CHINA'S FOOD ECONOMY TO THE 21ST CENTURY:
SUPPLY, DEMAND, AND TRADE

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China's emergence as the world's fastest growing economy has both raised hopes that East Asia's giant can join the ranks of modernizing nations and fueled concerns that its rapid transition will upset the fragile equilibria of global markets and institutions. The nexus of China's growth, the management of its food economy, and its potential impact on world agricultural product markets compellingly illustrates the delicate balance facing policymakers. Directed properly, China's growth provides an unprecedented opportunity for achieving major gains in food security, poverty reduction, and nutritional improvement inside China. Without suitable policies, China's development may wreak havoc on sectors of its own society as well as the rest of the world.

Unfortunately, China's leadership and the international community have limited scope for understanding future trends, evaluating socio-economic tradeoffs, and sorting through policy options. Current analytical tools are quite simple, having almost no structural basis and providing little policy guidance. Predictions have been notoriously sensitive to fundamental assumptions, creating such a wide range of forecasts that policy makers have not become enlightened, but have felt defenseless when confronted with assertions on future supply, demand, and trade balances. The shallowness of understanding was exposed by the outrageous pronouncements by Brown, when he projected, without any research-based underpinnings, massive food shortfalls in China by 2030.[2] The ensuing panic in China's agricultural hierarchy, however, could not be suppressed since no research team inside or outside of China could respond authoritatively.

Predictive frameworks are not easy to construct. China is a country experiencing rapid economic and social transformation. Industrialization proceeds at one of the fastest rates in the world. These forces are causing wrenching changes: market development, urbanization, environmental degradation, and budgetary stress. These factors should be expected to have as great, if not greater, impact on supply and demand than traditional determinants such as income growth and price movements. Dealing with the challenges of managing their food sector in such a rapidly changing environment requires that China's leaders have a clear understanding of the structure of the economy, especially how supply, demand and trade are affected by any number of key economic, technological, and social forces.

The goal of this paper is to help establish a more comprehensive, transparent, and empirically sound basis for assessing the future growth of China's food supply and demand balances. We hope this paper helps shed light on the debate on China's future grain balance, identifies the kinds of structural transformations and policy decisions which might cause huge grain deficits, and shows the circumstances under which China might maintain its current status as near self sufficient.

To meet this goal, the paper first examines China's current grain balance sheet and history of grain imports, and reviews previous efforts to project China's growth of grain supply, demand, and trade. Our own assessment of the future grain economy begins by investigating a series of factors, beyond income and prices, which may affect grain demand and supply. We develop a supply and demand projections model, which includes 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, the results of the baseline projections are presented, and alternative scenarios are examined using different rates of growth in income, prices, and wages, population, and investment in research and irrigation.

Although we limit our analysis to grain, some of the projections may be surprising. Even in this fairly homogeneous sector of China's food economy, the socio-economic forces act very differently on rice, wheat, and maize, the study's three major crops. Not only does migration, technological change, income growth, and other trends have important impacts on the future supply and demand of the commodities, under a completely reasonable set of assumptions, we can show how there could be a complete reversal in historic global trade patterns for all three grains. Whereas since 1980 China has been a net exporter of rice and maize and the world's largest importer of wheat, under our baseline scenario, we show that China could import rice and maize in the 21st century, and satisfy its own demand for wheat.

Annual Grain Production and Utilization in China

Total grain production (in trade weight) rose to 403 million metric tons (mmt) in 1993-1995 (Table 1). After decline 2 mmt in stocks (which increase current grain supply), and importing 2 mmt of grain, the total annual supply of grain during this period was 407 mmt. 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 took up the greatest part of total supply, about 65 percent in 1993-95. Animal feed accounted for 23 percent of utilization. On a per capita basis, the average resident in China consumed 222 kilograms in a year of grain, a level quite high even in comparison to the rest of East Asia. In contrast, meat and fish consumption are relatively low. The feed supply helped provide the average resident with about 30 kilograms of meat, poultry, and fish product.

Aggregate grain balances disguise different patterns of rice, wheat, and maize utilization in terms of the use for feed and food and rural-urban dietary habits (Table 1, rows 2 to 5). China's residents consume most of the nation's rice (85 percent) and wheat (91 percent) directly as food grain. The livestock sector uses most of maize (84 percent) for feed.

Even general consumption aggregates vary by sector of the economy. Urbanites eat far less rice (68 kilograms) and more meat and poultry (34 kilograms) than their rural counterparts (103 and 20 kilograms, respectively--Table 1, rows 7 to 9). Wheat is more complex. Unlike the rest of East and Southeast Asia, China has a large wheat economy and its per capita *rural* consumption of wheat exceeds urban intake. Although there are sharp regional variations, the average rural resident consumes 90 kilograms per year of wheat versus only 72 kilograms for those in cities and towns. Commodity and sectoral differences in demand patterns become important in deriving future balances, since economic forces and structural changes affect each consumer group differently as well as the size and composition of the groups themselves.

The waxing and waning of supply and demand in the past several decades has caused imports and exports to rise and fall (Table 2). When China began its reform program in 1978, policy makers 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 mmt (row 2). Rapid growth of grain yields in the early 1980s reversed these trends, and by 1985 China became a net exporter. With continued demand growth in the mid-1980s, poor harvests drove net imports back up to more than 10 mmt by 1989. Soft demand and a resurgence of agricultural growth allowed imports to fall once again to the point where China was nearly self sufficient in overall grain in the early 1990s.[3] In the mid 1990s, the cycle repeated. Net imports reached historic highs of nearly 20 MMT in 1995 but are projected to decline in 1997.

