Discussion Paper

CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH
P. O. BOX 36-306
TAIPEI, TAIWAN
REPUBLIC OF CHINA

CHIER

Discussion Paper

CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH
P. O. BOX 36-306
TAIPEI, TAIWAN
REPUBLIC OF CHINA

DISCUSSION PAPER
No: . 8201

A STUDY OF REGIONAL FACTOR PRODUCTIVITIES IN CHINESE AGRICULTURE

Kang Chao and Pei-chen Chang

1. The Issue

Mainland China's population of one billion people is supported by a very limited endowment of arable land, 1.5 mou (0.247 acres) per person. Its per capita grain output was 342 kg in 1979, substantially below the world average of 437 kg in that year.[1/] The problem of feeding such a huge population with domestic food supplies is, therefore, one of the nation's most fundamental concerns.

It is difficult, however, to evaluate agricultural performance partly because no sufficient statistics have been made available by the Chinese government to the outside world, and partly because the country has adopted so many controversial policies whose potential impacts are dubious in theory. During the course of 28 years beginning from 1952, when the country had fully recovered from previous wars, to 1979, for which the latest information is available, the average growth rate of food grain in the country was 2.7 percent,[2/] as compared with the 2 percent annual increase of population in the same time period. Whether this performance should be considered successful or not depends on whether it can be proven better than what could have been obtained under alternative programs.

In his recent study,[3/] Professor Anthony M. Tang has carefully calculated the total factor productivity of China's agricultural production between 1952 and 1977. The resulting indexes are as follows (with 1952 = 100):

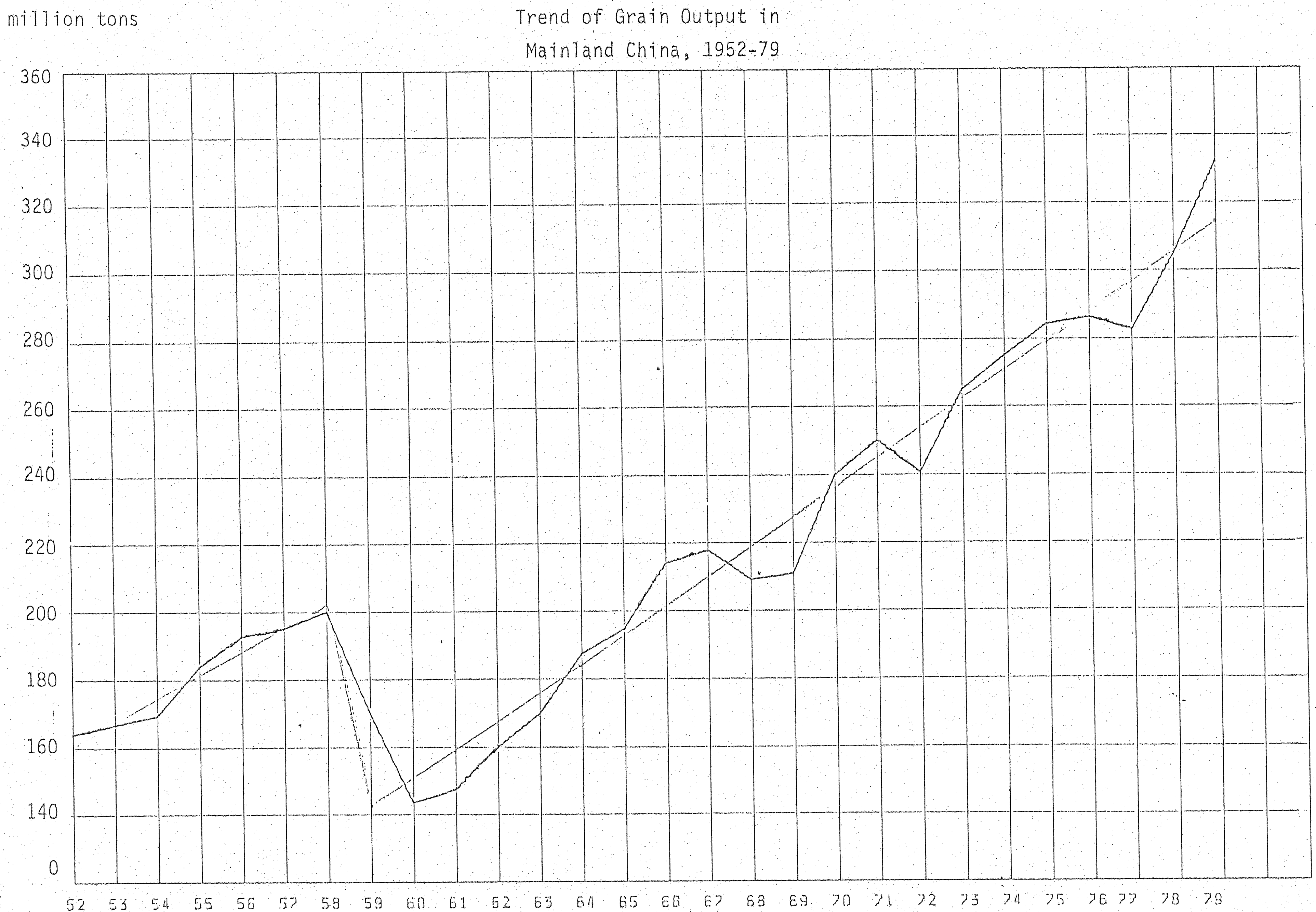
		1961	85	1971	98
1952	100	1962	91	1972	98
1953	101	1963	95	1973	100
1954	101	1964	99	1974	97
1955	106	1965	100	1975	95
1956	104	1966	103	1976	90
1957	108	1967	105	1977	85
1958	112	1968	97		
1959	90	1969	95		
1960	75	1970	101		

