PROSPECTS FOR GROWTH IN GRAIN PRODUCTION IN CHINA

Randolph Barker, Beth Rose, and Daniel G. Sisler[1]

China's capacity to increase production and economic efficiency in agriculture in the 1980s will depend on its ability to adopt appropriate policies and to overcome technical and environmental constraints. Insistence on local and regional self-reliance led to an overemphasis on grain production at the expense of cash crops (oilseeds, cotton, soybeans, etc.) and fodder acreage. The effectiveness of policy changes will depend on the ease with which technical and environmental constraints can be overcome.

Approximately 50 percent of China's gross agricultural product is derived from grain, and grain provides close to 90 percent of all calories consumed in China.

Until recently there have been few data on which to judge the past performance or future potential of Chinese agriculture. Even now, available data are spotty and frequently of variable quality, rendering any attempts at quantitative analysis suspect. For such a large and climatically diverse country, national aggregates provide no clear understanding of technical constaints or growth potentials.

Regional Growth in Grain Production

Following the work of Buck, it is common to distinguish between north and south China, wheat being the dominant crop in the north and rice in the south. The dividing line is set between the Yangtze and Huai Rivers, and extends westward at approximately 33 degrees north latitude. Historically, the balance of progress in agricultural development has tended to shift back and forth between the dry north and the humid south.

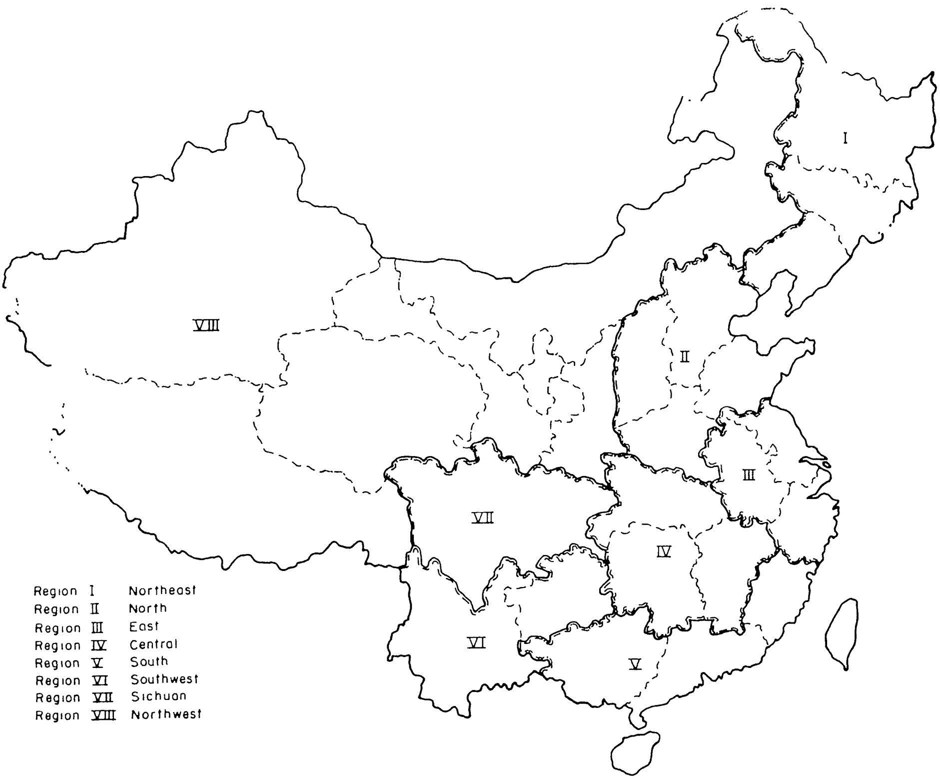
We have divided China into eight broad agricultural regions: I--Northeast, II--North, III--East, IV--Central, V--South, VI--Southwest, VII--Sichuan, and VIII--Northwest (figure 1). In general, we have followed the designations used by Western agriculturalists since Buck. An exception is the province of Sichuan which we show as a separate region (VII). We feel that agriculture within Sichuan is unique and cannot logically be combined with any adjacent region.

