the Chinese press on the subject of pork and pig sales, which exceeded the commerce bureau's storage capacity in a number of areas. One such report for Hunan province is found in FBIS, *PRC*, January 29, 1980, pp. P2, P3. In Beijing overprocurement has engendered local administrative pressure to lower the purchase price and reduce the amount of grain awarded for large pigs. Superior levels have prevented the move (FBIS, *PRC*, April 23, 1980, p. P4).

[285] Shigeru Ishikawa, Hitotsubashi University, conversation, Tokyo, February 1980.

[286] Stone, "A Review of Statistics," Table 9A.

[287] Ibid.

[288] Chou Chin, "China's Most Populous Province: Back to Order," *Peking Review*, December 1, 1978, pp. 20-2.

[289] Based on preliminary findings of research in progress conducted by Thomas B. Wiens in Jiangsu (Thomas B. Wiens, letter to Randolph Barker, January 31, 1980).

[290] FBIS, *PRC*, July 10, 1979, p. L13, March 14, 1979, p. L14; Xinhua, news bulletin, February 21, 1980.

[291] In sparsely populated Heilongjiang, for example, mechanized sowing was applied in 80 percent of the wheat and soybeans and 50 percent of miscellaneous grain acreage (FBIS, *PRC*, April 14, 1980, p. S1). In Jilin's grain base, 5.6 million people or about one-third of the province's moderate population, produce one half of its grain (Xinhua, news bulletin, February 21, 1980). In 1979, 50 percent of spring acreage in the base was machine sown—up 20 percent from 1978 owing to preferential allocations (FBIS, *PRC*, June 7, 1979, p. S4).

[292] See footnotes 290 and 291; in addition, see FBIS, *PRC*, December 14, 1979, p. S1, September 6, 1979, pp. S5, S6. Since the entire province of Heilongjiang has been designated a commercial grain base, it will receive a large supply

of preferential inputs. But the province will further concentrate these supplies in the hands of 42 rich brigades to maximize growth in provincial agricultural output.

[293]FBIS, *PRC*, April 24, 1979, p. L6.

[294]FBIS, *PRC*, March 5, 1979, p. L1.

[295]For afforestation see FBIS, *PRC*, March 8, 1979, p. M1; March 9, 1979, p. M2; March 19, 1979, p. R1; and March 23, 1979, p. T1. Water for irrigation from the Yellow River currently sets a world's record for greatest silt content among irrigation waters extensively employed (Stone, "A Review of Statistics," Table 12, discussion). For an article discussing some success cases in the war to arrest soil erosion on the loess plateaus through forestry, see Xinhua, news bulletin April 16, 1980; FBIS, *PRC*, April 17, 1980, pp. L12, L13.

[296]Eighteen major agricultural purchases prices were raised 15 to 50 percent ("Higher Purchases Prices Bring Good Results," *Beijing Review*, November 9, 1979, p. 5).

[297]Mark Elvin, *The Pattern of the Chinese Past: A Social and Economic Interpretation* (Stanford: Stanford University Press, 1973); Dwight Perkins, *Agricultural Production in China* (Chicago: Aldine, 1969); Carl Riskin, "Surplus or Stagnation," in Dwight Perkins, ed., *China's Modern Economy in Historical Perspective* (Stanford: Stanford University Press, 1975).

[298]Dharm Narain, "Growth of Productivity in Indian Agriculture," Occasional Paper No. 93, Cornell University, Department of Agricultural Economics, Technological Change in Agriculture Project, Ithaca, N.Y., June 1976.

[299]Average grain yields in Wusih County, Jiangsu (with a population of approximately 1 million and with 61,153 cultivated hectares) grew from 3.6 tons per hectare in 1949 to 5.3 in 1956, 8.1 in 1965, and 12.5 in 1976 (Chin Chi-chu, "New Picture on a Blank Sheet of Paper: Farm Mechanization in Wusih County (1)," *Peking Review*, July 29, 1977, pp. 20-4). Average yields in Pingting County, Shansi (with a population of 300,000 and 31,500 cultivated hectares) rose from 2.74 tons per hectare in 1974 to 5.25 tons in 1977. They hope to achieve yields of 7.5 tons per hectare in 1980 (Chin Chi-chu, "All-out Effort to Develop Agriculture—A Glimpse of Pingting County in Shansi Province," *Peking Review*, June 30, 1978, pp. 12-5). Hsiyang County's celebrated Tachai Brigade increased their average yields from 1.3 tons per hectare in 1949 to 1.9 in 1953, 4.1 in 1958, 5.6 in 1963, 6.0 in 1964-65, 8.0 in 1967, 7.7 in 1973, and 9.8 in 1977 (Kuo Feng-lien, "The Tachai Road," *Peking Review*, October 4, 1974, pp. 18-25, and *Peking Review*, December 9, 1977, p. 30). Such success stories are common in the Chinese press and are borne out by visitor's reports.

