CHINA'S GRAIN PRODUCTION AND TRADE

by

Fu-Ning Zhong

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ABSTRACT

China's grain production, consumption and trade are key factors in the world grain market. Past experience indicates that China's grain production is strongly influenced by government policy. For example, the policy failure during the Great Leap Forward led to grain shortfalls in the early 1960's. Subsequently, the successful economic reforms in the late 1970's contributed towards a rapid growth in grain production.

Regional diversification plays an important role in determining the components of China's grain production which, in turn, will influence China's grain trade flows. Thus, an analysis of regional grain production provides an alternative approach to understanding the components of China's grain production and trade in the future.

The basic objectives of this study were:

1. To measure the impact of government policy on China's grain production and consumption explicitly by using policy instruments as major variables in econometric models;

2. To project China's grain production, consumption and trade into the year 2000.

The major findings of this study are:

1. China's grain yields are quite sensitive to price incentives;

2. Budgetary pressures will limit further increases in grain prices and as a result the growth of China's grain yields will slow down;

3. As the total population continues to increase, China's grain sown areas will decline further;

4. The growth rate of China's grain production will decline in the coming years;

5. As personal income continues to increase, the Chinese will gradually shift their food consumption towards more meat and other indirect grain consumption;

6. Wheat and rice production is likely to increase at much faster rates than other grain crops; and

7. China will continue to import a limited amount of grain but imports will shift from wheat to feed grains.

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Finally, I dedicate this thesis to my family and friends for their support and understanding.

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CHINA'S GRAIN PRODUCTION AND TRADE

1. Introduction

1.1. The Objectives of This Study

The policies of the Chinese government have a very strong influence on China's grain production, consumption and trade.[1] This study will explicitly assess these interrelationships in order to understand the historical patterns of grain production, consumption and trade, and to project them into the future.

As China is such a large country, the regional differences in climate and level of development are quite significant and so is the growth rate in grain production. Recognizing the importance of a disaggregate analysis, this study will specify and estimate regional models of China's grain economy whenever data are available.

The various components of grain consumption will be analyzed separately, as direct and indirect demands have very different responses to an income change. Changes in consumption components influence the demand for various kinds of grains--for example, rice and wheat versus coarse grains, which in turn have implications for production and trade.

Since the basic objective of this study will be to project China's grain production, consumption and trade into the future, policy changes are a major variable and they will play a key role in the analysis.

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[1]China refers to the People's Republic of China throughout this study. Grain production, consumption and trade in Taiwan Province are not analyzed in this study.

1.2. China's Historical Role as a Major Grain Trader

Even though she is now considered a major grain importer, in the 1950's China was actually a major grain exporter. During the 1950-60 time period, China exported a total of 25 million metric tons (mmt) of processed grain.[2] If a milling rate of 82 percent is applied to this figure to convert it to unprocessed grain, the estimate for exported grain would be 30.5 mmt in unprocessed form, which is 2.77 mmt annually.[3] Over the same time period, the imports of grain were negligible--only 0.9 mmt in total.

China's grain exports during the 1950's can be attributed to several factors. First, grain production increased quite rapidly during the recovery from the Japanese occupation (1937-45) and subsequent Civil War (1946-49) and the associated production incentives which were stimulated by the land reform of 1950-52.

The foundation of the People's Republic of China in 1949 ended wars that were decades long. Grain production increased very quickly

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[2]Chinese State Statistics Bureau, China's Statistical Yearbook, 1984, Statistical Publishing House, Beijing, 1985.

[3]Two types of figures are reported in China's official grain statistics, processed and unprocessed. To be consistent, only unprocessed figures are to be used in this study. The 82 percent milling rate is calculated from the two data series on grain procurement, processed and unprocessed, for the time period 1952-83 in China's Statistical Yearbook, 1984. The export figures might be underestimated, however, as China's major export grain is rice, for which the milling rate is 70 to 73 percent.

in the initial recovery period of 1949-52, from 111.2 mmt to 160.6 mmt.[4] This represented a 44.4 percent increase in just three years and it exceeded the previous historical production record of 148.7 mmt in 1936 (just before the Sino-Japanese War).[5]

Before the land reform, less than 10 percent of the rural population owned more than 70 percent of the total arable land and the rent they typically charged was about 50 percent of total output. By 1952, the land reform had been basically completed and approximately 300 million farmers (more than 60 percent of the rural population) received 46.7 million hectares of land (about one-half of the total arable land) without any payment. As a result, about 35 mmt of grain of annual rent (20 to 25 percent of total national grain production) was simply abolished.[6] With this change in ownership came great incentives to improve farming practices and management, to reclaim land and to increase multiple cropping. As a result, grain production reached a new peak of 193.5 mmt in 1958 without any increases of modern inputs. This meant a 20.5 percent increase in only six years, or 3.2 percent annually from 1952 to 1958.

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[4]Chinese State Statistics Bureau, China's Statistical Yearbook, 1984. Note that the production of potatoes is converted to grain at the rate of four to one prior to 1964 and five to one after 1964 in official data, but a five to one rate is used throughout this study for consistency. The figures prior to 1964, therefore, required adjustment.

[5]Department of Agricultural Statistics, Chinese State Statistics Bureau, The Great Achievement in China's Agriculture, Statistical Publishing House, Beijing, 1985.

[6]Ibid.

Together, over these two periods, the increase in grain production was 74 percent in total, or 6.3 percent yearly from 1949 to 1958. The average grain production per capita increased by 42.9 percent in total, or 4 percent yearly, over the same time period. (From 205 kg in 1949 to 293 kg in 1958.)

Secondly, the increased exports in the 1950's came about due to the large Chinese demand for foreign exchange, which was required in order to finance industrialization. In the 1950's, industrialization was a top priority in the country. More than 90 percent of the imports (in value terms) were inputs for use in production (mostly for industrial use) but about 75 percent of the exports were farm products or manufactured from farm products.[7] Thus, grain exports were kept at a high level as long as possible.

From 1958 to 1960, grain production suddenly dropped by 50 mmt (or 28 percent) from 193.5 mmt to 139.4 mmt (see Table 1). This was attributed to policy errors by the Party and the Government in guiding economic development. Poor weather was also a factor. This production shortfall exhausted the grain reserves, reduced grain production per capita from about 293 kg to 210 kg, and forced China to import a large quantity of grain beginning in 1961.

In 1965, China's grain production reached 194.5 mmt, slightly higher than the 193.5 mmt attained in 1958, which was the highest level before the critical shortfall period. But, as population increased in the seven intervening years, the production per capita was only 268 kg

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[7]Chinese State Statistics Bureau, China's Statistical Yearbook, 1984.

Table 1
China's Grain Production and Population
1949-84

Year	Grain Production	Population	Average Production
	---mmt----	-million--	-kg/capita-
1949	111.2	541.7	205.3
1950	129.6	552.0	234.8
1951	140.9	563.0	250.3
1952	160.6	574.8	279.4
1953	163.5	588.0	278.1
1954	166.1	602.7	275.6
1955	180.2	614.7	293.2
1956	188.4	628.3	299.9
1957	190.7	646.5	295.0
1958	193.5	659.9	293.2
1959	165.2	672.1	245.8
1960	139.4	662.1	210.5
1961	143.2	658.6	217.4
1962	155.3	673.0	230.8
1963	165.7	691.7	239.6
1964	187.5	705.0	266.0
1965	194.5	725.4	268.1
1966	214.0	745.4	287.1
1967	217.8	763.7	285.2
1968	209.1	785.3	266.3
1969	211.0	806.7	261.6
1970	240.0	829.9	289.2
1971	250.1	852.3	293.4
1972	240.5	871.8	275.9
1973	264.9	892.1	296.9
1974	275.3	908.6	303.0
1975	284.5	924.2	307.8
1976	286.3	937.2	305.5
1977	282.7	949.7	297.7
1978	304.8	962.6	316.6
1979	332.1	975.4	340.5
1980	320.6	987.1	324.8
1981	325.0	1,000.7	324.8
1982	354.5	1,015.4	349.1
1983	387.3	1,025.0	377.9
1984[a]	407.3	1,034.8	393.6

[a]Figures for 1984 are from the Chinese State Statistics Bureau, China's Statistical Abstract, 1985.

Source: Chinese State Statistics Bureau, China's Statistics Yearbook, 1984. The figures on grain production prior to 1964 have been adjusted by applying a five to one potatoes to grain conversion rate.

in 1965, 8.5 percent lower than the 1958 level of 293 kg. It was not until 1971, 13 years later, that China restored grain production per capita to its 1958 level of 293 kg. It slowly increased to 316.6 kg in 1978.[8]

For the 1965-78 period, the direct food consumption was quite stable. It fluctuated slightly, from 173 kg to 195 kg per capita.[9] This stability was a reflection of both restricted food rationing in the urban areas and procurement of quotas in the rural areas. On the other hand, the net income per capita increased from 227 yuan in 1964 to 316 yuan in 1978 for urban people and from 107.2 yuan in 1965 to 133.6 yuan in 1978 for rural people. Over the same time period, the price index of consumer goods increased by only 2.8 percent for urban people and that of manufactured goods sold to rural areas actually declined by 7.3 percent.[10] The increase in real income stimulated the demand for other goods including those using grain as a major input. This increased demand was met by increased production. For example, meat production increased 3.05 mmt from 1965 to 1978, and this required about 10 to 15 mmt of additional feed grain yearly. Liquor retailing increased 1.52 mmt (162.5 percent) from 0.94 in 1965 to 2.46 in 1978.[11] This required about 1.4 mmt of grain as additional input (according to the input/output ratio as of 1980) yearly. Also, more

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[8]See Table 1, China's Grain Production and Population.

[9]Chinese State Statistics Bureau, China's Statistical Yeabook, 1984, p. 447.

[10]Ibid.

[11]Ibid.

grain was required by industries such as textiles and pharmaceuticals.

During this time period, the value of China's exports steadily increased from 2.23 billion U.S. dollars in 1965 to 9.75 billion in 1978 and the share of farm products and goods manufactured with farm products in the export figure declined from about 75 percent in the 1950's to 62 percent in the late 1970's. On the other hand, the share of imported consumer goods increased from less than 10 percent in the 1950's to about 20 percent in the 1970's.[12] These data indicated that the achievements in China's industrialization drive made China less dependent on the agricultural sector to finance further development, which resulted in less pressure on the grain sector.

Thus, China's net grain imports during the 1961-78 period can be easily explained. It is shown in Table 2 that from 1961 to 1965 the net imports were quite stable, ranging from 3.46 to 4.35 mmt yearly (3.95 on average). This indicates there was an urgent need for grain as a basic food. (Although these imports accounted for only 3 percent of total grain consumption in the country, they represented about 10-15 percent of state retail grain sales.) Beginning in 1966, China recovered from the food crisis, but the country still required grain imports in order to meet increasing demand and to reestablish reserve stocks. China maintained grain imports but more of a fluctuating pattern developed; net imports ranged from 0 to 6.5 mmt between 1965 and 1978 (2.3 mmt on average).[13]

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[12]Chinese State Statistics Bureau, China's Statistical Yearbook, 1984.

[13]See Table 2, China's Grain Trade.

Table 2

China's Grain Trade

Year	Exports	Imports	Net Imports
	----------	mmt	----------
1950	1.49	0.07	-1.42
1951	2.40	-	-2.40
1952	1.86	-	-1.86
1953	2.23	0.01	-2.22
1954	2.09	0.03	-2.06
1955	2.72	0.18	-2.54
1956	3.23	0.15	-3.08
1957	2.55	0.17	-2.38
1958	3.52	0.22	-3.30
1959	5.07	-	-5.07
1960	3.32	0.07	-3.25
1961	1.65	5.81	4.16
1962	1.26	4.92	3.66
1963	1.82	5.95	4.13
1964	2.22	6.57	4.35
1965	2.95	6.41	3.46
1966	3.52	6.44	2.92
1967	3.65	4.70	1.05
1968	3.17	4.60	1.43
1969	2.73	3.79	1.06
1970	2.58	5.36	2.78
1971	3.19	3.17	-0.02
1972	3.57	4.76	1.19
1973	4.75	8.13	3.38
1974	4.44	8.12	3.68
1975	3.42	3.74	0.32
1976	2.15	2.37	0.22
1977	2.02	7.34	5.32
1978	2.29	8.83	6.54
1979	2.01	12.36	10.35
1980	1.97	13.43	11.46
1981	1.54	14.81	13.27
1982	1.53	16.12	14.59
1983	2.39	13.44	11.05
1984		10.45	

Source: Chinese State Statistics Bureau, China's Statistics Yearbook, 1984. The export figures have been adjusted to reflect unprocessed grain by applying a milling rate of 82 percent.

It is very interesting to observe from Table 2 that China's grain imports then jumped to a record level of 12.36 mmt in 1979 and attained an even higher level in succeeding years. These imports reached record levels even though during the same period China came close to setting new records in grain production every year in terms of both total output and output per capita.[14] (This will be analyzed in-depth later in this study.) In the period from 1979 to 1983, China's grain imports fluctuated from 12.36 to 16.12 mmt and were 14.03 on average. The net grain import figure fluctuated from 10.35 to 14.59 mmt and was 12.14 on average. In 1984, China imported 10.45 mmt of grain.

Table 3 gives the relative importance of China's grain imports in the world market. For the world as a whole, wheat accounts for about one-half of total grain imports; but for China, wheat accounts for about 85 percent of her grain imports. Therefore, China's share in the world wheat market is relatively more important than in the total grain market. It has averaged about 8.9 percent in the wheat market since 1961. The trends of China's shares in both wheat and total grain markets are similar to those of volumes, but more moderate. They declined in the late 1960's and 1970's until 1978, then sharply increased to the levels attained in the early 1960's. The share of wheat in China's total grain imports declined slightly after 1978, from 87 to 83 percent, which may reflect the relatively greater indirect demand for grain which rapidly followed the increased net income per capita after 1978.

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[14]See Table 1, China's Grain Production and Population.

Table 3

World Grain Imports
1961-83

Year[a]	World		China		China's Share	
	Total Grain[b]	Wheat	Total Grain	Wheat	Total Grain	Wheat
	----------mmt----------				----percent----	
1961	82.8	46	5.81	3.88	7.0	8.4
1962	78.8	43	4.92	3.54	6.2	8.2
1963	95.4	56	5.95	5.59	6.2	10.0
1964	90.8	50.1	6.57	5.37	7.2	10.7
1965	109.5	61.0	6.41	6.07	5.9	10.0
1966	105.3	55.6	6.44	6.21	6.1	11.2
1967	100.0	52.1	4.70	4.39	4.7	8.4
1968	92.0	46.6	4.60	4.45	5.0	9.5
1969	100.9	52.1	3.79	3.74	3.8	7.2
1970	110.3	54.8	5.36	5.30	4.9	9.7
1971	116.6	55.7	3.17	3.02	2.7	5.4
1972	140.4	71.9	4.76	4.33	3.4	6.0
1973	149.8	68.5	8.13	6.30	5.4	9.2
1974	143.3	66.3	8.12	5.38	5.7	8.1
1975	147.4	67.5	3.74	3.49	2.5	5.2
1976	146.6	60.5	2.37	2.02	1.6	3.3
1977	162.2	71.8	7.34	6.88	4.5	9.6
1978	168.1	72.9	8.83	7.67	5.3	10.5
1979	194.5	84.0	12.36	8.71	6.4	10.4
1980	205.0	92.3	12.43	10.97	6.1	11.9
1981	222.0	101.0	14.81	13.07	6.7	12.9
1982	195.3	97.5	16.12	13.53	8.3	13.9
1983	197.8	96.0	13.44	11.02	6.8	11.3

[a]Fiscal year for the world and calendar year for China.

[b]Including wheat, coarse and rice. Figures for rice from 1979 onward are exports.

Source: FAO, Commodity Review and Outlook, various issues for the world; and Chinese State Statistics Bureau, China's Statistics Yearbook, 1984 for China.

These data clearly show that China has become one of the world's largest grain importers since 1961, and her wheat imports increased sharply in the early 1980's. One might ask whether China will continue to import large quantities of grain in the future and whether the current components of imports will change after the recent significant increases in China's grain production and the accompanying shift in consumption patterns. To answer this question, it is necessary to analyze China's grain production and consumption in the past and to pay special attention to the impact of economic reforms carried out recently.

1.3. China's Grain Production and Trade Subsequent to 1978

Since 1978, China's grain production has increased at a much faster rate than before, although the area devoted to grain has declined. In 1978, the total output of grain production was 304.8 mmt and in 1984 it reached a new record of 407.3 mmt which means a 33.6 percent increase in only six years, or a 4.95 percent increase per year.

This growth rate is significantly higher than the long-run growth rate of 2.5 percent between 1952 and 1978. If the critical shortfall period of the late 1950's and early 1960's is excluded, the growth rates for the 1952-57 and 1965-78 time periods are both about 3.5 percent. Therefore, the 1978-84 increase is still significantly higher.

The production gains were unexpected by many observers of Chinese agriculture. For example, the USDA predicted that there would be no

large increase in China's grain production in 1982.[15] However, the increase turned out to be 25.9 mmt, or 9.1 percent higher than the year previous. Again, it was predicted by USDA that the total grain output would decline in 1983, but the increase was even higher--32.8 mmt or 9.3 percent. The USDA forecast of grain production in 1984 was for a 0.7 percent increase, but the actual increase was 20 mmt or 5.2 percent.[16]

The lower predictions by USDA and others[17] are based on the fact that China's grain sown area has declined under the new policy and the growth rates of major modern inputs have slowed down at the same time. They did anticipate increases in grain yields but they did not expect the increases in yields to be so large. The decline in grain sown area was offset by these higher yields. It seems the USDA did not expect the new policies would have such a great influence on grain yields.

China's arable land is very limited and the cultivated area has been declining for a long time. Under the post 1978 policy, the increase in local autonomy has led to increases in the sown area to cash crops,[18] and to decreases in multiple cropping in some important grain production areas.[19] The combination of these and other factors resulted in a 6.4 percent decline in sown area to grains between 1978

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[15]USDA, China: Review of Agriculture in 1981 and Outlook in 1982.

[16]USDA, China: Outlook and Situation Report.

[17]For example, the Chinese government did not expect the 1985 grain output target would be reached one year ahead of time.

[18]See Table 4, China's Sown Area.

[19]For Example, in Southern Jiangsu Province.

Table 4

Crop Sown Area in China
1952-84

Year	Total Area million hectares	Grain Crops million ha	Grain Crops percentage	Cash Crops million ha	Cash Crops percentage
1952	141.26	123.98	87.8	12.49	8.8
1953	144.04	126.64	87.9	11.66	8.1
1954	147.93	128.99	87.2	12.42	8.4
1955	151.08	129.84	85.9	13.99	9.3
1956	159.17	136.34	85.7	14.70	9.2
1957	157.24	133.63	85.0	14.46	9.2
1958	151.99	127.61	84.0	13.77	9.1
1959	142.40	116.02	81.5	13.55	9.5
1960	150.58	122.43	81.3	12.91	8.6
1961	143.21	121.44	84.8	9.32	6.5
1962	140.23	121.62	86.7	8.76	6.3
1963	140.22	120.74	86.1	10.19	7.3
1964	143.53	122.10	85.1	11.99	8.4
1965	143.29	119.63	83.5	12.21	8.5
1966	146.83	120.99	82.4	12.24	8.3
1967	144.94	119.23	82.3	12.20	8.4
1968	139.83	116.16	83.1	11.35	8.1
1969	140.94	117.60	83.4	11.43	8.1
1970	143.49	119.27	83.1	11.71	8.2
1971	145.68	120.85	83.0	11.93	8.2
1972	147.92	121.21	81.9	12.53	8.5
1973	148.55	121.16	81.6	12.80	8.6
1974	148.64	120.98	81.4	12.89	8.7
1975	149.55	121.06	80.9	13.40	9.0
1976	149.72	120.74	80.6	13.72	9.2
1977	149.33	120.40	80.6	13.53	9.1
1978	150.08	120.59	80.3	14.44	9.6
1979	148.48	119.26	80.3	14.77	10.0
1980	146.38	117.23	80.1	15.92	10.9
1981	145.16	114.96	79.2	17.56	12.1
1982	144.75	113.46	78.4	18.79	13.0
1983	143.99	114.05	79.2	17.76	12.3
1984	144.22	112.88	78.3	19.29	13.4

Source: Chinese State Statistics Bureau, China's Statistics Yearbook, 1984, and China's Statistics Abstract, 1985.

and 1984. In the earlier period from 1965 to 1978, the sown area to grain did not change significantly from year to year. However, it declined by about 1 percent per year every year thereafter.

Besides the area sown to grain, the growth rates of almost all modern agricultural inputs slowed in 1978-84, compared with those in the earlier 1965-78 period.[20] The decline in the growth rate of chemical fertilizer utilization was the most moderate, from 12.5 to 12.0 percent. However, for tractors and irrigation and drainage equipment, deterioration of growth rates was quite significant, from 56.7 to 15.7 percent and from 16.4 to 3.0 percent, respectively.