Unlike aggregate imports, trends for specific commodities have been more steady. Despite a primary reliance on domestic sources, China imported more wheat than any other country in the world since the mid-1980s. Averaging 10 mmt of wheat per year means China accounts for 10 to 15 percent of world trade (Table 2, row 2). In contrast, except for 1995 and 1996 (and 1989 for rice), China has exported maize and rice (rows 3 and 4). By 1997, the recent trade patterns have returned. International traders forecast China will export more than 5 mmt of maize in 1997 and will dominate the northeast Asia maize export markets at least through.[4]

Alternative Projections of Grain Demand and Supply in China

Various attempts at projecting future trends in China's grain imports and exports have been published or are currently being used and periodically updated.[5] 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. CAAS forecasts that China will have the capacity to export 47 mmt in the year 2000.[6] Chen and Buckwell construct a scenario where they argue China can move from being an importer of about 10 mmt in the mid-1980s to a net exporter of 17 mmt in 2000.[7]

Other analysts believe China will eventually become a net importer of grain, some believing imports will rise gradually, others more sharply. The medium-term forecasts of the Economic Research Service of the United States Department of Agriculture (henceforth ERS) predict China will be a moderate importer through 2005.[8] Anderson, et al. predict China's grain imports will rise to 33 mmt in the early 21st century.[9]

In contrast, another set of researchers predict China's grain imports will increase significantly. Other than Brown, who predicts imports could exceed 350 MMT by 2030, Garnaut and Ma project that at per capita income growth rates of 6 to 7.2 percent (rates under those experienced between 1992 and 1994), China will require imports of between 50 to 90 mmt by 2000.[10] Carter and Zhong predict that consumption will outpace production, leaving a food balance deficit of more than 100 mmt by 2000.[11] Chen and Buckwell arrive at a high-growth scenario where China imports 59 mmt by 2000.[12]

Since all analysts are essentially forecasting from the same general base period, the predicted changes in the *relative* rates of growth of grain supply and demand lead the differences in expected grain balances.[13] Brown projects actual declines in grain production of 0.6 per cent per year (or a 20 percent decline by 2030), most of which comes from a nearly 50 percent fall in sown area.[14] Carter and Zhong project zero growth in production, while all other estimates of grain production growth are positive, ranging from 1.1 per cent to 1.8 per cent for baseline or slow growth scenarios, and to 2.9 per cent for rapid growth scenarios.[15]

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 demand growth rates well in excess of 2 percent are projected by Garnaut and Ma and Chen and Buckwell.[16] The long term predictions from ERS predicts much higher cereal imports, a number of the alternative scenarios forecasting food balance shortfalls of 100 mmt.[17] Given the significant variation in both supply and demand projections, it is not surprising that projected net imports are widely differing. The largest import projections result from highly pessimistic supply projections (Brown; Carter and Zhong), and high-side demand projections (Garnaut and Ma; ERS).[18]

Projections by commodities are much less common. Fan, Cramer, and Wailes predict that rice exports will continue, mainly due to their assumption that demand elasticities will continue to be positive and rice production growth will continue at current levels.[19] Unpublished projections by Fan and Agcaoili and recent long range projections by the ERS forecast rising imports for wheat.[20] Their estimates, however, do not take into consideration many of the structural changes facing China's food economy.

The most difficult part of evaluating current projections results is that the sources of the parameters of the forecasting models, and forces behind the changes in important state variables (e.g., population and income growth), are not transparent. The parameters on which all of these grain projections are based (except Carter and Zhong; and Fan, Cramer, and Wailes) are either partly or wholly synthetic.[21] There also is little scope for assessing the impact of policy variables. With the exception of the ERS and Fan and Agcaoili models, no other model can be used to systematically assess the effect of policy tools that are under the control of government. Fundamental forces in the economy, such as urbanization and market development, are ignored. Given the rapid structural change in China's economy-in-transition and the importance of policy in China, the omission of such important variables reduces the robustness of predictions from currently available models.

Structural Change and Government Intervention in China's Agriculture

As China's economy continues to change and grow, one of the main questions facing policy makers is how future patterns of utilization can most effectively be met. China is a country in rapid transition from a socialist system to one where an increasing proportion of its goods and services, including food, are being allocated by market forces.[22] It also is a country that is rapidly developing. There are many forces arising from these development and transition processes that will affect China's food economy. Any attempt to accurately forecast food future supply and demand trends must account for these major economic forces.

Demand Shifters: Income, 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.[23] In this sector, prices and income changes most likely will be the fundamental force driving consumption pattern changes. Real income per capita for urban residents has risen rapidly in recent years, jumping an average of more than 5 percent annually between 1985 and 1995. At the current average level of income for most urban residents rice and wheat consumption rises very little with new increments in income; meat consumption, on the other hand, is still very much influenced by income changes.[24]

Rural residents live in a different environment than their urban counterparts, and exhibit different demand behavior. While rural incomes have grown more slowly since the mid-1980s, demand for food grains and meat products have still increased as incomes have risen.[25] The average rural consumer, however, will spend less of their additional income on rice, wheat, and other staple food grains as they become richer during the development process.

Rural consumption markets also are less complete, but as transition improves the market environment, dietary habits may change. 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 as 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 primarily purchased goods, such as meat and fruit, and the level of market development, holding income and prices constant.[26] Discontinuous free markets, lack of refrigeration, and generally high transaction costs for procuring food in rural areas affect rural consumption patterns in China. Even with rapid changes in rural markets, in 1992 China扭 farmers still purchased only 46 percent of their food. As markets develop, and activity on rural consumption markets increases, apart from changes in income and prices, consumption patterns will be affected.

Across Asia, as countries urbanize the behavior of consumers changes dramatically.[27] Urban dwellers consume less rice and demand higher levels of meats, milk products, and fish than their rural counterparts, even after accounting for the differences in income and prices. The ratio of urban to rural residents in China is changing fast. The urban population has grown from 19 percent of total population in 1980 to 28 percent in 1992. The impacts of this population shift on consumption in China have been documented.[28] While structural transformations of the economy should be accounted for in any predictions of future consumption patterns, few projections explicitly consider the differences in the consumption between rural and urban consumers.

The case of wheat may unfold in an unexpected pattern in China when compared to its Asian neighbors, although the dietary changes from migration will differ depending on what part of the country one is examining. Other countries in East and Southeast Asia always have experienced rising wheat demand with migration, since farmers in these countries produce and consume few wheat products.[29] Migrants from southern rice-producing areas may be expected to follow this path since their current production and consumption patterns resemble those in neighboring countries. In contrast, city-bound migrants from north China consume very high levels of wheat, about 200 kilograms per capita in many northern province, levels that exceed or approach those of traditional wheat-producing, bread-eating nations, such as Pakistan, Turkey and Egypt. North China migrants will cut their consumption of wheat dramatically as they adopt the dietary patterns of urban dwellers. Since the nation's average rural consumption level exceeds that of urban areas (Table 1), if the same magnitude of migration occurs in both North and South, China's future migration most likely will have a dampening net effect on wheat demand, unlike its other urbanizing Asian neighbors.[30]

Supply Shifters: Technology, Investment, and Environmental Stress

On the supply side, many sharp transitions are also underway. Above all, technological change needs to be considered explicitly, since it has been the engine of China's agricultural economy.[31] China's technological base grew rapidly during both the pre-reform 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.[32] Wheat and maize enjoyed similar technological transformations.[33] China's robust growth in the stock of research capital has been significantly responsible for these dramatic changes. Recent work has shown that the contribution of technology to crop growth equaled or exceeded that of the Household Responsibility System in the early reform period. Technological change contributed almost all crop growth in the late 1980s and early 1990s.[34]

There is concern, however, that China's system maybe suffering from neglect after more than a decade of reform.[35] Real annual expenditures on agricultural research fell between 1985 and 1990, before resuming real growth in 1990.[36] 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 and may affect production.