This time series illuminates two striking features: (1) The trend of the index seems to have been broken into two distinct segments. Between 1952 and 1958 the total factor productivity showed a visibly rising tendency, but it dropped to a much lower level in 1959 and remained stagnant at that level thereafter. (2) The overall result for the whole period was a declined factor productivity; with 1952 = 100, the 1977's index is 85.

These findings are partially supported by official data on grain output [4/] which normally accounts for more than 80 percent of the land used for agricultural production in the country. The 1952-58 output data and the 1959-79 data form two clearly distinct trend lines represented by the following two equations, where G denotes grain output in million tons and t denotes crop years.

Figure 1

Trend of Grain Output in
Mainland China, 1952-79



$$G_1 = 154.8 + 6.7t \quad (t = 1,.....7)$$

$$R^2 = 0.95119, \qquad D.W. = 1.81$$

$$G_2 = 133.3 + 8.5t \quad (t = 1,....21)$$

$$R^2 = 0.95862, \qquad D.W. = 1.45$$

The second equation has a much lower intercept. The sharp shift is more obvious when the data are plotted on a graph (see Figure 1).

Estimation of factor productivities must consider both the output and the input sides together to see whether the additional output has been obtained with a smaller basket of inputs. But the interpretation of the results is by no means straightforward. What is termed "factor productivity change" is the difference between the output index and the aggregate input index. As a residual, the factor productivity index reflects the working of all those elements that exert some influence on the output level but cannot be duly included in the calculation as quantitative changes of inputs. Ordinarily, this residual is positive, because by far the most important element responsible for the residual is technological change which has not been embodied in any of the calculations on included inputs. Since technological changes normally yield rising factor productivities in one way or another, negative residuals, or downward shifts of the production function, like that found in the case of Chinese agricultural production, are rather rare.

Professor Tang believes that the command economic system and the Chinese development strategy tend to undermine producer - worker incentives, discourage cost-reducing innovations, distort economic signals, and exaggerate risk aversions.[5/] All these may be held responsible for the rising resource cost per unit of agricultural output in the country.

