China's Food Economy to the Twenty-First Century: Supply, Demand, and Trade

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and Mark W. Rosegrant

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Contents

Tables

Foreword

This is the nineteenth paper in the Food, Agriculture, and the Environment Discussion Paper series, a product of IFPRI's 2020 Vision initiative, which seeks to develop an international consensus on how to meet future world food needs while reducing poverty and protecting the environment. Jikun Huang, Scott Rozelle, and Mark W. Rosegrant here explore the factors that will determine China's supply and demand balances of grain through the year 2020.

Because of the country's sheer size, China's grain situation could have an enormous effect on the world's grain supply and prices. But researchers have not reached a consensus on just what China's grain balances are likely to be. In fact, projections of China's grain trade into the twenty-first century vary dramatically. While some researchers predict that the country's demand for grain imports is likely to shoot up and threatens to starve the world, others project that China will become an exporter of grain. Some of these studies, however, fail to consider some of the most important factors affecting China's future grain balances.

This paper accounts for the structural changes now taking place in China and thus offers a clearer picture of China's future. It suggests that China is not likely to become either an enormous importer or a large exporter of grain. Ultimately, though, China's grain balances will depend on decisions made by Chinese policymakers rather than natural resource constraints. As Huang, Rozelle, and Rosegrant show, the country's level of investment in agriculture will determine whether China will be buying or selling grain on world markets and could mean the difference between manageable trade in grain and a worldwide grain crisis.

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rojections of China's balances of grain into the twenty-first century vary greatly. Many Chinese economists have predicted that the country's capacity to produce grain will outpace demand in the next several decades (Chen and Buckwell 1991; Mei 1995). Large Chinese exports of grain in the future would cause great consternation among some of China's major trading partners because these exports could drive down world prices and reduce export revenues of other countries (Tuan 1994). Other analysts, however, have projected that China's imports may top 50 million metric tons in the mid-1990s (Yang and Tyers 1989), could reach 90 million metric tons by 2000 (Garnaut and Ma 1992), and could exceed 200 million metric tons by 2030 (Brown 1994).[1] Brown states that China's production will fall between 216 and 378 million tons short of meeting demand. According to Brown's analysis, the imports flowing into China to meet this shortfall, financed by the foreign exchange earnings of its booming export sector, will drain world supplies, force grain prices up, and deny less able countries the grain stock they need to feed their populations.

The range of net import predictions is perplexing. The consequences of China's emerging as either a major importer or a significant exporter could be enormous for world grain markets and prices. Hence, it is surprising that relatively little work has been done on the factors that will affect China's future demand and supply of grain. With only few exceptions (Fan, Cramer, and Wailes 1994; Carter and Zhong 1991), all major projections efforts have used assumed demand, supply, and trade elasticities and other parameters (ERS 1995; FAO 1991; World Bank 1990; Garnaut and Ma 1992; Chen and Buckwell 1991). Most projections models also consider only the effects of expected changes in population, income, and prices on demand and supply.

China, however, is experiencing rapid development and economic and social transformation. Its economy is industrializing at one of the fastest rates in the world. These forces are causing wrenching changes: market development, urbanization, environmental degradation, privatization, and budgetary stress (which affects national investment). These factors should be expected to have an impact on supply and demand that is as great as, if not greater than, traditional determinants. Some studies implicitly account for some of these structural changes (for example, by including an exogenous growth factor), but these studies usually lack transparency, making it impossible to validate or disaggregate the impact of specific factors.

This paper aims to help establish a more comprehensive, transparent, and empirically sound basis for assessing the future growth of China's food supply and demand balances. The paper first reviews previous efforts to project China's growth of supply, demand, and net deficit or surplus of grain and rice in the coming years. The first steps in creating a framework to assess China's future grain balances are to examine China's current grain balance sheet and to assess a series of factors, beyond income and prices, that may have important effects on Chinese grain demand and supply. A supply and demand projections model is developed, based almost entirely on econometrically estimated parameters. This model explicitly accounts for a series of important structural factors and policy variables, including urbanization and market development on the demand side, and technology, agricultural investment, environmental trends, and institutional innovations on the supply side. After reviewing the baseline assumptions and forecasts, the paper presents the results of the baseline projections. Then, alternative scenarios are examined under different rates of growth in income, population, and investment in research and irrigation, and policy implications are derived from the alternative scenarios.

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[1] All tons in this paper are metric tons.

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Alternative Projections of Grain Demand and Supply in China

Growth in grain output has played a big part in China's success in maintaining a low grain deficit. China's agricultural economy has grown steadily since the early 1960s, and after the reforms of the late 1970s, production and yield growth accelerated for seven years. Since the mid-1980s, growth in the grain economy has fallen to a pace below the average growth rate of the 1960s and 1970s but is still positive.

With steady production growth, fluctuating consumption levels have been a major determinant of the need to import. From the 1950s through the mid-1970s, consumption was held artificially low by Mao's self-sufficiency policies (Walker 1984). When China began its reform program in 1978, policymakers decided to allow a general increase in imports to relieve the constrained demand of consumers. Several years after import restrictions on wheat and other grains were relaxed, imports grew to nearly 15 million tons (ZGTJNJ 1980–93). Rapid growth of grain yields in the early 1980s reversed this trend, and by 1985 China became a net exporter. With continued strong demand growth in the mid-1980s, successive poor harvests from 1985 to 1988 drove imports back up to more than 10 million tons in 1990. The rural recession that plagued much of China for several years after 1989 once again pushed imports down to the point at which China was nearly self-sufficient in overall grain in the early 1990s (Rozelle and Jiang 1994). In 1994 and 1995, however, imports sharply expanded again.

These patterns, however, vary among China's crops. China has always imported more wheat than any other grain product. Throughout the 1980s and early 1990s, about 90 percent of the country's grain imports were wheat, with annual average imports of 12.5 million tons. Grain trade planners frequently try to arbitrage the price difference between rice and wheat. Since 1978, China has been a net exporter of rice every year except 1989. In the early 1990s, maize exports came out of the northeast provinces in substantial quantities for the first time. Most of the maize exports from Jilin and Heilongjiang Provinces have gone to northeast Asian countries, and they are expected to continue despite maize shortages elsewhere in the country (Tuan 1994). Transportation bottlenecks in the northeast corridor have kept large quantities of maize and soybeans from entering the domestic market in the south.

Various attempts at projecting future trends in China's grain and rice imports and exports have been published or are currently being used and periodically updated (Table 1). The most striking feature of the projections of grain surpluses and deficits is their wide range. At one extreme, China is predicted to become a net exporter of grain. The Chinese Academy of Agricultural Sciences forecasts, in its more optimistic scenario, that China will have the capacity to export 47 million tons in the year 2000 (CAAS 1985). Chen and Buckwell (1991) construct a scenario in which they argue that China could move from being an importer of about 10 million tons in the mid-1980s to a net exporter of 17 million tons in 2000 if rapid growth in production can be sustained. ERS (1995) predicts China will be approximately self-sufficient in grain through the 1990s but will have small imports by the first decade of the next century.

Other analysts, however, believe China will eventually become a large net importer of grain. Brown (1994) forecasts that a rapidly modernizing China will import at least 216 million tons by 2030 even if per capita consumption of grain does not increase. Garnaut and Ma (1992) project that at per capita income growth rates of 6.0 to 7.2 percent (rates lower than those experienced between 1992 and 1994), China will require imports of between 50 and 90 million tons by 2000. Carter and Zhong (1991) predict that consumption will outpace production, leaving a grain deficit of more than 100 million tons by 2000. Chen and Buckwell (1991) arrive at a high-income scenario in which China imports 59 million tons by 2000. Earlier work by Yang and Tyers (1989) predicted China's grain imports to be from 38 to 70 million tons by the mid-1990s.