Historic patterns of research spending and China抯 investment plans affect how supply of rice, wheat, and maize will respond to research expenditures in the future. Agricultural planners have traditionally invested most heavily in rice, wheat, and maize research.[37] Technological breakthroughs and greater extension efforts in rice and wheat have pushed yields closer to their frontiers than in the case of maize. Interviews with breeders from multinational seed corporations commonly reveal that the yield potential in all crops still exists, including rice and wheat, but that it is higher in maize.

A number of other factors similarly will affect future supply. Investment in agricultural infrastructure, especially irrigation, is another important determinant of China's agricultural growth in recent decades.[38] Irrigation investment and the stock of facilities have followed patterns similar to those for research, falling in the early reform period before recovering in recent years. Trends in environmental degradation, including erosion, salinization, and loss of cultivated land show that there may be considerable stress being put on the agricultural land base.[39] Erosion and salinization have increased since the 1970s, although in a somewhat erratic pattern, and these factors have affected output of rice, wheat, maize, and other agricultural products.[40]

A Framework for Forecasting China's Grain Supply and Demand

The major components of this paper's forecasting framework include a supply model for the rice, wheat, maize, other grain, and cash cropping sectors of the agricultural economy, and demand models specified separately for rural and urban consumers for rice, wheat, other grain, and 6 other animal products. Real world price projections are generated by IMPACT, a partial equilibrium global trade model developed by Rosegrant, Agcaoili, and Perez.[41]

Grain supply is assumed to respond to the crop's own-price, prices of other crops, quasi-fixed 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, salinization, and the breakdown of the local environment.[42] The full set of results and detailed discussion of the model can be found in Huang, Rosegrant, and Rozelle.[43]

Grain Demand

Grain consumption is divided into two parts: grain that is directly consumed for food and that which is fed to animals and consumed indirectly. Direct food equations are divided into rice, wheat, and other grains.

Food Grain Demand. Rural and urban food grain demand are modeled separately for several reasons. Consumption patterns are inherently different between rural and urban consumers.[44] Income differentials, expenditure growth, and rates of change of population, and other demographic factors also vary dramatically between rural and urban regions. 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.

Econometrically estimated parameters also are used for this part of the analysis. Using an Almost Ideal Demand System framework and household survey data, the authors estimated the demand parameters.[45] The estimated coefficients and elasticities are discussed in detail in two articles by Huang and Rozelle, and one by Huang and Bouis.[46] Expenditure elasticities are estimated so that they may vary according to the level of income. As projected incomes rise throughout the projection period, income elasticities fall. Urban food grain income elasticities become zero in 2000 and turn negative in 2010; those for rural residents become zero in 2010.

Feed Grain Demand. Indirect grain consumption is imputed from the underlying demand equations for pork, beef and mutton, chicken, fish, eggs, and milk. Demand parameters for the products are estimated for rural and urban residents.[47] 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 small town residents. Similarly, during the first decade of next century, demand patterns of urban consumers in small- and medium-sized cities will become more like those of consumers in super cities in the 1990s.

Once the demand for meat and other animal products are known, the implied feed demand (and hence the overall demand for grain) is calculated by applying a set of feed conversion ratios.[48] The feeding efficiency of hogs is expected to increase slightly over time. Meat production is assumed to be produced in China, and to be sufficient to satisfy the demand for animal products, an assumption that is relaxed later in the analysis.

Baseline Assumptions

All simulations begin from the year of 1993-1995, the base period. Base period data on production and utilization (discussed above) are three year averages centered on 1994. Summaries of demand and supply factors which potentially affect the future development of China's food situation are in Appendices 1 and 2. A complete detailing of the structural elasticities and projected demographic structure of the economy can be found in Huang, Rozelle, and Rosegrant.[49]

Demand Side Assumptions

Income growth and population growth will remain an important determinant of 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. Relying on the United Nation's demographic predictions, the growth rate during 1995-2000, is assumed to be 1.055 percent per annum. This annual rate falls during the next two decades to 0.740 and 0.649 percent, a level that is considerably under the world's projected growth rate (about 1.70 percent), but above recent projections by China抯 demographers.[50] The shares of urban population will raise from 28 percent in the base year to 31 percent by 2000 and to 45 percent in 2020.

Baseline per capita income growth rate is forecast to average about 3 percent in the rural sector and 3.5 percent in the urban sector. The recent growth rates in the late 1980s and early 1990s were substantially above this level in the urban economy (around 6-7 percent), and significantly below this in rural areas (less than 1 percent per year between 1985 and 1992). But in recent years the overheated urban growth has slowed, and since 1991, the rural economy has begun to pull out of its recession, growing at 4 percent per year. The impact of high growth rates also are simulated to check the sensitivity of the grain projections to the alternative growth assumptions. Market factors will also change over time. Price trends are projected to follow those of world prices.[51] The rate of rural market development is expected to increase at 10 percent per year.[52]

Supply Side Assumptions

The supply side assumptions are identical to those used in Rozelle, Huang, and Rosegrant and Huang, Rozelle, and Rosegrant and will not be repeated.[53] Following the discussion above, supply will respond most sharply to new technology and irrigation investment. However, annual expenditures on research declined from 1985 to 1990, and irrigation expenditures dropped from

1975 to 1985. Because of lags, these early investment dips will keep baseline projections of investment growth below historic rates in the early projection period. The recent recovery in research and irrigation investments, together with the experience of other Asian countries and China's commitment to a strong domestic grain economy, leads to the expectation that China will sustain its recent upturn in investment funding over the long run. 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 food grain consumption in China hit its zenith in the late 1990s. From the baseline level of 222 kilograms, food grain consumption per capita rises slightly until 2000 and falls over the remaining forecast period (Appendix 3). The average rural resident will increase food grain consumption through 2010, before reducing demand in the second decade of the next century. The ebb of per capita rural food grain demand occurs at a time when rice and wheat income elasticities, although lower than the late 1990s, are still positive. As markets develop, rural consumers have more choice, and will move away from food grains. Urban food grain consumption per capita declines over the entire projections period.

