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ABSTRACT

Wheat production in China is analyzed using a seven-region model and data for 1978-1997. The empirical results indicate; 1) the area planted to wheat in China is responsive to the real wheat procurement price, 2) contrary to prior expectations, the growth in GNP, a proxy for industrialization and urbanization, did not seem to impact the wheat area significantly, 3) wheat yield showed a significant upward trend in all regions over time, depicting combined impacts of increased chemical fertilizer use, expansion of irrigated areas, increased investment, and other technological improvements, and 4) Chinese wheat production is projected to range from 132.33 to 139.78 million metric tons for year 2005 under three alternate scenarios. Given these projections, China is expected to continue importing at least 9.5 million metric tons of wheat per year through 2005. Annual Chinese wheat imports could reach 16.9 million metric tons by 2005 if China completely liberalizes the wheat sector after joining WTO.

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An Analysis of China's Wheat Production, Projections and Implications for Imports

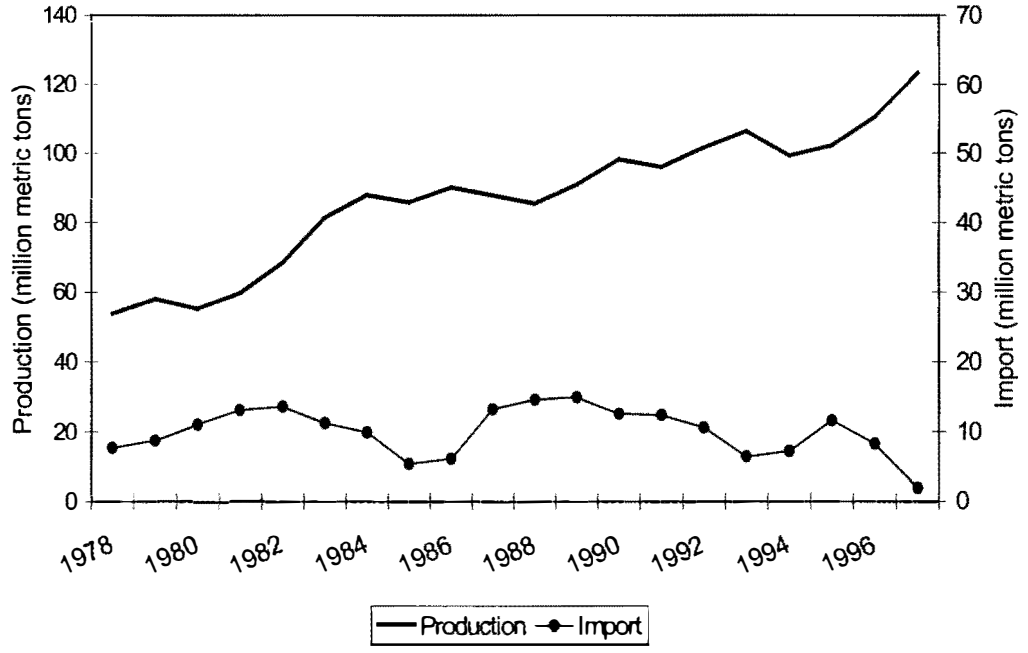
1. Introduction

Wheat imports into China have fluctuated greatly during the last two decades, reaching a historical high of 13.53 million metric tons (mmt) in 1982 and then dropping to 5.38 mmt in 1985 (CSB). Chinese wheat imports set a new record at 14.88 mmt in 1989, followed by the import of only 6.42 mmt in 1993. Wheat imports into China again increased to 11.59 mmt in 1995 and then dropped to 1.86 mmt in 1997. China's role as an erratic buyer in the world wheat market over last two decades is primarily the result of fluctuations in China's domestic wheat production (Figure 1).

Following reforms implemented in 1978, wheat production in China increased at an average annual rate of 10 percent during 1978-84, which in turn reduced China's demand for imported wheat after 1982. However, during 1985-94, the yearly growth in Chinese wheat production was generally lower (negative in some years), while domestic consumption continued to increase. Consequently, annual wheat imports into China reached a record high in 1989.

In response to widespread concerns regarding China's capacity to produce enough grain to meet growing domestic consumption, a new grain policy, commonly known as the "grain-bag" policy, was initiated in early 1995. The goal of the "grain-bag" policy was to create conditions for increased grain self-sufficiency (Crook 1997). Chinese wheat production did increase during the three years following the implementation of this policy (1995-1997).

Fig 1. Chinese Wheat Production and Import, 1978-1997.



There is a great deal of uncertainty about the Chinese role in world wheat trade. Brown (1995) argued that Chinese food needs would be so large that the rest of the world would also feel the impact of world-wide foodstuff shortage in the 21st century. Koo, et al (1996) projected that Chinese wheat yield for 2005 would be 3.78 metric ton (mt) per hectare, an increase of 10.9 percent over the 1993 yield. They projected that Chinese imports would be between 8 and 25 mmt in 2005. Carter and Zhong (1991) forecasted that China's future grain imports (including wheat) would be large. On the other hand, Rozelle and Huang (1998) projected more optimistic levels of Chinese wheat production and concluded that China would be neither a large importer nor a large exporter of wheat in the near future. The objective of this paper is to project wheat production in China for years 1998-2005, compare our forecasts to those reported in earlier studies, and draw some implications concerning Chinese wheat imports during this period.

2. Defining Geographic Regions of China

Geographic conditions and suitability of land for growing wheat vary greatly in China. Accordingly, for the purpose of this study, China was divided into seven regions with relatively homogeneous geographic characteristics and cropping patterns (Figure 2). The regional importance of wheat in terms of area planted and production is depicted in tables 1-3. A brief description of these regions follows.

Region 1 is located in the north and northeast of China. It includes the provinces of Helongjiang, Jilin, Liaoning, and Inner Mongolia, with humid climate and snow-forests. This is mainly a

Fig 2. Geographic Regions of China.