Whereas most analysts believe that future grain imports will likely consist of wheat and feedgrains (Garnaut and Ma 1992; Carter and Zhong 1991), they view rice exports quite differently. The World Bank (1990) and Yang and Tyers (1989) predicted, respectively, that China would export 3.2 and 6.3 million tons of rice in the mid-1990s. Looking ahead to 2000, Fan, Cramer, and Wailes (1994) project that China will export rice, but only from 0.9 to 1.6 million tons (even though they believe China will stockpile substantial quantities of rice in government grain warehouses). The ERS (1995) team projects that China will export 0.1 million tons of rice in 2000.

Since all analysts are forecasting from the same general base period, the differences in expected grain balances stem from the predicted changes in the relative rates of growth of grain supply and demand (Table 1). Brown (1994) projects declines in grain

Table 1—Alternative projections of China's grain supply and demand balances

Study	Projection Period	Description	Annual Growth of Total Grain Production	Annual Growth of Total Grain Demand	Grain Imports/ Exports	Rice Imports/ Exports
			(percent)		(million metric tons)	
Brown 1994	1994–2030	No model formally specified.	–0.6	1.0–1.9	Imports: 216–378	n.a.
CAAS 1985 (see Chen and Buckwell 1991)	1980s–2000	No model presented.	1.7–2.2	1.1–2.3	From exports of 47 to imports of 13	n.a.
Carter and Zhong 1991	1995–2000	Econometrically estimated.	0	1.7–2.0	Imports: 100–115 in 2000	n.a.
Chen and Buckwell 1991	1980s–2000	Assumes no price response on demand side and supply increase is a continuation of earlier trends.	1.8–2.9	2.1–2.9	From exports of 17 to imports of 59[a]	n.a.
ERS 1995	1994–2006	Similar to Yang and Tyers but more disaggregated by commodities; all elasticities are assumed.	1.09 (rice: 0.5)	1.16 (rice: 0.4)	Imports: 20	Exports: 0.1
Fan, Cramer, and Wailes 1994	1994–2000	Econometrically estimated model with endogenous price equations that are linked to world market equations.	Rice only: current 0.9; liberalized 1.4[b]	Rice only: current 0.8; liberalized 0.01	n.a.	Exports: 0.9 under "current" policy; 1.6 under reform markets
Garnaut and Ma 1992	1990–2000	Uses Taiwan consumption patterns as paradigm for China.	1.3	1.9–2.7	Imports: 50–90	n.a.
World Bank 1985	1990–1995	Uses World Bank's MAT-I model; attempts to account for changes in agricultural investment and grain subsidies/taxes.	1.7 (rice: 1.2)	1.7 (rice: 0.7)	Imports: 8	Exports: 3.2
Yang and Tyers 1989	1988–1995	Estimates some elasticities econometrically and links demand and supply projections to World Trade model with endogenous prices.	n.a.	n.a.	Imports: 38–70	Exports: 6.3

Note: n.a. indicates not available.

[a] The total grain export and import projections are based on a medium growth rate of supply of 1.23 percent per year and compared with the low-and high-consumption scenarios (see Chen and Buckwell 1991 for details).

[b] "Current" means existing rice price policies will be continued. "Liberalized" means trade in rice will be liberalized.

production of 0.6 percent per year (or nearly 20 percent decline by 2030), and Carter and Zhong (1991) project zero growth in production. All other estimates of grain production growth are positive, ranging from 1.1 percent to 1.8 percent for baseline or slow growth scenarios and to 2.9 percent for rapid growth scenarios.

Variation in demand projections is similar. Several projections of demand growth are in the range of 1.0 to 1.7 percent per year, but Garnaut and Ma (1992) and Chen and Buckwell (1991) project demand growth rates well in excess of 2.0 percent. Given the significant variation in both supply and demand projections, it is not surprising that projected net imports differ widely. The largest import projections result from highly pessimistic supply projections (Brown 1994; Carter and Zhong 1991). Those who project slow rates of growth in demand (for example, CAAS 1985, 1.10 percent per year; and ERS 1995, 1.16 percent per year) have projected that China will either export grain (CAAS 1985, export 47 million tons) or import grain in amounts only slightly larger than previous highs (ERS 1995, import 20 million tons). Those predicting high demand growth (such as Garnaut and Ma 1992 and Yang and Tyers 1989) project that China will import more than 50 million tons of grain.

Regardless of the final magnitude of the supply or demand growth rates, the most difficult part of interpreting the results is that the sources of the parameters of the forecasting models, and the forces behind the changes in important variables (such as population and income growth), are not transparent. The parameters on which all of these grain projections are based (except Carter and Zhong 1991 and Fan, Cramer, and Wailes 1994) are either partly or wholly assumed. In many of the models, the sensitivity of the predictions is tested against different rates of growth and different rates of change of key parameters. For example, the World Bank (1990) shows the effects of falling demand elasticities over time. Except for references to changing policies or different assumptions about the future robustness of the economy, however, almost no model empirically estimates the effects of changes in the structure of the Chinese economy on grain supply and demand.

In most studies, almost all of the changes in the future growth of supply are dependent on assumed changes in technology (even though this process of technical change is not always explicitly recognized), and demand growth mostly depends on changes in income (and to some degree on the effects of price changes). Most studies ignore fundamental forces in the economy, such as urbanization and market development. Given the rapid structural

change in China's economy-in-transition, this omission is probably a reflection of the poorly developed empirical literature on China's food economy. The studies also fail to assess the effects of policy variables. With the exception of the World Bank's model (which includes a variable simulating the impact of agricultural investment and sectoral subsidies on grain output), no other model can be used to systematically assess the effect of policy tools that are under the control of government.

Annual Grain Production and Use in China

Total grain production (in trade weight) rose to 385 million tons in the early 1990s (Table 2, p. 6). After adding 2 million tons to stocks (which reduced current grain supply) and importing 3 million tons of grain, China had a total annual supply of grain of 386 million tons during this period. This supply was used to meet a number of needs: seed, animal feed, nonfood manufacturing, and direct consumption for food. Grain used for direct food consumption made up the greatest part of total supply, about 67 percent in the early 1990s, and animal feed accounted for 20 percent of use. The average resident of China consumed 225 kilograms of grain a year, a level quite high even in comparison with the rest of East Asia. In contrast, meat and fish consumption was relatively low. The feed supply helped provide each resident with 25 kilograms of meat, poultry, and fish products.

The largest share of supply is contributed by rice. The production of milled rice was about 130 million tons, about one-third of the nation's grain supply. In the early 1990s, China was still exporting rice, sending about 1 million tons to various destinations in Asia and Africa. After 2 million tons of rice were put into national grain stocks, most of the remaining rice went for direct food consumption. Chinese farmers used about 8 percent of the crop for feed, more than farmers in other rice-growing countries.

Most of the remainder of China's grain supplies consists of wheat and maize. While the total production of each crop is almost the same (99 million tons for wheat and 97 million tons for maize), total supply on domestic markets differs significantly. In the early 1990s, China imported about 11 million tons of wheat, making total supply 110 million tons. During the same period, 4 million tons of maize were put into storage and 9 million tons were exported, leaving only 84 million tons of maize available for domestic use. Most of the wheat was used for direct food consumption. In contrast (and unlike earlier years when much maize

was directly consumed), in the early 1990s two-thirds of China's maize was being used for feed.

As China's economy continues to change and grow, one of the main questions facing policymakers is how future patterns of use can most effectively be met. Can domestic producers continue to meet most of the demand by China's consumers? What forces will cause current trends to change? And, if policymakers are concerned about keeping a stable supply of all grains for the domestic market, what factors under the government's control can be used to meet these concerns?

Structural Change and Government Intervention in China's Agriculture

China is in rapid transition from a socialist system to one in which an increasing proportion of its goods and services, including food, are being allocated by market forces (Sicular 1995b; Rozelle, Park, and Huang 1995). The country is also developing rapidly. China's government, however, far from giving up its activist role as a major actor in the economy, remains deeply involved in guiding the nation's development process. Many forces arising from these development and transition processes may be affecting China's food economy, and any attempt to accurately forecast food future supply and demand trends must account for these major economic forces.