Because of the higher quality of fine grains, total rice and wheat consumption per capita will rise slightly through the year 2000 (Appendix 3). Reflecting their still positive, albeit small, income elasticities, both rural and urban consumers demand higher quantities of rice and wheat. Per capita demand for other food grains, however, falls monotonically over the projection period. Consumption per capita of all food grains is projected to be more than 5 percent lower in 2020 than current levels.

In contrast, per capita demand for red meat is forecast to rise sharply throughout the projection period (Appendix 4). China's consumers will more than double their consumption by 2020, from 19 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 middle 1990s an urban resident consumed about 60 percent more red meat than his/her rural counterpart). While starting from a lower level, per capita demand for poultry and fish rise proportionally more.

The projected rise in meat, poultry, fish, and other animal product demand will stimulate aggregate feed grain demand (Appendix 5). In the baseline scenario, demand for feed grain will increase to 117 mmt by 2000, and will reach 240 mmt by 2020. This growth rate implies that feed grain as a proportion of total grain utilization will move from 23 percent in 1994 to 40 percent in 2020. The process of moving from an agricultural economy which produces grain primarily for food to one which becomes increasingly animal feed-oriented typifies rapidly developing economies.[54]

When considered with the projected population rates, the projected per capita demands for food and feed grain imply that aggregate grain demand in China will reach 449 mmt by the year 2000 (Table 3, column 1), an increase of 10 percent over the level of 1994 (407 mmt--Table 1, column 4).[55]

Although per capita food demand falls in the later projection period, total grain demand continues 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 600 mmt (Table 3, column 7), nearly 50 percent higher than the initial baseline demand. During this same period, rice demand will reach 147 mmt, a rate increase of only 15 percent. The declining importance of rice as the dominant commodity in China can be seen by noting its proportion of total grain demand is projected to fall from 31 percent in 1994 to approximately 24 percent in 2020. The share of wheat falls by 4 percent (from 27 to 24 percent) during the same time period.

Baseline projections of the supply of grain shows that China's producing sector gradually falls behind the increases in demand (Table 3, columns 2, 5, and 8). Aggregate grain supply will attain 429 mmt (in trade weight) by the year 2000. Of this, rice and wheat make up about 31 percent and 25 percent, or 131 mmt and 109 mmt. This projection implies a rise in grain output of only about 6.5 percent over the 1992-94 baseline, a figure below the estimates given in recent years by MOA officials who had hoped to meet its target of 455 mmt by 2000 (or 500 mmt in nontrade weight figures).[56]

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 488 mmt in 2010, an increase of 14 percent during the preceding 10 years. Production will reach 569 mmt by 2020, an even higher percentage increase for the decade (16.6 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 1.48 percent per year, 0.76 percent from the rise in population and 0.72 percent due to rising per capita grain demand. Nearly all of the higher per capita grain demand is from the increased demand for feed grain (it rises by 2.89 percent while aggregate demand for food is stagnant). Grain production during this period grows only 1.35 percent annually. Imports surge to 28 mmt by 2010 and remain at a similar level through 2020 (30 mmt, Table 3, row 1).

Unlike the predictions of Fan, Wailes, and Cramer or ERS, 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 and following years (Table 3, row 2).[57] The baseline projection shows the nation consuming 3 mmt of imported rice by the end of the current decade. In fact, China is a net rice importer in 2000 under all of the alternative assumptions. While China has been a net rice exporter in the early 1990s, recent rises in rural income have removed surplus off of the domestic market and China imported rice in 1995 and 1996.

The most surprising results of the commodity projections are those for wheat. Under the baseline scenario, the initial widening gap during the late 1990s implies a rising deficit. Wheat consumption rises at about 1.60 percent annually, while production grows only by 1.30 percent. Wheat imports rise from their recent levels of about 10 mmt per year to 13 mmt in 2000 (Table 3, row 3). Wheat imports peak shortly thereafter, and fall back their current levels by 2010 and by 2020 fall to zero, implying that China will achieve self-sufficiency in wheat.

Several factors distinguish the wheat results from those of other studies. More than anything, falling wheat demand resulting from rural to urban migration and emerging rural consumption markets allows supply to catch up. Other studies, such as Fan and Agcaoili and ERS, which do not consider urbanization and market development forces, predict higher wheat imports.[58] Moreover, while there is considerable range in this study抯 projections for rice and even more for maize, few changes in assumptions result in predictions of China becoming a significantly larger wheat importer than it currently is. Most all major demand factors that appear to be inexorably increasing梪rbanization, income growth (with zero or negative income demand elasticities), and market liberalization--push China抯 consumers to reduce wheat demand over the next 25 years.

The deficit of other grain (which is mostly maize), on the other hand, experiences a rapid rise, and by 2020 almost all of China抯 cereal import needs will be for maize (Table 3, row 4). Taste preferences for meat and rising incomes stimulate meat demand, and indirectly feed demand, to such a great extent that after maize imports begin early in the 21st century, they expand continuously even though maize supply also accelerates. Major breakthroughs in maize technology (such as adoption of varieties with BT corn genes or new foreign-bred hybrids) could delay large imports.

In fact, structural change of any type, such as unanticipated shifts in cropping patterns, could drastically alter the pattern of commodity-specific forecasts. For example, rising wages could induce farmers to give up their intensive wheat-maize rotations in North China. If relative prices favored maize over wheat, large numbers of farmers might decide to stop producing winter wheat and plant a single crop of higher yielding maize. Such a change would work against the formation of the new patterns of imports, and China could end up continuing to import wheat and export (or at least not import) maize. The same type of trade-off could happen in the Yangtse Valley in the intense rice-wheat regions.

Alternative Projections

To test the sensitivity of the results to changes in the underlying forces driving the supply and demand balances, a number of alternative scenarios are run, altering the baseline growth rates of the key variables, including income, wages, and price, population, and investment in technology. The results indicate that low population growth rates would reduce grain demand by 32 mmt in 2020 and make China into a marginal grain exporter by the end of the projection period (Table 3, rows 5). With high population growth, imports increase to 56 mmt (rows 6).

Low income growth causes a decline in projected total grain demand from 601 mmt to 555 mmt, resulting in moderate exports of grain in 2020, while rapid income growth causes projected imports to nearly triple to 85 mmt (rows 7-8).