After the downfall of the "Gang of Four" and the rise of a new and more pragmatic leadership, economic performance and policy in virtually every sector was put under thorough review. So far as agricultural production is concerned, more than 200 articles written by knowledgeable experts in the field were published in the People's Daily in 1979 alone; the discussions contained therein were summarized later in the 1980's Year Book of Chinese Agriculture.[6/] Virtually all discussants acknowledged in some manner that a very dear price had been paid for the progress achieved in the past two decades or so. Some of the attributable factors suggested by those discussants may be dismissed either because they were too insignificant in effect to account for such a drastic deterioration of the aggregate production function, or because their gradual occurence in the past 30 years was inconsistent with the abruptness in the shift of the production function after a certain point of time. The following developments appear to be highly relevant and deserve special attention.

Virtually all the discussants agreed, implicitly or explicitly, that the institutional transformation in the rural sector in 1958 was extremely harmful. Undoubtedly, they meant the commune system introduced in that year. Their reasoning was that the new "mode of production" was not commensurate with the existing productivity in the sector. Yet, in the eyes of many Western observers, the crucial problem was simply that the equalitarianism incorporated in the farm income distribution mechanism weakened the work incentives of farmers. In a sense, the "quality" of labor inputs under the new institution is suspected to have been substantially lowered.

Many Chinese writers tended to stress the permanent ecological damage generated by some erroneous policies, such as the conversion of timber lands, grass land and natural lakes into farmland. Such conversion took place in large scale in 1958 and ensuing years. The national campaign calling for the construction of backyard steel furnaces in 1958 compelled people to cut down trees for fuel. The subsequent famines in the following "three hard years" further induced the government to formulate a policy to shift lands from other uses to grain production.

A number of crucial, ecologically damaging changes have been cited as the results of such campaigns. The ratio of forest-covered land to the total territory of the southwestern region was reduced from 28% in the 1950's to 13% in the 1970's.[7/] In Szechwan province alone, the ratio declined from 19% to 9% over the period.[8/] In the northwestern region where the loess plateau was almost already bare during the 1950's, grass lands were then reclaimed for growing grain. As a partial consequence, 300 million mou of land became new desert,[9/] and another 90 million mou became highly sandy.[10/] The silt rate not only deteriorated further in the Yellow River, making it the worst case in the world, but also more than doubled in the Yangtze River over the past 20 years.[11/] Under the vigorous efforts to create polders, the water surface of TungTing Lake was reduced from 4,350 square kilometers to 2,740 square kilometers, or an approximate 37% reduction; 740 out of the 1,066 lakes in Hupeh disappeared from the map completely.[12/] The inevitable effect was the weakened capacity of those inland water bodies to function as reservoirs.

Ecologically, these actions led to a reduction in land productivity in two important ways. First, more of the top soil protecting farmland was washed away. According to official records, the area effected by soil erosion has increased by 400,000 square kilometers over the past 20 years.[13/] Second, the country became more vulnerable to natural disasters, as evidenced by the official testimony that the average area of farmland inflicted by natural calamities was 300 million mou per year in the 1950's but jumped to 500 million mou in the 1970's.[14/] The unprecedented case of two major floods in a single year, 1981, in the upper Yangtze region finally focused the attention of the whole nation on the possible ecological consequences of existing agricultural policy.

Equally heated discussion has taken place in recent years on the lasting damage of the salinization of farmland caused by the liberal construction of water reservoirs in plain areas. All natural surface water contains a certain amount of dissolved salts which injure plant life when concentrated. Improperly designed water reservoirs tend to raise the water table of the surrounding land above the critical level and cause such salinization. Moreover, the salinization process usually takes many years to complete, and still worse, once the damage is done, an even longer time is required to de-salinize and to restore the original quality of the farmland. In other words, such irrigation projects are likely to have reduced the productivity of land on a long-term basis. One official survey reports that the salinization effects over a large area in Honan was removed only slowly over a period of more than ten years; the effects of similar damage in the northwestern region are still influential today. A crash program to construct water reservoirs was launched in 1958. By 1961, more than 30 million mou of farmland in the north China plains had been salinized, the ill effect of which has never been successfully eliminated.[15/]