Contrary to the decline in both sown area and input growth rates, wheat and rice production increased significantly. Some new techniques contributed to the increase. An important innovation, hybrid rice, contributed substantially to the increased rice yield. The area sown to hybrid rice varieties increased from 4.33[21] to 6.75[22] million hectares between 1978 and 1983 and its yield was 16.9 percent higher than the average of total rice in 1982. But as hybrid rice only accounted for about 20 percent of the total rice sown area, it cannot fully explain the increase in rice production. However, the production and yield of wheat rose much faster than in the case of rice, 8.5 and 8.3 percent versus 4.5 and 5.1 percent yearly, respectively. According to Wiens, the growth in grain production in the North China Plain in

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[20]See Table 5, Major Agricultural Inputs.

[21]W.R. Coffman and S.S. Virmani, Advanced Rice Technology in the People's Republic of China, 1983, edited by R. Barker and B. Rose.

[22]Agricultural Yearbook Editing Committee, China's Agricultural Yearbook, 1984.

Table 5

Major Agricultural Inputs in China
1965-84

Items	Year			Growth Rate	
	1965	1978	1984	1965-78	1978-84
				----percent-----	
Large and medium tractors, 1,000 units	72.6	557.4	853.9	17.0	7.4
Small and hand tractors, 1,000 units	4.0	1,373.0	3,298.0	56.7	15.7
Irrigation and drainage equipment, million hp	9.1	65.6	78.5	16.4	3.0
Chemical fertilizer, million metric tons	1.9	8.8	17.4	12.5	12.0
Electricity, billion kwh	3.7	25.3	46.4	15.9	10.6

Source: Chinese State Statistics Bureau, China's Statistics Abstract, 1985.

the late 1960's and 1970's was largely due to increased tube well irrigation.[23] This is a major wheat production area, but it has been reported by Chinese officials that the ground water level significantly declined in the late 1970's and a serious shortage in the supply has occurred. Even so, the growth rate of wheat production was still higher in 1978-84 than in 1965-78, 8.5 versus 3.5 percent, respectively. Annual yields grew by 8.3 percent in 1978-84 versus 4.7 percent in 1965-78. Thus, the accelerated growth in grain production has been solely due to the increased yields. The development of new techniques can only partly explain these yield increases. As we will see later, the policy changes, such as price incentives, the production responsibility system and the free market were largely responsible for these yield improvements after 1978.

The large quantity of grain imports after 1978 can also be explained by the new policies. After the purge of the "Gang of Four" in 1976, the party reevaluated its economic policies. In the past, the economic goals had been aimed at production itself, the gross value of production, not consumer goods nor net products. Grain production had been given first priority in agriculture. Self sufficiency had been required everywhere regardless of economic efficiency and this was enforced by the assigning of sown area to grain crops by the government. These rigid policies resulted in a very small increase in net incomes and an inadequate supply of consumer goods, especially in the rural areas. It was subsequently found that the low incomes further

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[23]T. Wiens, "Technological Change," in The Chinese Agricultural Economy, edited by R. Barker, R. Sinha and B. Rose, Westview Press, Boulder Colorado and Croom Helm, London, England, 1982.

restricted the growth of production itself. From 1965 to 1976, the net income per capita in rural areas rose only 5.5 percent in total (in 11 years!), from 107.2 yuan to 113.05 yuan.[24] In the urban area, the wage rate had declined by 7.2 percent over the same time period (7.7 percent in real terms). Only because the ratio of the labour force to total population increased (from 39.4 to 53.2 percent) did the net income per capita increase. In nominal terms it increased by 25.4 percent, or 2.1 percent yearly and in real terms, 24.6 percent and 2.0 percent, respectively.[25]

These types of policies were self defeating and major changes have occurred since the end of 1978. The main purpose of the new economic reform is more balanced growth between capital and consumer goods. Economic efficiency has been given top priority. This new shift in policy has promised rapid increases in net income, especially in the rural area.

Consequently, the pressure on grain self sufficiency has been eased to some extent and farmers are allowed to reallocate their resources, including land, to more profitable crops. That was the major reason why the sown area to cash crops increased so rapidly. However, the government still has the obligation to supply those rural people, who are involved mainly in cash crop production, with grain for their food consumption. Also, since some additional farmers are now involved in meat, milk, poultry and egg production (the so-called

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[24]Department of Agricultural Statistics, Chinese State Statistics Bureau, The Great Changes in China's Rural Life. Statistical Publishing House, Beijing, 1985.

[25]Calculated from China's Statistical Yearbook, 1984.

"specialized households"), the government has to supply them with feed grain. Therefore, grain resales by the government to rural areas increased from 19 to 34.6 mmt between 1978 and 1983. (Feed sales may not be included in these figures.)[26]

Besides the food grain resales to rural areas for more efficient resource allocation, the government had to meet the increasing indirect demand resulting from the increasing income. From 1978 to 1983, net income per capita increased from 316 yuan to 526 yuan in the urban area, 66.5 percent nominally or 43 percent in real terms; and from 134 yuan to 310 yuan in the rural area, 131.3 percent nominally or near double in real terms.[27] Consequently, meat production increased from 8.56 to 15.41 mmt between 1978 and 1984 and liquor production increased from 2.46 to 6.79 mmt during this period.[28] These two items alone require about 30 mmt of grain as additional inputs each year. (Direct consumption of grain also increased during this period.)

Some other factors may have also contributed to the large quantity of grain imports. These include: (a) transportation bottlenecks and other difficulties in grain shipments interprovincially;[29] (b) the

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[26]According to the Chinese definition, a grain sale or resale usually only refers to food grain sales or resales.

[27]Chinese State Statistics Bureau, China's Statistical Yearbook, 1984.

[28]Chinese State Statistics Bureau, China's Statistical Abstract, 1985, Statistical Publishing House, Beijing, 1986.

[29]Frederic M. Surls, "Grain Marketing and Imports," in China, Outlook and Situation Report, 1984, USDA.

establishment of food security objectives to ensure a stable society;[30] and (c) the long-term grain trade agreements, especially in the most recent years.

All of these factors, especially the policy changes which shift the efficiency and structure of agricultural production and the level and structure of consumption, may have various influences on Chinese grain imports. More thorough study is needed to understand the patterns of grain production, consumption and trade in China, especially under current policies.

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[30]Karen Minden, "Politics and Business: The Canada-China Wheat Trade, 1960-1984" in Canadian Agriculture in the Global Context: Opportunities and Obligations, edited by I. Kneil and J. English, University of Waterloo Press, Waterloo, Ontario, 1985.

2. Literature Review

2.1. Growth in China's Grain Production and its Sources

There are many studies available on China's agriculture. However, only some of the most recent ones will be reviewed here. In this section, studies concerning the growth in China's grain production and its sources will be discussed. The literature on modelling and projections of China's grain production and consumption will be covered in the following sections.

In analyzing China's grain production, Barker, Sisler and Rose noticed that the measure of long-term growth rate depends on the base year chosen.[31] They gave the following examples:

1949-51/1955-57	6.7 percent
1955-57/1977-79	2.4 percent
1952-53/1977-79	2.8 percent
1949-51/1978-80	3.3 percent

They pointed out, as the period of 1949 to 1957 was a recovery period during which the growth rate of grain production was markedly high, the long-term growth rate would be overestimated if 1949 was chosen as base year. For this reason they regarded the periods 1955-57 to 1977-79 as being most appropriate for measuring long-term growth. The growth rate of 2.4 percent, as they suggested, is not impressive in grain production. It is only slightly above the rate of population

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[31]Randolph Barker, Daniel G. Sisler and Beth Rose, "Prospects for Growth in Grain Production" in The Chinese Agricultural Economy, edited by R. Barker and R. Sinha with B. Rose, Westview Press Inc., Boulder, Colorado and Croom Helm Limited, London, England, 1982.

growth in China and close to the average performance of other developing countries.

Similar issues were raised by Perkins and Yusuf.[32] According to them the most reliable base figures for the earlier years are for 1955-57. Compared with figures for 1978-80, they found that the growth rate of grain production, 2.25 percent per year, was only slightly faster than that of population. But they pointed out that this 1955-57 base came just before the Great Leap Forward, which led to a sharp decline in grain output in 1959-61, and the recovery to the earlier level was not achieved until 1965. If the 1964-66 period were chosen as a base, the growth rate would rise to 3.4 percent per year. They noticed that much of this more impressive growth occurred in the mid 1960's and after 1977, and the big increase in 1978 and 1979 coincided with the sharp rise in grain prices.

There seems to be agreement that there was a shift in the growth rate in 1978 when major policy changes were initiated. But, according to Barker et al., this was only a temporary shift from the normal growth path, largely due to the short-run weather effects. They predicted that the Chinese would face serious technical and environmental constraints to grain production in the immediate future.[33] Furthermore, they suggested that the under-investment in scientific manpower and agricultural infrastructure over the past two

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[32]D. Perkins and S. Yusuf, Rural Development in China, The John Hopkins University Press, Baltimore, Maryland, 1984.

[33]R. Barker, et al., Ibid.

decades would make it more difficult to overcome these constraints in the near future.

The inconsistency of their assessment with what actually developed between 1981 and 1984, may be due to the circumstances in the period during which they wrote their articles. In the early 1980's, the new policy had just begun and no one could foresee its evolution, let alone its full impact. Even the Chinese government did not really anticipate that the 10 year plan's target would be reached in 1984, one year ahead of the plan. Furthermore, Barker et al., observed a 3.5 percent decline in grain output in 1980.

As mentioned above, Perkins and Yusuf reasoned that the large increase in grain production in the late 1970's coincided with sharp price increases. To analyze the growth rates in various time periods they provided the following table:

Table 6

Chinese Grain Production Increases (1)

Time Period	1952-57	1957-65	1965-75	1975-80	1957-80	1981-82
Annual Change	3.5%	0.0%	3.9%	2.8%	2.1%	4.9%

Source: Perkins and Yusuf.[34]

[34]D. Perkins and R. Yusuf, Rural Development in China, The John Hopkins University Press, Baltimore, Maryland, 1984.

This table clearly indicates that the growth rate of grain production varies over time. Although the authors did not specify the criteria for dividing the time periods, it seems that the initial period is the first five-year plan period. This was a time period between the recovery from war and the Great Leap Forward. This time period is used by the Chinese analysts as a norm, or sometimes as the best time period of economic development between 1949 and 1979. The second period covers the Great Leap Forward and a recovery period following it. The fifth period in the table, 1957-80, is referred to by the authors as a time period from which a reliable long-run growth rate can be drawn. The last period is used to show the new trend. However, it is not clear why the year 1975 was chosen to divide the third and the fourth periods. As all other periods are associated with some major events in the policy evolution, the third period seems to refer to the Cultural Revolution, and the fourth, after the Cultural Revolution. But the Cultural Revolution was formally ended in 1976 and the economic policy which influenced grain production directly and substantially was not changed until the end of 1978. Since then, generally speaking, the policy has continued to change and roughly in the same direction.

Thus, it would seem to be more precise to divide the first 35 years of the People's Republic into five periods: recovery, first five-year plan, the Great Leap Forward and the following recovery, the Cultural Revolution and the economic reform. The growth rates in those periods are as follows:

Table 7

Chinese Grain Production Increases (2)

Time Period	1949-52	1952-57	1957-65	1965-78	1978-84
Annual Change	13.0%	3.5%	0.2%	3.5%	5.0%

Source: Estimated.

When analyzing the long-run trend in growth rates, the initial period is not relevant because of the recovery nature of grain production in this period. The third period might be ruled out, if it is reasonable to assume that the same mistake will not be made again, at least in the remainder of the century. Thus, the long-run trend between 1952 and 1978 might be taken as 3.5 percent per year, as in the second and fourth periods. It might be lower than 3.5 percent if the recovery nature in the beginning years of both periods are considered. Nevertheless, the shift in the long-run trend under the new policies of economic reform is quite significant; 5 percent versus 3.5 percent or less.

For the purposes of this study, the important factor is not growth rates themselves nor whether they are high or low compared to other countries. Rather, the sources of the growth are of interest and particularly the sources of the shift in growth under the new policies.

According to Perkins and Yusuf, the question of how to raise agricultural output can be addressed at two levels.[35] At one level are

[35]Ibid.

the direct inputs and at the other level the extent to which society is organized to effectively mobilize and efficiently use these inputs. The policies at the two levels are related. They divided the direct inputs into two categories: traditional and modern. Traditional inputs were referred to as cultivated land and water supply.

As they point out, after centuries of expansion of farm land, by 1950 there was not much unoccupied land left. Today, there remains only a small quantity of potentially arable land and it is not likely to be reclaimed in the near future because of the huge investments needed. On the contrary, the Chinese peasants have had to retreat down the mountainside and back from pastoral land to reduce erosion in some areas.

Constraints on the improvement of water supply is another factor influencing future land development. According to Perkins and Yusuf, southern China has an abundant water supply. The water management in this region has been advanced for centuries and there is little room left for improvement. Certainly the efficiency of the irrigation system in this region can be improved to reduce costs and to supply more water in drought years. Grain yields would not be increased too much in normal years by upgrading the existing water system. In Northern China, the shortage in water supply is not easy to overcome. The massive mobilization of the rural labour force, which started in the 1950's, did not help much. The widespread use of tube well irrigation in the North China Plain was the only factor which increased the irrigated area after 1965. The irrigated land increased by less

than 1 percent a year from 1965 to 1978. Since that time there has been no increase at all.

Perkins and Yusuf then go on to explain the growth of grain production as being due to an increase in the use of modern inputs. They break down the modern inputs into two categories: biological and mechanical. The biological category refers to chemical fertilizer associated with improved plant varieties, timely supplies of water, pesticides and other changes in farming practices. According to Perkins and Yusuf, since the 1960's, the use of chemical fertilizers has increased dramatically and the use of high-yielding plant varieties has spread quickly. This biological package is deemed to be a major contributor to the yield increases and in conjunction, the commune system helped the extension of new technology. Perkins and Yusuf pointed out that China had made substantial, but uneven progress, in applying a biological package to raise crop yields by the late 1970's. But they are skeptical that under the production responsibility system, the extension process might not work as it did under the commune system. They did not find contributions of this bilogical package to be helpful in speeding up the growth rate of grain production since 1979.

Perkins and Yusuf found that it was nearly impossible to precisely measure the economic gains associated with mechanical inputs. Although machinery has been widely used in threshing and milling, transportation, field work, and irrigation and drainage, mechanization was not called for due to a surplus of farm labour. Given the fixed arable land, labour-saving technology may not increase output.

Furthermore, they point out that since the late 1970's, there has been explicit recognition that some forms of mechanization have put large numbers of people out of work long before industry was ready to absorb them. Since then, the pace of mechanization has slowed down.

Looking into the future, they contend that major increases in farm output will come from more and better inputs over the long-run. However, as experience with the responsibility system in the early 1980's has demonstrated, there are also considerable gains in the short-term from reorganization and improved incentives.

Most analysts agree that short-term gains followed the policy changes. There is also a question of whether the policies have direct influences on the growth rates in various periods and whether the new policy will provide a better chance for the growth of farm output. Following Perkins and Yusuf, the question is whether the new policy can do better in organizing society to effectively mobilize and efficiently use these inputs. In other words, given the growth rate of inputs, the question arises whether the growth of output will be faster under the new policy than it would have been under the old one.

Perkins analyzed sources of growth in Chinese agriculture in an earlier paper.[36] After analyzing the role of growth in inputs, he argued that human beings are not machines. While machines will operate efficiently if properly maintained, human beings must be motivated to do what is right from an efficiency point of view. Perkins pointed out that in China, the main incentives are the rise in purchase prices, the

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[36]Dwight Perkins, "Constraints Influencing China's Agricultural Performance," in China, A Reassessment of the Economy, Joint Economic Committee Papers, U.S. Congress, 1975.

lack of an increase in agricultural tax and the grain import policy. The grain import policy was a signal to the peasants that the purchase quota would not increase. He wrote this in 1975, well before the initiation of economic reform. The economic reform since 1979 has stimulated great incentives not only in the ways Perkins suggested, but also in the decentralization of decision making and marketing to some extent. Thus, it seems obvious that the growth rate in grain production would have been much lower than it is had there been no such policy changes.

Thomas B. Wiens analyzed technological developments as another source of growth in Chinese agriculture.[37] According to him, the period of the early 1950's is characterized by the completion of many preliminary tasks such as the restoration of Chinese agricultural technology and production, building heavy industries for the necessary modernization of agriculture, the reorganization of the agricultural sector to permit a higher saving rate to facilitate purchasing of modern inputs, and the reorganization and enlarging of agricultural research and extension infrastructure. In the period of the Great Leap Forward, the level of technical knowledge was vastly improved, especially in plant breeding and in improvements in existing peasant practices such as interplanting techniques.

Actual technological development was realized by the 1960's. In 1964, the Chinese began full-scale distribution of dwarf rice varieties

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[37]Thomas B. Wiens, "Technological Change" in The Chinese Agricultural Economy, edited by Randolph Barker and Radhe Sinha with Beth Rose, Westview Press Inc., Boulder, Colorado and Crown Helm Limited, London, England, 1982.

with high-yield potential. These varieties have yields roughly equivalent to that of IR8 and have spread to over 80 percent of China's rice-sown area in 15 years. At about the same time, new hybrid maize varieties were released with higher yields.

As Wiens pointed out, "There was suddenly something worth promoting."[38] A co-ordinated seed replication system was established by 1963-65 to multiply the seeds as rapidly as possible and to prevent the deterioration of improved seeds. Under the system, pure-line breeding, selection and maintenance were carried out at the national level. County-level work concentrated on selection for adaptability and improvement of varietal characteristics. Communes' work was seed multiplication and replication on designated fields. Special brigades concentrated on seed raising only where crops were geographically concentrated. For hybrids, special farms were set up for seed production. The effects of this program were quite significant.

Large quantities of machines were introduced in the mid 1960's; including hand tractors, hydropowered pumps, rice transplanters, mechanically-powered fodder shredders, and in the late 1960's, tube well irrigation in the North China Plain. All contributed to the high growth rate after the Great Leap Forward.

According to Wiens, during the Cultural Revolution, the disruption of research and education slowed the flow of important research results and delayed the solutions to major problems. Local research and experimentation which was conducted under radical influences facilitated adoption or adaptation of the best of existing

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[38]Wiens, p. 111.

alternatives. However, this must be weighed against the damage done. This damage to agricultural development resulted from suppression of incentives and resumption of technological commandism[39] on the part of political cadres.

Wiens concluded that the long-run effects of the economic reform on the development and promulgation of new technology will be positive. In the short-run, China must rely on innovations already introduced or hastily borrowed from abroad. Wiens suggests that an appropriate agricultural policy, rather than technology, will be the limiting influence on Chinese agricultural growth in the next decade. The policy changes will affect the growth of agricultural production through their influence on research and extension.

Nicholas R. Lardy used an alternative approach to analyze the growth of output and the productivity in Chinese agriculture since 1949.[40] He was critical of the focus of many previous studies on the internal organization of collective agriculture while virtually ignoring the larger institutional setting. Lardy emphasized the evolution of farm institutions and the system of agricultural planning, especially the constraints imposed by the planning system on farm production decision making and the nature of farm markets. He pointed out that the changes in those external relations to farm units were crucial for the efficient allocation of resources in Chinese agriculture.

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[39]"Technological commandism" refers to extending new techniques through directives without testing their adaptability.

[40]Nicholas R. Lardy, Agriculture in China's Modern Economic Development, Cambridge University Press, 1983.

Lardy started with the system of direct and indirect planning, their influences on growth rates and the composition of farm output and the efficiency of resource allocation. According to him, indirect planning relies essentially on state manipulation of credit, procurement contracts, taxes and prices. The procurement prices are the major policy instrument which influence the growth and composition of farm products and deliveries to the state purchasing agents.

Lardy indicated that the periods of 1949-55 (or 1949-57), 1960-65 and since 1977 were dominated by indirect planning. During these periods, overall growth was more rapid and occurred across a broad range of products. This was due to greater price incentives, greater freedom of decision making, rising rates of marketing in both state purchases and rural peasant markets, larger and more efficient rural credit markets and larger and more secure private plots. These encouraged more efficient resource allocation and specialization based on regional and local comparative advantage and better farming practices.

On the contrary, direct planning or production planning, which started in 1956, prevailed during the Great Leap Forward and the Cultural Revolution. Those years are characterized by the imposition of detailed sown areas, output targets and specific cropping patterns by higher-level authorities on production units. There was little use of price incentives to encourage output growth or to influence crop composition during these periods. Labour and other inputs were used more intensively, well beyond the optimal point. As those periods coincided with political swings to the left, private plots and rural

peasant markets were suppressed or eliminated. Credit was allocated more by political than economic criteria. So, when direct planning dominated, resource allocation was inefficient which was reflected in lower rates of growth. Output growth concentrated only on a few major grain crops.

The results are consistent with the theory of price and quantity control. When uncertainty and large costs of gathering information from millions of production units are involved, price control is superior to quantity control in a planned economy.

In summary, it is clear that government policy has had a significant influence on the growth of grain output. Even those who insisted that the main sources of growth are technological changes and the increasing use of modern inputs cannot deny that the rapid growth after 1978 was stimulated by economic reform, just as the sharp decline during the Great Leap Forward was caused by policy failure. As Wiens indicated, the path of technological progress is also influenced by policy changes.[41] It is certain that more inputs and better technology are necessary to support sustained growth. However, the efficient use of inputs and technology, and the development of the production of modern inputs and suitable technology require appropriate policy environments. Therefore, a proper policy will lead not only to more rapid growth, given inputs and technology, but also more inputs and better technology to enhance the growth in farm products. The major policy changes since 1979 are price incentives, the responsibility system, an improvement in decision making, specialization among

[41]Wiens, ibid.

regions, and improvement in marketing. Among these, according to Lardy, price is by far the most important policy instrument.