In calculating regional and national growth rates, we relied principally on official production estimates compiled by Tuan for the 1970s, and on provincial information gathered by the Committee of the Economy of China, Social Science Research Council, for the 1950s. From 1957 until the middle 1970s almost no official provincial figures were released, so that we have chosen to estimate growth rates using the years 1955-1957 and 1977-1979 (table 1). In addition, these years were not marked by any major political or social upheaval. Regional estimates were obtained by summing provincial estimates within the respective regions.

Table 1 presents annual growth rates in grain production for China in total for the eight regions. The growth rate in grain production has varied widely from 3.1 percent per annum in northeast China to 1.3 percent per annum in southwest China. Regions I to IV have grown much more rapidly than regions V to VIII. There is, of course, considerable variation in growth rate among provinces within regions. Guangxi, in south China, has shown remarkable growth compared to its neighbouring provinces. Conversely, Anhui's growth (III) is extremely low compared to its neighbours.

Over 45 percent of Chinese grain acreage (about two-thirds of production) is irrigated, thereby reducing some of the uncertainty associated with erratic rainfall patterns. We have computed yearly deviations from trends for China as a whole and for seven regions (omitting the Northwest) from 1957 to 1979. The average yearly deviations from the value predicted by a fitted trend line amounted to about 5 percent of the average grain production. The Northeast

Figure 1. Agricultural Regions of China



showed the highest year-to-year fluctuations during the 1970s. Grain production dropped sharply in Sichuan and the Southwest in 1974, which was otherwise a good weather year, and in the Northeast in 1972 and 1976 which were poor weather years over the whole country.

The government procures very little grain for shipment to deficit rural areas. Thus trends in grain production can be presumed to have an influence on regional consumption. Estimates of per capita unmilled grain production are shown for 1955-1957 and 1977-1979 in table 2. The recovery rate for milled rice is typically about 72 percent, which is lower than wheat (85 percent) or maize (92 percent). Hence, in relative terms, the predominantly rice eating regions of southern China have a lower per capita availability than is suggested by the data in table 2. Those regions with the lowest per capita production in 1955-1957, the North and the East, showed the largest gains over the last two decades. Regions I to IV all showed significant increases, while Regions V to VIII showed little increase (and, in the case of VI, a decline) over the period.

Crop Yields

The recent decline in some regions in the intensity of cropping (e.g., shifts from triple to double cropping) make it apparent that the rational limit of land intensification has been reached. As a consequence, future production gains will

Table 1. Annual Growth in Total Grain Output by Region, PRC

	Region	1955-1957	1977-1979	1977-1979/ 1955-1957
		Million metric tons		Percent
I.	Northeast	17.3	33.3	3.1
II.	North	37.7	68.5	2.8
III.	East	31.4	52.7	2.4
IV.	Central	27.7	49.6	2.7
V.	South	21.6	34.3	2.1
VI.	Southwest	10.7	14.2	1.3
VII.	Sichuan	21.9	30.2	1.5
VIII.	Northwest	15.6	22.4	1.7
	Total	183.7	305.2	2.3

be determined almost entirely by increases in single crop yields. Currently there is very little reliable data on crop yields, even at the national level.

The most notable technological achievements the Chinese have made are in the areas of rice and wheat. They include the introduction of modern fertilizer responsive varieties in the 1960s, and the development of the world's first F^1 hybrid rices in the 1970s. The slow growth in rice yields, despite these achievements, may be explained in part by overzealous efforts to intensify production through the expansion of triple cropping.

On a regional level, crop yield and acreage data are sparse and sometimes unreliable. We can make some assessment of regional yields by looking at climatic analogues. Climatically the lower Yangtze River Valley is similar to southern Japan and Guangdong Province to Taiwan. As best we can determine from the information available, rice yield levels in these two regions are similar to those achieved in Japan and Taiwan 15 to 20 years ago. As we look back on the development experience of Japan and Taiwan, we are reminded of the substantial incentives, including raising rice prices well above the world market price, that brought rice yields in those two countries to their current highs.