Demand Shifters: Market Development and Urbanization

On the demand side, recent changes in the urban economy have made urban consumers almost entirely dependent on markets for their consumption needs (Rozelle 1994). In this sector, prices and income changes will likely be the fundamental forces driving changes in consumption patterns. Urban incomes rose at a steady rate of nearly 8 percent per year in the early years of reform (Table 3, p. 6). These rising incomes meant an increasing demand for almost all food products, including fine grains like wheat and rice. Real income per capita for urban residents continued

to rise in recent years, jumping an average of 7 percent between 1985 and 1992. At the current average level of income for most urban residents, foodgrain consumption rises very little with new increments in income; meat consumption, however, is still strongly influenced by income changes (Garnaut and Ma 1992; Carter and Zhong 1991).

Rural residents live in a very different environment from their urban counterparts and exhibit different demand behavior. Although rural incomes have grown much more slowly since the mid-1980s, demand for foodgrains and meat products has increased as incomes have risen (Huang and Rozelle 1994, 1995b; Fan, Cramer, and Wailes 1994; Halbrendt et al. 1994). Rural consumption markets also are less complete. Farmers in many areas face limited choices in their consumption decisions since many of the products they desire on a daily basis, such as meat and fresh fruit, are not always available, even when their incomes rise. In a sample of households drawn from the national household income and expenditure survey by the authors, a strong and significant correlation was found between the level of consumption of goods obtained primarily by purchase, such as meat and fruit, and the level of market development, holding income and prices constant (Huang and Rozelle 1995b). Discontinuous free markets, lack of refrigeration, and generally high transaction costs for procuring food in rural areas have been shown to strongly affect the consumption patterns of rural consumers in China. Although rural markets have developed rapidly, in 1992 Chinese farmers purchased only 46 percent of the food they consumed (HIES 1993). Apart from changes in income and prices, further development of markets and increased activity on rural consumption markets will affect consumption patterns.

Across Asia, it has been shown that as countries urbanize, the behavior of consumers changes dramatically (Huang and David 1993; Bouis 1989). Urban dwellers consume more wheat and less rice and demand more meat, milk products, and fish than their rural counterparts, even after accounting for the differences in income and prices. In China the ratio of urban to rural residents is changing fast. The urban population grew from 19 percent of total population in 1980 to 28 percent in 1992 (Table 3).[2]

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[2]This measure does not include a big part of the temporary migrant community (the so-called floating population). In the short run, this part of the population must be ignored because little is known about their consumption patterns. Moreover, there is no reason to expect that by adding this group to the urban population at this time, the impact of urbanization would be increased. It may be that their consumption patterns are more rural than urban in their temporary living conditions. But to the extent that some of these residents end up staying in the cities permanently, they will almost certainly eventually adopt some urban habits.

Table 2—Annual grain production and use in China, 1990–92

Grain	Production	Change in Stock[a]	Net Import	Total Supply	Seed	Animal Feed	Nonfood Manufacturing	Waste	Food	Average	Rural	Urban
										Per Capita Consumption[b]		
				(million metric tons)						(kilograms)		
Total grain	385	-2	3	386	16	76	19	15	260	225	242	178
Rice[c]	130	-2	-1	127	4	11	3	4	105	91	100	67
Other grain	255	0	4	259	11	66	17	11	153	133	141	111
Wheat	99	0	11	110	n.a.	4	n.a.	n.a.	105[d]	91[d]	n.a.	n.a.
Maize	97	-4	-9	84	n.a.	56	n.a.	n.a.	28[d]	24[d]	n.a.	n.a.

Sources: Computed by authors except for wheat and maize, which are from ERS 1995.

Note: n.a. indicates not available.

[a] A negative number indicates an increase in stocks, which reduces total grain supply.
[b] Includes direct home consumption, grain purchased and consumed outside of home, and processed foods.
[c] Rice in milled form (trade weight).
[d] Includes all nonfeed grain use.

Table 3—Important factors affecting the supply of and demand for grain and rice in China's economy, 1958–92

Year	Urban Income Per Capita	Rural Income Per Capita	Market Development Index[a]	Share of Population in Urban Areas	Agricultural Research Stock	Agricultural Research Expenditures	Irrigation Stock	Irrigation Expenditures	Erosion Area[b]	Salinized Area[b]
	(real 1985 yuan)		(percent)			(real 1985 million yuan)			(million hectares)	
1958	n.a.	n.a.	n.a.	16	n.a.	165	6,766	3,053	n.a.	n.a.
1965	n.a.	n.a.	n.a.	18	n.a.	357	17,375	1,314	n.a.	n.a.
1970	n.a.	n.a.	n.a.	17	239	401	23,280	3,256	n.a.	n.a.
1975	229	101	21	18	352	700	42,928	4,526	118	7.2
1980	372	167	31	19	408	791	47,819	3,209	118	7.1
1985	490	298	42	24	573	1,078	49,928	2,016	129	7.7
1990	593	306	45	26	789	808	53,476	3,006	136	7.5
1992	778	319	46	28	880	977	59,003	5,527	163	7.7

Sources: Urban and rural income: ZGTJNJ 1980–93; market development index: Huang and Rozelle 1995b; urban population: United Nations 1993; agricultural research stock and expenditures: SSTC 1991 and 1993; irrigation stock and expenditures: MWREP 1988–92; erosion and salinized area: MWREP 1988–92.

Note: n.a. indicates not available.

[a] The proportion of food purchased by rural households on consumption markets.
[b] Described in Huang and Rozelle 1994.

The effects of this population shift on consumption in China have been documented (Huang and Bouis 1996). Although structural transformations of the economy should be accounted for in any predictions of future consumption patterns, only the projections of the World Bank (1990) and Carter and Zhong (1991) explicitly take into account the differences in consumption between rural and urban consumers.

Supply Shifters: Technology, Investment, and Environmental Stress

Many sharp transitions are also under way on the supply side. Above all, technological change must be considered explicitly, since it has been the engine of China's agricultural economy (Stone 1988). China's technological base grew rapidly during both the prereform and reform periods. For example, hybrid rice, a breakthrough pioneered by Chinese rice scientists in the 1970s, increased yields significantly in many parts of the country and rapidly spread to nearly one-half of China's rice area by 1990 (Lin 1991). Other grains enjoyed similar technological transformations (Stone 1988). Robust growth in the stock of China's research capital has in significant part been responsible for these dramatic changes (Table 3; Fan and Pardey 1992). There is concern, however, that China's agricultural research system may be suffering from neglect after more than a decade of reform (Conroy 1987; Pray, Huang, and Rozelle 1995). Real annual expenditures on agricultural research fell between 1985 and 1990, before resuming real growth (SSTC 1993). The slowdown in growth in annual investments in the late 1980s will result in slower growth in the overall stock of research in the 1990s.

How large a role has technology played in China's recent growth? Although one-time institutional changes did contribute to the high growth enjoyed by China's agricultural economy in the early 1980s (McMillan, Whalley, and Zhu 1989; Lin 1992), other analyses have shown that technology was at least as important in the early reform period and was responsible for almost all of the growth in the agricultural economy in the late 1980s and early 1990s (Huang and Rozelle 1996; Huang, Rosegrant, and Rozelle 1995). The ability of China's research system to maintain a stream of technical innovations will critically affect the growth of grain supply and the nation's grain balance.

Investment in agricultural infrastructure, especially irrigation, has been another important determinant of China's agricultural growth in recent decades (Nickum 1995). Irrigation investment and the stock of facilities have followed patterns similar to those for research (Table 3). Since the early 1950s, China has invested heavily in irrigation, raising irrigated area from 18 percent of cultivated area to nearly one-half (ZGTJNJ 1993). Real annual expenditures on irrigation rose rapidly until 1975, before beginning a 10-year decline. In 1985, however, annual expenditures began to grow again and were at an all-time high in 1992.

Trends in environmental degradation, including erosion, salinization, and loss of cultivated land, show that there may be considerable stress on the agricultural land base: erosion and salinization have increased since the 1970s, although in a somewhat erratic pattern (Table 3). A number of recent studies have shown that these factors affect output of grain, rice, and other agricultural products (Huang and Rozelle 1995a, 1996; Rozelle, Huang, and Veeck forthcoming; Huang, Rosegrant, and Rozelle 1995).