It should be noted that, for some of the questionable policies, the ill effects have been concentrated or particularly pronounced in certain regions or provinces. The impacts of de-forestization were said to be most serious in the south-western region including Szechwan; the reduction of the water surfaces of lakes took place largely in Hunan, Hupeh and Anhwei; salinization became a problem only in the northern plains plus Anhwei, viz., the locations of the Three Rivers (Yellow, Hai and Huai). Whether the impairment of land quality supposedly emanating from these policies was truly responsible for a large measure of the declined factor productivity in the aggregate production function can be tested only against the changes of factor productivities in various regions or provinces during the period in question. An attempt will be made here to answer this question. In other words, a process of elimination will be used in order to identify, to the greatest possible extent, the causes underlying Professor Tang's findings.

2. Measuring Output and Inputs*

We intend to measure the total productivity changes of agricultural factors in individual provinces by using the growth accounting methodology. Ideally, factor productivity indexes should be constructed not for political subdivisions but for agricultural regions defined on the basis of climatic, topographical and cropping conditions; but such an endeavor is impossible because published official data have not been classified according to agricultural regions. Even on the basis of political subdivisions, data are available only for 16 provinces, though this data incorporates regionally diffuse, and the most agriculturally important provinces. Temporally, it would be ideal to cover all years of the period under consideration in order to uncover the "turning points," if any, along with the sources of growth. But the extreme paucity of data compels us to make only a binary comparision, or a calculation of the average growth rates, between the year 1953 and the year 1979 for each province. Fortunately, 1953 was officially classified as an average crop year[16/] whereas 1979 was an unusually good year with the gross value of agricultural production and grain output increasing 8.5 percent and 9.0 percent, respectively.[17/] No understatement could have resulted from the selection of base year and

---

*Owing to space limitations, the raw data for various provinces are not presented in the text of this paper, but are available upon request.

terminal year. Following are the data that have been used in the study; they are undoubtedly very crude.

Output: In our study, output is measured by the quantity of grain produced in a year in physical units in order to avoid the difficulty of interpreting the ambiguous prices at which the official gross values of agricultural production have been computed. Even the official value series in terms of constant prices are open to interpretation because the basis of constant prices has been shifted several times. The use of grain output to represent the overall agricultural production is justified by the fact that it has always been by far the largest item in this sector and the land sown to grain has always accounted for more than 80 percent of the total sown area in the country.[18/] In order to achieve a perfect comparability of grain output between the two years, however, we must adjust the 1979 grain output by subtracting the soybean output and converting potatoes into grain according to the previous ratio of four to one.

The land input: This input item is measured by the area in each province sown to grain, as there are no statistical breakdowns of cultivated areas for grain and non-grain.[19/] In fact, it is by no means easy to determine the cultivated area for grain under the multiple-cropping system, because the land that has been sown to grain as the first crop may be used to produce a non-grain item as the second crop.

One possible distortion may arise in the case of measured land input. When the sown area, instead of the cultivated area, is taken as the measured land input, the resulting aggregate factor productivity is likely to be somewhat understated if the multiple-cropping index of the province has increased during the time period. The land is less productive when sown to the second crop than that for the first crop, even if the two are identical crops. This possibility will be examined later.

The labor input: The basis of estimating the labor input is the mid-year rural population in each province in the two years. To derive therefrom the labor force employed in agricultural production requires the age structure data of the rural population and the proportion of rural labor devoted to agriculture. Yet, both these types of information are unavailable. On the other hand, one official source reveals the following statistics:[20] (population in 1,000)

	1952	1979
Total population	57,482	97,092
Urban population	7,163	12,862
Rural population	50,319	84,230
as % of total population	87.54%	86.75%
Social labor force	20,729	40,581
Rural labor force	18,243	30,582
as % of total population	31.37%	31.49%
as % of rural population	36.25%	36.30%

The amazing stability of the percentage of the rural population in the total population, the percentage of the rural labor force in the total population and the percentage of the rural labor force in the rural population fully justifies the use of the index of rural population itself directly as the labor input index.