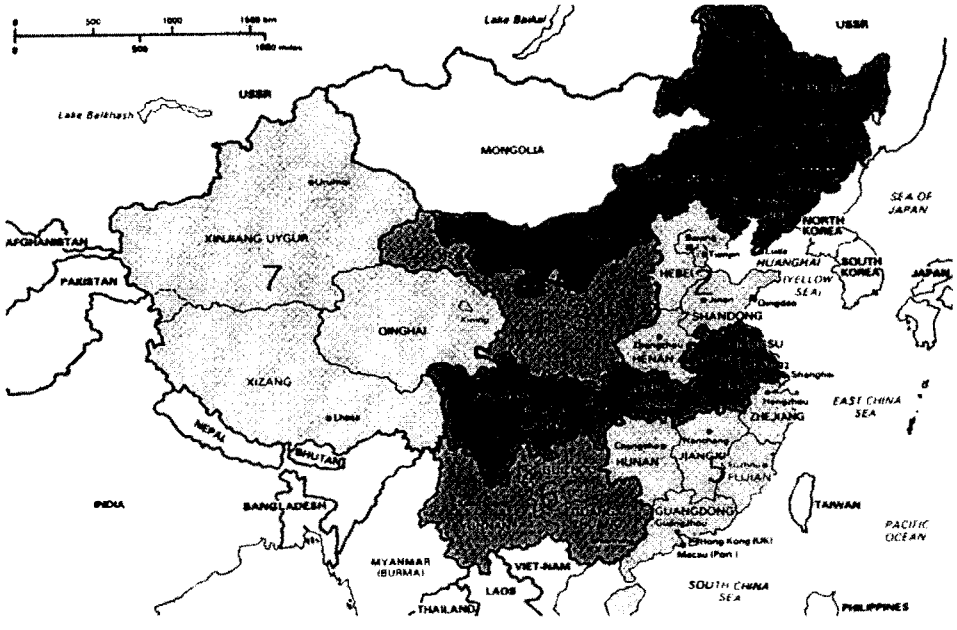


Table 1. Proportion of Land allocated to Major Grains in China, 1995-1997 Average.

Region	Total Grain Area (mil ha)	Proportion of Grain Area Under			
		Wheat	Rice	Corn	Soybeans
1	18.894	13.1%	11.8%	40.5%	20.9%
2	24.931	47.4%	3.4%	30.1%	7.6%
3	10.752	38.9%	2.1%	21.5%	10.7%
4	26.732	29.5%	37.3%	11.9%	6.6%
5	18.014	3.4%	77.4%	2.2%	5.3%
6	10.284	12.3%	39.9%	21.2%	11.0%
7	2.233	55.9%	3.5%	20.2%	5.9%
China	111.840	26.4%	28.1%	21.2%	9.8%

Source: Data from the Chinese Statistical Yearbooks (1996-98).

Table 2. Area Planted under Major Grains in China, by Region, 1995-2005 Avreage.

Region	Wheat		Rice		Corn		Soybeans	
	Area (mil ha)	Share	Area (mil ha)	Share	Area (mil ha)	Share	Area (mil ha)	Share
1	2.479	8.4%	2.13	6.8%	7.651	32.3%	3.955	36.0%
2	11.819	40.1%	0.84	2.7%	7.515	31.7%	1.892	17.2%
3	4.187	14.2%	0.23	0.7%	2.315	9.8%	1.151	10.5%
4	7.889	26.7%	9.972	31.9%	3.176	13.4%	1.759	16.0%
5	0.618	2.1%	13.941	44.5%	0.392	1.7%	0.96	8.7%
6	1.27	4.3%	4.104	13.1%	2.181	9.2%	1.128	10.3%
7	1.248	4.2%	0.078	0.2%	0.452	1.9%	0.131	1.2%
China	29.509	100%	31.295	100%	23.682	100%	10.972	100%

Source: Data from the Chinese Statistical Yearbooks (1996-98).

Table 3. Production of Major Grains in China, by Region, 1995-1997 Average.

Region	Wheat		Rice		Corn		Soybeans	
	Prod.(mmt)	Share	Prod.(mmt)	Share	Prod.(mmt)	Share	Prod.(mmt)	Share
1	6.83	6.1%	13.78	7.1%	42.42	32.5%	7.04	38.7%
2	55.13	49.2%	5.80	3.0%	36.7	28.1%	3.15	17.3%
3	11.56	10.3%	1.50	0.8%	9.90	7.6%	1.19	6.5%
4	29.13	26.0%	70.83	36.6%	29.63	22.7%	3.33	18.3%
5	1.53	1.4%	78.88	40.7%	1.31	1.0%	1.70	9.4%
6	2.60	2.3%	22.38	11.6%	7.69	5.9%	1.49	8.2%
7	5.23	4.7%	0.51	0.3%	2.73	2.1%	0.28	1.5%
China	112.01	100%	193.68	100%	130.38	100%	18.18	100%

Source: Data from the Chinese Statistical Yearbooks (1996-98).

corn and soybean growing area. In recent years, 13 percent of grain acreage in the region has been planted under wheat, accounting for 6 percent of the domestic wheat production.

Region 2, also in northern China, includes the metropolises of Beijing and Tianjin and the provinces of Hebei, Henan, and Shandong. This region has dry microthermal climate as well as snow covered forests. In recent years, 47 percent of this region's grain acreage has been under wheat, producing 49 percent of Chinese wheat. Corn is the other important grain of the region.

Region 3 is in west central China and includes the provinces of Shanxi, Shaanxi, Ningxia, and Gansu. This region has dry climate and accounts for 10 percent of China's wheat production.

Region 4 is in the middle of China and includes the provinces of Jiangsu, Anhui, Hubei, and Sichuan with mainly humid subtropical climate. Rice and wheat are the major crops in this region. This region accounts for 26 percent of China's wheat production.

Region 5 includes the southeast provinces of Zhejiang, Jiangxi, Fujian, Hunan, Guangdong, and the metropolis of Shanghai. This region has humid subtropical, climate and the predominant crop in the region is rice. Wheat production in the region is very limited, and accounts for about 1 percent of the national production.