It must be made clear that the rapid growth of grain production, stimulated by the new policies, is basically due to the increase in yields. As the grain sown area has declined since 1977 and the rate of decline has accelerated, the difference between the growth in yield and that in total output must be underscored. Even if the recent growth rate of grain yields is sustained for a certain time period, the growth rate of total grain output may not.

2.2. Modelling and Projections of China's Grain Production

In 1980, Anthony M. Tang made projections of China's grain production and consumption for the 1977-2000 period.[42] In his model of grain production, Tang used the following formula:

$$\text{output index} = \text{factor productivity index} * \text{weighted input indices}$$

There were four inputs in the model: labour, land, capital and current inputs. Tang assigned different weights to each input: 0.5 to labour, 0.25 to land, 0.1 to capital and 0.15 to current inputs. He then calculated the output index and input indices for the period of 1952-77 and found that the factor productivity had declined by 0.65 percent per year in this period.

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[42]Anthony M. Tang and Bruce Stone, Food Production in the People's Republic of China, Research Report, International Food Policy Research Institute, Washington, D.C., 1980, p. 35-38.

Using this same method, Tang found that an increase of 2.3 percent per year in factor productivity was necessary to fulfill the output target set by the 1976-85 ten-year plan, which he regarded as unattainable. However, having considered the new policy initiated since 1979, Tang reasoned that the 0.65 percent annual decline in factor productivity might be too low to make a projection, so he assumed a 0.5 percent increase in factor productivity per year for the remainder of the century. Thus, he used three sets of productivity indices: a 2.3 percent annual increase, a 0.5 percent annual increase and a 0.5 percent annual decline and made three projections: high, medium and low.

The annual growth rates of inputs in the projections are 0.9 percent for land (sown area), 6 percent for capital, 7 percent for current inputs, which are derived from data in the period 1952-77, and assumed to be maintained throughout. The rate for labour supply was assumed to be 1 percent based on the government's population policy. Inserting these input indices and the three assumed factor productivity indices into the above formula, along with 273 mmt as a base in 1977, Tang projected three figures of grain production to the year 2000: high, 785; medium, 524; and low, 420 mmt. Tang believed that the medium figure is the most probable. However, if Tang's method is used to project China's grain output between 1978 and 1984, the results are systematically below the actual figures:

Table 8

China's Grain Output
1978-84

Year	-------Tang's Projection------- High	Medium	Low	-Actual Figure-
	----------million metric tons----------			
1978	286	281	278	305
1979	300	289	283	332
1980	314	298	289	321
1981	330	307	295	325
1982	346	317	301	355
1983	363	327	308	387
1984	382	337	315	407

Source: Tang and Stone, Food Production in the People's Republic of China and China's Statistical Yearbook, 1984.

Substituting actual quantities of inputs may not improve the projection in this period because the sown area for grain has declined 1 percent per year in this period, instead of increasing 0.9 percent annually. The difference between Tang's projection and the actual figure may be even larger. But the fundamental problem with this model is not the calculating of inputs but the arbitrary weights assigned to inputs and the arbitrary factor productivity assumed. Thus, it is more desirable to explicitly incorporate some policy instrument into this type of model, instead of assuming a 0.5 percent annual increase in factor productivity under a new policy against a 0.65 percent annual decline of that in the past.

Hee Mock Noh modelled and projected China's grain production with another method.[43] Noh found that the quadratic time trend model,

$$Y = a + bt + ct^2 + e$$

best fit China's grain output in the 1949-81 time period and an ARIMA (1, 1) model best fit the estimated residuals. The quadratic model and an ARIMA (1, 1) model were then combined to project grain output in the 1982-2000 period. However, Noh's projection for the first three years, 1982-84, is also systematically below actual figures: 344.6, 356.7 and 368.8, against 354.5, 387.3 and 407.3 mmt.

This result is not surprising because there was a uniform growth pattern in Noh's model and he did not even mention the rapid growth since 1979. On the other hand, the time period may be too short to apply the ARIMA model, which requires a longer time series.

There are some other approaches which have been used to make these projections. The input-output analysis used by Rock Creek Research is one example.[44] In their study, Rock Creek Research divided the whole economy of China into 20 sectors and projected outputs of all 20 sectors simultaneously. Grain production is one sector among the 20.

They projected that the total grain output in China will be 423.6, 444.7 and 435.3 mmt for the years 1990, 1995 and 2000. These projections are quite low compared with Tang (524 mmt for the year 2000) and Noh (446.4, 519.8 and 601.1 mmt for the years 1990, 1995 and

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[43]Hee Mock Noh, Prospects of Grain Production, Consumption and Trade in China, Ph.D. thesis, Kansas University, 1983.

[44]Rock Creek Research, "Post-Reform China," a written summary of statistics and analysis from the Rock Creek Research, Fall 1985 China Projection Report, Washington, D.C., 1985.

2000). In the quoted summary they did not give details regarding the structure and parameters of their model. The projected decline in China's grain output after 1995 seems to be based on the fact that China's arable land will continue to decline. Also, they did not expect a further increase in grain yields and, therefore, the Rock Creek Research gave quite conservative projections of China's grain production into the future.

The virtue of this approach is the explicit expression of intersectoral relations. It does suggest that ideally one cannot take grain production as being totally independent. On the other hand, this approach is rather complicated and is subject to many uncertain factors and unknown structural parameters. Thus, when applying input-output analysis to make long-term projections one should be more cautious.

As policy instruments will be employed below as a major variable to make projections of China's grain production, the constraints on policy instruments, especially on the grain purchasing prices, must be considered. Nicholas R. Lardy estimated that the state subsidies of food consumption had been 23.8 to 25.6 billion yuan in 1981, which accounted for 23 to 26 percent of the state budgetary revenue (at all levels of government).[45] In his estimation, the subsidies include the indirect subsidy on domestic cereals and edible oils, the direct and indirect subsidies on nonstaple foods and the indirect subsidy on imported cereals.

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[45]Nicholas R. Lardy, Agricultural Prices in China, World Bank Staff Working Papers No. 606, 1983.

According to Professor An, Beijing Agricultural University,[46] the government subsidies to agriculture were more than 20 billion yuan in 1981, not much different from Lardy's estimate, but he did not define the components. However, he indicated that this figure had almost tripled from the 1978 level. Also, An pointed out that the subsidies on grain, cotton and edible oils accounted for 17 percent of the government budgetary revenue in 1981, compared with only 3.4 percent in 1978. The subsidies of agriculture increased again in 1982, and the subsidy on domestic cereals alone reached 15 billion yuan (compared with 12.9 billion yuan for cereals and edible oils in 1981), which accounted for more than 13.3 percent of the total state budgetary revenue. Based on this fact, Professor An reasoned that a further increase in government purchasing prices was not possible. This opinion is held by most analysts both within and outside China. When price is to be used as one of the major policy instruments in modelling, as in this study, the budgetary constraint on any further price increase must be kept in mind.

Another issue central to the analysis of grain production and trade is regional variation. As China is such a large country, regional differences in development, as well as in grain production, are quite significant. A regional model might be more accurate than an aggregate model in reflecting factors such as climate, resource endowments and the level of development and the impacts on the growth pattern of grain production. Most likely due to the lack of data,

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[46]Xiji An, "A Tentative Proposal for the Solution to the Recent Problems in Grain Prices," Unpublished paper, Beijing Agricultural University, 1983.

neither Tang nor Noh attempted to employ regional models. Today, the regional data on grain production in China is still far from adequate, but at least the official figures on provincial production since 1979 are available. So, in this study, regional models will be built along with national models.

2.3. Modelling and Projection of China's Grain Consumption

In modelling China's grain consumption, Anthony M. Tang and Bruce Stone used the method of moving averages.[47] The underlying assumption is that the total grain consumption, including human consumption, seed and feed requirements and industrial uses is determined by the government. As the basic goal is the security of food supply, the government simply sets consumption equal to the average supplies of the current year and the two preceding years, multiplies it by 1.0235, resulting in the long-run growth trend in grain output. After 1965, 0.5 percent of the average supply was set aside for reserves. The grain supply is the output plus net imports. After the estimation of consumption, the difference between current supply and consumption is taken as the change in stock reserves.

This model did not provide any detail on the demand for grain and its determinants. Of course, the demand for grain is distorted in China because of food rationing. But this model cannot answer these questions:

- Why the government continues to import grain?

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[47]Anthony M. Tang and Bruce Stone, Food Production in the People's Republic of China, Research Report, International Food Policy Research Institute, Washington, D.C., 1980.

- Why did it not just set the consumption at a level which equals the moving average of domestic output?

- How the government determines the quantity of trade?

Obviously the Tang and Stone method cannot be used for projection purposes. Usually consumption should be determined first, then trade can be derived accordingly. However, the Tang and Stone model requires that trade be determined first and this is not an appropriate approach.

Tang and Stone did not use this method to make projections in their study. In their projections, they assumed that the growth rate of demand for grain is the sum of the population growth rate and the income growth rate multiplied by the income elasticity of demand for grain. Further, they broke down the demand for grain into direct and indirect, and assigned different weights and elasticities to each component. The indirect demand referred to that derived from the demand for livestock products. Thus, a weighted income elasticity of demand for all grain was calculated. They assumed three different values for the population growth rate, the income growth rate and the weighted income elasticity in order to estimate the growth rates of total demand. They also projected three values of total demand to the year 2000 as they had done previously in projecting China's grain production.

Tang and Stone's projections have some weaknesses. First of all, the weights assigned to direct and indirect demand are arbitrary. The income elasticity of direct or indirect demand is assumed, not derived from actual data. Other grain usage such as seed, industrial use and losses are not considered. The quantity of the above items may not be a large proportion of the total demand but if it is considered along

with imports, the number is very significant, much larger than China's imports in the peak years.

In modelling and projecting China's grain consumption, Noh used the combined quadratic time trend and ARIMA (1, 1) model as he did in the production model.[48] This method does not link grain consumption with any economic variable. It also does not take into consideration the various components of consumption which may have different growth patterns. A more precise projection should be able to distinguish the growth rates of various components of total grain consumption and to explain them with other economic variables.

Jacques van der Gaag projected private household consumption in China with the estimated Engel curve.[49] In his study, Gaag estimated the income elasticities of demand for food, clothing, fuel and housing, etc., using the pooled provincial data in 1981 and 1982 and the linear Engel curves. He then assumed different scenarios for per capita income growth and population growth in China. Gaag made a projection of the probable consumption of those major items into the years 1990 and 2000.

Gaag also pointed out some sources of uncertainty such as the projection of income and population growth, the functional form chosen, the problem of making time-series projections based on cross-sectional data, the share of consumption as income in-kind, the changes in prices

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[48]Hee Mock Noh, Prospects of Grain Production, Consumption and Trade in China, Ph.D. thesis, Kansas University, 1983.

[49]Jacques van der Gaag, Private Household Consumption in China, World Bank Staff Working Paper No. 701, the World Bank, Washington, D.C., U.S.A., 1984.

and the constraints from the supply side. The food consumption in his model is in value terms and in aggregate form and thus was not suitable for the purpose of this study.

Gaag then went on to estimate income elasticity, own-price elasticity and cross-price elasticity, using data from the Beijing Municipality and Hubei Province in 1981 and 1982. Assuming different increases in prices, Gaag projected food consumption in Beijing into the years 1990 and 2000.

Yang Shengming used another approach to project consumptions in China into the years 1990 and 2000.[50] In his projection, Yang assumed that the individual's consumption is determined by his/her personal income, which in turn is determined by the national income and saving rate. Here the national income, defined by the Chinese concept, is the sum of the net value of products from material production industries. This definition is different from its conventional meaning in the West, in terms that the income from service sectors, government, etc., are not included. Yang then assumed the growth rates of this national income and population, the capital accumulation share in total national income and the share of collective consumption, and finally derived the personal income per capita. Yang found a gap between the personal income per capita in urban areas and that in rural areas. Therefore, he assumed different growth rates for urban and rural areas. He then calculated personal income per capita for the years 1990 and 2000.

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[50]Yang Shengming, "Using A Statistical Data Approach to Forecast Consumption Structure for a Comfortable Standard of Living," in Li Xuezeng, Yang Shengming and He Juhuang, The Structure of China's Domestic Consumption, World Bank Staff Working Papers No. 755, The World Bank, Washington, D.C., 1985.

Yang found that the average personal income in urban areas projected for 1990 was already achieved by some households in the 1982 sample survey. Then, the consumption level for those households in the sample survey was simply taken as being average in the year 1990 for urban people and the consumption structure was derived. As there was a lack of comparable data, Yang did not make a projection into the year 2000 using the same methods. He then estimated the changes of different items shared in total consumption and assumed the changing rates for the future; hence he derived the structure of consumption and the level of each component to the year 2000. To project the consumption level in rural areas in 1990 and 2000, Yang simply used the data for urban people with the same level of personal income in 1982. Different ratios of urban population to rural population were then assumed and the national consumption total was summed up.

In Yang's model, the Chinese concept of national income is not a relevant measure from which to derive personal income. It does not take into account other sources of income, namely, the income from service sectors. The income from service sectors is certainly a part of any individual personal income and influences consumption. This component of income has grown more rapidly in recent years. The food consumption in Yang's model is in value terms and in aggregate form, which is consistent with his purpose of analyzing the Chinese consumption structure but cannot serve the purpose of this study.

Many analysts have constructed food balance sheets for China at different times. The list of these studies is quite long, however,

some examples include J.L. Buck,[51] V. Smil,[52] A. Piazza,[53] T. Wiens[54] and FAO.[55] Although these food balance sheets do not explain the level of consumption with any economic variable, such as income, to facilitate modelling China's grain utilization, they do provide many useful methods to estimate the grain usage other than human consumption. They also help in the construction of complete consumption or, more precisely, a utilization model.

A review of these studies suggests that an appropriate model should be meaningful in the economic sense and it should be able to explain China's grain economy with economic variables. Accordingly, this model should be able to exploit the statistical data and new information now available.

It is apparent that an economic model cannot avoid errors due to uncertainty, misunderstanding of underlying true relationships and data constraints. However, with more data now available, an economically

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[51]John L. Buck, Food and Agriculture in Communist China, Praeger, New York, 1966.

[52]Vaclav Smil, "Communist China's Food: Still a Long Way to Go" in Issues and Studies 16(April 1980); "China's Food: Availability, Requirements, Composition, Prospects" in Food Policy (May 1981); and "Food in China" in Current History 75(1978):69-72.

[53]Allan Piazza, Trends in Food and Nutrient Availability in China, 1950-81, World Bank Staff Working Paper No. 607, The World Bank, 1983.

[54]Thomas Wiens, "Agricultural Output" in Quantitative Measures of China's Economic Output, edited by Alexander Eckstein, University of Michigan Press, 1980.

[55]FAO, Food Balance Sheets, 1964-66 Average (Rome: FAO, 1971); Provision Food Balance Sheets, 1972-74 Average (Rome: FAO, 1977); and 1981 Production Yearbook (Rome: FAO, 1982).

meaningful model might give better understanding and more reliable projections.

To build such a model a more precise understanding of the performance of China's grain economy in the course of policy evolution, especially under current policies, is essential. Thus, a more detailed discussion of Chinese agricultural policies is necessary.

3. Policy Changes Implemented Since 1978 and Regional Differences

3.1. The Communal System Prior to 1978

The Rural People's Commune is a unique Chinese institution. It integrates all aspects of rural life into one unit: politics and administration, tax collection, production management, finance and credit, social security and military affairs, and social welfare and services.

As a local government, the Commune's Management Committee (or Revolutionary Committee during the Cultural Revolution) had the obligation and authority to fulfill all policy requirements of the party and the government, including those concerning political movements, production and procurement targets, population control, and health and education. These policies were pursued either directly by the Management Committee or by transmitting them to production brigades and teams under the supervision of the Committee.

On the other hand, as an economic unit and farmer's co-operative, the Commune and the brigades and teams under it, owned most means of production for agriculture, forestry, animal husbandry, small industry and sideline production, and fishing. These resources included surface water, land, farm machinery, irrigation, drainage and transportation equipment, small factories and workshops, product processing equipment, etc. The Commune organized production activities to fulfill the government target if it owned the required means of production directly. If not, it would transmit the target to production brigades and teams under it and supervise them if the relevant production means were owned by either brigades or teams. After a fiscal year had

passed, the commune, brigades and teams would quantify incomes earned from the production controlled by each unit. The net products were then distributed as follows: first, tax and procurement requirements were filled in cash and in kind; second, the collective need was satisfied. This expenditure included items such as capital accumulation and reinvestment, social welfare, reserves for potential disasters, management and administration. Finally, the remaining income was distributed among members according to the hours they worked.

This basic system started in 1958 and has experienced several reforms since then. In 1958, about 680,000 Agricultural Production Co-operatives, which had existed for only two years, merged into 26,578 Rural People's Communes. About 99 percent of the rural population (approximately 550 million people) became commune members within half a year. On average, one commune had 20,000 people (about 4,500 households) and 4,000 hectares of arable land at that time.[56]

At the beginning, most production activities were organized by the commune. All labour on the commune was paid monthly, based on a wage rate established by the commune. As the communes were so large in size, farmers could not see any apparent relationship between their work and their wage payments. Consequently, the production incentives declined and it became impossible for any Commune Management Committee to co-ordinate production efficiently on such a large scale.

The declining incentives, combined with poor management, contributed to the recession after 1958 and thus, most production

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[56]Frederick W. Crook, "The Commune System in the People's Republic of China, 1963-74," in China: A Reassessment of the Economy, JEC, 1975.

activities were carried on by brigades after 1959. The commune kept its position in government functions and still owned and ran some small industry, clinics, shops and schools, and perhaps some tractor stations. Land and most other means of agricultural production were owned by the brigades. Under this system, income was distributed by the brigades themselves to their members. However, the monthly wage payment system was only used for a few months. To replace it, a "work point" system was adopted. There was no fixed wage rate and work points were assigned to a farmer according to the length of time required for a job and the difficulty of the work done. Work points were recorded and accumulated. At the end of a fiscal year, and after a deduction of all costs and reserves for the collective use, the total net income was divided by the sum of work points accumulated by all members. Then, an individual's income was calculated by multiplying his/her total work points by the value of one work point.

The brigade proved to be too large to operate efficiently. Unfortunately, there are no data on the exact size of the brigades at that time. However, according to Crook, an average commune in 1974 had 15 production brigades and 100 teams, 3,346 households, 14,720 persons and 2,033 hectares of arable land.[57] So, on average, a brigade probably had 200 households, 900 persons and 140 hectares of arable land. This is certainly too large to organize manual work efficiently.

By late 1962, production teams were made basic accounting units. The communes and brigades still owned some small factories, shops and service facilities, but land and other major means of agricultural

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[57]Ibid.

production were now owned by teams. From then on, teams organized farm production, quantified and distributed incomes. The communes and brigades paid wages to members of corresponding teams for the work done by them in factories or shops owned and run by the commune or brigades. If they realized a profit, it was used to reinvest, to finance social welfare programs, or it was transferred to teams for distribution. This is not to say the communes and brigades were passive in the operation of the farms. They often owned and operated tractor stations and they often allocated both modern inputs and credit. Most importantly, they still transmitted government production and procurement targets and supervised their fulfillments.

However, as the size of a team, the basic production and accounting unit, was 33 households, 147 persons and 20 hectares of arable land (in 1974 and in 1980--31,143 and 18, respectively) it worked much better than either a commune or a brigade with the existing technology. The communes and brigades continued to run those factories or services which required large scale co-ordination. All in all, this three tiered level of ownership worked relatively well until the end of 1978.

3.2. Policy Changes Since 1978

As was mentioned above, some very important policy changes occurred at the end of 1978, which stimulated a much greater growth in grain production and also in the total value of agricultural production. The first change was with regard to the locus of decision making.

Before 1978, although the production team was the basic production and income distribution unit, all decisions, including the area and varieties of crops, the rotation system, the techniques, dates of plowing, sowing, transplanting, applying fertilizers and insecticides, and harvesting, were made from higher level authorities. Some were made by governments at county or upper level and transmitted either by the commune or production brigade. Some were made by the commune or production brigade themselves according to government policies. The double function of the commune as an economic unit and as a local government supported its position in both transmitting and giving direct orders. However, the commune and county governments were not totally free in transmitting and making decisions. They had to follow orders from higher levels of government.

Since 1979, local autonomy has increased tremendously. Production teams and individual peasants can now make decisions concerning their own production measures. The production target is no longer compulsory. Production teams are allowed to allocate their resources into various activities to achieve higher incomes and improved efficiencies as long as they can fulfill procurement quotas and the social welfare requirements imposed by the commune and brigade.