Like other inputs (except for land), labor cannot be further broken down between grain production and non-grain production. The implicit assumption is that the distribution of labor inputs between the two categories remained approximately unchanged.

The current inputs: Included in this category are organic fertilizer and chemical fertilizer, both measured in terms of plant nutrients. While it is fairly simple to calculate the primary nutrient contents of various types of chemical fertilizer, some degree of uncertainty exists in the estimation of nutrients contained in organic fertilizer. Based on the suggestion of a Chinese official source, the gross quantities of organic fertilizer are estimated according to the following rates:[21/]

1) Night soil: the number of rural population multiplied by 500 kg per year.
2) Pig excreta: the number of pigs multiplied by 2,000 kg per year.
3) Manure of large animals: the number of cattle multiplied by 5,000 kg per year.

The Chinese official conversion rates are then applied to derive the nutrient contents from those gross quantities.[22/] Minor types of organic fertilizer, such as compost plant residue and pond mud, are omitted due to inadequate data. The distortion created by such an omission is believed to be insignificant.

The capital input: The irrigated acreage in each province is taken as the proxy variable representing capital. This selection is justified by the fact that, unlike most other types of agricultural capital such as farm machines which are primarily labor-replacing, irrigation facilities are directly pertinent to the level of farm output.

3. Input Weights

Like most "growth accounting" models, the assumed production function is an unrestricted Cobb-Douglas function with constant returns to scale. When written in log linear form, it is

$$\frac{\Delta G}{G} = \alpha_1 \frac{\Delta L}{L} + \alpha_2 \frac{\Delta A}{A} + \alpha_3 \frac{\Delta K}{K} + \alpha_4 \frac{\Delta F}{F} + \frac{\Delta T}{T}$$

Where

G = Grain output

L = Labor

A = Sown area for grain

K = Capital inputs

F = Current inputs

T = Total factor productivity

All variables are now expressed as growth rates or index numbers. In the absence of technological changes, the growth of grain output should be fully explained by the sum of input growths weighted by, respectively, their output elasticities (α's). What cannot be explained by the aggregate input growth will appear in the residual term T. Thus, the residual reflects the broadly defined "total factor productivity changes" as well as estimation errors.

Ordinarily, income shares are taken to be the input weights, the α's. Or, in the case of studying agricultural production, where both primary factors and current inputs are included, the cost shares of inputs are used as the coefficients. This approach is acceptable for a free market economy because its factor costs more or less reflect the competitive equilibrium prices of inputs in the market, and its income shares are close to, and hence good proxies of, the production elasticities of those factors. Unfortunately, this condition is not met in Mainland China, especially for the agricultural sector, where both the output prices and input prices have been seriously distorted by the Chinese authorities.

Nor can we directly compute the α's of the production function by fitting them to output and input time series. The problem is that although the focal point of our study is total factor productivity, it can be observed only indirectly through the "residual." Yet, the conventional regression technique will treat the residual as "errors" and will choose the α's in such a way as to minimize those "errors." The results tend to overstate the contributions of the tangible inputs that can be measured whereas they tend to understate the changes in total factor productivity, if any, that must be embodied in the residual.

There are two possible alternatives to resolve this situation. One is to use a set of cross-section data taken from a given point in time. Even given an absence of technological improvement, the productivity of agricultural factors may have varied from region to region due to different climatic conditions. If the influence of such variations can be properly accounted for, the coefficients for various tangible inputs obtained by minimizing "errors" should be close to the true elasticities of the production function. The other alternative is to utilize certain input weights computed for a market economy which, during the period of study, had factor endowments fairly similar to that of Mainland China in the past two decades.