Region 6, in southwest China, includes provinces of Guangxi, Guizhou, and Yunnan and has humid subtropical climate. Rice and corn are the main grain crops. Wheat production accounts for 2 percent of national wheat production.

Region 7, located in the west, includes Tibet, Xianjiang, and Qinghai. With mostly desert and arid climate, this region has limited grain production. Neverthless, this region accounts for 5 percent of Chinese wheat production.

3. The Model

A seven region Chinese wheat production model was specified as follows:

$$AREAti = \alpha 1i + \alpha 2i\ RGDPti + \alpha 3i\ RWP(t-1) + \alpha 4i\ GPOLt + \alpha 5i\ AREA(t-1)i + ut i \quad (1)$$

$$YLDti = \beta 1i + \beta 2i\ TRENDti + \beta 3i\ GPOLt + vti \quad (2)$$

$$PRODti \equiv AREAti * YLDti \quad (3)$$

$$PRODt \equiv \sum_{i=1}^{7} PRODti \quad (4)$$

Where t = 1, 2, . . . , 17 (years),
i = 1, 2, . . . , 7 (regions),
u = random error, $N(0,\sigma^2)$,
v = random error, $N(0,\sigma^2)$,
AREAt = wheat planted area in year t(1,000 hectare),
RGDPt = real gross domestic product in year t (100 million 1978 yuan),
GPOLt = dummy variable for the "grain-bag" policy, 0 for 1981-1994 and 1 for 1995-1997,
RWPt-1 = real national wheat procurement price in year t-1 (1978 yuan/100 kg),
YLDt = wheat yield per hectare in year t (kg/ha),
TRENDt = trend (1981 = 1, 1982 = 2, . . . , 1997 = 17), and
PRODt = national wheat production in year t (10,000 metric tons).

The expected relationship between wheat planted area and the real GDP, a proxy for industrialization and urbanization, is negative. The wheat procurement price and the lagged wheat planted area are expected to have positive effects on the wheat planted area. The time trend[2], a proxy for technical improvement over time, is expected to have a positive effect on wheat yield. The impact of the "grain-bag" policy on wheat planted area and wheat yield is expected to be positive.

[2] Chemical fertilizer use, irrigated area, and national government expenditure on agriculture showed a high degree of positive correlation with the time trend in initial runs. Accordingly, the time trend was included in the yield equation to capture the combined effect of changes in chemical fertilizer use, the irrigated area, the national government agricultural expenditure, and other technological changes on wheat yield over time.

The regression model is assumed to be linear in the parameters. The independent variables are assumed to be non-stochastic and not identical throughout the sample period. The random error terms, u and v, are assumed to be unrelated. It is further assumed that the model is compatible with the assumptions of the classical linear regression model (Gujarati 1995).

4. Data and Procedures

The annual data used in this study were obtained from the China Statistical Yearbooks for years 1982-1998. Since the regions defined in this study are different than the administrative regions in China, the regional wheat area and production data were obtained by combining the appropriate province level data. The regional contributions to the GDPs for years 1981 to 1990 were calculated from national GDP data, assuming that the regional growth rates were similar to the national growth rates during these years. The regional data on wheat procurement prices and the government expenditures on agriculture were not available. Assuming that the regional growth rates for these variables were similar to the national growth rates over the sample period, the national data for these variables were used as a proxy for the regional data. The GDPs, the regional contributions to the GDP, the wheat procurement prices, and the national government expenditure on agriculture were deflated using a GDP deflator.

The model was estimated with the ordinary least squares (OLS) method using the Statistical Analysis System (SAS) for windows release 6.12 (1996). First, the OLS regressions of the model were run with the annual data from 1981-1997. Tests for detecting multicollinearity and autocorrelation were conducted. Second, in-sample validations of estimates were completed and the prediction errors of the models were computed utilizing the

root-mean-square (rms) percent error and Theil's *inequality coefficient (U)*[3]. Since the "grain-bag" policy was instituted during the last three years in the sample period (1995-1997), the out-of-sample validation was forgone in order to study the impact of the "grain-bag" policy. Third, the values for explanatory variables were extrapolated beyond the sample period (i.e.1998-2005) under alternative scenarios. Finally, the predictions for China's wheat production for years 1998-2005 were obtained under alternative scenarios.

5. Estimated Wheat Area Equations

The results of the regional wheat planted area equations are summarized in table 4. The coefficients of regional contributions to the real gross domestic production (RGDP), a proxy for industrialization and urbanization, are insignificant for all except regions 6 and 7. This indicated that industrialization and urbanization did not have any significant impact on wheat area in these regions. The coefficients for both regions 6 and 7 are statistically significant at the 1 percent level. However, the coefficient for region 7 has a positive sign, which can't be explained.

The positive coefficients of the real wheat procurement price, RWP(t-1), are statistically significant at the 10 percent or lower levels for regions 2-4. This suggests that the increases in the wheat planted area are associated with the increases in the RWP(t-1) in these regions.

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[3] The formulas for these statistics are as follows:

$$\text{rms percent error} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^s - Y_t^a}{Y_t^a}\right)^2} \qquad U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s\right)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^a\right)^2}}$$

Where Y_t^s = simulated value of Y_t, Y_t^a = actual value, T = number of periods in the simulation.

The rms is the percentage of the root-mean-square simulation error. It is a quantitative measure of fitness of individual variables to their corresponding data. The lower rms simulation errors are, the better the simulation fit is. Theil's *inequality coefficient (U)* is a simulation statistic useful to evaluate the overall forcasting performance in sample and out of sample. When $U = 0$, there is a perfect fit in simulation; when $U = 1$, the forecasting performance of the model is poor. See Pindyck and Rubinfeld (1991).

Table 4. The OLS Regression Coefficients for Regional Wheat Area Equations.