Table 2. Per Capita Production of Rough Grain

	Region	1955-1957	1977-1979	1977-1979/ 1955-1957
		Kilograms/year		Percent
I.	Northeast	332	347	4.5
II.	North	225	294	30.7
III.	East	283	342	20.8
IV.	Central	324	384	18.5
V.	South	300	300	0.0
VI.	Southwest	297	246	-20.7
VII.	Sichuan	303	311	2.6
VIII.	Northwest	326	306	-6.5
	Total	285	320	12.3

Both the level and the rate of increase in Chinese wheat yields are almost identical with equivalent areas in India and Pakistan. Significant yield gains have been achieved through the extensive use of modern varieties, fertilizers, and the expansion of irrigated area. China's largest wheat area is the North Central Plain, and this area accounts for almost three-quarters of total production. The growth of irrigation in this area, as in the Indo-Gangetic Plain, has occurred largely through the use of tubewells. Currently more than 80 percent of the wheat in this area is said to be irrigated, while the 1950 level was probably less than 20 percent. Despite this progress the national wheat yield is currently only 2 tons per hectare. In Mexico and Egypt, where most of the wheat production is also under irrigation, yields are approaching 3.5 tons per hectare.

As noted previously, maize production has risen significantly in China over the past three decades. Between 1957 and 1977 it rose from 11 to 17 percent of total grain production. Unlike rice and wheat, a substantial portion of the increase in production was due to area expansion, as higher-yielding maize was substituted for lower-yielding sorghum (gaoliang) and millets, principally in north and northeast China. Maize yields have improved significantly over this period from 1.5 to 2.5 tons per hectare, but even today are considerably less than half those of the United States (6 tons per hectare).

Inputs

The principal sources of future yield growth in grain production can be identified as: (1) varietal improvement, (2) fertilizer, and (3) irrigation. Varietal improvement depends on research or on the transfer of technology. Research is needed to develop new varieties of grain with greater yield potential and resistance to insects and diseases, and to develop new cultural and management practices. The potential exists for borrowing from the experience of other countries. However, new agricultural technology must be adapted, not only to local climatic conditions, but also to the particular factor endowments and socioeconomic conditions of China. For example, historically it has been difficult to introduce new foreign plant varieties to China because the intensive crop rotations demanded an early maturity not found in most exotic plant materials.

It would appear that, in the recent past, research priority has been given to rice, followed by wheat, with maize and other grain crops getting much less attention. It is difficult to assess the degree to which the Cultural Revolution (1966-1976) and its aftermath may have set back agricultural research, and how long it will take to overcome that deficiency. It is equally difficult to judge China's capacity to transfer technology from other parts of the world. China imported significant amounts of Mexican wheat seed in the 1970s. Mexican wheat and Chinese-Mexican crosses are being grown on approximately a quarter of the total wheat area, principally in the Northeast and south of the Yangtze River. At present the most active programme of scientific exchange and manpower training involves extensive interaction with the International Rice Research Institute in the Philippines.

In the initial steps to modernize agriculture following independence, principal emphasis was placed on organic compost as the primary source of plant nutrients. With the development of small scale rural industries following the Great Leap Forward (1958-1961), ammonium bicarbonate became an important source of nitrogen fertilizer. The importation of 13 modern urea plants in the 1970s led to a near doubling in the production of chemical fertilizer (5.5 million tons nutrient weight in 1975 to 10.7 million tons in 1979). The national fertilizer application rate now exceeds 100 kilograms per cultivated hectare. However, over half of fertilizer by nutrient weight is still supplied by organic materials, an extremely large share compared with other developing countries.

The third major technical constraint in the expansion of grain production is water availability. Here again, as in the case of fertilizer, there has been a shift away from local self-reliance. The national government has taken increasing responsibility for decisionmaking in the construction and improvement of irrigation facilities. Emphasis has moved from small scale projects under county, commune, and brigade control to more capital intensive large scale projects. This is a reflection of the fact that opportunities for development of small scale systems have been almost fully exploited. Further expansion may require the development of major projects with relatively long gestation periods. There is a growing reluctance to exploit local labour for the completion of projects of this type. Although the PRC is still considering some large scale water management projects, many prominent scientists suggest more research, particularly environmental investigation, is necessary before actual building commences, and current capital constraints make it difficult for China to proceed.

The kinds of problems that have been outlined above are by no means insurmountable. However, they do suggest the need for appropriate policies and skilful management at all levels of planning and production.

Conclusions

Grain occupies a dominant position in the Chinese agricultural economy. What happens in the grain sector will have a critical effect on the rate of agricultural and economic development in the future. If production slows and imports increase markedly, resources will have to be diverted away from potentially more profitable activities to boost production.