In this paper, we employ both approaches. The basic solutions are obtained from the fitting of a regression to some cross-province data, but they are then modified on the basis of a comparison with the input weights for Japan, Taiwan and Korea. In the computation we combine the cross - province data from both 1953 and 1979, because either sample is too small in size to yield meaningful results. In addition, we have introduced two new variables, the amount of rainfall (RF) and the length of frost-free period in the year (NF), to account for the major natural elements that cause regional differentials in agricultural productivity. The resulting regression equation is given below, with standard errors in parentheses.

$$\begin{aligned} LnO = {} & -1.524 + 0.424LnL + 0.303LnA + 0.003LnK + 0.253LnF \\ & \;(0.921) \quad\; (0.240) \qquad (0.174) \qquad (0.060) \qquad (0.070) \\ & - 0.055LnNF + 0.359LnRF \\ & \;\;(0.042) \qquad\quad (0.175) \end{aligned}$$

$R^2 = 0.93$

Here, all the coefficients, except for the capital input and the duration of frost-free time, may be considered statistically significant given the crudeness of our data. The negative sign of the frost-free duration probably reflects the fact that in localities where the growing season exceeds a critical point a second crop is usually grown, which tends to pull down the yield per sown area.

Over time, however, the influence of natural factors remains constant or varies at random; only the coefficients of the four categories of tangible inputs are relevant in measuring growth and change. Table 1 shows the cost shares of the four items in Japan, Taiwan and Korea during the 1950's and 1960's. Our estimated elasticities of labor, land and current inputs are very close to what has been demonstrated in these three market economies with factor endowments reasonably comparable to that of the Chinese Mainland. The insignificant capital input coefficient in Mainland China is most likely the result of the poor quality of our data and the co-linearity between variables, since it is inconceivable that irrigation facilities in all provinces were useless. After analyzing the information from other Asian countries, especially Taiwan, we decided to raise the weight of capital to 5 percent. The redistributed weights for the four items are presented in the last line of Table 1 for easy comparison.

Table 1

Comparison of Factor Cost Shares

in Selected Countries

(percent)

Country and Period	Labor	Land	Capital	Current Inputs
Japan, 1955-65	50.9	22.1	11.8	15.2
Taiwan, 1960-70	39.5	30.7	6.7	23.1
Korea, 1953-69	34.2	44.3	9.5	12.0
Mainland China, 1953-79	40.0	30.0	5.0	25.0

Sources: For Japan, Taiwan and Korea, the data are taken from Yujiro Hayami, Vernon W. Ruttan and Herman M. Southworth, Agricultural Growth in Japan. Taiwan, Korea and the Philippines, Honolulu: The University of Hawaii Press, 1979, p. 211.

4. Findings

Table 2 presents the indexes of output, various inputs, and total factor productivity in agricultural production in 16 Chinese provinces between 1953 and 1979. The most shocking observation is that the total factor productivity decreased substantially over this time period in all the provinces. The unweighted average of the 16 provinces is 69.1, with 1953 = 100. This confirms Professor Tang's calculation on the basis of national agricultural statistics and the broken trend line of grain outputs as shown in Figure 1.

The fact that such productivity deterioration occurred in all the 16 provinces without a single exception suggests that the fundamental cause or causes are likely to be nation - wide. In a serious and unusual case like this, one would naturally re-examine the reliability of data and the computation methods in order to make sure that they were not major sources of error. In this study, the item of current inputs is especially conspicuous, since its rate of increase over this period is the highest among all inputs and it supposedly has made the largest contribution to the output growth. Two questions may be raised: (1) Was the nutrient content of chemical fertilizer produced in China much lower than the standard level on the basis of which we have computed the indexes of current inputs? (2) Was the weight assigned to this item (0.25) too high?

Table 2

Indexes of Grain Output and
Inputs in Mainland China, 1979
(1953 = 100)