	Estimated Coefficients						
Region	INTERCEPT	RGDP	RWP(t-1)	GPOL	AREA(t-1)	R-square	F
1	497.088	-0.077	28.700	-325.708	0.508*	0.575	4.051**
	(.421)	(-.487)	(1.283)	(-.941)	(2.127)		
2	529.293	0.168	50.319*	-662.053	0.774***	0.844	16.284***
	(.212)	(1.052)	(2.061)	(-1.456)	(3.557)		
3	1804.896*	0.041	17.953**	-289.550**	0.443**	0.731	8.167***
	(2.071)	(.325)	(2.603)	(-2.381)	(2.183)		
4	2932.295*	0.122	36.596**	-462.989	0.429*	0.734	8.265***
	(2.120)	(1.233)	(2.205)	(-1.304)	(1.967)		
5	143.696	-0.021	8.423	-73.552	0.518**	0.86	18.41***
	(.564)	(-1.265)	(1.743)	(-.898)	(3.052)		
6	-112.655	0.385***	5.252	-169.85**	0.713***	0.968	90.028***
	(-.552)	(4.307)	(1.138)	(-2.313)	(6.062)		
7	862.312*	-1.200***	9.628	18.114	0.316	0.906	28.77***
	(1.984)	(-3.088)	(1.705)	(.192)	(1.083)		

Note: 1) Values in parentheses are *t*-ratios. 2) *, **, and *** indicate significant at 10%, 5%, and 1% level, respectively.

Contrary to the expectations, the coefficients of the "grain-bag" policy (GPOL) are either insignificant or negative for all regions except region 7. Coefficients of regions 3 and 6 are statistically at the 5 percent level. The positive coefficients of the lagged wheat planted area, AREA(t-1), are statistically significant at 10 or lower percent levels for all regions except region 7, indicating that only partial adjustment in the wheat area planted take place in the one year.

Regression diagnostics indicated the presence of some multicollinearity and the lack of serial autocorrelation in these equations[4]. The presence of some multicollinearity, however, should not affect the predictive performance of the model.

[4]VIFs and CIs statistics were used for detecting the presence of multicollinearity. "Runs Test", a non–parametric test, was used to detect the presence of serial autocorrelation.

The regional wheat planted area regressions show a reasonably good fit to the data explaining 58 to 97 percent of the regional variations. The regions 2, 3, and 4 account for 86 percent of the wheat planted area in China. The wheat area equations for each of these regions explain at least 73 percent of the variations.

6. Estimated Wheat Yield Equations

The statistical estimates of the regional wheat yield equations are presented in table 5. The time trend coefficients are positive and statistically significant at 10 or lower percent levels for all regions, indicating that wheat yields per hectare have increased in all seven regions over

Table 5. The OLS Regression Coefficients for Regional Wheat Yield Equations.

	Estimated Coefficients					
Region	INTERCEPT	TREND	GPOL	R-square	F	*d*
1	1320.188***	90.583***	-15.742	0.866	45.223***	1.515
	(12.306)	(7.197)	(-.097)			
2	2620.032***	114.823***	203.361	0.895	59.57***	0.948
	(19.996)	(7.469)	(1.029)			
3	2180.766***	40.464**	-66.517	0.462	6.015***	1.523
	(17.872)	(2.826)	(-.362)			
4	2937.833***	36.729*	162.970	0.454	5.826***	1.210
	(19.139)	(2.039)	(.704)			
5	1880.97***	31.138**	98.684	0.594	10.228***	2.815
	(20.413)	(2.880)	(.710)			
6	1187.159***	57.844***	-65.289	0.661	13.649***	1.529
	(9.993)	(4.150)	(-.365)			
7	1729.880***	158.843***	-84.030	0.985	446.061***	1.165
	(29.410)	(23.017)	(-.947)			

Notes: 1) Values in parentheses are *t*-ratios. 2) *, *, and *** indicate signifiance at 10%, 5%, and 1% levels, respectively.

time. The increase in yield depicted by trend is actually due to increased use of chemical fertilizer, irrigation, and investments in agriculture and other technological improvements.

The coefficients of the "grain-bag" policy (GPOL) are mixed and none of the coefficients is significant. This suggests that it may be too early to draw any inference with regard to the impact of the "grain-bag" policy on China's wheat yield. Regression diagnostics indicated the absence of serious multicollinearity or autocorrelation problems in the yield equations[5].

The regional wheat yield regressions show a reasonably good fit to the data, explaining 45 to 99 percent of the regional variations. Regions 2,3, and 4 collectively account for 86 percent of the wheat production in China. The yield equations for regions 2, 3, and 4 explained 90, 46, and 45 percent of the relevant regional variations, respectively.

7. Wheat Production Estimates and In-Sample Validation

The wheat production estimates for each of seven regions were obtained from Equation 3. Regional wheat production simulations seem to reproduce the long-term wheat production trends. Some short-term fluctuations in wheat productions are not reproduced well and some of the turning points are missed.

The predictive performance of the model for each region was evaluated by using the rms percent error and the Theil's *inequality coefficient* (*U*). The results of these statistics are reported in table 6. For the three largest wheat-producing regions (regions 2, 3, and 4), the rms percent errors are relatively low and the *Us* are reasonably close to zero. Thus, the predictions for these three regions are quite reliable.

[5]VIFs and CIs statistics were used for detecting the presence of multicollinearity. The Durbin-Watson *d* statistics indicate that there is no autocorrelation problem at the 1 percent level in the yield equations for regions 1, 3, and 6, and some autocorrelation problem at the 5 percent level in the equation for region 2. The *d* statistics for regions 4, 5, and 7 are inconclusive at the 5 percent level.