In 1983, the local township government (or xiang in Chinese) was restored. The reestablished township government has removed the governing function from the commune. The central government has forbidden anyone from giving direct production orders to production teams and peasants. By the end of 1984, only 249 communes (about 5 percent of the total) still functioned as combined government/economic

units. Most communes now are an economic unit, mainly running small industries and services. In some areas, the commune has been totally dissolved. The small industries and services are now under the corresponding department of the township government, or have become a relatively independent economic unit--possibly, a co-operative jointly owned by production brigades and/or teams. This increase in local autonomy has led to more efficient decision making and has instilled greater incentives which have improved both field operations and management.

The production responsibility system and the "specialized households" have had further important effects on the efficiency of production and yields. Various production responsibility systems were begun in 1979. In 1982 and 1983, the "full responsibility system" became the most prevalent type. In this system, households negotiated with the production team (or grassroots government) to farm given parcels of land, raise livestock, or care for trees. These households agreed to return a certain quantity of their output to fulfill collective and state obligations and they were then permitted to retain the surplus for themselves. By the end of 1984, about 98 percent of total rural households were involved in various types of production responsibility systems and 96.6 percent of them were involved in the "full responsibility system" alone.[58]

Under the former work point system, farmers were not necessarily concerned with the quality of their work nor the contribution of their

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[58]China's Agricultural Yearbook, 1983 and 1984 and China's Statistical Abstract, 1985.

work to the final output. They were not concerned about production costs but only the quantity of their work, or more precisely, the number of work points they could earn. This inevitably led to poor management, low yields, high costs, low income and a redundant use of labour.

Under the new system, farmers' income became directly related to their final output and the per unit cost. It provided incentives to improve management and has resulted in higher yields and output, lower costs and more income. Farmers also have more spare time which they can use in sideline production activities to increase their income. Under this system, farmers behave more or less like independent producers. However, the teams, the commune and brigades still continue to co-ordinate some large scale operations such as irrigation and drainage. Some farm machinery is now owned privately but a large number of machines is still owned collectively and is contracted out to specialized households. This co-ordination is necessary because each household has only about 0.5 hectares of arable land contracted to it, on average. To improve efficiency, farmers must co-operate with one another through such measures as the sharing of machinery.

In January 1, 1985 the party and the government declared that the right to use contracted land will last at least 15 years. Furthermore, the land allocated to individuals can now be transferred and compensation for land transfers can be negotiated between individuals. These policies will encourage farm investment and concentration of production in order to take advantage of economies of scale.

Management will also be improved as now the land will be concentrated in the hands of experts (specialized households).

Specialized households are those peasants who are engaged in one or two kinds of production activity on a larger scale than average. At the beginning, most specialized households were involved in raising livestock and small animals, the caring of fruit trees, or sideline production and services. Now, more and more reports have been released about specialized households being involved in grain production. Specialized households are now producing several tens of thousands of tonnes of commercial grain.

Some important policy changes have also taken place in the area of procurement and marketing. Farm products in the past were marketed under three different categories according to the nature of the product and their importance to people's lives. The goods in the first category, including grain, cotton, edible oil and oilseeds were called "state monopoly purchasing and marketing" goods. Beginning in 1953 these were bought and sold solely by state commerce or grain departments. The government assigned a procurement quota to each group of producers--co-operatives, communes, brigades or teams. These producers had an obligation to fulfill the required amount unless a serious disaster occurred. The government set the quota price and offered an above-quota price for extra deliveries. This price was 30 percent higher than the quota price for grain produced prior to 1978. The government not only set grain procurement quotas but also set a total output target based on historical production figures. The procurement quota and output targets would normally be fixed for a

three or five year period. If the actual output turned out to be substantially higher than the target, then 30 percent of the above-target output was required to be sold to the state at the above-quota price. As the state commerce or grain department was the sole buyer, the farmers might wish to sell more than the required amount. During the 1970's, the additional sales would be purchased at a "negotiated price," which was also set by the government. It was 20 percent higher than the above-quota price. In the case of cotton, all output would be sold to the state, except a small amount of the output which was set aside for the farmer's own use. The quantity that each farmer could set aside for his/her own use was also determined by the government.

The second category of goods was called "imposed purchasing" goods and these included meat and aquatic products, tobacco, tea, sugar cane and silk. The government also set compulsory purchasing quotas and prices for these products. After fulfilling the quota, producers were permitted to market the surplus in their local market.

There were no compulsory purchases of goods in the third category. These products were not considered as important in terms of being a necessity in people's life and in terms of supporting the economic development of the country. However, as long distance transportation and marketing was not allowed before 1979, the state commerce department was the main (or even the sole) buyer of goods in both the second and third categories. In some cases there was limited local consumption. The price set by the commerce department was dominant in the local markets.

The procurement prices of farm products increased dramatically in 1979. In this one year alone, the price of 18 major farm products increased by 24.8 percent on average, which resulted in a 22.1 percent increase in the price index for total procured agricultural goods. The price of procured grain increased by only 17.5 percent in the 13 year period of 1965-78 (1.25 percent yearly) but there was a 20 percent increase in the quota price in 1979 alone! The above quota premium of grain increased even more rapidly in 1979 from 30 to 50 percent.

The total procurement of grain increased along with total production but the amount procured under quota declined by about 7.5 mmt in four years. The share of above-quota procurement increased, however, to about 70 percent. So, the average procurement price increased steadily (25.6 percent in 1979, 9 percent in 1980, 5.9 percent in 1981, and 2.8 percent in 1982). Except for 1979, this was solely due to the increasing share of above-quota selling.

Since 1979, farmers have been allowed to sell surplus grain in the free market after fulfilling the state procurement. Long distance transportation and marketing by individuals are also possible now. There were four large traditional "rice markets" along the Yangtze River prior to the 1950's. These markets were closed as the result of state procurement but have been reopened in the past two years.[59] There are now both cash and forward markets which trade rice, wheat, corn, soybeans, peanuts, rapeseed and vegetable oil, and so on. Among them, Jiujiang (in Jiangxi Province) marketed more than 100,000 tonnes of grain and oilseeds in 1984 and the Wuxi market (in Jiangsu Province)

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[59] Outlook Weekly (Chinese), April 15, 1985.

3.4 mmt. The Wuhu (Anhui Province) rice market reopened in August 1984. The total cash and future contracts signed in the first month was more than 100,000 tonnes. Another market is in Changsha, Hunan Province, which formally opened in April 1985. The total quantity traded in this market was about 10,000 tonnes in the first two months.

Another new and very important development in grain marketing is that, beginning in 1985, there will no longer be any compulsory purchasing quotas. In the case of grain purchases, the government's commerce department will negotiate contracts with farmers before sowing. For the contracted quantities, 30 percent will be paid at the former quota prices and 70 percent at the former above-quota prices. Farmers can sell all their surplus in free markets but the government does have an obligation to buy all the surplus offered by farmers at the quota price.

3.3. Impact of Policy Changes on Grain Production

The accelerated growth rate of China's grain production can be largely attributed to the recent policy changes because the technology has not been significantly advanced. A set of labour intensive techniques was developed thousands of years ago and they are still in use. However, these techniques are quite complicated for illiterate or semi-literate peasants. Besides, since the communization of agriculture, the peasants had little incentive to learn the techniques. Under the radical policies of 1958-61 and the Cultural Revolution, many techniques were developed with the sole purpose of achieving the highest yield possible. They were developed under unrealistic conditions and in disregard of the reality and the quality

of the labour force. Although new technical developments have been encouraged since the new policy in 1979, they have not had sufficient time to mature. Therefore, there is a tremendous amount of potential for improving farming techniques in future years.

Since the late 1960's, junior middle schools have become increasingly popular at the production brigade level and usually each commune has at least one senior middle school. This has improved the peasants' literacy level and subsequently improved the quality of the labour force. However, the education level in the rural areas is still far from being adequate. At the higher level of education, by the end of 1983, 90 agricultural universities and colleges (including forestry, aquatic products and water conservancy) had opened their doors to some 113,000 undergraduate students and 2,345 graduate students. They were reopened since the end of 1977. At the same time, agricultural technical schools numbered near 500, with about 120,000 students.[60]

On the other hand, peasants are now enthusiastic to learn new technology. According to Outlook Weekly,[61] by the end of 1984, 93 percent of the counties had established science and technology societies, numbering 2,277. Those societies at the township level numbered 41,000. Specialized mass organizations numbered more than 60,000 with members of 3.5 million. The task of these societies is training peasants and carrying out extension activities. By the end of 1984, the county and township science and technology societies had

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[60]Agricultural Yearbook Editing Committee, China's Agricultural Yearbook, 1984.

[61]Outlook Weekly, April 22, 1985.

conducted 12,000 technique schools of more than one year duration (1.2 million people) and 381,000 short-term schools with more than 45 million participants. Also, many households have begun to sign contracts with technicians who agree to provide advice to farmers in return for a share of the increase in production. This new development encourages researchers and technicians to develop more suitable techniques and pay more attention to extension work.

In summary, the move towards local and producer's autonomy, the production responsibility system, the improvement in marketing practices, the increase in prices and farmer's income, and the favorable economic environment in general, all have contributed to farmer's incentives and improved management. In turn, this has led to much better use and extension of existing technology.

3.4. Regional Division of Agricultural Production

With 9.6 million square kilometres, China is the third largest country in the world. For the purposes of this study, the country will be divided into six regions according to major grain crops.[62] Data have been collected on each region and each region will be modelled separately and then the results will be aggregated (in Chapter 4).

There are two important factors influencing areas devoted to grain crop production. The first is topography. Generally speaking, China is higher in the northwest and lower in the southeast, although Xinjiang Uygur Autonomous Region is lower than the Tibetan Plateau south of it. The second factor is location. China is located on the

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[62]See Table 9 and Figure 1, which displays a map of "Agricultural Regions of China."

Table 9

Sown Areas of Major Grain Crops and Their Shares in Total Grain Area (1983)

Regions and Provinces	----Wheat-----		-----Corn----		-----Rice-----		---Potatoes---	
	Area	Share	Area	Share	Area	Share	Area	Share
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Pastoral[a]								
Nei Monggol	911.3	23.7	493.7	12.9	16.5	0.4	253.7	6.6
Ningxia	303.7	43.7	20.8	3.0	50.3	7.2	38.4	5.5
Xinjiang	1,304.9	65.6	469.3	23.6	95.7	4.8	8.7	0.4
Xizan	41.2	21.5	2.1	1.1	0.6	0.3	0.3	0.2
Qinghai	224.0	55.4	-	-	-	-	49.3	12.2
Gansu	1,508.0	52.5	241.3	8.4	3.9	0.1	250.9	8.7
Spring Wheat[a]								
Heilongjiang	2,096.3	29.0	1,641.6	22.7	245.5	3.4	260.5	3.6
Jilin	80.7	2.3	1,714.9	47.8	266.3	7.4	106.0	3.0
Liaoning	21.3	0.7	1,219.9	38.5	403.2	12.7	54.0	1.7
Winter Wheat[b]								
Beijing	187.1	35.3	200.7	37.9	46.1	8.7	7.2	1.4
Tianjin	155.5	30.8	176.9	35.6	24.1	4.8	8.1	1.6
Shandong	3,587.0	-	2,191.5	-	105.0	-	1,007.1	-
Shanxi	947.3	28.2	583.5	47.4	9.1	0.3	274.8	8.2
Hebei	2,345.9	34.0	2,001.6	29.0	126.7	1.8	454.6	6.6
Henan	4,319.1	46.5	1,768.3	19.0	410.7	4.4	969.6	10.4
Shaanxi	1,677.5	41.4	944.3	23.3	160.9	4.0	336.5	8.3
Wheat Rice[b]								
Hubei	1,375.1	26.0	417.7	7.9	2,617.4	49.5	375.5	7.1
Anhui	2,025.4	33.3	131.5	2.2	2,057.3	33.8	745.9	12.3
Jiangsu	2,014.1	31.1	457.1	7.1	2,520.3	39.0	316.0	4.9
Double Rice[b]								
Jiangxi	98.4	2.6	6.9	0.2	3,323.7	89.5	103.8	2.8
Hunan	211.0	3.9	115.5	2.1	4,418.9	81.5	312.2	5.8
Zheijiang	367.7	10.6	52.1	1.5	2,507.8	72.1	150.1	4.3
Guangdong	98.5	2.0	38.8	0.8	4,028.7	80.5	621.6	12.4
Guangxi	17.8	0.5	520.7	13.6	2,737.3	71.4	215.6	5.6
Fujian	117.3	5.6	1.1	0.1	1,618.0	77.6	231.1	11.1
Shanghai	37.3	7.8	5.9	1.2	298.5	62.4	0.1	-
Southwest Rice[b]								
Sichuan	2,250.4	22.5	1,916.0	17.2	3,158.9	31.6	1,761.1	17.6
Guizhou	259.0	11.2	671.7	29.2	777.9	33.8	284.3	12.3
Yunnan	467.1	13.5	1,018.9	29.4	1,107.0	31.9	224.9	6.5

[a]Spring Wheat.

[b]Winter Wheat.

Source: Calculated from the Agricultural Yearbook Editing Committee, China's Agricultural Yearbook, 1984.

Figure 1

Agricultural Regions of China

Region I -- Pastoral

1. Nei Monngol	2. Ningxia	3. Xinjiang
4. Xizang (Tibet)	5. Qinghai	6. Gansu

Region II -- Spring Wheat

1. Heilongjiang	2. Jilin	3. Liaoning

Region III - Winter Wheat

1. Beijing	2. Tianji	3. Shandong
4. Shanxi	5. Hebei	6. Henan
7. Shaanxi		

Region IV -- Wheat Rice

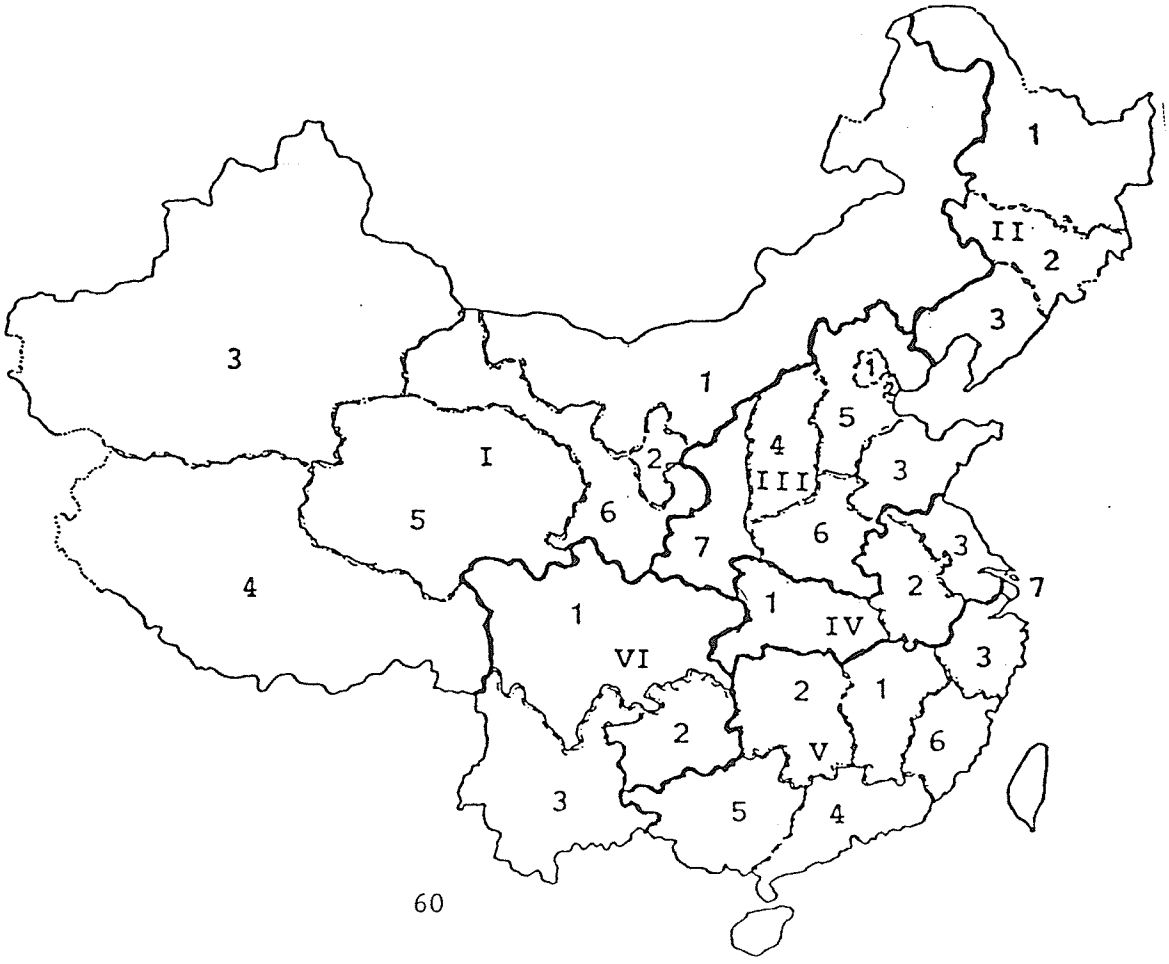
1. Hubei	2. Anhui	3. Jiangsu

Region V -- Double Rice

1. Jiangxi	2. Hunan	3. Zhejiang
4. Guangdong	5. Guangxi	6. Fujian
7. Shanghai		

Region VI -- Southwest Rice

1. Sichuan	2. Guizhou	3. Yunnan



eastern part of the great Euro-Asian land mass. Most precipitation is brought by inflowing winds from the Pacific Ocean to the southeast during the summertime. Topography and location jointly characterize China as being cool and dry in the northwest and warm and wet in the southeast. The whole of China can be further subdivided into several agricultural regions due to these influences.

First, a dividing line can be drawn along the Great Xingan Mountain in the northeast, via Yan Mountain in north China, to the boundary of the Tibetan Plateau in the southwest. This line is quite similar to the 400 mm isohyet and it has a very important influence on China's agriculture. Northwest of this line, it is cool and dry and most of the land is occupied by minority nationalities whose way of life is primarily pastoral farming. Major grain crops grown in this area are spring wheat, corn and miscellaneous dry land grains with only one crop a year.

This pastoral farming region consists of four minority nationality autonomous regions: Nei Monggol Autonomous Region, Ningxia Hui Nationality Autonomous Region, Xinjiang Uygur Autonomous Region, Xizang Tibet Autonomous Region; and two provinces: Qinghai and Gansu.

Because of the extreme climate and the traditions of nationalities, grain production is quite backward in this region and the grain yield is the lowest in China--about two tons per hectare on average.

Southeast of the 400 mm isohyet is an arable farming area. This area can be further divided into five agricultural regions: spring wheat, winter wheat, wheat-rice, double rice, and southwest rice.

Table 10

Multiple Cropping Index and Grain Yield

Regions and Provinces	Multicropping Indices				Grain Yields (tonnes/ha)			
	1981	1982	1983	Average	1981	1982	1983	Average
Pastoral								
Nei Monggol	90	90.8	91	90.6	1.32	1.34	1.46	1.37
Ningxia	97	93.4	101	97.1	1.77	1.79	2.09	1.88
Xinjiang	94	94.0	92	93.3	1.88	2.00	2.28	2.05
Xizan	95	96.0	93	94.7	2.51	2.29	1.92	2.24
Qinghai	86	86.9	87	86.6	1.96	2.27	2.21	2.15
Gansu	96	95.7	98	96.6	1.52	1.65	1.88	1.68
Spring Wheat								
Heilongjiang	100	97.2	98	98.4	1.72	1.62	2.14	1.83
Jilin	100	100.4	100	100.1	2.63	2.81	4.12	3.19
Liaoning	104	103.3	102	103.1	3.70	3.66	4.68	4.01
Winter Wheat								
Beijing	152	151.5	151	151.5	3.41	3.52	3.80	3.58
Tianjin	138	132.3	133	134.4	2.06	2.45	2.20	2.24
Shandong	144	143.2	146	144.4	2.84	3.09	3.47	3.13
Shanxi	106	105.9	107	106.3	2.12	2.33	2.40	2.28
Hebei	133	129.5	131	131.2	2.15	2.45	2.75	2.45
Henan	155	155.8	160	156.9	2.57	2.48	3.13	2.73
Shaanxi	128	125.5	127	126.8	1.84	2.30	2.39	2.18
Wheat Rice								
Hubei	195	200.7	200	198.6	3.30	3.80	3.76	3.62
Anhui	177	180.4	177	178.1	2.97	3.20	3.30	3.16
Jiangsu	183	186.2	184	184.4	3.93	4.47	4.72	4.37
Double Rice								
Jiangxi	219	231.7	229	226.6	3.38	3.77	3.93	3.69
Hunan	234	233.2	228	231.7	4.01	4.40	4.89	4.43
Zhejiang	255	254.5	252	253.8	4.21	4.98	4.55	4.58
Guangdong	201	202.6	200	201.2	3.27	3.87	3.92	3.69
Guangxi	183	182.8	177	180.9	2.93	3.44	3.56	3.31
Fujian	196	192.3	189	192.4	3.79	4.07	4.12	3.99
Shanghai	215	215.8	218	216.3	4.17	4.81	4.33	4.44
Southwest Rice								
Sichuan	185	184.8	181	183.6	3.36	3.68	4.01	3.68
Guizhou	150	154.1	153	152.4	2.84	2.87	3.05	2.92
Yunnan	140	139.5	140	139.8	2.59	2.72	2.75	2.69

Source: Agricultural Yearbook Editing Committee, China's Agricultural Yearbook, 1982-84.