	Grain Index	Labor Index	Land Index	Capital Index	Current Inputs Index	Aggregate Input Index	Factor Productivity Index	Ranking of Factor Productivity Index
Szechwan	176.7	149.3	104.6	284.6	550.8	243.0	72.7	6
Kweichow	167.2	162.3	141.7	228.9	457.6	233.3	71.7	8
Shensi	189.5	172.6	94.1	319.1	682.9	284.0	66.7	12
Kansu	153.2	145.2	79.2	153.5	470.6	207.2	73.9	5
Hunan	212.3	157.2	124.6	138.4	633.8	265.6	80.0	3
Kwangsi	191.8	195.4	110.6	146.2	463.0	234.4	81.8	2
Kwangtung	178.9	155.0	93.6	231.6	667.0	268.4	66.7	11
Kiangsu	233.9	174.1	99.5	180.3	1146.1	395.0	59.2	14
Chekiang	224.4	171.8	118.1	146.6	956.8	350.7	64.0	13
Anhwei	216.3	153.6	82.0	241.3	743.7	284.0	76.2	4
Fukien	198.6	191.1	115.6	140.6	703.0	294.0	67.6	10
Shantung	251.6	143.8	91.7	1153.9	829.2	350.3	71.8	7
Hopei	228.4	137.8	95.0	409.0	678.2	273.6	83.5	1
Shansi	194.7	165.6	91.4	290.3	657.2	272.5	71.4	9
Liaoning	229.1	188.6	86.3	964.8	1316.2	478.6	48.9	16
Kirin	196.3	213.3	111.5	655.2	986.0	398.0	49.3	15

Both questions can be tested. Let us first assume that the actual nutrient content of the Chinese fertilizer was only one-half of the standard level. It follows that the contribution of this item should be reduced by 50 percent. The results based on the new assumption show that 11 provinces still register a decline in factor productivity. Alternatively, we may change the weight of current inputs from 25 percent to 10 percent, a level lower than the three Asian countries compared in Table 1. Using the new weight still leaves 7 provinces with declined factor productivity. To carry out this test to the extreme, the weight for current inputs would have to be reduced to as low as 1 percent in order to keep the total factor productivity from falling below 100 percent in all the 16 provinces. This would simply mean that virtually the total amount of fertilizer applied by Chinese farmers during the period was wasted. This is a certain impossibility as the Chinese farmers were asked to pay the highest price in the world for the fertilizer they received from the government relative to the prices received for products sold to the government;[23/] they would certainly refuse to apply additional fertilizer if it failed to raise the yield.

The capital input, which is represented by the irrigation facilities, is the second ranking fast-growth item. However, the weight assigned to it, 5 percent, is already low; changing the weight by a few percentage points would not alter the results substantially. In view of the high cost for installing irrigation facilities, it is only reasonable to assume that Chinese farmers would not continue to expand this input unless it produced some positive results.

The only item that has increased in the period independent of any economic calculation is labor. While no reports claim that the marginal product of rural labor in China has become zero or negative on a national scale, the possibility of labor redundancy as a regional phenomenon cannot be ruled out. In Liaoning and Kirin, for instance, the low factor productivity indexes, ranking 15 and 16 among the 16 provinces, have been accompanied by fairly high labor growth rates. Labor redundancy is not determined by absolute density of rural population but by the potential of the cropping system to absorb labor, as dictated by the climatic and topographical conditions in the region. There is good reason, therefore, to suspect that the short growing seasons in Liaoning and Kirin are basically not conducive to highly intensive farming, and hence have a rather limited ability to absorb additional labor.

Closely related to the problem of labor redundancy is the issue of expansion of multiple cropping, which tends to absorb more labor but usually depresses the yield rate per unit of sown area. In other words, the rise in the multiple-cropping index implies a reduced "quality" of the land input measured in terms of sown area. For the country as a whole, the multiple-cropping index, 130 in 1952, rose to 149 by 1979, signifying a 15 = $\left(\frac{149 - 130}{130}\right)$ percent increase in the degree of multiple-cropping over the period. This change is insufficient to account for the rather drastic decline in the measured total factor productivity (the unweighted average for the 16 provinces shows a reduction of 31.9 percent). It is probably true, however, that in the areas where the multiple-cropping system has been overextended, the quality of land has substantially deteriorated. As shown below, in the four provinces with very low factor productivity indexes, the multiple-cropping indexes of grain land all have exceeded 200.[24/]

	Ranking of factor productivity	Multiple-cropping index of grain land in 1979
Kwangtung	11	226
Kiangsu	14	203
Chekiang	13	227
Fukien	10	200