A Framework for Forecasting China's Grain Supply and Demand

The major components of this paper's forecasting framework are a supply model for the rice, other grain, and cash-cropping sectors of the agricultural economy and demand models specified separately for rural and urban consumers for rice, grain, meat, and six other animal products. Real world price projections are generated by IMPACT, a partial equilibrium global trade model developed at the International Food Policy Research Institute (IFPRI) (Rosegrant, Agcaoili-Sombilla, and Perez 1995). The modeling framework for China includes, in addition to income and prices, a number of structural and policy variables to account for fundamental forces of transformation in China's rapidly reforming and modernizing economy.

Grain Supply

The supply model forecasts future trends in China's grain output using separate equations for rice and for other grains (total grain minus rice).[3] Unlike previous

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[3]Grain in China includes rice, wheat, maize, barley, sorghum, millet, and other coarse grains, as well as soybeans. Sweet and white potatoes are also included, but their actual weight is divided by five to turn them into grain equivalents.

models, the supply forecasting model uses parameters that have been econometrically estimated by the authors. Grain and rice supply elasticities are estimated using the normalized quadratic form of the dynamic dual value function approach developed in Epstein 1981 (Vasavada and Chambers 1986; Warjiyo 1991). The dynamic duality model is used because it recognizes that important production factors, such as labor and sown area, while responsive to changes in prices and other exogenous factors, only adjust to their equilibrium levels after several years (because of transaction costs, fixed investments, informational barriers, risk, or other such factors). Simultaneous with the two-grain supply equations, four other equations—cash crop supply, two quasi-fixed inputs (labor and sown area), and fertilizer—were estimated using a nonlinear solution algorithm. Grain output and other explanatory variables are assumed to respond to the crop's own price, prices of other crops, quasi-fixed and variable inputs, and the off-farm wage. Output also is a function of the stock of agricultural research, the stock of irrigation infrastructure, and three environmental factors—erosion (in the other grain equation), salinization, and the breakdown of the local environment.[4] Full results and a detailed discussion of the model can be found in Huang, Rosegrant, and Rozelle 1995.

Grain Demand

Grain consumption is divided into two parts: grain that is directly consumed for food and grain that is fed to animals and consumed indirectly. Direct food equations are divided into rice and other grains. Indirect grain consumption is imputed from the underlying demand equations for pork, beef and mutton, chicken, fish, eggs, and milk. The demand equations for all crops are specified separately for rural and urban consumers for all products. Different demand parameters are also used for each projection period: the 1990s; 2000–2010; and 2010–2020. Demand is specified as responding to own-price, the prices of other major commodities, income, and a variable representing the level of development of rural consumption markets (in the rural demand equations).

Foodgrain Demand. Rural and urban demand are modeled separately for several reasons. Consumption patterns of rural and urban consumers are inherently different (Bouis 1989; Huang and David 1993). Consumption patterns and market development in China's urban and rural areas differed significantly in the prereform era (Walker 1984), the early reform period (Sicular 1995a), and more recently (Rozelle 1994). Income differentials, expenditure growth, and rates of change of population and other demographic factors have varied dramatically between rural and urban regions (Khan et al. 1993). The effect of urbanization is accounted for by multiplying per capita grain projections for each sector by the projected changes in rural and urban populations, including the anticipated flows of rural residents into the cities.

Similar to the supply side, this part of the analysis uses econometrically estimated parameters. Demand parameters are estimated using an Almost Ideal Demand System framework (Deaton and Muellbauer 1980) and based on recently collected household survey data. Expenditure elasticities are estimated to vary according to the level of income. As projected incomes rise throughout the projection period, income elasticities fall. Urban foodgrain income elasticities become zero in 2000 and turn negative in 2010; those for rural residents become zero in 2010. The estimated coefficients and elasticities are discussed in detail in Huang and Rozelle 1994 and 1995b and Huang and Bouis 1996.

Feedgrain Demand. Demand parameters for pork, beef, chicken, fish, eggs, and milk are estimated for both rural and urban residents (Huang and Bouis 1996). Different sets of parameters are estimated for different types of cities. These estimates are used for the first 10 years of the projection period. Following the experience of the rest of Asia, it is assumed that after 10 years the income-demand relationship for meat by rural residents will be similar to the current expenditure pattern of the residents of small towns. Similarly, during the first decade of the next century, demand patterns of urban consumers in small and medium-sized cities will become more like those of consumers in large cities in the 1990s.

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[4]Technology was measured in stock form and was built by aggregating past government expenditures on research according to weighting criteria suggested by Pardey et al. (1992). Irrigation stock was constructed by aggregating public expenditures on irrigation, subject to a depreciation rate of 4 percent per year, a rate used by Rosegrant and Kasryno (1994). The environmental variables have been described and analyzed in Huang and Rozelle 1995a and Huang, Rosegrant, and Rozelle 1995. The severity of erosion is measured as a ratio of eroded area to cultivated area (which can exceed 1, since eroded area includes both cultivated and noncultivated area). Salinization is the proportion of total sown area where salinity levels are high enough to affect yields.

Once the demand for meat and other animal products is known, the implied feed demand (and hence the overall demand for grain) is calculated by applying a set of feed conversion ratios.[5] These ratios were supplied by the Economic Research Service of the U.S. Department of Agriculture and are consistent with estimates used by Chinese agriculturalists (NYJSJJSC 1989). The feeding efficiency of hogs is expected to increase slightly over time. Meat products are assumed to be produced in China and to be sufficient to satisfy demand. The alternative assumption of net import of meat is also made to investigate the effects of meat imports on the demand for total grain.[6]

Parameter Estimates

Income elasticities of demand for rice, other grain, and meat appear in Appendix Table 9. Current rural expenditure elasticities are used for the first period. These elasticities are estimated to decline in more distant periods, as discussed in the previous section. Price elasticities of demand for rice, other grain, and meat are included in Appendix Table 10. Parameters used to account for the effects of urbanization and the development of rural food consumption markets are reported in Appendix Table 11. Elasticities used for the supply projections are presented in Appendix Table 12.

Baseline Assumptions

All simulations begin from the early 1990s, the base period. Base period data on production and use are three-year averages centered on 1992. A number of

factors have the potential to affect the future development of China's food situation. Price movements of key commodities and resources affect both demand and supply side trends. Factors that affect demand include population and income growth, the movement of population between urban and rural sectors, and the level of market development. Supply side factors include changes in factor prices, variations in the pattern of government investment in agricultural research and irrigation, and changes in the state of the environment. Summaries of the assumptions for the major factors affecting future demand and supply growth appear in Appendix Tables 13 and 14.

Demand Side Assumptions

Income growth and population growth will remain important determinants of China's food balance in the future. Population growth peaked in China in the late 1960s and early 1970s. Since then, fertility rates and the natural rate of population growth have begun to fall. Based on the United Nations' demographic predictions, the growth rate during the first decade of the projection period, 1990–2000, is assumed to be 1.283 percent a year (Appendix Table 13). This annual rate falls during the next two decades to 0.740 and 0.649 percent, a level considerably lower than the world's projected growth rate of about 1.70 percent.[7]

Following Rosegrant, Agcaoili-Sombilla, and Perez (1995), alternative scenarios simulate a situation in which the Chinese government exercises less control over the population in the future and population growth rates slow to only about 1 percent a year after 2000. The movement of the population from urban to rural areas is expected to continue and affects

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[5]Feed conversion parameters are from ERS 1995. Officials in China's Ministry of Agriculture told us that they believed these rates were too high. If so, the demand for feed and imports is overestimated. However, commercialization of China's livestock industry is occurring rapidly, which would mean that conversion rates should increase over time (since farmers currently tend to feed scraps and other nongrain feedstuffs to hogs). Hence, any overestimation in the short run should be eliminated at some point during the study period.