Imports rise sharply to 44 mmt if real wages increase faster (e.g., 2 percent annually) than the baseline rate (1 percent--Table 3, row 5). However, China's still has a large, still-isolated agrarian population, of which only about one-third have off-farm jobs.[59] With rising wages, the labor force slowly is becoming integrated with the rest of the economy through emerging labor markets. The enormous increase in labor that can leave rural areas should keep rapid real wage increases from taking off for at least several decades. Moreover, even if wage rates do rise fast, and labor begins flowing off the farm, farmers will replace lower labor input with capital-intensive inputs such as farm machinery and herbicides. Since these types of capital inputs are not in the structural model (because of lack of data), the 1 percent increase in wage rates should be looked on as the percentage increase rise in the wage rate over the rate of rise of the price of capital. If real wages increases (relative to the cost of capital) did approach those in Taiwan and Korea (3 percent annual growth), imports could increase to as much as 58 mmt.

Table 4 also illustrates the large impact of investment in agricultural research and irrigation on production and trade balances (rows 2-3), a result that is hardly surprising given the large contribution to supply of agricultural research and the technology it produces. Increases in the growth rate of agricultural research and irrigation investment from 3.5 percent to 4.5 percent per year transform China from an importer to exporter by early 2010. If, instead, growth in annual investment in the agricultural research system and irrigation fell only moderately, from 3.5 percent per year (as forecast under the baseline projections) to 2.5 percent, by 2020 total production would only be 514 mmt. With no change in the demand-side assumptions, imports under such a scenario would reach a level of 83 mmt.

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 or could not respond as imports rose to with countervailing policy measures to stimulate food production growth. Agricultural research and irrigation investments, however, have already recovered in recent years, and in the mid-1990s when grain prices rose in response to short term tightening of grain supplies, policy makers have promised and have begun delivering greater agricultural investments.[60] While most of the investments have been targeted at irrigation, improvements in the operations of research institutes have also been announced.

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, there are currently several large international seed companies investigating the possibilities of moving into the 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. Weak intellectual property rights and tightly controlled and fractured domestic seed markets, however, remain a serious barrier to active participation by multinational technology firms in China.[61]

Production, demand, and imports, however, are insensitive to small changes in price trends, a characteristic that will affect projections of how China抯 entry into (or exclusion from) the World Trade Organization (WTO) will impact food balances. Output price trends do affect China's grain balances, but the effects are small. At the baseline level, for every 0.5 percent increase (decline) in the annual projected grain price trend, imports fall (rise) by 7 mmt in 2020

(Table 4, rows 6 and 7).[62] The baseline price assumption (an annual 0.5 percent world price decline as projected by both World Bank and Rosegrant, Agcaoili, and Perez), however, was chosen as the most likely to be realized for two reasons.[63] Grain prices have trended down in real terms during the entire twentieth century. Also, if China gains admittance to WTO, it politically cannot support prices at the level maintained by its East Asian neighbors. Even without WTO membership, fiscal problems in China may keep it from using high price supports. In the event that China could and decided to adopt a protectionist policy and prices rose in real terms at 0.5 (1.0) percent annually during the next 3 decades, China imports (exports) about 5mmt (7 mmt) in 2020.

Assuming a constant response of production to erosion and salinity as the level of environmental deterioration increases, slight increases in their trends (e.g., an increase of 0.2 percent per year from 0.2 to 0.4) have little impact on output (a decline of only about 4 mmt in 2020--Table 4, the last row). Extrapolating from these results, substantial impacts would not be found until the erosion and salinity rates accelerate to growth levels 5 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 only rise to 51 mmt. Unless the impact of environmental stress is exponential, and the government is unwilling (or unable) to invest in rectifying the adverse aspects of the deteriorating environment, these findings find Brown's pessimism is unfounded.

China has other food policy alternatives and could turn to international meat markets to satisfy its food needs, instead of importing grain as feed. China currently is a net exporter of meat, mostly to Hong Kong and Southeast Asia. If the model allowed for meat imports, China might choose to buy meat on global markets, a move that would reduce projected feed grain imports, but not total agricultural trade volume. If China imported a quantity of meat equal to 10 percent of its 2000 meat demand, grain net imports in 2020 could be reduced to 6 mmt from the baseline of 30 mmt when China relies completely on domestic sources of meat. Without good refrigeration or transportation infrastructure, however, meat imports will be constrained in the near future. In fact, many developing countries prefer to import feed grain and undertake the value-added activity in their own country. But, if high grain imports are unacceptable under China's current political doctrine, importing meat may be one way around such an ideological constraint.

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 authors' framework includes a demand-side model that, in addition to the impacts 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 consumption markets. The supply response model considers the impact 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 at ERS, Carter and Zhong, and Rosegrant, Agcaoili, and Perez, China's imports will rise steadily throughout the next decade.[64] By 2010, imports are expected to reach 28 mmt, respectively. Increasing imports arise mainly from the accelerating demand for meat and feed grains, as well as by the continued slowing of supply due to reduced investment in agricultural research in the late 1980s. However, after 2010, grain imports are expected to stabilize, as demand growth slows due to increasing urbanization and declining population growth rates; and supply growth is sustained with the on-going recovery of investment in agricultural research and irrigation. China 抯 dynamic economy and rapidly changing structure may cause changes in the historic patterns of food trade. It could by in 2010, for example, that China imports rice, and that by 2020 it is self-sufficient in wheat and one of the world抯 largest importers of maize.

There is considerable range in the projections, 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 is what should be expected from the factor that it has the largest marginal output response. While there are a few scenarios where projected levels of imports are somewhat large, from both the view point of China's own domestic needs, and relative to the size of current world market trade, there are factors which may keep China from becoming too large of the player in world markets. First, world grain prices would certainly rise in the face of large Chinese imports, a tendency which would dampen Chinese grain demand and stimulate domestic supply. Second, there may be major foreign exchange constraints to importing such large volumes of grain--either government policy makers 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, and perhaps most importantly, many political economy influences may make China's leaders react to increasing grain shortages. Regardless of China's comparative advantage, government leaders have historically, and continue to be, concerned with maintaining near self-sufficient 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 nations--especially those dealing with wheat (in the short run) and maize (in the long run) --will undoubtedly be the beneficiaries of these trends. If China's policy makers believe the projected level of imports are too high (either politically or because they see some other physical or economic constraint), investment strategies need to be devised 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 most likely determine whether the production-demand gap turns into a major agricultural crisis, or whether it will become an opportunity to more effectively develop the nation's food economy.