[300]Shigeru Ishikawa, "Agrarian Reform and Its Productivity Effect: Implications of the Chinese Pattern," a paper presented at the Conference on Comparative Economic Systems, Tokyo, 1968. Also see Subramanian Swamy's comments on Ishikawa's presentation. The fact that Chinese policy has continued to financially penalize and restrict the opportunities available to former landlords and rich peasants—and their progeny—long after other undesirable elements have been "uncapped" is some indication that central authorities are still aware that the current structure of farm organization may degenerate in some areas. Efforts to redress this situation were made in the 1979 round of legal reforms.

[301]Lardy, *Economic Growth*.

[302]Donnithorne, *China's Grain*

[303]Thomas B. Wiens, "China's Agricultural Targets: Can They Be Met?" *Contemporary China* 2 (Fall 1978): 115-27. Thomas B. Wiens, "Agricultural Statistics in the People's Republic of China," in *Quantitative Measures of China's Economic Output*, ed. Alexander Eckstein (Ann Arbor: University of Michigan Press, forthcoming).

[304]An exception to this statement appears to be developing in mountainous areas of Sichuan. This province, China's most populous, has suffered slow industrial growth and recent and temporary food deficits. The installation of tubewells and the introduction of rapid-spray irrigation technology may make more water available. A lack of water has effectively barred the transition to more intensive cropping patterns. Chou Chin, "China's Most Populous Province: Back to Order," *Peking Review*, December 1, 1978, pp. 20-2. Also see Wiens, "Agriculture in the Four," "China's Agricultural Targets," "The Evolution of Policy."

[305]A subset of available citations from the recent Chinese press appears in FBIS, *PRC*, for various provinces as follows:

Heilongjiang: April 2, 1980, p. S3; February 28, 1980, p. S1;
Hubei: April 8, 1980, p. P1;
Hunan: March 3, 1980, p. P3;
Gansu: January 22, 1980, p. T3;
Zhejiang: December 20, 1979, p. O12-O13;
Qinghai: February 8, 1980, p. T4;
Guangdong: April 16, 1980, p. P1.

[306]Yao Jinguan, "Preliminary Discussions on the Price Scissors"; Wiens, letter to Barker; Ishikawa, "China's Food and Agriculture"; Ishikawa, "Prospects for the Chinese Economy."

[307]Perkins, "Radical Land Reform," pp. 30-1, Ramon Myers, *The Chinese Agricultural Development in Peasant Economy: Hopei and Shantung, 1890-1949* (Cambridge, Mass: Harvard University Press, 1970), Ramon Myers, "Cooperation in Traditional Agriculture and Its Implications for Team Farming in the People's Republic of China," in Dwight Perkins, *China's Modern Economy in Historical Perspective* (Stanford: Stanford University Press, 1975), pp. 261-78, Ramon Myers, "Trends in Agriculture, 1911-49," Stanford University, Hoover Library, Stanford, Cal., no date. (Mimeographed.)

[308]Shigeru Ishikawa, "Chugoku no Kojin-Shotoku Kakusa to Kettai in (1) Seido Shoshiki no Sentaku to Shijo no Hattatsudo o Chushin Toshite" [China's Personal Income Disparity and Its Determinants (1) Choice of Institution and Degree of Market Development], *Ajia Keizai* [Asian Economy] 17 (June 1976).

[309]Ishikawa, "China's Food and Agriculture," pp. 100-1.

[310]Comparison with Liu Shaoqi's arguments drawn by Thomas B. Wiens, "China's Agricultural Targets."

[311]Christopher Howe, "Labor Organization and Incentives."

[312]Donnithorne, *China's Grain*.

[313]Field, McGlynn, and Abnett, "Political Conflict and Industrial Growth."