The Great Wall forms a dividing line between spring and winter wheat regions. The three provinces of Heilongjiang, Jilin and Liaoning lie north of the Great Wall. The crop which distinguishes this area from others is spring wheat and these three provinces produce one crop per year. Other major crops grown in this region include corn, sorghum, rice, soybeans and beans. The yields in this northern region are quite unstable as the weather fluctuates so much.[63] However, the largest amount of potential arable land lies in this region, with the majority being in Heilongjiang Province.

The winter wheat region lies between the Great Wall and the Qin Mountain-Funiu Mountain-Huai River line. This region consists of two municipalities: Beijing and Tianjin; and five provinces: Shandong, Shanxi, Hebei, Henan and Shaanxi. Besides winter wheat, the other crops produced, with multicropped indices of 130 to 160 percent, are corn, millet and miscellaneous dryland grains. This region is also a major cotton growing area. Grain yield in this region is higher in the east and lower in the west, mainly due to the difference in precipitation.

The wheat-rice region is between the Qin Mountain-Funiu Mountain-Huai River and the Yangtze River. The three provinces in this region are Hubei, Anhui and Jiangsu. However, as the boundaries of these provinces are not consistent with the dividing lines among agricultural regions, the northern part of these three provinces lies in the winter wheat region and the southern part in the double rice region. Because of data restrictions, the three provinces must be

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[63]Multicropping indices and grain yields are shown in Table 10.

considered as a unified region. The multicropping index ranges from 177 to 200 percent in this region. Winter wheat and rice account for 67 to 75 percent of the total grain sown area in this region. Other major grain crops are corn, potatoes, soybeans and miscellaneous crops. The grain yield in this region is quite high, from 3.16 tonnes per hectare sown in Anhui to 4.37 tonnes in Jiangsu. Cotton and rape-seed are other crops grown in this region.

South of the Yangtze River is the double rice region (excluding three southwest provinces: Sichuan, Guizhou and Yunnan, which form the southwest rice region). The double rice region has five provinces: Hunan, Jiangxi, Zhejiang, Guangdong, Fujian; and the Shanghai municipality; and the Guangxi Zhuang Nationality Autonomous Region. Rice is the dominant crop sown in this area as it accounts from 71.4 percent of the total grain area in Guangxi to 89.5 percent in Jiangxi. The multicropping index is very high here. Only in Fujian and Guangxi is it below 200 percent and this is due to mountains in the two provinces. It reaches its peak of 253.8 percent in Zhejiang Province. The average grain yield in this region is about 4 tonnes per hectare sown area.

The last region to be considered, the southwest rice region, consists of three provinces: Sichuan, Guizhou and Yunnan. As it lies between the Tibetan Plateau and Yangtze River Valley and Zhu River Valley, there are many mountains, hills and basins in this region. Rice accounts for about one-third of total grain sown area, other crops are corn, potatoes and miscellaneous crops. The multicropping index ranges from 140 percent in Yunnan to 183.6 percent in Sichuan. The

average yield is 2.7 tonnes per hectare sown area in Yunnan, 3 tonnes in Guizhou and 3.7 tonnes in Sichuan.

These six agricultural regions form the base on which regional models are to be built in this study. Although there are many differences within any individual region or province, each region is characterized by major grain types, climate, yield, and multicropping indices. These similarities are important in the further development of grain production. Furthermore, as only six years (1979-84) of provincial data are available, a pooled time-series and cross-sectional model has to be used to achieve an acceptable level of statistical significance.

The common factors considered in the delineation of the regions are likely to result in similar responses to policy changes within one region. There are two additional factors which may influence grain production in response to a policy change such as a variation in the price ratio of grains to cash crops. One is average grain production per capita in the rural area; another is the percentage of grain area in total sown area. These two factors combined will largely determine to what extent the production in one province can be shifted from grain to cash crops, or vice-versa. However, these two criteria are not in conflict with the division of the six regions.[64] In the pastoral region, the percentage of grain area in total sown area is usually over 80 percent, with Xinjiang at 68 percent as an exception (where there is a major cotton area). The grain production per rural capita usually is lower in the pastoral region, about 200 to 400 kg, with Xinjiang and

[64]See Table 11.

Table 11

Grain Production Per Rural Population and Proportion of Grain to Total Sown Area (1983)

Regions and Provinces	Grain Production Per Rural Population	Proportion of Grain to Total Sown Area
	---------kg---------	-------percent--------
Pastoral		
Nei Monggol	404.3	82.9
Ningxia	501.7	82.1
Xinjiang	514.2	68.4
Xizan	212.6	90.3
Qinghai	283.2	80.6
Gansu	330.8	82.6
Spring Wheat		
Heilongjiang	820.4	84.1
Jilin	1,061.8	88.1
Liaoning	712.9	84.8
Winter Wheat		
Beijing	635.6	83.0
Tianjin	449.4	83.0
Shandong	504.8	74.3
Shanxi	433.3	81.3
Hebei	415.2	79.6
Henan	452.6	82.0
Shaanxi	409.9	85.0
Wheat Rice		
Hubei	577.8	71.5
Anhui	476.5	77.4
Jiangsu	622.3	75.7
Double Rice		
Jiangxi	546.0	67.9
Hunan	572.7	70.0
Zhejiang	518.2	76.0
Guangdong	410.6	79.6
Guangxi	415.9	82.9
Fujian	420.2	85.8
Shanghai	428.6	62.6
Southwest Rice		
Sichuan	472.6	84.6
Guizhou	299.1	79.4
Yunnan	332.3	87.5

Source: Calculated from Agricultural Yearbook Editing Committee, China's Agricultural Yearbook, 1984.

Ningxia over 500 kg as exceptions. In the spring wheat region, the percentage of grain in total sown area ranges from 84 to 88 percent and average per rural capita grain production, 700 to 1,050 kg. In the winter wheat region the share of grain area is 80 to 85 percent, with Shandong at 74 percent as an exception (which is also a major cotton production area). In this region, the average grain output per rural capita ranges 400 to 500 kg, with the exception of Beijing at 635 kg. In the wheat rice region, the percentage of grain area is anywhere from 71.5 to 77.4 percent and average output 475 to 622 kg. In the double rice region, the grain area is 68 to 86 percent and average output 410 to 570 kg, respectively. In the southwest rice region, the figures are 80 to 87.5 percent and 300 to 470 kg, respectively. It seems clear that, although there are differences in terms of the percentage of grain area and average grain output per rural capita within any individual region, they are small enough, compared with those among various regions, that a region may be expected to react more or less as a whole.

These two factors (grain area and per rural capita output) are important because most grain output is consumed by producers themselves. Only when farmers have a surplus of grain can they ship the surplus or shift to cash crops. The percentage of grain area was particularly important in the early 1980's as there were fixed quotas on grain, rapeseed and cotton procurement. When grain production dramatically increased and the double-price system (quota and above-quota prices) was in effect, a province such as Shandong could take advantage of lower procurement quotas on cotton to shift land to cotton

production and then get a higher percentage of the above-quota prices. In 1979, the grain sown area accounted for 82 percent of total sown area in Shandong and then declined to 74.3 percent in 1983, most of it went to cotton production. Some provinces such as Jiangsu could not transfer sown areas so easily because its percentage of grain to total area was relatively low (72.8 percent in 1979) and hence it had a higher procurement quota on both grain and cotton.

Since the double pricing was abolished in 1985, this additional advantage will eventually disappear. However, as long as the Chinese still largely depend on local grain production, the average grain output and the percentage of grain to total area will continue to play an important role in determining the change of grain sown area.

A pooled time-series and cross-sectional economic production model will be specified and estimated for each of the six regions. The results of these models will give a more accurate picture of the factors affecting production and they will permit an analysis of the regional differences in crop production and consumption which may have an effect on trade in grains.

3.5. Trends in the Near Future

The analyses of potential trends are based on the assumption that the current government policies will continue to be in effect or that at least changes will be in the same direction as those implemented in the early 1980's.

The potential trend in grain area is discussed first. To analyze grain area or total sown area in China, it must be borne in mind that the potential arable land in China is very limited. According to a

study by the Chinese government's Bureau of Land Management (Ministry of Agriculture, Animal Husbandry and Fishery), the potential for expanded acreage is only about 10 million hectares or 10 percent of total existing arable land. To reclaim this land would require a large amount of investment and it is highly unlikely that it will be carried out in the near future.

On the contrary, the arable land seems to be decreasing at an accelerating rate. The combined population and economic growth have put extreme pressure on land use in China.

Under current population policy, the net growth rate of total population has declined to about 1 percent annually. There were two population growth peaks in the late 1950's and mid 1960's. People born in those two periods are still in their child-bearing age. Those born in the mid and late 1960's are going to create another population growth peak. Therefore, it is unlikely that the net growth rate will decline any further. Taking 1 percent as a probable rate, the absolute population growth figure will be at least 10 million a year which would result in about 0.2 million hectares of arable land shifting to nonfarm use yearly.

The economic growth requires more and more land to be used for industries, transportation, residence, commerce, recreation, etc. Most of the land will come from reducing arable land in the more developed areas, hence higher productivity.

The increasing incomes in China will stimulate a greater desire for improved living standards which will result in additional land being shifted to nonfarm use in the rural areas. For example,

according to the People's Daily (November 8, 1985), the amount of newly built home construction in the rural areas was 3.5 billion square meters over the 1979-85 period. These homes are partly replacing old ones but, as average housing area has increased by 5.5 square meters per capita,[65] and as population has increased, housing alone would have required about 0.44 million additional hectares (only for buildings). Also, better housing requires more affiliated area. On the other hand, construction for public usage and industrial usage accounted for more than 6,000 hectares per year over the same time period.

The government's rural development policy may have enhanced this trend in land use and it is likely to enhance it even further in the near future. As a result of recent agricultural development, more and more of the rural labour force needs to shift to other sectors. To avoid the problems which usually occur in large cities, and probably in part to avoid the burden of providing food to an increasing urban population (which requires transportation and retailing subsidies), the government is now carrying out a policy to control the size of large cities and to develop small towns. Farmers will be separated from the land but not from the countryside. This means that farmers will shift to small industry, the service sector, etc., but still live in rural areas and buy food directly from the free market. This policy may have many significant social and economic advantages but from the point of view of land use, it may result in an accelerated decline in arable land, particularly since the total average land per capita for

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[65] China's Statistical Yearbook 1984 and China's Statistical Abstract 1985.

residence use in small towns or villages is twice as large as in cities.[66]

The government has announced that transportation and energy production will be given first priority in the economy, and both of these activities may require a large amount of arable land. Thus, the shifting of arable land to nonfarm uses is likely to continue and quite possibly to be accelerated in the coming decades.

As the amount of arable land in production will decline, so will the total sown area, and this may decrease even faster. The amount of total sown area is different from arable land mainly due to multicropping but the index of multicropping cannot be increased very much because of both technical and economic restrictions. It has already declined from 149 percent in 1979 to 146 percent in 1983.

The grain sown area may be further influenced by the grain purchasing price and the price ratio of grain to major cash crops such as cotton and oilseeds. As China was a large edible oil and cotton importer in the late 1970's, the prices of these crops were raised and their ratio to grain increased. This led to a relatively faster decline in grain area compared to the total area. However, as China suddenly became a large cotton exporter in 1983 and oilseeds have been in surplus since 1983, their relative prices are going back to the 1978 level. Inasmuch as the government declared in 1985 its intention to reduce the amount of cotton purchased through contract, the cotton sown area will drop sharply. This may not increase grain's share of total acreage however. The new government policy of using contracted

[66]Bureau of Land Management, unpublished research paper.

purchasing instead of quota procurement, and the unified price instead of double pricing for quota and above quota purchasing, is likely to reduce the actual grain purchasing price. This already had an impact on the amount of wheat production in 1985 as in many areas both sown area and yield declined.

However, in the foreseeable future, the price ratio of grain to major cash crops is likely to increase once more, albeit only slightly. Several major cash crops such as cotton and oilseeds are now also in surplus and the demand for them is more restricted than that for grain. For grain, the demand will continue to increase and as the free market will play a more and more important role, the actual average grain price received by farmers will increase steadily.

But, the effect of price is not likely to offset the influences analyzed earlier and the rate of decline in grain sown area may be as fast as it was in the past few years, if not faster.

On the other hand, grain yield is likely to increase continuously. First of all, the policy changes after 1978 still have the potential to push it further. Second, the increasing importance of the free market, although it has a negative impact on area, may have a positive impact on yield as it will contribute to the efficiency of grain production. The unified contracted price will also improve efficiency as it is no longer possible for any region to take advantage of a relatively lower quota level and a higher average price level. The allocation of land to grain production will be more efficient in future years. Third, the actual price is likely to increase. As the subsidies for food have in the past accounted for

about 20 percent of the government budget revenue, a significant increase in the government purchasing price is not likely to occur in the near future. However, as the free market price is substantially higher than the government purchasing price, the actual price received by farmers will increase. Furthermore, the government has declared that it will gradually decrease food rationing to urban residents and to farmers who are mainly involved in nongrain production. Thus, the free market will enlarge its share in grain food retailing, which will push up the average price of grain. Finally, the rapid increase of net income will accelerate investment by farmers and contribute to further increases in yield.

In summary, as in the past six years, the grain area will continue to decline and the yield will increase. Total grain production will depend on these relative magnitudes. In 1985, the government contracted price was lowered from its 1984 level. It had a negative impact on both area and yield so total production declined. Poor weather was also a factor in the decline. Studies reported in Chinese newspapers and magazines show that from mid 1985 on, public opinion towards grain production shifted from that of "surplus" to "still not enough". It is reasonable to expect some new policy in favour of grain production, or at least no further policy changes to encourage the further decline of grain production.

4. Production Models

4.1. A National Production Model

As discussed in previous chapters, the government policies have a direct and significant impact on China's grain production, consumption and trade. This chapter will measure the policy impact on grain production explicitly by taking policy instruments as major variables in modelling both national and regional grain production.

From the above discussion, the policies concerning population control, grain purchasing prices and the price ratio of grain to cash crops play very important roles in determining the grain sown areas and yields. An increase in population will reduce the total arable land and hence tend to reduce grain sown area. An increase in grain purchasing prices or the price ratio of grains to cash crops will tend to encourage an increase in grain sown area. Such an increase is also likely to increase yields as it encourages more inputs and better practice through stimulated incentives. Besides, better inputs (higher qualities of new seeds, fertilizers, etc.) and better cropping patterns may be developed as the result of technological progress. One way to consider technological advances is by taking time as its proxy; this method will be used in this study. Thus, the tentative model consists of the following three equations:

$$A = f(Pop, Pg, Pr) \quad (1)$$

$$Y = f(Pg, Pr, t) \quad (2)$$

$$Q = A * Y \quad (3)$$

where:

A = grain sown area;

Pop = population;

Pg = grain purchasing prices;

Pr = price ratio of grain to cash crops;

Y = grain yield;

t = time trend; and

Q = grain output.

However, it is difficult to estimate China's grain sown area with equation (1). Although equation (1) is theoretically appropriate, it must be modified under China's circumstances. Before 1979, the price instrument had little influence on the decision making concerning grain sown area. For the central planning authority, the main concern was the self-sufficiency in grain supply and the method used to achieve this goal was the direct control over sown area at that time. Production units were assigned a mandatory area plan and they were required to fulfill it so they could not adjust sown area when price changed. This method has been proved inefficient and has failed to stimulate higher production but it is quite efficient in controlling the sown area.

Population growth and economic development demand more land for nonfarm uses. However, this trend was offset by land reclamation in the 1950's and early 1960's and intensive multicropping since the early 1960's. From 1952 to 1965, the total reclaimed farm land was 18.8 million hectares, which accounts roughly for 19 percent of total arable land. Since the early 1960's, the double rice cropping system was introduced into practice and it increased sown area, given the quantity

of farm land. Thus, the total arable land and the total grain sown area were kept constant during the past 30 year period.

Since the late 1970's, there was little potential arable land left and the level of multicropping had gone beyond the optimal point under the political pressures of the radical policy. The sown area to grain began to decline in 1979 under the new policies. As farmers have more freedom to decide their own production, the level of multicropping has declined. As there is no newly reclaimed land, the sown area continues to decrease because the population keeps increasing.

The price instruments have certainly influenced the determination of the grain sown area since 1979. However, as the sown area was subject to quantitative control before 1979, and as the time period since 1979 is too short to estimate an econometric model with three exogenous variables, only population will be used to measure the corresponding changes in the grain sown area in order to achieve an acceptable level of statistical significance. Using one exogenous variable in this model, which has only five observations, not only maximizes the degree of freedom to obtain maximum significance in hypothesis tests, but also solves the problem of multicollinearity as the three variables in equation (1) are highly collinear in the five year period.

Population is chosen as the determinant variable because the arable land is fixed. The government wants to stabilize arable land, especially the grain sown area, and many measures have been taken to bring this about. However, the population growth will inevitably shift farm land into nonfarm usage. Therefore, the rate of decline in area

in farm land partly depends on how successful the population control is.

Assuming a linear function form, equation (1) is simplified as follows with only one exogenous variable:

$$A = a_0 + a_1 \text{ Pop} + e \qquad (4)$$

Given the data for the time period 1979-84,[67] the empirical results using ordinary least squares estimation procedures are as follows:

$$\hat{A} = \underset{(10.04)}{228.6} - \underset{(-4.96)}{0.11}\ \text{Pop}$$

$$F = 24.57 \quad R^2 = 0.89 \quad DW = 1.53$$

where sown area A is in million hectares and population, Pop, is in million persons. Figures in parentheses are t-ratios.

These empirical results support our hypothesis that the population growth will reduce grain sown area. It indicates that if the population continues to grow at 10 million per year as it has been recently, the grain sown area will keep declining at the rate of 1.1 million hectares yearly. This is a serious problem that the Chinese will have to deal with for many years to come.

Unlike sown area, the grain yield can be estimated using data before 1979. Yield is influenced by both the quantity of inputs and the efficiency in using inputs. Therefore, price instruments would influence yield through incentives even under quantitative control. However, the sharp decline of grain production in the early 1960's is

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[67]State Statistical Bureau, China's Statistical Yearbook, 1984.

not relevant in understanding the relationship between yields and prices.

That policy failure has no connection with price instruments. If we assume that the same mistake will not happen in the future, the proper base year is 1965 when China recovered from the disaster of the early 1960's.

To avoid the problem of multicollinearity, the price ratio has to be excluded as a factor. Assuming a linear function form, equation (2) becomes:

$$Y = b_0 + b_1 Pg + b_2 t + e \qquad (5)$$

where Pg is the grain purchasing price index adapted from the Statistical Data of China's Commerce and Prices.[68] This data series is a weighted average of the quota price, above-quota price and the negotiated price (free market price), and is more appropriate than the price index in the Statistical Yearbook, which only includes quota price and does not reflect the changes in above-quota premium and the share of above-quota deliveries. In the equation, t represents a time trend which equates to 1, 2, 3, ..., 19 to years 1965, 1966, ..., 1983. The empirical results using o.l.s. are as follows:

$$\hat{Y} = \underset{(11.4)}{1.06} + \underset{(4.75)}{0.003}\ Pg + \underset{(8.36)}{0.06}\ t$$

$$F = 284.2 \quad R^2 = 0.97 \quad DW = 1.64$$

where the yield $\hat{Y}$ is in tonnes/hectare.

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[68]Commerce and Price Department, State Statistical Bureau, Statistical Data of China's Commerce and Prices, Statistical Publishing House, Beijing, 1984 (see Table 12 for the price indexes).

Table 12

Grain Purchasing Price Index
(1952 = 100)

Year	Index	Year	Index
1953	112.9	1969	189.1
1954	112.9	1970	187.2
1955	113.1	1971	194.5
1956	115.2	1972	197.0
1957	116.5	1973	195.8
1958	119.5	1974	199.0
1959	121.1	1975	201.3
1960	125.0	1976	213.4
1961	216.6	1977	211.7
1962	228.8	1978	213.3
1963	190.4	1979	278.3
1964	170.4	1980	301.7
1965	170.4	1981	331.0
1966	192.2	1982	343.6
1967	191.5	1983	379.0
1968	190.0		

Source: Commerce and Price Department, State Statistical Bureau. Statistical Data of China's Commerce and Prices, Statistical Publishing House, Beijing, 1984, p. 402.

This model fits the data quite well. It indicates that when the price index increases by one percentage point, the yield per hectare will increase three kilograms and the yield will increase 60 kilograms yearly as the result of technological progress.

The estimated production is the product of the estimated area and yield. Comparisons of estimated and actual figures are presented in Table 13.

Table 13

Comparison of Estimated and Actual Grain Production

	1979	1980	1981	1982	1983
Population (millions)	975.42	987.05	1,000.72	1,015.42	1,024.95
Estimated Area (million ha)	118.7	117.4	115.8	114.2	113.1
Actual Area (million ha)	119.3	117.2	115.0	113.5	114.0
Price Index	278.3	301.7	331.0	343.6	379.0
Estimated Yield (tonnes/ha)	2.79	2.93	3.07	3.17	3.34
Actual Yield (tonnes/ha)	2.78	2.74	2.83	3.12	3.40
Estimated Output (mmt)	332.8	344.0	355.5	362.0	377.8
Actual Output (mmt)	332.1	320.6	325.0	354.5	387.3
Difference (mmt)	0.7	23.4	30.5	7.5	-9.5

Source: Estimated

The standard error between estimated and actual output is 18 mmt, which is about 5 percent of total production. Large differences

occurred when the total production dropped in 1980 and 1981 when the rising price index suggests that there should have been an increase. Thus, the model seems to be able to track the trend in grain production with a reasonable degree of reliability.