Table 1. Annual Grain Production, Utilization and Per Capita Food Consumption in China, 1993-1995.

	Production	Change in Stock[a]	Net Import	Total Supply	Disposal of Available Supply: Seed	Animal Feed	Nonfood Manu-facturing	Waste	Food	Per Capita Food Consumption[b]: Average	Rural	Urban
	(million metric tons)									(kilograms)		
Total Grain	403	-2	2	407	17	93	16	15	264	222	242	172
Rice	126	-3	-0	128	4	7	1	4	109	93	103	68
Wheat	103	-0	8	111	3	2	2	3	101	85	90	72
Other Grain[c]	174	1	-6	167	10	84	13	8	55	44	49	32
-- Maize	105	0	-5	100	3	65	2	3	28	24	31	7
Red Meat										19	27	17
Pork										17	23	14
Poultry										4	7	3
Fish										7	14	5

Sources: Computed by authors.

Note: Rice in milled form (trade weight). Base year is average of 1993-95.

[a] A negative number indicates a decrease in stocks, which increase total grain supply.

[b] Includes direct home consumption, grain purchased and consumed outside of home, and processed foods.

[c] Includes maize, other coarse grains and soybean.

Table 2. International Trade Balance (million metric tons) of Major Agricultural Commodities in China, 1985-1996

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996[a]
Grain	3.3	1.7	-8.9	-8.2	-10.1	-7.9	-2.6	2.0	7.9	4.3	-19.7	-6.1
Wheat	-5.4	-6.1	-13.2	-14.5	-14.9	-12.5	-12.4	-10.6	-6.4	-7.2	-11.6	-5.0
Maize	6.2	5.1	2.3	3.4	3.4	2.5	7.8	10.3	11.1	8.7	-5.1	-0.4
Rice	0.8	0.6	0.5	0.4	-0.7	0.3	0.6	0.9	1.3	1.0	-1.6	-0.3
Soybean	1.1	1.1	1.4	1.3	1.2	0.9	1.1	0.5	0.3	0.8	0.1	-0.2
Other grain	0.5	1.0	0.0	1.3	0.9	0.9	0.3	0.9	-0.1	0.0	-1.6	-0.2
Cotton	0.35	0.59	0.75	0.43	-0.25	-0.25	-0.17	-0.14	0.14	-0.39	-0.72	-0.39
Sugar	-1.73	-0.91	-1.38	-3.46	-1.15	-0.56	-0.67	0.57	1.40	-0.60	-2.47	-0.18

Sources: State Statistical Bureau, *Statistical Yearbook of China*, (Beijing: China, State Statistical Bureau Press, 1995); Ministry of Foreign Trade, *China Customs Statistics*, (Beijing: Ministry of Foreign Trade Press, January to December, 1995 and January to August, 1996).
[a] Data available only for first 6 months of 1996.

Table 3. Projections of Grain Production, Demand, and Net Imports (million metric tons) under Various Scenarios with Respect to Population and Income, 2000-2020.

Alternative Scenario	2000 Demand	2000 Production	2000 Net Imports	2010 Demand	2010 Production	2010 Net Imports	2020 Demand	2020 Production	2020 Net Imports
Baseline									
Grain	449	429	20	516	488	28	600	569	30
-- Rice	134	131	3	142	141	1	147	153	-6
-- Wheat	122	109	13	133	123	10	141	141	0
-- Other grain	193	189	3	242	224	17	312	273	38
Baseline with low population growth									
Grain	446	429	17	501	488	13	568	569	-1
Baseline with high population growth									
Grain	452	429	23	529	488	41	625	569	56
Baseline with low income growth									
Grain	441	429	12	494	488	6	555	569	-14
Baseline with high income growth									
Grain	458	429	29	542	488	53	655	569	85

See Appendix 1 for assumptions on population and income growth rates.

Table 4. Sensitivity of Grain Production, Demand, and Net Imports Projections to Alternative Assumptions on Public Investment, Wages, Price Trends, and Deterioration of the Environment, 2000-2020.

Alternative Scenario	2000			2010			2020		
	Demand	Production	Net Imports	Demand	Production	Net Imports	Demand	Production	Net Imports
Baseline	449	429	20	516	488	28	600	569	30
Baseline with low rate of investment in agriculture research and irrigation	449	424	24	516	465	50	597	514	83
Baseline with high rate of investment in agriculture research and irrigation	449	431	18	518	515	3	602	631	-29
Wage growth									
-- Low (0% per year)	449	432	18	517	496	21	600	584	16
-- High (2% per year)	449	427	22	516	481	36	599	555	44
World output price impact									
-- Large (0% per year)	449	430	19	516	492	25	600	576	23
-- Small (-1%)	450	428	21	517	485	32	600	563	37
Fertilizer price growth									
-- Low (0% per year)	449	433	16	517	501	16	601	594	7
-- High (2% per year)	449	425	24	516	476	40	598	546	52
Salinity and erosion growth									
-- Low (0% per year)	449	430	19	517	491	26	600	574	26
-- High (0.4% per year)	449	428	21	516	486	31	599	565	35

See Appendix 2 for assumptions on growth rates of prices, investment and environmental variables.

Appendix 1. Assumptions on the Growth of Factors Affecting Grain Demand in China,1994-2020.

Factors	Annual Growth Rate (%)		
	Low	Baseline	High
Total Population			
1995-2000	0.933	1.055	1.165
2000-2010	0.491	0.740	0.932
2010-2020	0.374	0.649	0.844
-- Rural			
1995-2000	0.218	0.343	0.461
2000-2010	-0.515	-0.252	-0.047
2010-2020	-0.873	-0.606	-0.413
-- Urban			
1995-2000	2.633	2.750	2.842
2000-2010	2.424	2.650	2.825
2010-2020	2.158	2.450	2.658
Per Capita Real Income			
-- Rural	2.0	3.0	4.0
-- Urban	2.5	3.5	4.5
Prices			
-- Rice	-1.0	-0.5	0.0
-- Other Grain	-1.0	-0.5	0.0
-- 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

Note: The shares of urban population under baseline assumption are 28, 31, 38, and 45 percent for 1995, 2000, 2010 and 2020. Population estimates are based on United Nations, *World Population Prospects*, *1994 Revisions*, (New York, NY: United Nations, 1995). Output prices are based on simulation analysis performed in collaboration with the IMPACT model developed by the International Food Policy Research Institute (M. Rosegrant, M. Agcaoili, and N. Perez, "Global Food Projections to 2020: Implications for Investment" 2020 Vision Discussion Paper Series, No. 5, International Food Policy Research Institute, Washington, DC, 1995). Figures for the rural market development are index numbers for the year indicated, J. Huang and S. Rozelle, "Market Development and Food Demand in Rural China." *China Economic Review*, forthcoming.