[314]Robert F. Dernberger, "The Program for Agricultural Transformation in the People's Republic of China," a paper prepared for the Seventh Sino-American Conference on Mainland China, Taipei, June 5-10, 1978. He cites evidence collected by John Gates, University of Michigan, Ann Arbor, for his honors thesis, and Marsh S. Marshall, "Red and Expert at Tachai: A Source of Growth Analysis," Oxford, U.K. (Mimeographed.) Dernberger's econometric investigation of this hypothesis, however, was inconclusive.

[315]In political science literature, see the works of Carl Walter (graduate program, Stanford University), relating to Liu Shaoqi and the role of criticism by negative example. As early as 1975 Walter's excellent paper predicted and placed in appropriate context Liu Shaoqi's current rehabilitation. For a sociological treatment, see Skinner and Winckler "Compliance Succession." For a more recent and somewhat amusing statement of related issues, see Johann Galtung, "Is there a Chinese Strategy of Development," United Nations University, Goals, Processes and Indicators of Development Project, Tokyo, 1979. (Mimeographed.)

[316]The issue of unprofitable current input investments has already been addressed. See Yao Jinguan, "Preliminary Discussions on the Price Scissors"; Xue Muqiao, "How Can We Effect Planned Management of the National Economy," *Renmin Ribao* [People's Daily], June 15, 1979; Ishikawa, "China's Food and Agriculture"; and Ishikawa, "Prospects for the Chinese Economy." In addition, in a variety of instances the marginal physical product of such investments has even been low. (Yao Jinguan, "Preliminary Discussions on the Price Scissors"; Wiens, "China's Agricultural Targets"; Chou Chin, "China's Most Populous Province."

[317]Stone, "A Review of Statistics," Table 8.

[318]FBIS, *PRC*, June 29, p. L17; State Statistical Bureau, "Communique on Fulfillment."

[319]"More Areas Sown to Hybrid Rice," *Peking Review*, March 3, 1978, p. 30.

[320]State Statistical Bureau, "Communique on Fulfillment."

[321]Thomas B. Wiens, "Agriculture Among the Four Modernizations," 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, p. 7.

[322]Xinhua, news bulletin, April 18, 1980; FBIS, *PRC*, April 18, 1980, p. L3.

[323]Wiens, "The Evolution of Policy," p. 677.

[324]Ibid.

[325]FBIS, *PRC*, March 1, 1979, p. M2.

[326]FBIS, *PRC*, March 8, 1979, p. G6; April 10, 1979, p. L17; June 24, 1979, p. L17.

[327]Nicholas R. Lardy, "The Prospects for Chinese Agricultural Growth," 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.

[328]See, for example, Wiens' research on the lower Yangtze region (Wiens' letter to Randolph Barker, January 31, 1980).

[329]The source for this section is Stone, "A Review of Statistics," Table 8 and discussion. This combines research by the author with research by Wiens and Lardy.

[330]Roughly estimated from the above information, Table 11, and Stone, "A Review of Statistics," Tables 8 and 9. Anything more reliable than this sort of rough approximation would require a region-by-region analysis of past trends and present technological potentials and production constraints.

APPENDIX 1

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[a] These rates are interpolated.

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

Aird	Official A	Official B
129,709	141,007	133,437
0.2691	0.2691	0.2691
34.905	37.945	35.906