4.2. Regional Model

In the above national model, as discussed, equations (1) and (2) have to be substituted with equations (4) and (5) because of data constraints. In modelling regional production, it is even more difficult to apply theoretically appropriate models. Population data at the provincial level are available only for three years, so equation (4) cannot be applied in the regional model as the time period is too short to derive statistically significant estimates.

One alternative is to use the area data for the first year and the last year to calculate the compound growth rate. This method depends only on the figures for the first year and the last year, hence the random disturbances in these two years will largely influence the reliability of the results. Another alternative is to use the population growth index as the exogenous variable against area, which implicitly assumes that the growth of population is expected to be roughly the same among regions. This assumption may be true because of the immobility of the Chinese population. Then, to reduce the influence of random disturbance, provincial data are grouped into regional data. Equation (4) is modified as follows:

$$A_i = C_{0i} + C_{1i} \text{ Pop ind} + e_i \qquad (6)$$

where,

A_i = grain sown area in region i (million ha);

Pop ind = national population growth index with 1979 = 100

The empirical results from o.l.s. estimation are as follows in Table 14:

Table 14

Regression Coefficients of Regional Area Model

Region	C_{0i}	C_{1i}	R^2
Pastoral	23.67 (2.87)	-0.131 (-8.235)	0.889
Spring Wheat	21.34 (3.89)	-0.071 (-1.337)	0.596
Winter Wheat	82.78 (2.715)	-0.484 (-1.628)	0.883
Wheat-Rice	20.24 (4.860)	-0.024 (-0.595)	0.118
Double-Rice	47.07 (3.264)	-0.221 (-1.572)	0.823
Southwest Rice	27.45 (3.491)	-0.111 (-1.450)	0.701

Figures in parentheses in Table 14 are t-ratios. The estimated coefficients of equation (6) indicate that as population increases, the grain sown area decreases in all regions. The rates of decline in grain sown area are different among regions. The estimated parameters are not very significant as most of the t-ratios are around -1.5. But nevertheless the differences between the expected areas and the actual ones are quite small. The standard error is about 1 percent of the actual sown area for each region (see Table 15). It means when

Table 15

Comparison of Estimated and Actual Sown Area

	1979	1980	1981	1982	1983	
Pastoral Region						
Estimated Area $\hat{A}$	10.57	10.41	10.23	10.03	9.90	
Actual Area A	10.67	10.35	10.11	10.00	9.99	
Difference $\hat{A}$ - A	-0.10	0.06	0.12	0.03	-0.09	
σ_{n-1} [a]						0.096
$\sigma_{n-1} / \bar{A}$ [b]						0.0094
Spring Wheat Region						
Estimated Area $\hat{A}$	14.24	14.15	14.06	13.95	13.88	
Actual Area A	14.31	14.06	13.93	13.79	13.99	
Difference $\hat{A}$ - A	-0.07	0.09	0.13	0.16	-0.11	
σ_{n-1}						0.130
$\sigma_{n-1} / \bar{A}$						0.0093
Winter Wheat Region						
Estimated Area $\hat{A}$	34.38	33.80	33.12	32.40	31.91	
Actual Area A	34.63	33.75	33.04	31.94	32.42	
Difference $\hat{A}$ - A	-0.25	0.05	0.08	0.46	-0.51	
σ_{n-1}						0.367
$\sigma_{n-1} / \bar{A}$						0.011
Wheat Rice Region						
Estimated Area $\hat{A}$	17.84	17.81	17.78	17.74	17.72	
Actual Area A	17.96	17.75	17.59	17.67	17.85	
Difference $\hat{A}$ - A	-0.12	0.06	0.19	0.07	-0.13	
σ_{n-1}						0.137
$\sigma_{n-1} / \bar{A}$						0.0077
Double Rice Region						
Estimated Area $\hat{A}$	24.97	24.70	24.40	24.06	23.84	
Actual Area A	25.22	24.59	24.13	24.08	24.03	
Difference $\hat{A}$ - A	-0.25	0.11	0.27	-0.02	-0.19	
σ_{n-1}						0.214
$\sigma_{n-1} / \bar{A}$						0.0088
Southwest Rice Region						
Estimated Area $\hat{A}$	16.35	16.22	16.06	15.89	15.78	
Actual Area A	16.49	15.96	16.13	15.92	15.77	
Difference $\hat{A}$ - A	-0.14	0.26	-0.07	-0.03	0.01	
σ_{n-1}						0.152
$\sigma_{n-1} / \bar{A}$						0.0095

Sources: [a] $\sigma_{n-1} = \Sigma(\hat{A} - A)^2 / (n - 1)$

[b] $\sigma_{n-1} / \bar{A} = \dfrac{\sigma_{n-1}}{\Sigma A / n}$

This static measures the ratio of the standard deviation to the sample mean.

N.B. Sown areas are calculated from figures in China's Agricultural Yearbooks and the population indices are calculated from year-end population data in China's Statistical Yearbook 1984. They are 100.0, 101.2, 102.6, 104.1 and 105.1 for 1979, 1980, 1981, 1982 and 1983, respectively.

equation (6) is used to estimate the sown area in any region, the estimated standard error is about 1 percent of the actual sown area. This relative measure of the estimated error is very small.

Equation (5) must also be modified in order to be applied to the regional yield model. The reason is the same as for equation (4)--data constraints. Here we have available only five years' yield data on a provincial base. During the five year period (1979-83), grain purchasing prices kept increasing. If a time trend is to be used along with the grain purchasing price index as the exogenous variable as in the national yield model, not only will the degree of freedom be reduced, leading to the loss of statistical significance, but also serious multicollinearity will lead to unacceptable estimates. Thus, only the grain purchasing price index will be used in the modified model. Further, a pooled time-series and cross-sectional model will be used to maximize the degrees of freedom and hence the statistical significance based on the assumption that the change in yield in any particular region will be the same for each province in the region. The modified equation is as follows:

$$Y = d_0 + \sum_{j=2}^{m} d_j D_j + d_1 P_g + e \qquad (7)$$

where D's are dummy variables, equal to one for j^{th} province and zero for other provinces (m is the number of provinces in the region).

This equation gives each province in any particular region the same regression coefficient but a different intercept. For example, the grain yield in the first province will be described as:

$$Y = d_0 + d_1 P_g + e \quad (D_j = 0)$$

For the second province the equation becomes:

$$Y = (d_0 + d_2) + d_1 P_g + e \quad (D_2 = 1, D_j = 0 \text{ when } j \neq 2)$$

For the third province:

$$Y = (d_0 + d_3) + d_1 P_g + e \quad (D_3 = 1, D_j = 0 \text{ when } j \neq 3)$$

And so on.

The empirical results are summarized in Table 16 and details are provided in Table 17. Comparisons of estimated and actual grain yields for the period 1979-83 are summarized in Table 18. As yields are subject to weather conditions, they fluctuate from year to year and thus the estimated yields are subject to errors. The fluctuation of yields in some provinces is quite large which leads to an error in estimates as high as 10 percent of actual yield in some cases. However, for most of the provinces, the estimated errors are about 5 percent of the actual yields. Considering the nature of fluctuation in grain yields, those estimates are acceptable.

The estimated production is the product of estimated area and yield. Here we have estimated grain sown areas at the regional level and yields at the provincial level. To estimate regional grain production, the estimated yields should be converted into regional ones. This can be done by assigning a weight to the yield of each province. The weights are equal to the share of one province's sown area to the regional total in each year so that the regional yields are weighted provincial yields.

Given the provincial sown area data, the weighted regional yields for the period 1979-83 are calculated and listed in Table 19.

Table 16

Summary of Estimates from Equation (7)

Region/Province	Intercept	d_1
Pastoral	-	0.00315
Nei Monggol	0.25	0.00315
Ningxia	0.70	0.00315
Xinjiang	0.91	0.00315
Xizang	1.23	0.00315
Qinghai	1.03	0.00315
Gansu	0.63	0.00315
Spring Wheat	-	0.00806
Heilongjiang	-0.74	0.00806
Jilin	0.27	0.00806
Liaoning	1.25	0.00806
Winter Wheat	-	0.00441
Beijing	2.00	0.00441
Tianjin	0.86	0.00441
Shandong	1.57	0.00441
Shanxi	0.64	0.00441
Hebei	0.91	0.00441
Henan	1.15	0.00441
Shaanxi	0.64	0.00441
Wheat Rice	-	0.00837
Hubei	0.68	0.00837
Anhui	0.15	0.00837
Jiangsu	1.41	0.00837
Double Rice	-	0.00537
Jiangxi	1.79	0.00537
Hunan	2.46	0.00537
Zhejiang	2.77	0.00537
Guangdong	1.76	0.00537
Guangxi	1.60	0.00537
Fujian	2.09	0.00537
Shanghai	2.67	0.00537
Southwest Rice	-	0.00681
Sichuan	1.26	0.00681
Guizhou	0.48	0.00681
Yunnan	0.30	0.00681

Source: Estimated.

Table 17

Estimated Parameters for Regional Yield Models

Parameter	Pastoral	Spring Wheat	Winter Wheat	Wheat Rice	Double Rice	Southwest Rice
d_0	0.25	-0.74	2.00	0.68	1.79	1.26
	(0.81)	(-0.75)	(6.07)	(1.14)	(3.33)	(3.86)
d_2	0.45	1.01	-1.14	-0.53	0.67	-0.79
	(4.05)	(4.00)	(-9.04)	(-3.46)	(3.25)	(-9.42)
d_3	0.66	(1.99)	-0.44	(0.73)	0.98	-0.96
	(5.92)	(7.89)	(-3.46)	(4.75)	(4.76)	(-11.5)
d_4	0.98		-1.21		-0.03	
	(8.80)		(-9.59)		(-0.17)	
d_5	0.78		-1.09		-0.19	
	(7.00)		(-8.65)		(-0.92)	
d_6	0.38		-0.85		0.29	
	(3.39)		(-6.76		(1.42)	
d_7			-1.37		0.88	
			(-10.8)		(4.28)	
d_1	0.00315	0.00806	0.00441	0.00837	0.00537	0.00681
	(3.41)	(2.71)	(4.53)	(4.64)	(3.38)	(6.30)
R^2	0.82	0.86	0.88	0.89	0.73	0.95
F	17.99	23.19	28.57	29.85	10.66	66.07

Source: Estimated.

Table 18

Comparison of Estimated and Actual Yields

Province	1979		1980		1981		1982		1983	
	$\hat{Y}$	Y	$\hat{Y}$	Y	$\hat{Y}$	Y	$\hat{Y}$	Y	$\hat{Y}$	Y
Nei Monggol	1.12	1.26	1.20	1.02	1.29	1.32	1.33	1.34	1.44	1.46
Ningxia	1.58	1.38	1.65	1.62	1.74	1.77	1.78	1.79	1.89	2.09
Xinjiang	1.79	1.73	1.86	1.79	1.95	1.88	1.99	2.00	2.10	2.28
Xizang	2.11	2.05	2.18	2.54	2.27	2.51	2.31	2.29	2.42	1.92
Qinghai	1.91	1.95	1.98	1.88	2.07	1.96	2.11	2.27	2.22	2.21
Gansu	1.51	1.55	1.58	1.67	1.67	1.52	1.71	1.65	1.82	1.88
Heilongjiang	1.50	1.98	1.69	2.00	1.93	1.72	2.03	1.62	2.31	2.14
Jilin	2.51	2.51	2.70	2.44	2.94	2.63	3.04	2.81	3.32	4.12
Liaoning	3.49	3.59	3.68	3.80	3.92	3.70	4.02	3.66	4.30	4.68
Beijing	3.23	3.09	3.33	3.39	3.46	3.41	3.52	3.52	3.67	3.80
Tianjin	2.09	2.37	2.19	2.46	2.32	2.06	2.38	2.45	2.53	2.20
Shandong	2.80	2.83	2.90	2.81	3.03	2.84	3.09	3.09	3.24	3.47
Shanxi	2.02	2.23	2.12	1.96	2.25	2.12	2.31	2.46	2.46	2.40
Hebei	2.14	2.30	2.24	2.03	2.37	2.15	2.43	2.53	2.58	2.75
Henan	2.38	2.36	2.48	2.42	2.61	2.57	2.67	2.48	2.82	3.13
Shaanxi	1.87	2.12	1.97	1.76	2.10	1.84	2.16	2.30	2.31	2.39
Hubei	3.01	3.37	3.21	2.87	3.45	3.30	3.56	3.80	3.85	3.76
Anhui	2.48	2.56	2.68	2.42	2.92	2.97	3.03	3.20	3.32	3.30
Jiangsu	3.74	3.93	3.94	3.70	4.18	3.93	4.29	4.47	4.58	4.72
Jiangxi	3.28	3.38	3.41	3.29	3.57	3.38	3.64	3.77	3.83	3.93
Hunan	3.95	3.89	4.08	3.90	4.24	4.01	4.31	4.40	4.50	4.89
Zhejiang	4.26	4.68	4.39	4.21	4.55	4.21	4.62	4.98	4.81	4.55
Guangdong	3.25	3.11	3.38	3.40	3.54	3.27	3.61	3.87	3.80	3.92
Guangxi	3.09	2.87	3.22	3.01	3.38	3.93	3.45	3.44	3.64	3.56
Fujian	3.58	3.53	3.71	3.68	3.87	3.79	3.94	4.07	4.13	4.12
Shanghai	4.16	5.06	4.29	3.77	4.45	4.17	4.52	4.81	4.71	4.33
Sichuan	2.52	3.12	3.37	3.28	3.51	3.36	3.60	3.68	3.84	4.01
Guizhou	1.74	2.45	2.53	2.68	2.73	2.46	2.82	2.87	3.06	3.05
Yunnan	1.56	2.15	2.35	2.41	2.55	2.59	2.64	2.72	2.88	2.75

Source: $\hat{Y}$'s are estimated and Y's from China's Agricultural Yearbook, 1980-84.

Table 19

Weighted Regional Yields

Region	1979	1980	1981	1982	1983
	----------(tonnes per hectare)---------				
Pastoral	1.45	1.53	1.62	1.65	1.76
Spring Wheat	2.31	2.38	2.63	2.74	3.02
Winter Wheat	2.34	2.44	2.57	2.67	2.82
Wheat Rice	3.08	3.29	3.53	3.64	3.91
Double Rice	3.57	3.70	3.96	4.03	4.22
Southwest Rice	2.18	2.97	3.17	3.26	3.50

$$\text{Weighted Yield} = \frac{\Sigma\, A_i\, \hat{Y}_i}{\Sigma\, A_i}$$

Source: Estimated.

$$\text{Weighted Yield} = \frac{\Sigma A_i \hat{Y}_i}{\Sigma A_i}$$

where A_i is the actual area of "ith" province and $\hat{Y}_i$ the estimated yield in that province.

Then, the estimated grain production can be calculated and compared with actual production in that time period (see Table 20). The estimated standard error for the national total is 17 mmt, which is approximately equal to 5 percent of actual production as in the national model. This indicates that the models fit the data reasonably well.

One should be more cautious when applying the regional yield equation to make projections into the future. The estimated regression coefficients of yields on the price index are 0.004 - 0.008 for most regions. Compared with 0.003 for the national model, these figures may lead to an overestimation of grain yields in the future if grain prices are expected to increase.

However, the regional models can be used to analyze changes in the share of grain production of each region and hence changes in the grain output mix. This may help us to analyze the potential grain trade mix in the future. Also, when more data are available, the regional models will presumably give better estimates on China's grain production than the national model.

Table 20

Comparison of Grain Production by Region

Region		1979	1980	1981	1982	1983
		----------million metric tons----------				
Pastoral	$\hat{Q}$	15.33	15.93	16.57	16.55	17.42
	Q	15.96	15.47	15.90	16.64	18.25
Spring Wheat	$\hat{Q}$	32.89	33.68	36.98	38.22	41.92
	Q	35.60	35.43	33.33	33.02	45.12
Winter Wheat	$\hat{Q}$	80.45	82.47	85.12	86.51	89.99
	Q	84.08	78.22	79.65	84.02	95.88
Wheat Rice	$\hat{Q}$	54.95	58.59	62.76	64.57	69.29
	Q	59.54	53.48	60.06	67.85	70.51
Double Rice	$\hat{Q}$	89.14	91.39	96.62	96.96	100.60
	Q	90.77	87.87	86.58	98.56	100.86
Southwest Rice	$\hat{Q}$	35.64	48.17	50.91	51.80	55.23
	Q	46.17	47.78	49.50	53.35	56.66
National Total	$\hat{Q}$	308.40	330.23	348.96	354.61	374.45
	Q	332.12	318.22[a]	325.02	353.43[a]	387.28

[a]In this table, actual production figures are adopted from China's Agricultural Yearbooks (for provincial data). However, the national totals for 1980 and 1982 are different from those in the Statistical Yearbook, 1984.

5. Consumption Models

5.1. Grain Consumption in Urban Areas

Grain, which can be consumed in different ways, is an important necessity in the daily life of individuals. Grain can be directly consumed by human beings. It can also be consumed indirectly in forms of meat, which is the animal product transformed from feed grain, and spirits, which are produced with grain as the main input. In China, the direct consumption of food grain is the most important source of nutrition intake and energy, and by far the largest component of grain utilization. Food grain consumption accounts for more than 75 percent of total grain production and about 85 percent of grain consumption in today's China. Feed grain is the second largest component of grain utilization, which claims about 12 to 15 percent of total grain production. However, a significant proportion of the total feed requirement can be substituted with the by-product of food grain processing. Spirits do not account for a large share of grain utilization. The grain used to produce spirits is less than 1.5 percent of total grain production. However, spirits production is the third largest component of total grain consumption. In absolute value, the quantity of grain used to produce spirits is not significant, about five to six mmt per year. All other possible forms of grain consumption, such as egg and dairy products from feed grain, are negligible.

The consumption levels of food grain, meat and spirits are determined by people's personal income and the established consumption habits. Consumption habits, in turn, are determined by people's income

in previous years. This suggests that the whole population should be grouped according to the income level per capita. Then, separate models can be built for each group in order to evaluate the different consumption patterns and possible changes in the future.

There exist many sources of income differences. Personal income varies with area, occupation, skills, education and age. Personal assets and savings in previous years also influence current income. However, the greatest income gap among social groups exists between urban and rural residents. In this study, the whole Chinese population has been divided into two broad groups--urban and rural residents. Consumption models will be developed for each group. In this section, three consumption models--food grain, meat and spirits--will be built on a per capita basis for Chinese urban residents. Although data for meat only includes pork, they are not too much different from the figures for total meat utilization as pork production accounts for 94 percent of total meat production in China.

The three consumption models are hypothesized to be represented by the following linear functional form:

$$C_t = a_0 + a_1 I_t + a_2 C_{t-1} + e \qquad (8)$$

where,

C_t = quantity of consumption per capita at time t;

I_t = income per capita at time t; and

C_{t-1} = quantity of consumption per capita at time t-1.

The lagged consumption C_{t-1} is used to take into account the influence of past consumption (i.e., the consumption habits) on current consumption.

Given the data in Table 21, the results from o.l.s. estimation are summarized in Table 22.

These three models are acceptable from a statistical point of view, provided that the estimates can pass the hypothesis tests, at a significance level of at least 15 percent.

According to these models, the level of past consumption plays an important role in determining the current consumption level. This is not surprising as this just reflects the pattern of people's consumption, especially in the case of necessity consumption such as foods. Thus, the change in current income does not change current consumption too much. Its full impact will be spread out over succeeding years.

There are two acceptable methods one could use in order to take into consideration the influence of past consumption on current consumption. One is using the lagged consumption as a proxy, as shown in equation (8). The other is using the lagged income as a proxy. However, when the lagged income was applied, the results indicated very serious autocorrelation. Even if the income was lagged three or four times, the empirical results still failed to pass the DW test for all models. This high order autocorrelation suggests that the lagged endogenous variable (lagged consumption) should be used as an exogenous variable instead of lagged income. Thus, equation (8) is used in this study and it gives acceptable empirical results in all models.