Over the longer period, the prospects for growth in wheat and maize production appear to be more favourable than for rice. The consequence of this must be evaluated in the context of shifts in demand for grain, which are as difficult to forecast as shifts in supply. The population growth rate will probably continue to decline. If incomes rise at the same time, there will likely be an increasing demand for livestock products and consequently for feed grains, particularly maize. Food grains can be supplied by either domestic production or imports. Furthermore, there is ample opportunity for substitution of wheat for rice in food grain consumption.

In summary, the question is not whether grain production can grow in the future, but whether needed supplies can be obtained without slowing the rate of growth of the rest of the economy. The efficient growth of domestic grain production in a severely overpopulated country depends on the development of new technology and infrastructure. Underinvestment in scientific manpower and agricultural infrastructure over the past two decades will make it more difficult to overcome the technical constraints on growth in grain production in the near future.

Note

[1]Barker and Sisler are Professors in Agricultural Economics, Cornell University. Rose is a Research Assistant in the Department of Agricultural Economics, Cornell University. The paper was presented by Bernard F. Stanton.

References

Buck, J. L., *Land Utilization in China*, University of Chicago Press, Chicago, 1937.

Tuan, F. C., "Provincial Total Grain Production, 1969-1979", *Research Notes on Chinese Agriculture*, No. 2, Economics and Statistics Service, USDA, Jan. 1981.

OPENER'S REMARKS—J. F. Martin

Indonesia

Measuring productivity growth in agriculture is fraught with difficulties. In Australia, for instance, I am aware of only ten empirical studies of total factor productivity growth in agriculture undertaken since the first such study in 1955. Hence Ahmad and Langham's efforts are to be highly commended. The paper could, however, be improved by including information on data sources, and expanding on the strengths and weaknesses of the methodology, particularly the undersized sample problem necessitating the use of Theil's "maximum entropy" techniques rather than ordinary regression techniques.

The authors justify the use of the translog function approach solely on the grounds that it is less data demanding. Theoretical issues should also be mentioned in the paper, given the fact that a lot of effort to develop functional forms has been directed towards overcoming the elasticity of substitution restrictions inherent in the commonly adopted Cobb-Douglas and CES functional forms. Productivity measurements are very sensitive to the data used; it would be useful to know whether this model has general application in other countries also having limited data. In relation to the productivity estimate itself, it is not possible to distinguish scale and substitution effects from technical change, and the model assumes neutral technical change. It would also be useful to compare the estimated results with other known productivity studies of Indonesian agriculture. Although there are numerous weaknesses in any empirical estimate of productivity growth, the accumulation of such studies can give us a feel for the extent and importance of productivity growth.

By comparison, estimates of total factor productivity growth in Australian agriculture range from -1.1 percent per annum to +3.96 percent per annum, depending largely on the time period, data source, and degree of aggregation. In general, the estimate of +0.6 percent per annum over the period 1950-1978 must be considered low.

An important aspect of the paper is to relate the levels of productivity change evident in the periods 1950-1958, 1959-1966, and 1967-1968 to the basic development strategies operative at the time. I would have liked to see this interpreted more cautiously, since it is not possible to establish a cause and effect relationship, given the inherent difficulties in measuring productivity growth, the short time span, the lack of any lagged response and the generality of the basic development strategies. However, the fact that government policy can substantially affect the rate of productivity growth in agriculture is of great importance, and further efforts should be made to quantify its effects. What is the relative importance of changes in monetary and fiscal policies, irrigation, varietal research, credit, and input/output prices which have been used to explain the variability in productivity growth between the sub-periods in Indonesia?

India

Subbarao's paper is of the most direct and important relevance to the discussion of growth with equity. This well-prepared paper also has the advantage of utilizing micro level data to test its hypothesis.

The institutional environment is defined as structure of landholdings, credit, and marketing institutions. Other elements such as access to government extension services could be included. However, there is little specific quantitative data given on this institutional environment, such as data on credit availability or access to marketing facilities. This is important, since the paper indicates that the eastern areas lag behind western areas in respect to every index of development. Hence productivity differences may be attributed to the adverse institutional environment, which may in fact be due to other factors, such as levels of education. It is not clear what has caused this difference, and isolation of specific variables would be useful.