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

FOOTNOTES

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

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

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

APPENDIX 2

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

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

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

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

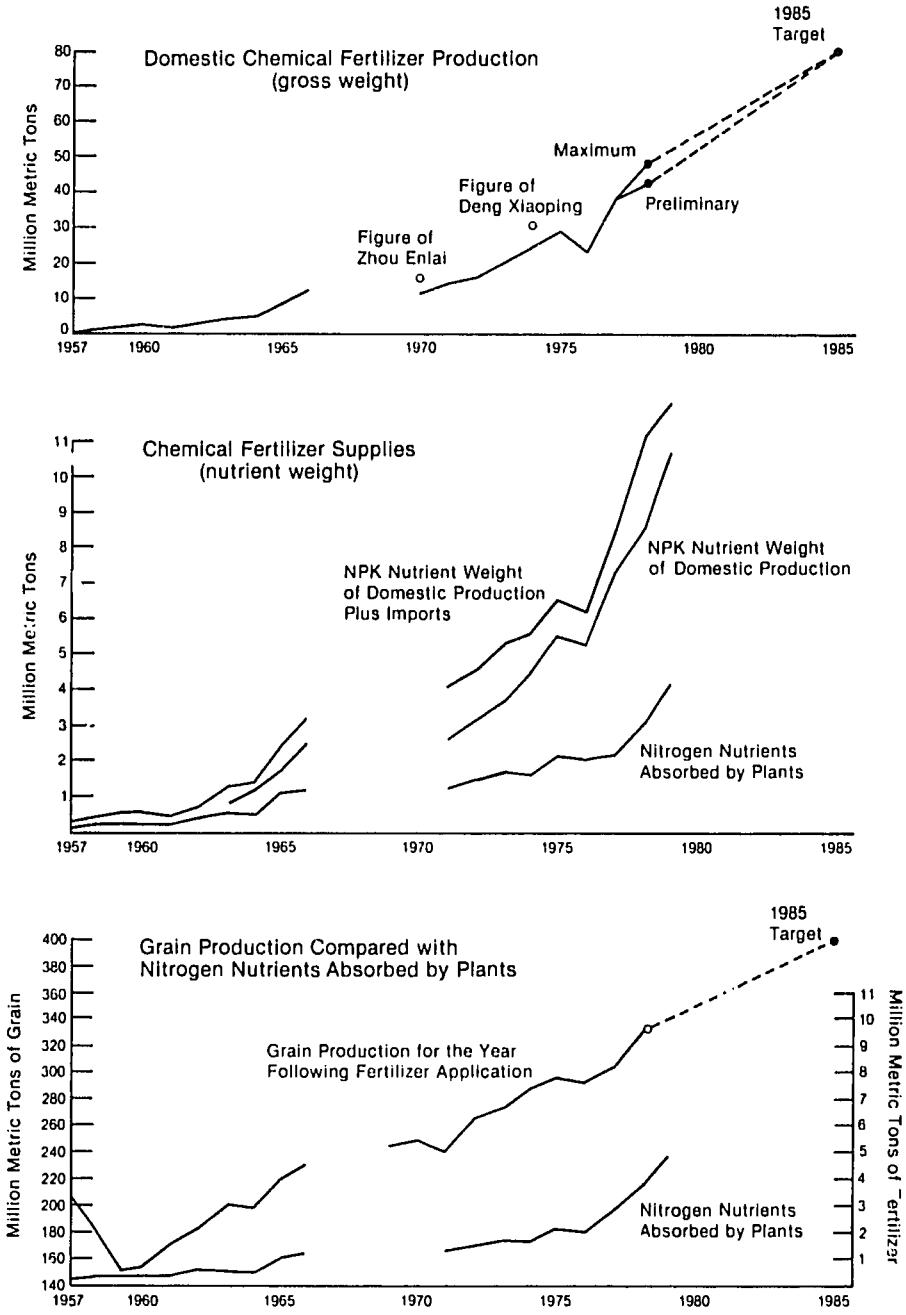
First of all, fertilizer statistics must not be used in gross weight terms. The nutrient content of fertilizers produced in the People's Republic has varied from around 1 percent to over 80 percent. The gross weight composition among these varieties of fertilizer shifted drastically between the mid-1960s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

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

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

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

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



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

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

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

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

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

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

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

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

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

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

may alter this situation temporarily.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[337]Ibid.

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

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

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

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

[342]According to Chang and Richardson, "Use of Soil Fertilization," 78 percent were; according to Li, *Renmin Ribao* [People's Daily], December 25, 1962, p. 5, 50 percent were; according to the studies cited in Lamer, *The World Fertilizer Economy*, 40-55 percent were.

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

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

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

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

[347]Stone, "A Series of Nutrients." The "proper" application ratio between nitrogen and phosphates was described "for most Chinese soils" as 1.4-2.0:1.0 in 1960 in *Tu-jang Hsueh-pao* [Soil Science], No. 2, 1960, pp. 79-100; cited in Liu, *China's Fertilizer Economy*, p. 115. When the ratio exceeds 2.5:1.0, yields of almost all types of rice are said to decline. Since domestic production and imports of nitrogen exceed this ratio, evaporation and leaching may be responsible for a duration of the nitrogen constraint.

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

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

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

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

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

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

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

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

[356]Ibid.

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

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

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

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