In fact, many Chinese agriculturists have recently reported that the conversion of a two-crop system into a three-crop system in certain areas of Kiangsu has damaged the original characteristics of land tissue.[25/]

The regional differentials in the factor productivity indexes manifested in Table 2 provide some other interesting clues. The fact that the factor productivity indexes of Hopei and Anhwei are relatively high, ranking 1 and 4, respectively, among the 16 provinces, implies that the salinization damage of farmland in the areas around the Huai River and the Hai River, produced by the construction of reservoirs on plains during the Great Leap years, was largely localized and not as serious as alleged in some official sources. Similarly, the relatively good performance of Kwangsi, Hunan, Szechwan, and Kweichow, ranking 2, 3, 6, and 7, respectively, in terms of factor productivity index, is contrary to the contention that the quality of farmland in these areas has been greatly injured by the ecological changes induced by the conversion of timberland, grassland and lakes into farmland.

If we eliminate Kirin, Liaoning, Kwangtung, Kiangsu, Chekiang, and Fukien, where the especially low factor productivity indexes might be partially accounted for by the extremely high multiple-cropping indexes, and by possible labor redundancy, the unweighted average index for the remaining ten provinces is about 75 percent. The implication is that the total factor productivity of agricultural production in the country as a whole has probably been reduced by nearly one-quarter from the 1953 level by some element that has generated a nation-wide diminishing impact.

The suspected culprit is the commune system. First, it represents a nation-wide institutional changes, which, theoretically, could have produced enormous disincentive effects. Second, as it embodies a drastic change in production organization, its impact can not be incorporated statistically in any of the tangible inputs. In other words, whatever effects this institutional change may have exerted on output levels must appear in the residual term. Third, the fact that the commune system was introduced in the latter part of 1958 is consistent with the turning point observed in Tang's factor productivity indexes and the broken trend line of grain output. Finally and perhaps most important, the above evaluation agrees with the official diagnosis of the Chinese authorities themselves, who have decided in recent years to switch from collective farming back to individual farming under the names of "po-chan-tao-hu" and "po-kan-tao-hu". The countless reports from every part of the country indicating how successful the reversed institutional changes have been in the rural sector in stimulating work incentives and raising output further confirm our inference.

Footnotes

(1) Agricultural Almanac of China, 1980, Peking: Agriculture Press, 1981.

(2) Agricultural Almanac, 1980, p. 350.

(3) Anthony M. Tang and Bruce Stone, "Food Production in the People's Republic of China," Research Report 15, International Food Policy Research Institute, 1980.

(4) Agricultural Almanac, 1980, p. 34.

(5) Tang and Stone, pp. 27-28.

(6) Agricultural Almanac, 1980, pp. 267-290.

(7) People's Daily, September 3, 1981.

(8) World Economic Herald, Shanghai, October 26, 1981.

(9) World Economic Herald, November 2, 1981.

(10) Agricultural Almanac, 1980, p. 16.

(11) World Economic Herald, October 26, 1981.

(12) People's Daily, September 3, 1981.

(13) World Economic Herald, November 2, 1981.

(14) Agricultural Almanac, 1980, p. 147.

(15) Agricultural Almanac, 1980, p. 289.

(16) Kang Chao, Agricultural Production in Communist China, 1949-1965, Madison: University of Wisconsin Press, 1970, p. 241.

(17) Agricultural Almanac, 1980, p. 34.

(18) Agricultural Almanac, 1980, p. 147.

(19) Agricultural Almanac, 1980, p. 293.

(20) Annual Economic Report of China(1981), Peking: Economic Management Press, 1981, pp. IV 3-7.

(21) Kang Chao, pp. 310-314.

(22) Ibid

(23) The exchange ratio in Mainland China in 1978 was 1 kg of grain to less than 1 kg of chemical fertilizer, whereas the ratio in the international market was 1 kg of grain to 1.5—2.0 kg of fertilizer. See State Statistical Bureau. The Baic Conditions of Chinese Agriculture, 1979, p. 98.

(24) Agricultural Almanac, 1980, p. 101.

(25) Agricultural Almanac, 1980, p. 279.