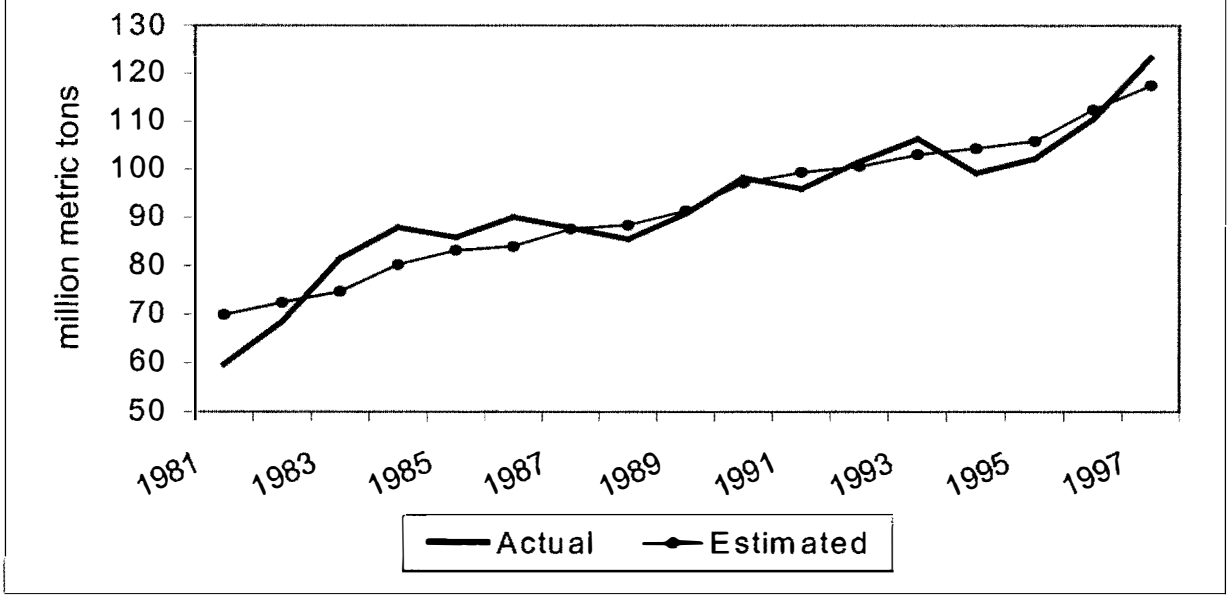
Table 6. Summary Statistics for In-Sample Validation.

Region	Variable	Mean(1)	rms percent error	U
1	AREA	2833.22	7.33%	0.035
	YLD	2132.65	8.46%	0.040
	PROD	599.83	14.16%	0.066
2	AREA	11379.32	2.00%	0.010
	YLD	3689.33	6.76%	0.028
	PROD	4228.51	8.17%	0.031
3	AREA	4354.81	1.44%	0.007
	YLD	2533.20	7.97%	0.039
	PROD	1103.55	8.79%	0.041
4	AREA	7738.30	1.74%	0.009
	YLD	3297.15	8.64%	0.037
	PROD	2555.35	8.59%	0.036
5	AREA	792.78	5.31%	0.027
	YLD	2178.63	7.76%	0.034
	PROD	170.84	7.70%	0.038
6	AREA	960.85	4.57%	0.020
	YLD	1696.23	13.36%	0.056
	PROD	169.18	14.64%	0.052
7	AREA	1415.27	3.43%	0.015
	YLD	3144.64	3.43%	0.015
	PROD	435.39	6.62%	0.027
China	AREA	29474.70	1.60%	0.008
	PROD	9262.58	6.09%	0.025

Notes: 1) AREA in 1,000 ha, YLD in kg/ha, and PROD in 10,000 meteric tons.

The prediction errors for region 7 are the lowest. Even though not a major wheat producing area, wheat is the major grain crop in this region. The prediction errors for region 5, which produces about 1% of the domestic wheat production, are reasonable. Regions 1 and 6 have the large rms percent errors and the U statistics. Since wheat is not a major crop in these two regions, a high degree of prediction accuracy for these regions is not crucial for overall reliability of the model's wheat production forecasts for China.

Figure 3. Actual and Estimated Wheat Production in China.



Estimates for Chinese wheat production are obtained by summing the regional estimates. The rms percent error and the *Us*, reported in table 6 indicate fairly good tracking of the aggregate Chinese wheat production by the model. In general, the simulated Chinese wheat production tracks well the actual historic wheat production data (figure 3).

8. Alternative Scenarios for China's Wheat Production Projection

Given the specified model, projecting Chinese wheat production beyond the sample period hinges upon assumptions about future levels of the real gross domestic product (RGDP), the real wheat procurement price (RWP), and the wheat yield (YLD). Regressing the RGDP over time showed that the Chinese RGDP increased by 10.25 billion 1978 yuan per year with the standard deviation of 0.62 billion 1978 yuan, which translates to an average annual increase of 4.10 percent during the sample period. Regressing the RWP over time showed a lack of any

upward or downward trend in the RWP during the sample period[6]. For the purpose of projecting Chinese wheat production beyond the sample period, three[7] alternative scenarios were specified. These scenarios are summarized in table 7.

Table 7. Alternative Assumptions for Forcasting China's Wheat Production, 1998-2005.

	Scenario 1	Scenario 2	Scenario 3
RGDP increase (annual change)	at trend (+4.1%)	at trend+2std (+4.6%)	at trend (+4.1%)
RWP increase (annual change)	no change (0.0%)	decreasing (-0.5%)	decreasing (-2.0%)
YLD increase (annual change)	at trend (+1.2%)	at trend (+1.2%)	at trend (+1.2%)

Notes: 1) std = Standard deviation, 2) RWP in 1997 was 40.17 1978 yuan/100 kg or about 168.76 US dollars per meteric tons.

Scenario 1.

It is assumed that the RGDP will follow the trend. Under this scenario, the RGDP is assumed to grow at an annual rate of 4.1 percent during the projection period and reach 296.6 billion 1978 yuan in 2005. Consistent with the declared goal of the Chinese government to keep the wheat procurement price stable, the RWP is assumed to remain at the 1997 level in real terms (i.e., 40.14 1978 yuan/100 kg). Wheat yield is assumed to follow the linear trend.

[6] The nominal wheat procurement prices in China increased slowly during the early 1980s and substantially during the periods of 1988 to 1989 and 1994 to 1996. After the mid-1990s, higher domestic wheat production almost matched the domestic demand. Consequently, in 1997 the Chinese government adjusted the wheat procurement price downward by more than 10 percent compared to the 1996 level. On an average, the changes in the nominal wheat procurement price offset the inflation during the sample period.