[6]China currently is a net exporter of meat, mostly to Hong Kong and Southeast Asia. If the model allowed for imports, China might choose to become a net importer at some point. This would reduce projected foodgrain and feedgrain imports but would have little effect on the total volume of agricultural trade. Without good refrigeration or transportation infrastructure, however, meat imports will be constrained in the near future. In fact, if high grain imports are politically unacceptable, importing meat may be one way around such an ideological constraint. If China would import 10 percent of its meat in 2000, net grain imports in 2020 could be 50 percent less than when China relies completely on domestic sources of meat.

[7]The baseline assumptions for population growth rates in the three study decades imply an overall population growth rate of 0.89 percent for the projection period. This level is slightly higher than the 0.74 percent assumed by Rosegrant, Agcaoili-Sombilla, and Perez (1995). There are many reasons to believe that with increasing reform, the government's ability to control fertility may lessen, and future rates of population growth may be greater than the baseline rates. Rosegrant, Agcaoili-Sombilla, and Perez use an alternative rate of 1 percent per year. In this study's high population growth scenario, it is assumed that the growth rate is 1.413 percent in the first decade, 0.932 percent in the second, and 0.844 percent in the third, implying an overall study period growth rate of 1.06. In a later section of this discussion paper, results are presented showing the sensitivity of the conclusions to the choice of population growth rates.

the rate of growth of rural and urban populations. The urban population is expected to grow by 3.993 percent per year in the 1990s, and this rate will continue at a high level, 2.341 percent per year, during the 2010–20 decade. Despite higher fertility, the rural population will grow by only 0.158 percent in the 1990s, reflecting high rates of rural to urban migration. The rate of rural population growth will actually become negative in the decade preceding 2020.

The baseline per capita income (consumption expenditure) growth rate is forecast to average about 3.0 percent in the rural sector and 3.5 percent in the urban sector. Growth rates in the late 1980s and early 1990s were substantially higher than this level in the urban economy (around 6–7 percent) and significantly lower than this in rural areas (less than 1 percent per year between 1985 and 1992). In recent years, however, the overheated urban growth has slowed, and since 1991 the rural economy has begun to pull out of its recession. These assumptions are largely consistent with those used in projection exercises conducted by ERS (1995), the World Bank (1990), FAO (1991), Carter and Zhong (1991), and Rosegrant, Agcaoili-Sombilla, and Perez (1995). The effects of very high growth rates (7 percent annual per capita income growth in the 1990s, 6 percent in 2000–2010, and 5 percent in 2010–20) will be simulated, though these levels of growth are not expected to be sustained.

Price trends in China are projected to follow those of world prices.[8] Once far out of line with world agricultural prices, China's market prices have converged with those in international markets in recent years (Huang and David 1995). In an initial set of runs, constant real prices were assumed. The projected growth rates in production and demand (and thus net imports of rice and other grains) were then simulated in IFPRI's IMPACT model to generate projected world prices with China entering as a significant importer. These prices were then used as the baseline projections for the China projections model: world grain prices are expected to fall by 0.5 percent annually throughout the projection period. Meat prices are assumed to follow a similar trend.

The development of rural consumer markets also affects the future demand for grain and meat in China's economy; as farmers gain access to a greater variety of goods, they will adopt different consumption patterns (Huang and Rozelle 1995b). Currently about 46 percent of food in rural China is purchased on the market. This share is expected to rise to 60 percent by the year 2000 and to increase by 10 percent in each of the next two decades. The trend will not so much affect total grain demand as the composition of the nation's grain needs. As markets develop, even with income and prices held equal, the amount of foodgrain consumption falls. This reduction is offset by the increased demand for feedgrain needed to meet the rising demand for meat that accompanies rural market development.

Supply Side Assumptions

Commodity price projections for producer prices are assumed to be the same as those used in the demand side analysis (Appendix Table 14). Following the World Bank (1990) and ERS (1995), fertilizer prices are expected to grow by 1 percent per year (although in recent years trends have included both falling price levels and rapid price hikes). The ratio of grain-to-fertilizer prices is expected to continue to deteriorate, as it has since the mid-1980s (Ye 1991). Extrapolation of recent trends in the labor market provided the projection that the opportunity cost of labor for agriculture will continue to rise at 1 percent per year during the study period. A similar growth rate is assumed for the opportunity cost of land.[9]

In addition to prices, Huang and Rozelle (1996) and Huang, Rosegrant, and Rozelle (1995) have shown that investment in agricultural technology and irrigation also should be expected to have a strong influence on China's future grain supply. As already noted, annual expenditures on research declined from 1985 to 1990 and irrigation expenditures dropped from 1975 to 1985, but both types of expenditures increased after these periods of decline. The recent recovery in research and irrigation investments, together with the experience of other Asian

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[8]In one sense, this assumption is consistent with China's entry into GATT, under which in the long run Chinese producers will not be protected or taxed by border restrictions. Since China's grain prices are nearly the same as world market ones, there is also no obvious one-time effect from liberalization. The case would be different if China went the way of its prosperous East Asian neighbors and began to protect its producers with increasing prices. Even the most ardent grain fundamentalists find this implausible, given the severe fiscal problems in China.

[9]The opportunity cost of land is calculated from China's cost-of-production data as real resource per unit of land, net of variable production costs and wages.

countries, recent discussions with agricultural leaders and academics, and China's commitment to a strong domestic grain economy, leads to the expectation that China will sustain a longer-run rate of increase in these investments. The baseline projections of investment growth nevertheless remain well below historical rates of growth. Erosion and salinization are expected to continue to increase at a steady but slow pace.

Results of Baseline Projections

According to the analysis, per capita foodgrain consumption in China hit its zenith in the late 1980s and early 1990s. From a baseline high of 225 kilograms, foodgrain consumption per capita falls over the forecast period (Table 4). The average rural resident will consume greater amounts through the year 2000, before reducing foodgrain demand in the first decade of the next century. This decline in the rural area occurs at a time when income elasticities, although

lower than in the late 1990s, are still positive. As markets develop, rural consumers will have more choices and will move away from foodgrains. Urban foodgrain consumption per capita declines over the entire projection period.

Per capita consumption of rice, a higher-quality product, will rise slightly through the year 2000 (Table 4). Reflecting the still positive, albeit small, income elasticities for rice, both rural and urban consumers demand higher quantities of rice. Per capita demand for other grains, however, falls monotonically after the early 1990s. Per capita consumption is projected to be more than 10 percent lower in 2020 than current levels.

In contrast, per capita demand for red meat is forecast to rise sharply throughout the projection period (Table 5). China's consumers will more than double their consumption by 2020, from 17 to 43 kilograms per capita. Rural demand will grow more slowly than overall demand, but urbanization trends will shift more people into the higher-consuming urban areas (in 1991 an urban resident consumed

Table 4—Projected annual per capita foodgrain consumption under alternative income growth scenarios in China, 1991–2020

Scenario	1991	2000	2010	2020
		(kilograms)		
Baseline				
Total grain	225	223	214	203
Rural	242	246	243	239
Urban	178	177	174	168
Rice	91	92	90	88
Rural	100	104	106	107
Urban	67	69	69	68
Other grain	133	131	124	116
Rural	141	142	137	133
Urban	111	108	105	100
Low income growth				
Total grain	225	220	211	202
Rural	242	243	240	237
Urban	178	175	172	167
Rice	91	90	88	85
Rural	100	102	103	103
Urban	67	68	68	68
Other grain	133	129	123	117
Rural	141	141	137	134
Urban	111	107	103	99
High income growth				
Total grain	225	225	215	203
Rural	242	249	246	240
Urban	178	177	173	165
Rice	91	93	92	88
Rural	100	105	109	108
Urban	67	70	70	68
Other grain	133	131	123	114
Rural	141	144	137	132
Urban	111	107	103	97

Note: See Appendix Table 13 for assumptions on growth rates.