To prove his case, partial productivity indices are adopted. These need to be treated cautiously, given the need for other things to be kept equal. Given the apparent substitution of capital for labour on the larger farms, other things are not equal. Increased investment may help explain the productivity differences. Although care is needed in interpreting partial productivity indices in isolation, other indices relating to irrigated area, area under tubewells, etc., do help reduce the reliance on the output per hectare indices.

Directly comparable data for western Uttar Pradesh are not presented. Data sources should be more closely examined. It does not seem reasonable that the small extra GVAO per hectare for small farms in eastern Uttar Pradesh between the periods 1966-1969 and 1975-1976 requires a threefold increase in the labour input. Hence, whilst we remain sympathetic to the objectives of the study, and appreciate the empirical work, the case is not proven. Future efforts should seek to strengthen the methodological framework and improve the basic data.

China

Is it a valid conclusion that future production gains will be almost entirely dependent on increases in single crop yields and that "over-zealous" efforts to increase cropping intensification have helped cause slower growth in rice yields? Firstly, what opportunities are there for utilizing technological developments to expand the cropping area? Secondly, can the problems caused by cropping intensification be overcome? The inherent problems are not specified. Is this due to lack of appropriate varieties, pest and disease build-up, lack of nutrition, poor water management, or other factors, many of which can be solved?

A main feature noted for Chinese grain production is its apparent year-to-year stability, attributed largely to irrigation. To what extent will the increased use of high yielding varieties, fertilizer, and greater itensification increase the riskiness and hence stability of production? Can the risk factor help explain, among other things, why China has been reluctant to utilize imported nonorganic fertilizer, particularly given the self-reliance objectives of the government?

The authors point to an impending major structural change in suggesting that small scale irrigation development possibilities are exhausted and larger projects are required. This raises the question not only of the economic viability of such large scale projects, but whether, apart from the capital and environmental constraints identified, the social, administrative, and institutional framework could adjust. The authors point out that already there are difficulties in getting labour for such projects. It would also be of particular interest, at this Conference which focuses on equity, to know whether, under the Chinese system of government, small and large scale projects have the same implications for equity.

There is an apparent contradiction in development strategy. The authors indicate that grain production is so important and self-sufficiency so politically essential that it must be encouraged. If production lags, they say, resources will have to be directed away from potentially more profitable activities to grain production. But given the desire for a more rational allocation of resources, why divert resources away from their most profitable use, except for political objectives?

The paper would be further improved by presenting more detailed information on the pricing policies and on investment in scientific manpower and agricultural infrastructure and management skills that are indicated at various points to be explanatory variables in the low productivity growth of Chinese grain production.

RAPPORTEUR'S REPORT—Robert L. Thompson

Most of the discussion centred on the paper by Subbarao, and was concerned with measurement of the relationship between farm size and productivity. It is irrelevant to compare farms of the same size in different regions of a country, or even in the same state, because of differences in climate, infrastructure, institutional environment, and technology. The farmer is important, not the size of farm. Since the institutional environment conditions the farmer's decision-making, the paper should have taken more institutional factors into account. Tenancy, extension, and access to education should also be considered. It was questioned whether Subbarao's finding of an inverse relationship between size and productivity in traditional agriculture should be interpreted as meaning that traditional institutions were more favourable to the small farmer. This contradicts what is known about traditional social structures. Technical change may be a particularly effective device for altering the traditional institutional structure.

Much of the controversy revolves around the noncontrolability of factors. Many early studies confused the effects of irrigation with those of farm size, while more recent studies have failed to recognize that farm size is often inversely correlated with land quality. There is a growing body of evidence that relative prices do differ among farm size groups, and that this may well account for the observed differences in productivity. The increasing availability of micro level data should make it possible to control more of these factors and more adequately test the relationship between farm size and productivity. It was recommended that a production function be estimated, with output a function of input levels, land quality, farm size, and institutional variables. One could easily test the hypothesis that a given farmer's ability to reach this production function, which represents the potential technical maximum, is directly related to farm size. The real crux of the productivity issue is access to land and services (credit, extension, etc.) and that all other explanations, including size, are spurious.

Participants in the discussion included S. H. Deshpande, K. Parikh, Per Pinstrup-Andersen (Session Chairman), S. Pudasaini, Inderjit Singh, and B. N. Verma.