[7] Two additional scenarios were also investigated: 1) the RGDP increasing at the trend plus two standard deviations, and the RWP staying at the 1997 level; 2) the RGDP increasing at the trend and the RWP decreasing at 0.5 percent annually. The projection results of these two scenarios were very close to scenarios 1 and 2. Accordingly, these additional scenarios were dropped.

Scenario 2

The RGDP is assumed to grow at the trend plus two standard deviations (i.e. at an average annual rate of 4.6 percent). Accordingly, the aggregate RGDP is assumed to increase by 11.48 billion 1978 yuan per year during the projection period to reach 306.4 billion 1978 yuan by 2005. The RWP is, however, assumed to decrease by 0.5 percent annually[8], and reach 38.76 1978 yuan/100 kg by 2004 under this scenario. Wheat yield is assumed to follow the linear trend during the projection period.

Scenario 3

Under this scenario the RGDP is assumed to follow the long-term linear trend while the RWP is to decrease by about 2 percent per year from 1997 level to reflect complete opening up of the Chinese grain sector[9]. Under this scenario, the Chinese wheat procurement price in 1978 yuan (RWP) in year 2004 is not to exceed the world wheat price by more than the 25 US dollars per metric ton - the cost of transporting imported wheat into China[10]. Accordingly, the Chinese wheat procurement price is to reach 34.85 1978 yuan/100 kg by 2004[11]. Under this scenario, wheat yield, is assumed to increase at the long-term trend level.

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[8] Increases in the wheat price in real terms are not likely during the projection period, especially after a drop of 10 percent in the nominal wheat price in 1997. Further, the Chinese wheat procurement price was equivalent to 168.76 US dollars per metric ton in 1997, which was significantly higher than the world price. For example, in 1997 the Gulf wheat price was 151 US dollars per metric ton (CSB and ERS, 1988). Rozelle and Huang (1998) assumed the wheat procurement price to decrease 0.5 percent annually. In order to facilitate the comparison of the result from this study with Rozelle and Huang's, in this scenario the RWP is assumed to decrease at 0.5 percent per year.

[9] After joining the World Trade Organization (WTO), China's grain sector is likely to face fierce competition from the world grain market. According to the Food and Agricultural Policy Research Institute (FAPRI) the US (Gulf), Canadian and Australian wheat prices in 2004 would be 146, 141 and 115 US dollars per metric ton, respectively. Due to the lowest price and geographical proximity, Australia could emerge as a major supplier of wheat to China.

[10] Based on the average US-China transportation cost. This information was obtained by personal communication with Mr. Jianqiang Lou from Sparks Companies, Inc. The actual Australia-China transportation cost may be different.

[11] The assumption ignores changes in the foreign exchange rate.

According to China's official estimation, the RGDP is expected to double during 2000-2010[12]. This implies an annual growth rate of 7.2 percent in the RGDP from 2001-2005. This official estimate seems to be quite optimistic. In this study, relatively more realistic RGDP growth levels are assumed (i.e. at 4.1 percent in scenarios 1 & 3, and 4.6 percent, in scenario 2). Scenario 2 seems to be the most likely as China's GDP is expected to grow strongly. Due to political difficulties in instituting large decreases in the wheat procurement price, Scenario 3 seems less likely unless China opens its wheat market after joining WTO in the near future.

9. Projection Results

The wheat planted area is projected to increase by 0.37 percent annually over the projection period under scenario 1 and reach 30.98 million hectares by 2005 (table 8). Under scenario 2, the area is also projected to increase to 30.77 million hectares (an increase of 0.28 percent per year) over the projection period (table 8). As compared to scenario 1, the scenario 2 assumed a slightly larger increase in the RGDP and a small decrease in the RWP. Since both of these variables are positively related with the wheat planted area, their impacts on the wheat area offset each other. Accordingly, the wheat planted area under scenario 2 is 0.21 million ha lower than under scenario 1. Under scenario 3, the wheat planted area is projected to decrease by about 0.25 percent annually over the projection period to 29.33 million hectares by 2005. Wheat yield is projected to follow the long-term trend and increase to 4.51 metric ton/ha with an average annual growth rate of about 1.2 percent under all three scenarios.

Wheat production is projected to be 139.78 mmt by 2005 under scenario 1 with an average annual growth rate of 1.58 percent. Under scenario 2, wheat production is projected to

[12] See Ribao (2000), for details on the Chinese Central Government's Tenth Five-Year Plan of National Economic and Social Development.

increase at a slightly less annual rate of 1.58 percent and reach 138.86 mmt by 2005. Because of a decrease in wheat planted area, the wheat production under scenario 3 is projected to be 132.33 mmt by 2005 (an average annual increase of 0.89 percent during the projection period).

The wheat planted areas in regions 1, 5, and 7 are projected to decrease under all scenarios. Specifically, wheat planted area is projected to decrease by 0.30-0.57 million hectares in region 1, 0.19-0.27 million hectares in region 5, and 0.33-0.40 million hectares in region 7. Wheat production in regions 5 and 7 are projected to decrease over the period under all three scenarios (except for region 7 under scenario 1). The production in region 1 is projected to decrease under scenario 3. However, under scenarios 1 and 2, the production in region 1 is projected to increase mainly due to yield increases.

Table 8. Projected Wheat Production in China for 2005.

	AREA (million ha)	YLD (meteric ton/ha)	PROD (million mt)
Actual (1997)	30.06	4.10	123.29
Projection (2005)			
Scenario 1	30.98	4.51	139.78
Scenario 2	30.77	4.51	138.86
Scenario 3	29.33	4.51	132.33

Notes: 1) 1997 data are from 1998 China Statistical Yearbook. 2) AREA times YLD may not exactly equal to PROD due to rounding.

In region 3, the wheat planted area is projected to decrease first and then increase slightly after 2002 under scenario 1, while it is projected to decrease under scenarios 2 and 3. It is projected that wheat area in this region will decrease 0.06-0.22 million hectares during the period. Under all three scenarios, the wheat production in region 3 is projected to decrease first in 1998 and then increase during the remaining projection period.