Table 5—Projected annual per capita consumption of meat and fish under alternative income growth scenarios in China, 1991–2020

Scenario	1991	2000	2010	2020
		(kilograms)		
Baseline				
Red meat	17	23	32	43
Rural	15	20	26	33
Urban	24	30	40	52
Poultry	2	3	5	8
Rural	1	2	3	4
Urban	4	6	8	12
Fish	6	10	17	28
Rural	4	6	9	14
Urban	12	18	28	43
Low income growth				
Red meat	17	22	27	34
Rural	15	18	22	27
Urban	24	28	34	42
Poultry	2	3	4	6
Rural	1	2	2	3
Urban	4	5	7	9
Fish	6	9	14	20
Rural	4	6	8	10
Urban	12	16	22	30
High income growth				
Red meat	17	25	36	53
Rural	15	21	30	41
Urban	24	32	46	65
Poultry	2	4	6	10
Rural	1	2	3	5
Urban	4	6	10	16
Fish	6	11	21	40
Rural	4	7	12	19
Urban	12	20	35	61

Note: See Appendix Table 13 for assumptions on growth rates.

about 60 percent more red meat than his or her rural counterpart). While starting from a lower level, per capita consumption of poultry and fish rises proportionally more.

The projected rise in demand for meat, poultry, fish, and other animal products will put pressure on aggregate feedgrain demand (Table 6). In the baseline scenario, demand for feedgrain will increase to 109 million tons by the year 2000. Although China does not publish aggregate feedgrain statistics, by the authors' calculations this represents an increase of 30 percent during the 1990s (up from 76 million tons in 1991). By the year 2020, the projected grain needed for feed will reach 232 million tons. At this rate of growth, feedgrain as a proportion of total grain use will move from 20 percent in 1991 to 38 percent in 2020. This process of moving from an

agricultural economy that produces grain primarily for food to one increasingly oriented to animal feed is typical of rapidly developing economies elsewhere in the world (Yotopolous 1985), and researchers have predicted such a shift in China (Carter and Zhong 1991).

When considered with the projected population growth rates, the projected per capita demand for food- and feedgrain implies that aggregate grain demand in China will reach 450 million tons by the year 2000 (Table 7), an increase of 17 percent over the level of the early 1990s (386 million tons, Table 2).[10] The projected aggregate demand for milled rice will rise by 14 million tons (or about 8 percent) from the early 1990s to 141 million tons in 2000.

Although per capita food demand falls in the later projection period, total grain demand continues

[10]In addition to projected foodgrain and feedgrain demand, total grain demand also includes use of grain for seed, nonfood manufacturing, and waste. Projected values of these uses are calculated by roughly maintaining the same ratios as found in the initial year of the baseline.

Table 6—Demand for feedgrain under alternative population and income growth scenarios in China, 2000–2020

Scenario	2000	2010	2020
		(million metric tons)	
Baseline population growth			
Low income growth	103	139	189
Baseline income growth	109	158	232
High income growth	116	181	286
Low population growth			
Low income growth	102	135	178
Baseline income growth	108	153	218
High income growth	114	175	269
High population growth			
Low income growth	104	143	197
Baseline income growth	110	163	242
High income growth	117	168	300

Notes: Total demand for feedgrain is 76 million tons in the base year (1991). See Appendix Table 13 for assumptions on income and population growth rates.

to increase through 2020 mainly because of population growth and the increasing importance of meat, poultry, and fish in the average diet. By the end of the forecast period, aggregate grain demand will reach 594 million tons, more than 50 percent higher than initial baseline demand (Table 7). During this same period, rice demand will reach 154 million tons, an increase of only 21 percent. The declining importance of rice as the dominant commodity in China is clear from its fall as a proportion of total grain demanded from 34 percent in 1991 to approximately 25 percent in 2020.

Baseline projections of the supply of grain show that China's producing sector gradually falls behind the increases in demand. Aggregate grain supply is predicted to reach 426 million tons (in trade weight) by the year 2000. Of this, rice makes up about 32 percent, or 138 million tons. This projection implies a rise in grain output of about 10.6 percent over the early 1990s, a figure far below the more optimistic estimates given in recent years by Ministry of Agriculture officials who had hoped to meet a target of 455 million tons by 2000 (or 500 million tons in non-trade-weight figures).

Production is expected to rise somewhat faster in the second and third decades of the forecast period. Mostly as a result of the resumption of investment in agricultural research during the forecast period, aggregate grain production is expected to reach 486 million tons in 2010, an increase of 15 percent over the preceding 10 years; production will reach 570 million tons by 2020, an even higher percentage increase for the decade (17 percent over the 2010 level).

Under the projected baseline scenario, the gap between the forecast annual growth rate of production

and demand implies a rising deficit. Total grain consumption rises at 1.72 percent per year—1.28 percent from the rise in population and 0.44 percent from rising per capita grain demand. Nearly all of this increased per capita grain demand is from the higher demand for feedgrain (it rises by 2.71 percent while aggregate demand for food is stagnant). Grain production during this period grows only 1.36 percent annually. Imports surge in the late 1990s to 24 million tons. After peaking in 2010 at 27 million tons, grain imports remain at 25 million tons in 2020.

Unlike the predictions of Fan, Wailes, and Cramer (1995) and ERS (1995), who expect China to be a net exporter in the late 1990s, this study's results show that China will need to import moderate amounts of rice in 2000 (Table 7). The baseline projection shows the country consuming 3 million tons of imported rice by the end of the current decade. While small relative to total grain trade, 3 million tons constitutes about 10 percent of total world rice trade. In fact, China is a net rice importer in 2000 under all of the alternative assumptions in Table 7. While China has been a net rice exporter in recent years, recent rises in rural income are expected to remove the surplus from China's domestic market. The tightening of rice markets is already occurring. In 1995 trade officials banned the export of rice. During a visit to Fujian by one of the authors in early 1995, officials of this province with a chronic deficit in rice announced that China's central government was preparing to grant provinces permission to enter the international rice market to meet their consumption needs.

Because per capita demand for rice falls over time—since rice is primarily a food crop—production gradually catches up to demand during the projection period. Under the baseline scenario, China is expected

Table 7—Grain demand, production, and net imports under alternative population, income, and technology scenarios, 2000–2020

Scenario	2000			2010			2020		
	Demand	Production	Net Imports	Demand	Production	Net Imports	Demand	Production	Net Imports
				(million metric tons)					
Baseline									
Grain	450	426	24	513	486	27	594	570	25
Rice	141	138	3	149	149	0	154	163	–9
Other grain	308	288	21	363	337	27	440	407	34
Baseline with low population growth									
Grain	445	426	19	496	486	11	561	570	–8
Rice	140	138	2	145	149	–4	146	163	–17
Other grain	305	288	18	351	337	15	415	406	9
Baseline with high population growth									
Grain	454	426	29	527	486	42	621	570	52
Rice	143	138	4	153	149	4	160	163	–3
Other grain	312	288	25	374	337	38	461	407	55
Baseline with low income growth									
Grain	440	426	15	489	486	4	549	570	–20
Rice	139	138	1	146	149	–2	151	163	–12
Other grain	300	288	13	343	337	6	398	407	–8
Baseline with high income growth									
Grain	459	426	34	537	486	51	647	570	78
Rice	143	138	5	152	149	3	156	163	–7
Other grain	316	288	29	385	337	48	491	407	85
Baseline with low rate of investment in agricultural research and irrigation									
Grain	450	418	32	512	462	49	593	517	76
Rice	141	137	4	149	145	4	154	153	0
Other grain	308	282	27	363	318	45	439	363	76
Baseline with high rate of investment in agricultural research and irrigation									
Grain	450	429	21	514	507	7	597	606	–10
Rice	141	139	3	149	153	–3	154	169	–14
Other grain	308	290	18	365	354	11	443	437	–5

Note: See Appendix Tables 13 and 14 for assumptions on population and income growth rates and investment in agricultural research and irrigation.

to reduce its imports (Table 7). It will probably re-enter the world market as a net exporter by 2020.

Alternative Projections

To test the sensitivity of the results to changes in the underlying forces driving the supply and demand balances, we simulated a number of alternative scenarios, altering the baseline growth rates of the key variables, including income, population, and investment in technology. The results, shown in Table 7, indicate that low population growth rates would reduce grain demand by 33 million tons in 2020. With high population growth, imports increase to 52 million tons. Low income growth causes a decline in projected total grain demand from 594 million tons to 549 million tons, resulting in exports of grain in 2020. With rapid income growth, projected imports would more than triple to 78 million tons.