From the estimated coefficients, it is predicted that the consumption of meat will increase at a faster rate than the consumption of food grain for a given increase in personal income. The income

Table 21

Urban Consumption and Income per Capita

Year	Grain	Meat	Spirits	Income
	----------kilograms----------			-yuan-
1952	240.35	8.92	4.34	183.2
1953	242.24	10.10	4.84	219.0
1954	236.21	10.15	4.15	215.1
1955	214.41	9.65	3.51	212.4
1956	200.26	8.38	3.45	233.8
1957	191.00	8.98	3.80	242.2
1958	185.55	8.03	3.31	231.3
1959	200.89	4.99	3.88	250.5
1960	192.59	2.71	4.79	265.8
1961	179.49	1.75	3.48	270.6
1962	183.84	3.79	3.60	296.4
1963	189.86	8.28	3.91	286.1
1964	200.05	10.80	3.83	289.5
1965	210.65	10.37	3.56	291.9
1966	205.76	12.88	3.56	311.1
1967	199.25	11.92	3.99	310.4
1968	188.85	11.67	4.14	306.3
1969	192.58	10.53	4.46	322.5
1970	201.79	10.75	4.35	314.6
1971	199.45	11.19	4.64	326.4
1972	205.96	12.52	5.11	363.0
1973	208.05	13.48	5.71	378.5
1974	204.69	14.32	5.92	390.6
1975	209.26	14.92	7.23	401.5
1976	212.02	13.85	7.52	409.9
1977	210.48	12.88	6.91	418.1
1978	205.29	13.70	6.69	440.8
1979	210.76	17.40	7.41	486.1
1980	213.88	18.98	7.75	569.1
1981	215.73	16.98	9.61	585.1
1982	217.29	17.56	10.86	609.8
1983	221.68	18.04	11.03	637.5

Source: Department of Commerce and Price, State Statistical Bureau. Statistical Data of China's Commerce and Prices, Statistical Publishing House, Beijing, 1984.

Table 22

Coefficients of Urban Consumption Models

Model	a_0	a_1	a_2	F	R^2	DW
Food Grain	38.55 (2.05)	0.019 (1.69)	0.778 (8.66)	39.2	0.74	1.52
Meat	0.19 (0.20)	0.036 (1.14)	0.900 (9.94)	84.8	0.86	1.40
Spirits	-0.64 (-1.85)	0.002 (2.13)	1.019 (14.94)	194.0	0.93	2.06

(Figures in parentheses are t-ratios.)

Source: Estimated.

elasticity of demand is estimated to be 0.032 for food grain and 1.102 for meat at the means. These elasticity figures may be underestimated because of the lagged variables used in the models. The lagged variables spread the income effect over time and thus lead to a lower regression coefficient and a lower elasticity estimate for current income. Nevertheless, the estimated income elasticity of demand for meat is much higher than that for food grain.

This is consistent with the fact that meat is a "luxury" in China. The models suggest that the Chinese have shifted their food consumption towards more meat and will continue to move in the same direction if their income keeps increasing. This will lead to increased demand for feed grain in the future.

5.2. Grain Consumption in Rural Areas

It can be expected that the consumption pattern in rural areas will be similar to that in urban areas. Both current income and past consumption will play important roles in the determination of the current consumption level. Therefore, equation (8) is also applied to the rural consumption of food grain, meat and spirits.

Given the data in Table 23, the regression results are presented in Table 24.

The comparison of the estimated a_1 coefficients between food grain consumption and meat consumption indicates that, unlike in urban areas, rural food grain consumption will increase faster than meat consumption in absolute value for a given increase in per capita income. However, the percentage change of meat consumption is greater than that of food grain consumption. The income elasticity of demand is 0.065 for food grain and 0.261 for meat in China's rural areas. As discussed in the previous section, these figures are underestimated. However, the large difference between the two income elasticities indicates that the consumption in the rural area with income growth will also shift towards more meat.

A simple comparison of the estimates in Table 22 and Table 24 indicate that for a given increase in per capita income, food grain consumption in the rural area will increase 5.7 times faster than in the urban area. However, meat consumption in the rural area will increase about one-third of that in the urban area. This has led to some changes in consumption levels in rural versus urban areas. The food grain consumption level was lower in the rural area prior to 1980

Table 23

Rural Consumption and Income per Capita

Year	Grain[a]	Meat[a]	Spirits[a]	Income
	----------kilograms----------			-yuan-
1952	191.72	5.50	0.69	57.0[b]
1953	190.50	5.47	0.79	60.6
1954	190.16	5.36	0.76	64.1[b]
1955	195.69	4.19	0.68	68.5
1956	205.02	4.00	0.83	72.9[b]
1957	204.38	4.35	0.91	72.9[b]
1958	201.80	4.61	1.01	72.9
1959	183.10	2.61	1.35	67.0
1960	156.00	1.22	1.18	61.0
1961	153.72	1.33	0.53	55.0
1962	160.57	1.89	0.63	58.1
1963	159.65	3.49	0.66	81.1
1964	178.31	4.57	0.71	94.2
1965	177.13	5.50	0.84	107.2[b]
1966	186.44	5.92	0.92	107.8
1967	183.61	5.90	0.93	108.4
1968	170.90	5.58	0.73	109.0
1969	170.53	5.03	0.87	109.6
1970	184.18	5.10	0.96	110.1
1971	186.03	6.19	1.07	110.6
1972	165.99	6.59	1.19	111.1
1973	188.40	6.50	1.11	111.6
1974	184.37	6.39	1.24	112.1
1975	196.94	6.23	1.21	112.6
1976	186.05	6.12	1.53	113.1[b]
1977	183.26	6.08	1.60	123.4
1978	193.33	6.37	1.68	133.6[b]
1979	206.20	7.95	2.05	160.2[b]
1980	213.80	9.39	2.43	191.3[b]
1981	219.97	9.73	3.23	223.4[b]
1982	227.36	10.41	3.95	270.1[b]
1983	234.72	11.01	4.59	309.8[b]

[a]Department of Commerce and Price, State Statistical Bureau. Statistical Data of China's Commerce and Prices, Statistical Publishing House, Beijing, 1984.

[b]Department of Agricultural Statistics, State Statistical Bureau. Great Changes in Rural Life in Our Country, Statistical Publishing House, Beijing, 1984.

N.B. All other income figures are projected by this study. It is assumed that the income in 1958 is the same as in 1957. The 55 yuan per capita income of 1961 is assumed given that the gross value product of agriculture had reached a record low in that year--45.1 billion yuan against 46.7 billion in 1952 and per capita income in 1952 was 57 yuan. Other missing values are derived from interpolation using the adjacent two figures.

Table 24

Regression Coefficients of Rural Consumption Models

Model	a_0	a_1	a_2	F	R^2	DW
Food Grain	42.72 (2.02)	0.108 (2.89)	0.712 (5.65)	49.3	0.78	1.77
Meat	0.16 (0.46)	0.013 (3.42)	0.719 (6.52)	161.8	0.92	1.02
Spirits	-0.30 (-4.17)	0.005 (3.63)	0.849 (7.44)	434.1	0.97	1.76

(Figures in parentheses are t-ratios.)

Source: Estimated

but, as income increased in both areas, rural residents now consume more food grain than urban people. The percentage change in meat consumption in the rural area may be higher than that in the urban area but the gap is even greater in absolute value than it was in the 1950's and 1960's.

The difference between the consumption patterns in rural and urban areas may be partly attributed to different lifestyles. However, it is also largely due to different income levels. Therefore, when these consumption models are used to project China's grain consumption into the future, the different consumption patterns and the different income levels in both urban and rural areas should be considered.

5.3. Other Uses of Grain

Besides human consumption, grain has many other uses. In a broader sense, these uses are also a part of grain consumption claimed by grain reproduction or production in other sectors.

Among these use categories, seeds have by far the largest share. Seed requirement is determined by sown area, crop components and technology. Unfortunately, there are no data available on seed usage so we do not know the actual quantity of seed used per hectare. However, some standards of seed usage can be found in technical handbooks. One of these handbooks, which is of the highest authority, gives the standards of seed usage in recent years.[69] Following are some examples:

Table 25

Seed Requirements in China
1980's

Rice	Wheat	Barley	Corn	Sorghum	Soybean
kilograms/hectare					
150-225	180-260	180-225	23-40	15-23	60-105

Source: See footnote 69.

[69]Handbook of Agro-Technological Economics Editing Committee, Handbook of Agro-Technological Economics, Agricultural Publishing House, Beijing, 1983.

According to these norms, seeds claim about 18 mmt yearly at the present time, and this accounts for about 4.5 percent of total grain production. The quantity of seed requirement in future years is likely to decline as the grain sown area continues to decrease. If there are no major changes in techniques, the above norms are likely to be in effect in the foreseeable future.

Grain used as industrial inputs was about 2.1 mmt in 1980 and is expected to increase to 4.2 mmt by the year 1990, according to a study by the Ministry of Commerce. As there are no actual data, and the quantity is not very large, the yearly increase in industrial uses of grains is simply taken as 0.2 mmt.

As mentioned earlier, the security of grain supply is a very important component of government policy. Thus, it will be the goal of the government to maintain grain stocks at a certain level and to allow stocks to increase with increases in the grain supply.

According to a study by the Ministry of Commerce, it will be desirable to keep grain stocks at the level such that the stored quantity is equal to eight months' supply by the end of March. As each new harvest begins in late May or early June, it means that net stocks by the government will ideally be kept at the level equal to a half year's supply.

In practice, the actual stocks cannot be kept at this desired level due to fluctuations in output and, to some extent, due to fluctuations of consumption and international trade. There are no data available on existing grain stocks. In this study, stock levels are

estimated for the period 1952-83.[70] Based on available evidence, grain stocks were built up during the 1950's and dropped to almost zero in 1961. Then they were rebuilt during the late 1960's and 1970's with some fluctuation from year-to-year. After a big jump in 1983, the level of grain stocks seems to have reached the desired quantity (55.5 mmt of stocks against 98.6 mmt of total government grain sales). As grain production in 1984 was 20 mmt above that in 1983 and the net imports in 1984 were only 3 mmt less than they had been in 1982, the stocks might have added another 10 to 15 mmt. However, as grain production dropped by 28 mmt in 1985, the quantity of stocks may well be lower than in 1983. As they are still within the desired range, grain stocks are not likely to be increased substantially. A further increase in grain stocks is only expected to be associated with increases in government grain supply.

Besides the state grain stocks discussed above, there are certainly some farmer-held stocks. This component of grain stocks will not to be discussed here because of the lack of reliable data. In many areas farmers have no grain reserves at all. Even in the grain surplus areas, the private grain stocks might not exceed one month's consumption. Also, in these areas, as farmers have easy access to grain markets, the private stocks may not increase in the future. All other types of grain usage are ignored in this study because the quantities are small and no data are available.

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[70]See Table 26.

Table 26

Estimated State Grain Stocks

Year	Purchases[a]	Sales[a]	Net Imports[b]	Losses[c]	Changes in Stocks[d]	Stocks[e]
	million metric tons					
1952	31.01	23.39	-1.86	0.76	6.67	6.67
1953	37.11	30.66	-2.22	0.91	4.74	11.41
1954	49.81	39.80	-2.06	1.21	8.94	20.35
1955	46.34	39.59	-2.54	1.13	4.56	24.81
1956	39.12	40.91	-3.08	0.96	-6.22	18.69
1957	45.44	41.44	-2.38	1.11	1.39	20.08
1958	51.83	48.14	-3.30	1.27	-0.07	20.01
1959	64.12	52.57	-5.07	1.56	7.46	27.47
1960	46.54	55.79	-3.25	1.14	-15.67	11.80
1961	34.44	44.23	4.16	0.96	-8.74	3.06
1962	32.18	36.06	3.66	0.88	-1.95	1.11
1963	36.57	36.04	4.13	1.01	3.77	4.88
1964	39.90	40.26	4.35	1.11	2.80	7.68
1965	39.22	41.64	3.46	1.09	-0.58	7.10
1966	41.42	40.71	2.92	1.14	2.65	9.75
1967	43.38	40.17	1.05	1.15	3.81	13.56
1968	40.41	38.59	1.43	1.08	2.57	16.13
1969	38.45	41.70	1.06	1.01	-3.91	12.22
1970	46.49	40.85	2.78	1.24	8.42	20.64
1971	43.83	43.52	-0.02	1.13	-0.77	19.87
1972	38.54	45.84	1.19	1.03	-8.74	11.13
1973	48.41	47.81	3.38	1.34	2.77	13.90
1974	46.89	46.51	3.68	1.31	2.83	16.73
1975	52.62	49.73	0.32	1.36	2.48	19.21
1976	49.15	52.50	0.22	1.21	-5.08	14.13
1977	47.67	54.95	5.32	1.31	-4.87	9.26
1978	50.73	54.78	6.54	1.41	0.19	9.45
1979	57.57	57.44	10.35	1.65	8.86	18.31
1980	57.07	63.88	11.46	1.66	1.50	19.81
1981	63.24	71.06	13.27	1.84	1.89	21.70
1982	72.09	77.95	14.59	2.08	5.36	27.06
1983	96.74	80.36	11.05	2.63	28.40	55.46

[a]Department of Commerce and Price, State Statistic Bureau. Statistical Data of China's Commerce and Prices, Statistical Publishing House, Beijing, 1984 (in processed form).

[b]Adopted from Table 2, this study.

[c]Assumed a loss of 2 percent of total selling to the State.

[d]The difference between State purchase and sale, converted into unprocessed form, plus net import.

[e]Accumulated changes in stock in current year and all previous years.

5.4. Grain Balance Sheets For The Early 1980's

As mentioned earlier, many food balance sheets have been constructed by different authors. In this section, a grain balance sheet will be constructed for China in the early 1980's. Human consumption data are adopted from Statistical Data of China's Commerce and Prices. For direct consumption, an 82 percent milling rate is used to convert the figures into unprocessed form. For meat consumption, a 4:1 conversion ratio of feed to meat is used to estimate feed grain consumption. For spirits, a 93 percent grain to spirits rate is applied, which was the actual rate in 1980. Other grain uses are estimated, based on the discussion in the previous section. Losses in storage, transportation and processing by the state are considered.[71]

Table 27

Estimated Domestic Grain Utilization

Year	Consumption	Seed	Industrial Uses	Stock Change	Losses	Total
			million metric tons			
1981	316.4	18.1	2.3	1.9	1.8	340.4
1982	332.4	17.8	2.5	5.4	2.1	360.1
1983	347.3	18.1	2.7	28.4	2.6	398.8

Source: Estimated. See contents of this section and the previous one for details.

[71]See Table 27 and Table 28.

Table 28

Estimated Grain Balance Sheet

Year	Output	Net Imports	Utilization	Difference
		million metric tons		
1981	325.0	13.3	340.4	-1.8
1982	354.5	14.6	360.1	9.0
1983	387.3	11.1	398.8	-0.4

Source: Output: China's Statistical Yearbook; Net Imports: Table 2; Utilization: Table 27.

The sum of output and net imports is the estimated total supply, and the utilization is expected to be about equal to total supply. However, as there are many items excluded from the model, errors can be expected. For example, the total utilization is underestimated because feed grain used for exported meat, nonpork meat, eggs, milk, etc., is not included. On the contrary, by-products from food processing used as feed are not subtracted from the feed requirement, and this may lead to an overestimation of feed demand. Besides feed, changes in private stocks are also a factor in total grain utilization which are not considered here. Its quantity may tend to increase as peasants have more grain, but it may tend to decrease as peasants can now easily buy or sell grain in the free market. Furthermore, the assumed feed:meat conversion ratio may not be exactly as it appears. Although the total utilization of grain is subject to errors, the results indicate that the errors are quite small, only about 1 percent of the total grain utilization on average.

The small differences between the estimated grain utilization and the actual grain supply in 1981-83 indicate that the overall model fits the data quite well. It is shown in Table 27 and Table 28 that when various consumption figures are summed, the results are very close to the actual supply figures in that period. This suggests that the estimation of China's total grain utilization in this study, including changes in stocks, is quite accurate and hence the underlying consumption equations are quite reliable in explaining China's grain consumption behaviour, at least in the given time period. Therefore, the projections, which are to be made with these equations, are also reliable if there are no major structural changes in the near future.

Of course, any projection involves errors. Besides the uncertainty in the future, there are many sources of data errors. Among the above-mentioned categories, the calculation of feed requirements is subject to the largest degree of error. It can easily be underestimated or overestimated. In the three years considered, opposite factors may have offset one another. If there are to be no major structural changes, they may continue to offset each other. If so, these same methods can be used to make projections.

6. Projections and Trade Implications

6.1. Production Projections

In Chapter 4, production models were constructed at both national and regional levels. In this section, these models are to be used to project China's grain production into the years 1990, 1995 and 2000.

In these models, grain sown area is a function of population, and yield a function of the purchasing price index. So both the growth rate of population and the grain purchasing price should be projected first. The population growth rates in the 1980's are listed as follows in Table 29:

Table 29

Population Growth Rates
1980-85

Year	1980	1981	1982	1983	1984	1985
Growth Rate	1.19%	1.38%	1.47%	0.94%	0.97%	1.12%

Source: Calculated from the Chinese official year-end population figures.

Under the current population control policy, the growth rates were reduced to below 1 percent in 1983 and 1984. However, as people born during the birth peak in the mid 1960's now are entering their child-bearing years, an increase in the population growth rate is likely to be observed in the coming years. Hence, an annual growth rate of 1.25 percent is assumed in this study for the period 1986-90 which is almost

the same as the target set by the government in the seventh Five Year Plan just released (1.24%). Then, the population growth rates are assumed to be 1.1 percent for the period 1991-95 and 1 percent for the period 1996-2000. For comparison, high and low population growth rates are also assumed for the three time periods. High growth rates are assumed to be 1.3, 1.2 and 1.1 percent, respectively; and low growth rates, 1.1, 1.0 and 0.9 percent, respectively.

Using these assumed growth rates and the 1985 year-end figure, Chinese population in years 1990, 1995 and 2000 are projected and listed in Table 30.

Table 30

Projected Chinese Population
1990-2000

Year	1990	1995	2000
	(millions)		
Population-high	1,116.2	1,184.8	1,251.4
-medium	1,113.5	1,176.1	1,236.0
-low	1,105.2	1,161.6	1,214.8

Source: Estimated.

With these population figures, the grain sown areas can be projected using the empirical model:

$$\hat{A} = 228.6 - 0.11 \text{ Pop}$$

derived in Chapter 4. The projected grain sown areas in 1990, 1995 and 2000 are listed in Table 31.

Table 31

Projected Grain Sown Areas
1990-2000

Year	1990	1995	2000
	----------(million hectares)----------		
Area - high	107.0	100.8	95.0
- medium	106.1	99.2	92.6
- low	105.8	98.3	90.9

Source: Estimated.

Table 31 suggests that the grain sown area in China is quite sensitive to the population growth rate. A 0.1 percent difference in annual population growth rate will lead to about a 2.5 million hectare difference in grain sown area in the year 2000. Thus, China's grain production largely depends on the success of population control.

To project grain yields into the future, using the production model, the grain purchasing price must be projected first. As the main instrument of the new agricultural policy, grain purchasing prices have continuously increased since 1979. If 1952 is taken as the base year, grain purchasing price indices in recent years and the percentage changes between any two succeeding years are as follows:[72]

[72]Department of Commerce and Prices, State Statistical Bureau, Statistical Data of China's Commerce and Prices, Statistical Publishing House, Beijing, 1984.

Table 32

Index of Grain Purchasing Prices
1978-83

Year	1978	1979	1980	1981	1982	1983
Price Index	213.3	278.3	301.7	331.0	343.6	379.0
Percentage Change		30.5	8.3	9.7	3.8	10.3

Source: See footnote 72.

The average annual growth rate of the grain purchasing price is about 12.2 percent. Even if the big jump in 1979 is excluded, the annual percentage increase is still quite high, about 8 percent.

As discussed earlier, the budgetary burdens of food subsidies have become heavier and heavier and the government cannot continue to increase grain purchasing prices at this rate. However, an increasing share of grain marketing is now going through the free market where the prices are significantly higher than those set by the government agency. The actual price received by grain producers is likely to increase continuously. However, the growth rate may be substantially below that of the early 1980's. It is reasonable to assume that grain prices will increase at an annual rate of 5 percent, as more and more grain will go through free markets, and the government has taken some measures to have grain producers subsidized by the profit from village industries. Also, a high rate of 6 percent and a low rate of 3 percent are assumed for comparison. The projected grain price indices are listed in Table 33.

Table 33

Projected Grain Price Indices
1990-2000

Year	1990	1995	2000
Price Indices-high	569.9	762.6	1,020.5
-medium	533.3	680.6	868.7
-low	466.1	540.4	626.4

Source: Estimated.

These figures in Table 33 are then applied to the empirical model:

$$\hat{Y} = 1.06 + 0.06\ t + 0.003\ P_g$$

as estimated in Chapter 4. The projected grain yields are listed in Table 34.

Table 34

Projected Grain Yields
1990-2000

Year	1990	1995	2000
	(tonnes/hectare)		
Yield-high	4.33	5.21	6.28
-medium	4.22	4.96	5.83
-low	4.02	4.54	5.10

Source: Estimated.

Table 33 and 34 show that the increase in grain price is essential for the further increase in grain yields. As the price instrument was the major engine of the increase in China's grain yields, to keep it running at a certain speed is necessary to maintain the growth rate of grain yields. If the growth rate of the grain price is 6 percent instead of 5 percent, as will be used in this study, the grain yield will be 2.6 percent higher in 1990, 5 percent higher in 1995 and 7.7 percent higher in 2000. On the contrary, if the growth rate of the grain price is 3 percent, the grain yield will be 4.7 percent, 8.5 percent and 12.5 percent lower in 1990, 1995 and 2000, respectively. As a 1 percent difference in yield means 4 mmt of total grain output, the importance of keeping prices increasing can never be overestimated.