Appendix 2. Assumptions on the Growth of Factors Affecting Grain Supply in China, 1994-2020.

	Annual Growth Rate (%)		
Factors	Low	Baseline	High
Output and Input Prices			
-- Rice	-1.0	-0.5	0.0
-- Other Grain	-1.0	-0.5	0.0
-- Fertilizer	0	1.0	2.0
Land and Labor			
-- Land opportunity cost	1.0	1.0	1.0
-- Wage	0.0	1.0	2.0
Agricultural Research Expenditure	2.5	3.5	4.5
Irrigation Expenditure	2.5	3.5	4.5
Environmental Factors			
-- Salinity	0.0	0.2	0.4
-- Erosion	0.0	0.2	0.4

Notes: Agricultural research and irrigation expenditures are extrapolated from recent trends and are adjusted based on Li Peng, 1996, 揘ational Economy and Social Development for the Ninth Five-Year Plan and 2010 Long Term Goals,” People抯 Press, Beijing. The "Land opportunity cost" growth rate is an extrapolations from trends State Price Bureau, 擟ompendium of Cost of Production Data,” (Beijing: State Price Bureau Press, 1988-95). Land opportunity cost is 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. Output price trends are based on simulation analysis performed in collaboration with the IMPACT model reported in M. Rosegrant, M. Agcaoili, and N. Perez, "Global Food Projections to 2020: Implications for Investment” 2020 Vision Discussion Paper Series, No. 5, International Food Policy Research Institute, Washington, DC, 1995. Fertilizer price trends are similar to those used by the World Bank, *Agriculture to the Year 2000,* A World Bank Country Study (Annex 2 to China: Long-term Development Issues and Options), Washington, DC, 1990. The trends in the deterioration of the environment are based on extrapolations of past trends.

Appendix 3. Projected Annual Per Capita Food Grain Consumption under Alternative Income Growth Scenarios in China, 1994-2020.

	Per Capita Food Grain Consumption (kg)			
Alternative Scenario	1994	2000	2010	2020
Base Line				
Total Grain	222	223	219	210
-- Rural	242	245	246	243
-- Urban	172	175	174	168
Rice	93	94	93	90
-- Rural	103	105	107	109
-- Urban	68	69	69	68
Wheat	85	86	87	86
-- Rural	90	92	95	95
-- Urban	72	74	76	75
Other Grain	44	42	38	34
-- Rural	49	47	44	40
-- Urban	33	31	29	25
Low Income Growth				
Total Grain		221	216	208
-- Rural		242	243	241
-- Urban		174	173	169
Rice		93	91	98
Wheat		85	86	84
Other Grain		43	39	35
High Income Growth				
Total Grain		224	221	211
-- Rural		247	249	246
-- Urban		176	174	167
Rice		95	95	92
Wheat		87	89	87
Other Grain		42	37	32

Appendix 4. Projected Annual Per Capita Consumption of Meat and Fish under Alternative Income Growth Scenarios in China, 1994-2020.

Alternative	Per Capita Meat Consumption (kg)			
Scenario	1994	2000	2010	2020
Baseline				
Red Meat	19	23	32	43
-- Rural	17	20	26	33
-- Urban	27	30	40	52
Poultry	2	3	5	8
-- Rural	1	2	3	4
-- Urban	5	6	8	12
Fish	8	10	17	28
-- Rural	5	6	9	14
-- Urban	14	18	28	43
Low Income Growth				
Red Meat		22	27	34
-- Rural		18	22	27
-- Urban		28	34	42
Poultry		3	4	6
-- Rural		2	2	3
-- Urban		5	7	9
Fish		9	14	20
-- Rural		6	8	10
-- Urban		16	22	30
High Income Growth				
Red Meat		25	36	53
-- Rural		21	30	41
-- Urban		32	46	65
Poultry		4	6	10
-- Rural		2	3	5
-- Urban		6	10	16
Fish		11	21	40
-- Rural		7	12	19
-- Urban		20	35	61

Appendix 5. Demand for Feed Grain under Alternative Population and Income Growth Scenarios in China, 1994-2020.

Alternative Scenario	Demand for Feed Grain (million metric tons)		
	2000	2010	2020
Baseline Population Growth			
-- Low Income Growth	111	147	197
-- Base Income Growth	117	166	240
-- High Income Growth	124	189	294
Low Population Growth			
-- Low Income Growth	110	143	186
-- Base Income Growth	116	161	226
-- High Income Growth	122	183	277
High Population Growth			
-- Low Income Growth	112	151	205
-- Base Income Growth	118	171	250
-- High Income Growth	125	194	308

Note: Total feed grain is 93 million metric tons in the base year (1993-95).

Endnotes

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[13] Alternatively, if the baseline starting points differ, significant variations in predictions can occur, even if the projection frameworks are alike in all other aspects. In fact, because of differences in estimates of meat consumption, one of the factors that causes the largest differences among the models is that some analysts use per capita meat production figures as a starting point for their baseline take-off point, while others use figures bases on consumption figures. Unfortunately, because of overreporting of production figures (due to double counting

and local leader exaggeration) and under estimation of consumption (due to the fact that current enumeration techniques overlook much of the consumption activities that occurs outside of the household--e.g., in restaurants), production-based estimates of demand have grown to be more than 200 percent higher than those estimates based on consumption data. In a recent conference, the Post-Conference Workshop on “China’s Food Economy in the 21st Century,” Annual Meetings of the American Agricultural Economics Association, Toronto, July 31, 1997, the baseline level of meat demand projections was determined to be one of the single most important factors distinguishing the various predictive models.

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[15] Carter and Zhong.

[16] Garnaut and Ma; Chen and Buckwell.

[17] ERS.

[18] High import projections for supply-side reasons come from Brown; Carter and Zhong; those for demand side reasons are from Garnaut and Ma; ERS.

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[40] Huang, Rosegrant and Rozelle.