Perhaps the most important result shown in Table 7 is the enormous impact of investment in agricultural research and irrigation on production and trade balances. This result is hardly surprising given the large contribution that agricultural research—and the technology it has produced—has made to agricultural productivity in recent years (Huang and Rozelle 1996; Huang, Rosegrant, and Rozelle 1995). Increases in the rate of growth in investment in agricultural research and irrigation from 3.5 percent to 4.5 percent per year are projected to shift China from an import to an export position by 2020. If, instead, growth in annual investment in the agricultural research system and irrigation fell moderately, from 3.5 percent per year (as forecast under the baseline projections) to 2.5 percent, total production would only be 517 million tons by 2020. With no change in the assumption regarding the level of food demand, imports under such a scenario would reach a level of 76 million tons.

This level of grain imports could be expected only if there was continued decline in the growth of agricultural investment and if the government did not respond with countervailing policy measures as import levels rose. Such a scenario could unfold only if the government was unwilling or unable to under-take policies to stimulate food production growth. However, agricultural research and irrigation investments have already recovered in recent years, and in recent months, as grain prices have risen in response to short-term tightening of grain supplies, government policymakers have responded with promises of greater investments in agriculture (Mei 1995). While most of the investments have been targeted at irrigation, improvements in the operations of research institutes have also been announced.

As implied by the much higher output elasticities for investment in agricultural research compared with the elasticities for irrigation investment (Appendix Table 12), increases in the level of irrigation investment would lead to relatively smaller increments in production and a smaller reduction in projected imports than increases in research investment. Given that the level of irrigation expenditures is already larger than agricultural research, if budgets allow an increase in one budget category but not the other, policymakers may want to maintain or expand the investment in agricultural research if they are concerned about limiting the growth in grain imports.

In addition to domestic investments, the government could also look to the international arena for technological products that would allow China time to redevelop its agricultural research system. In fact, several large international seed companies are currently investigating the possibilities of moving into China's market for seeds. Such moves would reduce the expected decline in grain supply and also decrease the expected level of imports even if growth in public investments slowed.

Finally, Table 8 shows that production, demand, and imports are insensitive to small changes in price trends. Output price trends do affect China's grain balances, but the effects are small. At the baseline level, for every 0.5 percent increase in the annual projected grain price trend, imports fall by 2 million tons, and for every 0.5 percent decline in the annual projected grain price trend, imports rise by 2 million tons.[11] Similar magnitudes are observed with changes for the price of fertilizer; when the projected growth of fertilizer prices increases by 1 percent, imports increase by 4 million tons, and when the growth of prices decreases by 1 percent, imports

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[11] Import projections are not very sensitive to changes in prices for two reasons. First, our estimated supply own-price response elasticities are small, a characteristic that is commonly found in other Asian countries where the government frequently intervenes in the agricultural decisionmaking process. Second, on the demand side, although there are fairly large negative own-price elasticities, positive cross-price elasticities dampen the reduction in demand when prices rise and the increase in demand when prices fall.

Table 8—Sensitivity of projections to alternative assumptions about price trends and the deterioration of the environment, 2000–2020

	2000			2010			2020		
Scenario	Demand	Production	Net Imports	Demand	Production	Net Imports	Demand	Production	Net Imports
				(million metric tons)					
Baseline	450	426	24	513	486	27	594	570	25
World grain price growth									
Low (0 percent per year)	450	424	26	513	482	31	593	562	31
High (−1 percent per year)	449	427	22	512	491	21	596	577	19
Fertilizer price growth									
Low (0 percent per year)	450	430	20	513	496	17	595	588	7
High (2 percent per year)	450	422	28	512	477	35	593	552	41
Growth of land cost									
Low (0 percent per year)	450	428	22	513	493	20	595	582	13
High (2 percent per year)	450	423	27	512	480	32	594	558	36
Wage growth									
Low (0 percent per year)	450	430	20	513	496	17	595	586	9
High (2 percent per year)	450	422	28	512	477	36	593	553	40
Salinity and erosion growth									
Low (0 percent per year)	450	427	23	513	490	23	594	576	18
High (0.4 percent per year)	450	424	26	512	483	30	594	563	30

Note: See Appendix Tables 13 and 14 for assumptions on the growth rates of prices and environmental variables.

16

decrease by 4 million tons. Hence, if past trends hold—that is, falling grain prices and rising fertilizer prices—the change in China's output-to-input price ratio means more imports will be required to meet the nation's projected deficit (at least through the medium run when higher imports would force prices up, offsetting part of the deteriorating output-to-fertilizer price relationship).

Assuming a constant response of production to erosion and salinity as the level of environmental deterioration increases, slight increases in their trends (for example, an increase of 0.2 percent per year from 0.2 to 0.4) have little effect on output (a decline of only about 7 million tons in 2020). Extrapolating from these results, substantial effects would not be found until the erosion and salinity rates accelerate to growth levels five times greater (or to 1 percent per year increases in erosion and salinity). Even at this level of environmental stress, projected grain imports in 2020 rise to only 48 million tons.

Conclusions

The purpose of this paper was to examine trends in China's grain economy, review the current set of studies that project future supply and demand trends, and then, on the basis of more comprehensive and structurally sound, econometrically estimated models, explore the factors that may be behind these alternative predictions. The framework includes a demand-side model that, in addition to the effects of income and population trends (as well as income response parameters that vary as income levels rise), accounts for the effects of urbanization and the changing level of the development of rural consumer markets. The supply response model considers the effects of prices, public investment in research and irrigation, institutional change, and environmental factors.

The projections show that under the most plausible expected growth rates in the important factors (most of which are broadly consistent with the major projection models ERS 1995, World Bank 1990, FAO 1991, Carter and Zhong 1991, and Rosegrant, Agcaoili-Sombilla, and Perez 1995), China's imports will rise steadily throughout the next decade. By 2000, imports are expected to reach 24 million tons, a level nearly two times higher than their historic high. Increasing imports arise mainly from the accelerating demand for meat and feedgrains, as well as from the continued slowing of supply as a result of reduced investment in agricultural research in the late 1980s. After 2000, however, grain imports are expected to stabilize, as demand growth slows owing to increasing urbanization and declining population growth rates and supply growth is sustained with the ongoing recovery of investment in agricultural research and irrigation.

Projections range considerably, however, when baseline assumptions are varied in both the short and long run. Different rates of agricultural investment create some of the largest differences in expected imports, but this result is what should be expected from the factor that has the largest marginal output response. Although a few scenarios project high levels of imports, both from the viewpoint of China's own domestic needs and relative to the size of current world market trade, several factors may keep China from becoming too large a player in the world market. First, world grain prices would certainly rise in the face of large Chinese imports, a tendency that would dampen Chinese grain demand and stimulate domestic supply. Second, China may face major foreign exchange constraints to importing such large volumes of grain; either government policymakers will not allocate foreign exchange for additional grain imports or exchange rate movements will discourage imports. Third, limitations on the ability of China's ports and other parts of the nation's transportation and marketing infrastructure to handle large quantities of grains may constrain import levels. Finally, many political economy factors will make China's leaders react to increasing grain shortages. Regardless of China's comparative advantage, government leaders have historically been, and continue to be, concerned with maintaining near self-sufficiency in domestic agricultural production capacity. National defense, pride, and ideology will necessarily put a premium on maintaining a rough balance between domestic demand and supply.

On the basis of the results presented in this paper, it appears that China will neither empty the world grain markets nor become a major grain exporter. It does seem likely, however, that China will become a more important player in world grain markets as an importer in the coming decades. Both potential exporters outside of China and those charged with managing China's food needs through domestic production and imports need to be ready. Exporting countries—especially those dealing with wheat and maize—will undoubtedly be the beneficiaries of these trends in the short run. If China's policymakers believe the projected level of imports is too high (either politically or because they see some other physical or economic constraint), they

must devise investment strategies in the near future because of the long lags between the period of expenditure and the time when such investments can affect production. Investment in facilities and institutions needed to handle the increased volume of incoming grain will smooth the shock of production shortfalls and reduce the time and expense of importing grain. China's foresight in dealing with the upcoming challenge will likely determine whether the production-demand gap turns into a major agricultural crisis or becomes an opportunity to more effectively develop the nation's food economy.