The combination of three projected area figures and three projected yield figures will give nine output projections. For simplicity, only three scenarios will be analyzed here. The high projection of grain output requires low population growth rate and high level of prices. The medium projection requires medium growth rates of both population and price. The low projection requires high population growth rate and low rate of price increase. The results of the three scenarios are listed in Table 35:

Table 35

Projected Grain Production
1990-2000

Year	1990	1995	2000
	---------(million metric tons)---------		
Production-high	463.3	525.2	596.6
-medium	447.7	492.0	539.9
-low	425.3	446.3	463.6

Source: Estimated.

The two extreme projections, although considered unlikely to happen, indicate how grain production will be influenced by the policies concerning population control and grain prices. The medium projections are considered most probable in this study. These projections require a yearly growth rate of 1.59 percent for 1984-90, 1.91 percent for 1990-95 and 1.38 percent for 1995-2000, in China's grain production. Compared with growth rates in most of the last 35 years, they are quite low and hence are likely to be realized if there are no dramatic shifts or reversals in government policy or large scale disasters.

Based on the same assumptions regarding the future growth rates of population and the grain purchasing price, a similar projection can be made with the regional models. In our regional models, grain sown area is a linear function of the population index with 1979 as the base year, and grain yield a linear function of grain purchasing price index. The projected population indices with 1979 as the base year are

as follows: 114.2 for 1990, 120.6 for 1995 and 126.7 for 2000. The projected grain sown areas, yields and productions are summarized in Table 36 (for simplicity, only medium projections are listed).

As in the regional production models in Chapter 4, the grain yield is the weighted average of yields within a region. Assuming that the grown sown areas in different provinces will change proportionately within a region, the weights are averages of grain sown area shares in the time period 1979-83 (see Table 37).

Compared with the medium projections from the national model, the regional model suggests a sharper decline in grain sown area and a higher growth in grain yield. The gap between the two projected grain sown areas occurs in the time period 1985-90 and remains constant to the end of the century. The difference between the two projected yields will continue to increase. This may be due to the different functional forms of the two models. In the national model, two exogenous variables are used in estimating grain yields. One of the two, the time trend, increases at a constant rate and the other, the price index, at an exponential rate. In the regional model, only the price index is used so that the growth of yield, which increases at an exponential rate, will be greater.

As a result, the projected grain output for the regional model is lower at the beginning but higher as time passes compared with the medium projections in the national model. If more data were available so that the same structural models could be estimated at both the national and regional levels, a more precise comparison could be possible. Nevertheless, the projected levels of regional grain

Table 36

Projected Regional Grain Production
1990-2000

Region	1990			1995			2000		
	Area	Yield	Output	Area	Yield	Output	Area	Yield	Output
Pastoral	8.71	2.25	19.60	7.87	2.72	21.41	7.07	3.31	23.40
Spring Wheat	13.23	4.27	56.49	12.78	5.45	69.65	12.34	6.97	86.01
Winter Wheat	27.51	3.46	95.18	24.41	4.11	100.23	21.46	4.94	106.01
Rice	17.50	5.37	93.98	17.35	6.46	112.08	17.20	8.04	138.29
Double Rice	21.83	4.95	108.06	20.42	5.74	117.21	19.07	6.74	128.53
Southwest Rice	14.77	4.56	67.35	14.06	5.57	78.31	13.39	6.85	91.72
Total	103.55	4.26	440.66	96.89	5.15	498.99	90.53	6.34	573.96

Source: Estimated.

Table 37

Average Share of Sown Area
1979-83

Pastoral Region	
Nei Monggol	38.0%
Ningxia	7.0%
Xinjiang	20.7%
Xizang	1.9%
Qinghai	4.0%
Gansu	28.4%
Spring Wheat Region	
Heilongjiang	51.8%
Jilin	25.4%
Liaoning	22.8%
Winter Wheat Region	
Beijing	1.6%
Tianjin	1.6%
Shandong	24.6%
Shanxi	10.4%
Hebei	22.0%
Henan	27.3%
Shaanxi	12.5%
Wheat Rice Region	
Hubei	29.9%
Anhui	34.3%
Jiangsu	35.8%
Double Rice Region	
Jiangxi	15.4%
Hunan	22.5%
Zhejiang	14.0%
Guangdong	21.3%
Guangxi	16.2%
Fujian	8.7%
Shanghai	1.9%
Southwest Rice Region	
Sichuan	63.1%
Guizhou	14.8%
Yunnan	22.1%

Source: Calculated from China's Agricultural Yearbook, 1980-84.

output, as mentioned before, can be used to analyze the potential output mix and its trade implications.

6.2. Demand Projections

Total domestic demand for grain includes human consumption, seed requirements, industrial uses and the reserve in stock requirements. Consumption models in Chapter 5 have been estimated for both urban and rural residents. To project the quantity of human consumption into the future, the growth rate of personal income must be assumed. The income growth rates of urban and rural residents in recent years are summarized in Table 38.

Table 38

Growth Rate of Personal Income
1978-83

	1978-79	1979-80	1980-81	1981-82	1982-83	Average
	----------percent----------					
Urban	10.28	17.07	2.81	4.22	4.54	7.66
Rural	19.91	19.41	16.78	20.90	14.70	18.32

Source: Calculated from Tables 21 and 23.

These rates tend to decline in the early 1980's. For rural residents, they are 14.59 percent and 11.83 percent for 1983-84 and 1984-85, respectively. In the seventh Five-Year Plan, they are set at 7 percent and 4 percent for rural and urban residents, respectively. In this study, they are assumed to be 5 percent per year for rural

residents and 3 percent for urban residents for the time period 1984-2000.

The direct human consumption of food grain cannot increase infinitely. After reaching a certain point it will stabilize. If meat and other food consumption continues to increase, direct grain consumption may even decline. In this study, the upper bound is assumed to be 250 kg per year for urban residents and 260 kg per year for rural residents (in processed form). Then, the projected human consumption demand for grain, derived from equation (8) in Chapter 5, is listed in Tables 39 and 40.

In order to estimate the total demand for grain in the future, the ratio of urban to rural residents must be projected. This ratio was 19.4:80.6 in 1980, 20.2:79.8 in 1981, 20.8:79.2 in 1982, 23.5:76.5 in 1983 and 31.9:68.1 in 1984. The large increase in 1984 is due to the change in the status of people in small towns, thus further increases may be much smaller than it was in 1984. In this study, the ratio of urban to rural population is assumed to be 35:65 in 1990, 37.5:62.5 in 1985 and 40:60 in 2000.

As in the previous section, three scenarios of population growth rates are assumed: high, 1.3 percent for 1985-90, 1.2 percent for 1990-95, and 1.1 percent for 1995-2000; medium, 1.25 percent for 1985-90, 1.1 percent for 1990-95, and 1 percent for 1995-2000; and low, 1.1 percent for 1985-90, 1 percent for 1990-95, and 0.9 percent for 1995-2000. Based on these assumptions, the projected total consumption demand for grain is estimated and is reported in Table 41.

Table 39

Projected Rural Consumption Demand for Grain
1984-2000

Year	Food Grain	Meat	Spirits	Total Grain[a]
	(kilograms per capita)			
1984	239.53	11.94	5.33	344.83
1985	244.53	12.80	5.04	355.02
1986	249.73	13.62	6.75	365.30
1987	255.17	14.43	7.42	375.80
1988	260.00	15.24	8.10	385.57
1989	260.00	16.07	8.79	389.53
1990	260.00	16.91	9.48	393.53
1991	260.00	17.79	10.19	397.71
1992	260.00	18.70	10.90	402.01
1993	260.00	19.65	11.64	406.50
1994	260.00	20.64	12.41	411.17
1995	260.00	21.68	13.20	416.07
1996	260.00	22.77	14.01	421.18
1997	260.00	23.91	14.86	426.53
1998	260.00	25.11	15.75	432.16
1999	260.00	26.37	16.67	438.06
2000	260.00	27.69	17.63	444.23

[a]The figures for total grain demand is expressed in unprocessed form by applying an 82 percent milling rate to food grain, a 4:1 feed to meat ratio and a 0.97:1 spirits to grain ratio and then summing them up.

Source: Estimated.

Table 40

Projected Urban Consumption Demand for Grain
1984-2000

Year	Food Grain	Meat	Spirits	Total Grain[a]
	(kilograms per capita)			
1984	223.49	18.60	11.70	357.83
1985	225.27	19.19	12.42	362.95
1986	227.05	19.76	13.17	368.18
1987	228.82	20.37	13.97	373.52
1988	230.62	20.99	14.87	378.98
1989	232.43	21.63	15.69	384.56
1990	234.28	22.29	16.62	390.32
1991	236.16	22.97	17.59	396.24
1992	238.09	23.67	18.61	402.34
1993	240.06	24.38	19.69	408.59
1994	242.08	25.12	20.81	415.05
1995	204.16	25.88	21.99	421.73
1996	246.29	26.66	23.22	428.59
1997	248.49	27.47	24.51	435.71
1998	250.00	28.30	25.86	442.13
1999	250.00	29.15	27.26	446.83
2000	250.00	30.03	28.73	451.71

[a]The figures for total grain demand is expressed in unprocessed form, by applying an 82 percent milling rate to food grain, a 4:1 feed to meat ratio and a 0.97:1 spirits to grain ratio and then summing them up.

Source: Estimated.

Table 41

Projected Total Consumption Demand for Grain
1990-2000

Year	Scenario	Population	Average Consumption[a]	Total Demand
		-million--	-----kg/capita------	----mmt-----
1990	high	1,116.2	392.41	438.0
	medium	1,113.5	392.41	436.9
	low	1,105.2	392.41	433.7
1995	high	1,184.8	418.19	495.5
	medium	1,176.1	418.19	491.8
	low	1,161.6	418.19	485.8
2000	high	1,251.4	447.22	559.7
	medium	1,236.0	447.22	552.8
	low	1,214.8	447.22	543.3

[a]Weighted by urban:rural population ratio.

Source: Estimated.

Assuming that seed requirements will decrease proportionately with the grain sown area predicted by the national model, the projected seed requirement is 16.8 million metric tons for 1990, 15.7 million metric tons for 1995 and 14.7 million metric tons for 2000.

As the total quantity of grain for industrial uses is quite small, any reasonable assumption about its increase will not significantly influence the projection of total grain demand. Thus, for simplicity it is assumed that it will increase at the present rate, about 0.2 mmt per year. Hence, it is assumed to be 4.2, 5.2 and 6.2 mmt in 1990, 1995 and 2000, respectively.

As discussed above, the government grain reserves are estimated at the present government desired level. For the remainder of the century, they may not increase dramatically as more and more grain will be marketed through free markets. Also, the private stocks may not increase significantly as peasants are gaining easier access to open markets. However, for food security reasons, the stocks may continue to increase at a moderate rate. Hence, the increase is assumed to be 3 mmt per year so that the total grain reserves will reach 100 mmt by the end of the century.

With all major components having been projected, a domestic grain balance sheet can be constructed as in Table 42. The first scenario assumes a high rate of increase in grain prices (6 percent yearly) and a low population growth rate (1.1 percent for 1985-90, 1 percent for 1990-95 and 0.9 percent for 1995-2000). It suggests that if these requirements can be met, China's grain production will be in surplus and the surplus will continue to increase in the 1990's. However, as discussed earlier, these growth rates are unlikely to be reached because the government cannot afford the huge subsidy burdens and this population growth rate is quite low.

The third scenario indicates that there will be a serious shortage of grain in China if the prices increase at only 3 percent per year and the population increases at a relatively high rate. If these assumptions are accepted, the shortage in China's domestic grain supply will be 36.7 mmt in 1990 and it will increase to 70 mmt in 1995 and 119.7 mmt in 2000. These results would undoubtedly be unacceptable

Table 42

Projected Domestic Grain Balance Sheet
1990-2000

Scenario	Year	Output	Consumption	Seed	Industrial Uses	Changes in Stocks	Deficit
		million metric tons					
1[a]	1990	463.3	433.7	16.9	4.2	3	-5.5
	1995	525.2	485.8	16.0	5.2	3	-15.2
	2000	596.6	543.3	15.1	6.2	3	-29.0
2[b]	1990	447.7	436.9	16.8	4.2	3	13.2
	1995	492.0	491.8	15.7	5.2	3	23.7
	2000	539.9	552.8	14.7	6.2	3	36.8
3[c]	1990	425.3	438.0	16.8	4.2	3	36.7
	1995	446.3	495.5	15.6	5.2	3	70.0
	2000	463.6	559.7	14.4	6.2	3	119.7

[a]High rate of increase in grain purchasing prices and low growth rate for population.

[b]Medium growth rates for both population and grain prices.

[c]Low rate of increase in grain purchasing prices and a high rate for population growth.

Source: Estimated.

to the Chinese government and necessary measures would presumably be taken to prevent them from happening. Nevertheless, they indicate the sensitivity of our results to the price of grain and the rate of population growth.

The decline of China's grain production in 1985 was partly due to the lack of any further increase in grain prices. There was no increase in the average prices paid by state agencies in 1985 and the

unified "contracted price" initiated in the same year was lower than the former above-quota price. As a result, farmers received lower marginal prices in 1985 than in the previous few years and there was a lack of incentives to increase grain production further. Consequently, the government announced a plan to permit farmers to sell more grain in the free markets and for them to obtain subsidies from village industries. These measures may ensure grain producers will receive higher grain prices in the coming years.

The second scenario, which is considered most probable, assumes medium increases in both grain prices and the population. It suggests that if grain prices increase at 5 percent yearly and the population increases at 1.25 percent for 1985-90, 1.1 percent for 1990-95 and 1 percent for 1995-2000, China's grain supply will still be short. The shortage is projected to be 13.2 mmt in 1990, 23.7 mmt in 1995 and 36.8 mmt in 2000.

For many reasons, the Chinese government would like to reach a level of self-sufficiency in grain. However, under current circumstances, grain self-sufficiency is not likely to be reached in the 1990's if no major technological development is made in the near future. The important question is, how large will the shortage in China's grain supply will be. In this study, it is believed that the annual shortage will be 13 to 25 mmt in most of the 1990's, given current technology.

6.3. Trade Implications

As discussed in the previous section, China's domestic grain supply is projected to be in deficit in the 1990's. Under current

policy, the deficit in grain supply is likely to be solved with imports rather than through restrictions on consumption if the deficit is not too large.

Based on the second scenario in Table 42, which is considered most probable, the annual deficit will be 15 to 25 mmt during most of the 1990's. A large part of this deficit may be reduced with imports. Past experience indicates that 10 to 15 mmt of grain imports are not in conflict with the government's policy towards grain self-sufficiency and are within China's capability in terms of transportation and balance of payments. Therefore, if the total demand increases in the 1990's and transportation and balance of payments are improved, more grain imports are possible.

The components of China's grain imports may well change in the future. Table 39 and 40 clearly indicate that further increases in grain consumption will come mainly from increased feed requirements. The increase in feed demand is about three mmt per year, which may exceed the increases in coarse grain production.

As mentioned previously, the regional models tend to overestimate grain yields in the future. However, they may be used to analyze the relative share of each region's grain production[73] and the grain output mix in the future.

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[73]See Table 43.

Table 43

Projected Grain Output Shares, by Regions
1990-2000

Region	1990	1995	2000	1979-83 Average
	----------percent----------			
Pastoral	4.45	4.29	4.08	4.79
Spring Wheat	12.82	13.97	14.99	10.64
Winter Wheat	21.60	20.09	18.47	24.58
Wheat Rice	21.33	22.47	24.09	18.14
Double Rice	24.52	23.49	22.39	27.08
Southwest Rice	15.28	15.69	15.98	14.77

Source: Estimated.

Table 43 suggests that the relative share of grain production will increase in spring wheat and wheat rice regions but decrease in winter wheat and double rice regions with only small changes in pastoral and southwest regions. If the grain output mix were kept at the 1979-83 levels for each region, the national rice production would be 192.5, 211.6 and 233.2 mmt in 1990, 1995 and 2000, respectively. Also, wheat production would be 83.7, 91.0 and 98.3 mmt in the same years. (Using the production figures in scenario 2 in Table 2, output shares in Table 3, and the average output mix for each region in 1979-83 period calculated from China's Agricultural Yearbook, 1980-84.)

After deducting seed requirements, the total quantity of rice and wheat production will meet 76.6 percent of the total food grain demand in 1990, 78.9 percent in 1995 and 82 percent in 2000. In the 1979-84

period, it only met 76.3 percent of total food grain consumption. Therefore, the import demand for food grain may decline in the future if the food grain consumption structure does not change too much during the remainder of the century.

Furthermore, as pointed out earlier, wheat production increased much faster than total grain production during the 1979-83 period, 8.5 percent versus 4.0 percent. If this trend will continues to the end of the century, wheat will have a larger share of total grain output. The import demand for food grain, or more precisely that for wheat will then decline. Future grain imports will most likely be feed grains.

Generally speaking, coarse grains do not have a yield advantage in China and Chinese agriculturalists have paid less attention to coarse grains. Thus, coarse grain are not expected to have a yield advantage in the near future. When the world market price is in favour of importing coarse grains, a shift from importing wheat to importing coarse grains is quite possible.

The World Bank made projections of China's grain trade into the year 2000. They suggested that by the year 2000 China's excess demand for feed grain would be 45 to 60 mmt while her rice production would be 30 mmt in surplus annually and this imbalance would be solved through international trade.[74] They went on to suggest that China might not be able to export so large a quantity of rice as the total international market only absorbed 12 mmt of rice yearly in the early 1980's.

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[74]The World Bank, China: Long-Term Issues and Options, Report No. 5206-CHA, and China: Long-Term Development Issues and Options, 1985 (Main Reports and Annex B's).

Therefore, there would presumably be some acreage shift from rice to other crops.

It is believed in this study that the Chinese may not be willing to import such a large quantity of feed grain as the World Bank's projections suggest. Besides the political consideration, such a quantity of feed grain imports may be beyond China's physical port capacity. Therefore, if the World Bank's projections are correct, the Chinese government will probably take measures to encourage the shift of rice to feed grain production in order to reduce the domestic grain production imbalance.

7. Summary

After recovering from the food crisis in the early 1960's, China's grain production increased at an annual rate of 3.51 percent from 1965 to 1978. This long-run growth rate in grain production was basically achieved by increasing yield at an annual rate of 3.44 percent.

Under the current policy which was initiated in 1979, this long-run growth rate was largely surpassed. During the 1979-84 period, the annual growth rate of grain production was about 4 percent and that of grain yield was even higher, 6.1 percent. The large increase in grain yield can be attributed to the production incentives and hence the increased efficiency stimulated by the new economic policy. The major policy instrument is the government's grain purchasing price.

However, this increase in grain yield can also be attributed in part to the yield potential previously accumulated but not realized due to unfavourable policy conditions. This type of yield potential may have become exhausted. Also, as the grain price is not likely to increase as rapidly as it did in the 1979-84 period, the yield growth rate may slow down for the remainder of the century. Therefore, grain output may increase but at a lower rate as the sown area will continue to decrease.

In this study, the yield growth rate is projected to be 2.63 percent per year for the 1984-90 period and 3.28 percent for the rest of the century. Using a national model, the corresponding growth rate of grain output is then projected to be 1.59 percent for the 1984-90 period and 1.9 for the remainder of the century. These projections are quite conservative. It suggests that the growth rate of yield will

revert back to the long-run trend of the 1965-79 period. As the yield in China is high compared with international standards in developing countries, to keep up the long-run growth rate of yield is not an easy task.

To maintain the required yield growth rate, input usage must continue to increase. This requirement is likely to be satisfied, but this is not enough. Grain production in China is still less profitable than many cash crops or nonfarm production. The price structure must be reformed further in order to generate incentives for an increase in grain yield. As the direct government subsidies will probably not increase significantly, the future price incentives depend on the success of reforms in the marketing structure. Besides generating a higher price in the free market, a more efficient market will lead to better resource allocation and lower marketing costs. Thus, a successful reform of the grain marketing system will encourage higher grain yields and production.

To slow down the declining rate of grain sown area is as important a task as increasing grain yields. The population growth rate has been substantially reduced and further decreases are unlikely under current circumstances. Another problem is that, as the nonfarm use of land is much more profitable than farm usage, the shift of land from farming to other production activities has been quite substantial, especially in 1985. The grain sown area was reduced by 4.4 million hectares in 1985, much higher than the projected figures (about one million hectares). Thus, more restrictive regulations on land use are essential to keep the grain sown area at an acceptable level. This may slow down overall

economic growth to some extent. However, if the Chinese are not willing to import a large quantity of grain, more restrictive regulation on land utilization is necessary.

The Chinese government has repeatedly claimed that it is not willing to import a large quantity of grain. There are many reasons for this policy, such as the security of food supply, the shortage of foreign exchange, etc. But as past experience indicates, China will import a certain amount of grain if necessary. The quantity may well be as large as 16 mmt per year as it was in 1982. However, these future imports will be largely comprised of coarse grains rather than wheat as in the past. This will allow the Chinese standard of living to continue to improve.

This study is the first attempt to quantitatively analyze the impact of the government policy on China's grain economy. This approach gives a better understanding of new developments in China's grain economy since 1979 and provides more precise projections into the future. The regional models employed in this study were used to analyze the grain output mix and its implications in international trade. This approach indicates a new direction in the research area on Chinese agriculture, and more thorough studies will be conducted in the future with a variety of regional models when data are available.

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