In major wheat production areas (regions 2 and 4), the wheat area, yield and production are projected to increase under all three scenarios. Similarly, wheat area, yield, and production are also projected to increase in region 6 under all scenarios.

10. Comparison of Projection Results with Previous Studies

The projections of Chinese wheat production in this study are higher than the previously reported studies (table 9). Three studies of wheat production reviewed earlie in this paper were Brown (1995), Koo et al. (1996), and Rozelle and Huang (1998). Since Brown (1995) did not provide any specific projections, we will only compare our projections with the other two studies.

Table 9. Comparison of Forecast Results With Other Studies.

		Rozelle	This Study		
	Koo et al.	and Hunag	Scenario1	Scenario2	Scenario3
Sample Period	1975-1993	1976-1995	1981-1997	1981-1997	1981-1997
Projection Period	1994-2005	1996-2020	1998-2005	1998-2005	1998-2005
Assumptions:					
GDP growth	6.60%		trend (4.1%)	trend+2SDs (4.6%)	trend (4.1%)
Yield growth	trend (0.8%)		trend (1.2%)	trend (1.2%)	trend (1.2%)
Wheat Price Change/year	-	-0.50% - 0%	0%	-0.5%	-2%
Investment in agriculture	-	2.5-4.5%	-	-	-
Environmental factors	-	0.2%	-	-	-
Projections for 2005:					
Planted Area (milion ha)	28.68-30.52	-	30.98	30.77	29.33
Yield (metric ton/ha)	3.28-3.74	-	4.51	4.51	4.51
Production (mmt)	98.09-111.81	112.39-118.41	139.78	138.86	132.33

The wheat planted area forecasts of 29.33 to 30.98 million hectares in this study are comparable with the projection of Koo et al. (28.68 to 30.52 million hectares) by 2005.

However, the production forecasts for year 2005 in this study are higher than those of Koo et al. by 20.52 to 41.75 mmt. This is mainly because of higher wheat yield projections in this study. Their sample period was from 1975 to 1993. In the 1970s wheat yield in China was relatively low (less than 2 metric ton/ha). The sample period for this study is from 1981 to 1997. Wheat yield in China increased steadily after 1980. Therefore, the annual increase depicted in the wheat yield trend in this study is higher. In this study, the wheat yield increase is 80.48 kg/ha or 2.56 percent annually at mean. This translates into 1.2 percent growth in yield during the projection period.

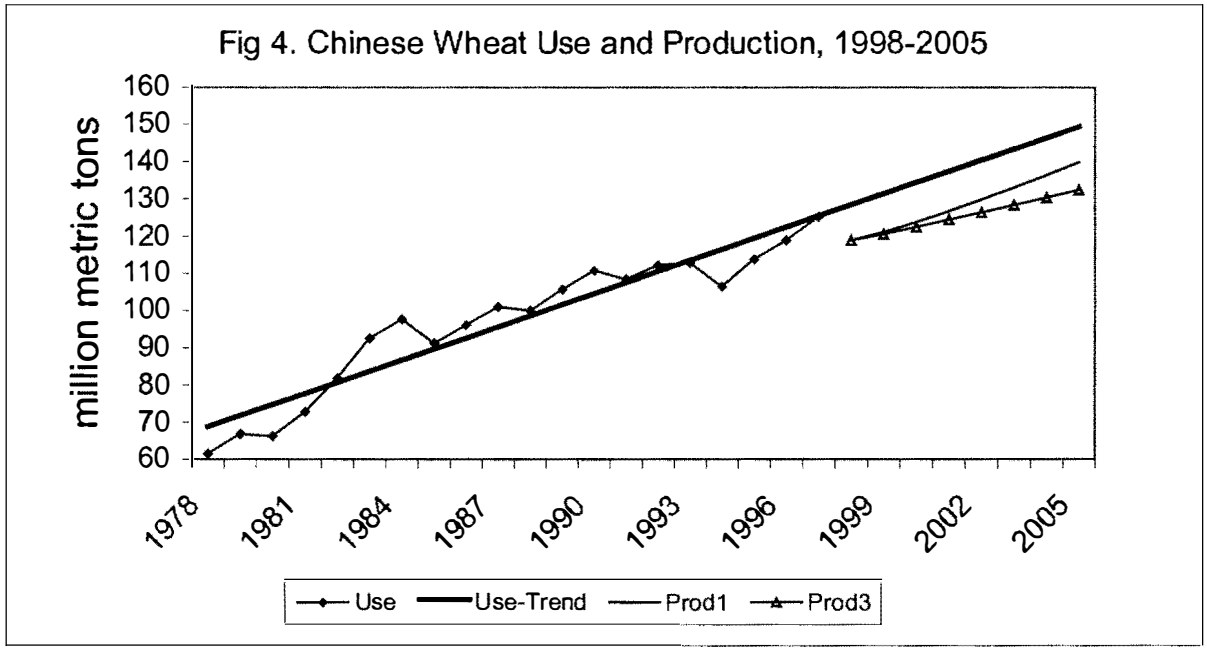
Compared with Rozelle and Huang's projections, wheat productions in this study are 13.92 to 27.45 mmt higher. This difference is because of different assumptions in the two studies. First, Rozelle and Huang specifically modeled the negative impact of environmental factors (including salinity and erosion) on China's wheat production. This study did not model the impacts of environmental factors on wheat production. Second, Rozelle and Huang assumed that investment in agriculture would increase at 2.5-4.5 percent annually during 1996-2020, whereas the average annual growth rate of investment in agriculture was 5.6 percent during 1981-1997. In this study, the wheat yield is assumed to follow the trend implying 1.2 percent growth during the projection period. It is reasonable to expect that the Chinese government will continue to emphasize self-sufficiency in food production and that the investment in agriculture, and consequently the grain yields will continue to follow the historic trend.

11. Implications for Chinese Wheat Imports

Given these projections for production, what are the implications for the Chinese wheat imports during the years 1998-2005? Obviously, the import quantities depend on domestic production and demand. The analysis of domestic Chinese wheat demand is complicated by the

fact that reliable historic data on Chinese wheat stock changes are not available. Under the circumstances, it was assumed that the domestic wheat use is equal to the domestic production and net imports. Assuming further that the annual Chinese domestic wheat use follows a linear trend over time, Chinese domestic wheat use is projected to be 128.37 mmt in 1998 and 149.23 mmt in 2005 (See Use Trend in Figure 4).