Appendix: Supplementary Tables

Table 9—Income elasticities of demand for grain and livestock products, early 1990s–2020

Commodity	Early 1990s		1990–2000		2000–2010		2010–2020	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Grain	0.246	0.092	0.150	0.000	0.000	−0.050	−0.050	−0.100
Rice	0.326	0.140	0.200	0.100	0.100	0.000	0.000	−0.050
Other grain	0.175	0.052	0.105	−0.083	−0.089	−0.091	−0.095	−0.141
Livestock products	0.757	0.835	0.757	0.835	0.835	0.870	0.835	0.870
Pork	0.765	0.782	0.765	0.782	0.782	0.797	0.782	0.797
Beef and mutton	0.343	0.689	0.343	0.689	0.789	0.686	0.689	0.686
Poultry	0.854	0.985	0.854	0.985	0.985	1.064	0.985	1.064
Egg	0.512	0.455	0.512	0.455	0.455	0.491	0.455	0.491
Milk	1.557	1.637	1.557	1.637	1.637	1.912	1.637	1.912
Fish	1.053	1.244	1.053	1.244	1.244	1.290	1.244	1.290

Note: Elasticities for rice in rural areas are from Huang and Rozelle 1994, which reports elasticities by income group. Given the income elasticity of 0.326 for rural residents with per capita expenditures of 659 yuan (the average in rural China in 1992), a declining trend of income elasticities is generated based on the patterns suggested by the above study. Rice elasticities in urban areas in the early 1990s are from Huang and Rozelle 1995c, which reports elasticities ranging from 0.14 to 0.29 for Jiande city (the 0.14 is used in this study). Urban elasticities after 1995 follow a pattern similar to that in rural areas. Elasticities for total grain in early 1990s are from Huang and Bouis 1996, while those after 1995 are assumed to decline in the same pattern as observed in the case of rice. Based on the elasticities for total grain (E_G) and rice (E_R), income elasticity for other grain (E_{OG}) was generated using the following formula:

$$E_{OG} = E_G \times Q_G/Q_{OG} - E_R \times Q_R/Q_{OG},$$

where Q stands for the quantity consumed.

Elasticities for animal products in the early 1990s are from Huang and Bouis 1996. Huang and Bouis report total expenditure elasticities for superlarge provincial capitals and small cities. The expenditure elasticities are then multipled by 0.9 to account for different growth rates of income and expenditures. For elasticities after 1990, elasticities of small and superlarge cities in the early 1990s are applied to those for rural and urban consumers in 2000–2020, respectively.

Table 10—Price elasticities of demand for rice, other grain, and meat

Commodity	Elasticity with Respect to the Price of Rice	Elasticity with Respect to the Price of Other Grain	Elasticity with Respect to the Price of Meat
Rice	−0.20	0.10	0.10
Other grain	0.10	−0.30	0.10
Meat	0.04	0.10	−0.30

Sources: Elasticities for rice and meat: Huang and Rozelle 1994. Other grain: based on assumptions made on the basis of a survey of the literature (for example, Halbrendt et al. 1994 and Fan, Wailes, and Cramer 1995).

Table 11—Urbanization and food market development in China, 1990–2020

| Year | Share of Population | | Food Market Development | | | |
| | | | | Demand Elasticity[a] | | |
	Rural	Urban	Index[b]	Rice	Other Grain	Meat
	(percent)		(percent)			
1990	74	26	45	−0.11	−0.11	0.32
2000	66	34	60	−0.08	−0.08	0.20
2010	58	42	70	−0.06	−0.06	0.10
2020	50	50	80	−0.02	−0.02	0.05

Sources: Population data: United Nations 1993; other data and parameters: Huang and Rozelle 1995b and Huang and Bouis 1996.
[a]Demand elasticities of rice, other grain, and meat with respect to food market development measure the effect of the expansion and modernization of rural food consumption markets on consumption, holding everything else constant (for example, income and prices). See Huang and Rozelle 1995b for details.
[b]The proportion of food bought by rural residents in local food markets. The rest of food is produced by rural residents themselves.

Table 12—Elasticities of rice and other grain output supply response in China

Factors	Rice	Other Grain
Agricultural research stock	0.322	0.685
Irrigation stock	0.070	0.109
Land and labor		
Land opportunity cost	−0.020	−0.097
Wage	−0.084	−0.112
Output and input prices		
Rice	0.179	−0.100
Other grain	−0.100	0.200
Fertilizer	−0.082	−0.124
Environmental factors		
Salinity	−0.072	−0.020
Erosion	−0.032	−0.214

Sources: All elasticities are from Huang, Rosegrant, and Rozelle 1995 except for other grain own-price elasticity (0.2, which is assumed and corresponds with an estimate from World Bank) and cross-price elasticities between rice and other grain (−0.1, which comes from ERS 1995). The elasticity of rice output with respect to soil erosion is estimated based on Huang and Rozelle 1996.

Table 13—Assumed growth rates of factors affecting grain demand in China, 1990–2020

Factors	Low Growth Rate	Baseline Growth Rate	High Growth Rate
	(annual percent)		
Total population			
1990–2000	1.142	1.283	1.410
2000–2010	0.491	0.740	0.932
2010–2020	0.374	0.649	0.844
Rural			
1990–2000	0.029	0.158	0.284
2000–2010	−0.844	−0.603	−0.413
2010–2020	−1.030	−0.764	−0.572
Urban			
1990–2000	3.827	3.993	4.124
2000–2010	2.729	2.983	3.180
2010–2020	2.062	2.341	2.539
Per capita real income			
Rural	2.0	3.0	4.0
Urban	2.5	3.5	4.5
Prices			
Rice	−0.5	−0.5	−0.5
Other grain	−0.5	−0.5	−0.5
Meat	−0.5	−0.5	−0.5
Rural market development			
2000	0.60	0.60	0.60
2010	0.70	0.70	0.70
2020	0.80	0.80	0.80

Sources: Population estimates are based on United Nations 1993. Per capita rural income growth figures are similar to those used in ERS 1995; World Bank 1990; FAO 1991; and Rosegrant, Agcaoili-Sombilla, and Perez 1995. Output prices are based on simulation analysis performed in collaboration with the IMPACT model developed by the International Food Policy Research Institute; see Rosegrant, Agcaoili-Sombilla, and Perez 1995. Figures for rural market development are index numbers for the year indicated (Huang and Rozelle 1995b).

Table 14—Assumed growth rates of factors affecting grain supply in China, 1990–2020

Factors	Low Growth Rate	Baseline Growth Rate	High Growth Rate
	(annual percent)		
Output and input prices			
Rice	−0.5	−0.5	−0.5
Other grain	−0.5	−0.5	−0.5
Fertilizer	1.0	1.0	1.0
Land and labor			
Land opportunity cost[a]	1.0	1.0	1.0
Wage	1.0	1.0	1.0
Agricultural research expenditures	2.5	3.5	4.5
Irrigation expenditures	2.5	3.5	4.5
Environmental factors			
Salinity	0.2	0.2	0.2
Erosion	0.2	0.2	0.2

Sources: Agricultural research and irrigation expenditures are extrapolated from recent trends and are adjusted based on recent Ministry of Agriculture plans (Liu 1991), pronouncements in newspapers, and interviews with Ministry of Agriculture and provincial officials. The land opportunity cost growth rate is an extrapolation from trends from SPB 1988–92. Output price trends are based on simulation analysis performed in collaboration with the IMPACT model developed by the International Food Policy Research Institute; see Rosegrant, Agcaoili-Sombilla, and Perez 1995. Fertilizer price trends are similar to those used by the World Bank 1990 and ERS 1995. The trends in the deterioration of the environment are based on extrapolations of past trends (Huang and Rozelle 1994).

[a]Assumed to be the return to grain cropping (total revenues) net of expenditures for labor (including own labor valued at the market wage), farm chemicals, and other cash expenses.

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