[41] M. Rosegrant, M. Agcaoili, and N. Perez, "Global Food Projections to 2020: Implications for Investment," 2020 Vision Discussion Paper No. 5, International Food Policy Research Institute, Washington, DC, 1995.

[42] Technology was measured in stock form, and was built by aggregating past government expenditures on research according to a weighting criteria suggested by P. Pardey, R. Lindner, E. Abdurachman, S. Wood, S. Fan, W. Eveleens, B. Zhang, and J. Alston, "The Economic Returns to Indonesian Rice and Soybean Research," Report Prepared by the Agency for Agricultural Research and Development (AARD) and the International Service for National Agricultural Research (ISNAR), November 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 M. Rosegrant and F. Kasryno, "Dynamic Supply Response for Indonesian Food Crops," Working Paper, International Food Policy Research Institute, Washington DC, 1994. The environmental variables have been described and analyzed in J. Huang and S. Rozelle, "Environmental Stress and Grain Yields in China," *American Journal of Agricultural Economics* 77, No. 4 November 1995):246-256.

[43] The general supply-side parameter were first estimated in Huang, Rosegrant, and Rozelle. More recent commodity specific estimates for wheat are in Rozelle and Huang (1997); and for maize are in Huang and Rozelle (1997).

[44] H. Bouis, "Prospects for Rice/Supply Demand Balances in Asia," Working Paper, International Food Policy Research Institute, Washington DC, 1989; and Huang and David. The parameters relating demand behavior to rises in income use expenditure data instead of income due to the difficulty in comparing urban and rural income since the former includes large subsidies for housing, health care, etc. The analysis does not consider the impact of urban housing, education, and health reforms, which would have two effects on food consumption. If urban residents paid market rates for all good and services, the income effect would reduce consumption of all goods, including food. The cross price effects, however, would offset part of this drop.

[45] A. Deaton and J. Muellbauer, "An Almost Ideal Demand System," *American Economic Review* 70(1980):321-26.

[46] Huang and Rozelle, "Income, Quality, and ..., 1994; J. Huang and S. Rozelle, "Urban Life, ...," 1995; and Huang and Bouis.

[47] See F. Fuller and J. Rude, "An Approach to Policy Analysis and Projection for the Agricultural Sector of the People's Republic of China," Paper Presented at the Post-Conference Workshop on "China's Food Economy in the 21st Century," Annual Meetings of the American Agricultural Economics Association, Toronto, July 31, 1997. There is still much uncertainty about the current estimates of meat demand parameters, mainly due to data problems. In the published data, production statistics report a level of pork output that is more than twice as great as the level of pork consumption as reported in China's income and expenditure data. The discrepancy probably has a number of components. Many researchers in China believe current demand figures miss a significant part of family member consumption that occurs out of the household (e.g., dining in restaurants, etc.). It is also suspected that production figures are inflated, in part because of statistical problems (mostly a double counting problem), and in part because local official may have an incentive to overstate pork production, since unlike grain, monitoring of livestock production is much more difficult and the probability of being caught for exaggerating production numbers is minimal.

[48] Feed conversion parameters are from ERS and are consistent with estimates used by Chinese agriculturists found in handbooks used by Ministry of Agricultural officials. Officials, however, told us that they believed these rates were too high. This would mean that the demand for feed

and imports are over estimated. However, commercialization of China's livestock industry is occurring rapidly, which would mean that conversion rates should increase over time (since farmers tend to feed scraps and other non-grain feed stuffs to hogs). Hence, any over-estimation in the short run should be eliminated at some point during the study period. Current research by the authors is centered on obtaining a better set of feed efficiency rates.

[49] Huang, Rozelle, and Rosegrant.

[50] The baseline assumptions for population growth rates in the three study decades implies an overall projection period population growth rate of 0.89, a level slightly higher than that assumed by Rosegrant, Agcaoili, and Perez (0.74). There are many reasons to believe 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 and Perez use an alternative rate of 1 percent per year. In this study's high-population growth scenario, it is assumed the growth rate in the first decade is 1.413, the second, 0.932, and the third, 0.844, implying an overall study period growth rate of 1.06. In a later section, results are presented showing the sensitivity of the conclusions to the choice of population growth rates.

[51] According to J. Huang and C. David, "Price Policy and Agricultural Incentive in China," A Report Submitted to Food and Agriculture Organization of UN, FAO, Rome, 1995, while once far out of line with world agricultural prices, in recent years China's market prices have converged with those in international markets. 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 grain) were then simulated in IFPRI's IMPACT model to generate projected world prices with China entering as a significant importer. These projected world 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.

In this sense, the assumption is consistent with China's entry into GATT, where in the long run Chinese producers will not be protected or taxed by border restrictions. Since China's current 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 route of its prosperous East Asian neighbors, and begin to protect its producers with ever-increasing prices. Severe fiscal problems, however, most likely rule out such a strategy.

[52] Huang and Rozelle, “Market Development ...,” 1997.

[53] S. Rozelle, J. Huang, and M.. Rosegrant, “How China will NOT Starve the World,” *Choices* (First Quarter 1996):10-16; J. Huang, S. Rozelle, and M. Rosegrant, “Supply, Demand, and Trade in China,” An IFPRI 2020 Vision Working Paper, International Food Policy Research Institute, Washington, DC, 1996.

[54] P. Yotopolous, “Middle-Income Classes and Food Crisis: The “New” Food-Feed Competition,” *Economic Development and Cultural Change*, 33 (April 1985):463-484.

[55] In addition to projected food and feed 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.

[56] MOA

[57] Fan, Wailes, and Cramer; and ERS.

[58] Fan and Agcaoili; and ERS.

[59] S. Rozelle, G. Li, M. Shen, J. Giles, and T. Low.
[60] J. Huang, "Agricultural Policy and China's Agricultural Performance," Working Paper, Center for Chinese Agricultural Policy, Beijing, China, 1996.
[61] Rozelle, Pray, and Huang.
[62] 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 into the agricultural decision making process. Second, on the demand side, although there are fairly large negative own-price elasticities, positive cross price elasticities dampen the reduction (increase) in demand when prices rise (fall). Similar magnitudes are observed with changes for the price of fertilizer; by increasing (decreasing) the projected growth of fertilizer prices by 1 percent, imports increase (decrease) by 4 MMT. Hence, if the past trends hold--i.e., 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.
[63] Rosegrant, Agcaoili, and Perez.
[64] ERS; Carter and Zhong; and Rosegrant, Agcaoili, and Perez.