Chinese wheat import levels are estimated by comparing projected use with projected



domestic production under alternative scenarios. Under scenario 1, Chinese wheat production is projected to be 118.82 mmt in 1998 and 139.78 mmt in 2005 (Prod-1 in Figure 4). Accordingly, under scenario 1, wheat imports into China are estimated to be 9.55 mmt in 1998 and 9.45 mmt in 2005 (the difference between the Use-Trend and Prod1 in Figure 4). Chinese wheat production projections under scenario 2 are very similar to those under scenario 1[13]. Both scenarios 1 and 2 assume continuation of current policies under which Chinese wheat market is

[13] Under scenario 2, Chinese domestic wheat production is projected to be 118.86 mmt in 1998 and 138.86 in 2005,. Accordingly the Chinese wheat imports are estimated to be 9.51 mmt in 1998 and 10.37 mmt in 2005.

protected from the world wheat market, and higher degree of self-sufficiency in grain production continues to be a policy goal.

Under scenario 3, it is assumed that the Chinese wheat market will be progressively liberalized and that the Chinese wheat procurement price in 2005 will differ from the world wheat price only by the cost of transporting imported wheat to China. However, the demand side impact of lowering the wheat price is not included in the analysis. Under this scenario, Chinese wheat production is projected to be 118.82 mmt in 1998 and 132.33 mmt in 2005. Under this scenario, Chinese wheat imports are expected to grow from 9.55 mmt in 1998 to 16.90 mmt in 2005 (the difference between the Use-Trend and Prod3 in Figure 4).

12. Summary and Conclusions

Wheat production in China was analyzed using a seven-region model estimated by the Ordinary Least Squares method. Three of these regions (2, 3, and 4) accounted for eighty percent of wheat planted area and eighty-five percent of wheat production in China during 1995-1997. Key findings of the Chinese wheat production analysis are as follows:

1) Real domestic production, a proxy for industrialization and urbanization, showed no significant impacts on wheat planted areas in major wheat producing regions and significant but conflicting impacts in two regions with only limited wheat production.
2) The wheat procurement price, adjusted for inflation and lagged by one year, showed a significant impact on wheat planted areas in the three largest wheat producing regions.
3) Contrary to the prior expectations, the "grain-bag" policy showed a significant negative impact on wheat planted area in two regions. Similarly, the "grain-bag" policy failed to show any significant impact on regional wheat yields in any region. Since the "grain-bag"

policy regime was put in place during the last three years of the period analyzed, it is difficult to draw any conclusions with regards to the effectiveness of this policy.

4) The lagged wheat planted area showed significant positive impacts on the wheat planted area in all except one region. This confirms that the adjustments in the Chinese wheat planted area in response to exogenous factors are partial in nature.
5) Wheat yields showed significant positive trends in all seven regions over time, depicting combined impacts of increases in chemical fertilizer use, irrigated areas, investment in agriculture, and other technological improvements.

The regional yearly wheat production simulations for each of the seven regions were obtained by multiplying the regional planted area and the yield estimates, which seem to reproduce the respective long-term wheat production trends. The yearly Chinese wheat production simulations were obtained by summing the regional estimates, which also tracked well the historical Chinese wheat production data.

For Chinese wheat production projections for years 1998-2005, three alternative scenarios were specified. Wheat yield was assumed to grow at trend or at 1.2 percent per year during the projection period. These scenarios differ only in terms of rate of growth in real GDP and the real Chinese wheat procurement price. A brief description of these scenarios and projections of Chinese wheat production under these scenarios follows.

1) Under scenario 1, the real GDP is assumed to grow at trend (4.1 percent per year) and the real wheat procurement price is assumed to stay at 1997 level. Under this scenario, the Chinese wheat production is forecasted to grow from 123.29 million metric tons in 1997 to 139.78 million metric tons in 2005.

2) Under scenario 2, the real GDP is assumed to grow at trend plus two standard deviations (4.6 percent per year) and the real wheat procurement price is assumed to decrease at 0.5 percent per year. Under this scenario, the Chinese wheat production is projected to grow to 138.86 million metric tons by 2005.
3) Under scenario 3, the real GDP is assumed to grow at 4.1 percent per year and the real wheat procurement price is assumed to decrease at 2 percent per year to reflect complete opening of the Chinese wheat market after joining the WTO. Under this scenario, Chinese wheat production is projected to grow to 132.33 million metric tons by 2005.

Our projections of Chinese wheat production for year 2005 are 20.52 to 41.75 million metric tons higher than those of Koo et al. (1996). This is primarily due to the fact that their analysis was based on older data (1975-1993) with lower yields. They projected that yield for year 2005 will be in the range of 3.28 to 3.74 metric tons/ha while the actual wheat yield in 1997 was 4.10 metric tons/ha.

Similarly, our projections for Chinese wheat production for year 2005 are also 13.92 to 27.45 metric tons higher than Rozelle and Huang (1998). This difference is attributable to differences in assumptions. First, Rozelle and Huang (1998) specifically included the negative impacts of environmental degradation on their yields. Second, Rozelle and Huang (1998) assumed that investment in agriculture would increase at the rate of 2.5-4.5 percent annually during 1996-2020. In contrast, during the 1981-1997 period, the average annual growth rate of investment in agriculture was 5.6 percent. Our analysis assumed that the continuation of the yield trend, which implies 1.2 percent per year increase in the yield during the projection period.

Assuming that the annual Chinese domestic wheat use follows a linear trend over time, Chinese domestic wheat use is projected to be 149.23 mmt in 2005. Even under the current

policies, aiming at promoting higher grain self-sufficiency, China is expected to import about 10 mmt wheat annually during 1998-2005. Chinese wheat imports could reach 16.90 mmt by 2005 if China completely liberalizes the wheat sector after joining WTO.

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