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The Rise of the Middle Class
and China's Future Food Deficit

by

Scott D. Rozelle¹
Pan A. Yotopoulos²
Jikun Huang³

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Center for Economic Policy Research
Stanford University
Stanford, CA 94305
(415) 725-1874

¹Stanford University
²Stanford University
³Center for Chinese Agricultural Policy

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Contact author:
Pan A. Yotopoulos
Food Research Institute
Stanford University
Stanford, CA 94305

Phone: 415-329 8159; Fax: 415-329 8159
E-mail: yotopoul@leland.stanford.edu
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Abstract

Scott Rozelle, Pan A. Yotopoulos, and Jikun Huang
Stanford University and Center for Chinese Agricultural Policy

One of the most closely watched debates by researchers on China’s food economy addresses the question: Will China be able to produce most of what it needs to feed itself in the 21st century? The preponderance of evidence from research favors the viewpoint that China will essentially be able to feed itself even though future imports of grains will most likely rise. This conclusion, to the extent that it is based on historical data, may not reflect the new pressures on the food economy that emanate from structural changes in China as a result of rapidly rising wealth, urbanization, marketization, and technological change. Notable among the neglected structural factors that change the contours of the demand for food is the graduation of consumers from poverty to the middle class (Yotopoulos, 1985). This has a twofold impact on demand. First, the income elasticity for livestock products is higher than for food grains (which means as incomes rise, more grain is demanded). Second, the switch in classes, from one with a food grain-based diet (and low consumption of grains) to another with a higher level of consumption of grain-intensive livestock products, also creates a large jump in total demand for grains. The size of the additional demand depends on the number of people who graduated to improved diets and on the difference between the old standard at which they were consuming and the new. While the income elasticity of demand is accounted for in projections, the graduation effect of the switch in classes is often overlooked.

The purpose of this paper is to revisit the debate on the impact of China’s development at home and in the world by systematically exploring the implications of China’s rapid growth of income, the structure of that income growth (or the pattern of inequality), and the competition of consumers for food and feed. Using a set of structural parameters estimated by the authors from primary and secondary data, a supply and demand modeling framework projects the future balance of China’s major grain commodities, while explicitly examining the impact of the new food-feed paradigm. An upward revision of projected demand increases the potential for short-term grain deficits that could lead to abrupt price rises. The concatenation of these events will almost certainly not starve the world; but it is likely to create serious food security problems for those inside and outside China who rely on food markets and who are not in a position to pay high prices for food in the short run.
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1. Introduction

One of the most closely watched debates by researchers on China's food economy, whether inside or outside the country, addresses the question: Will China be able to produce most of what it needs to feed itself in the 21st century? Or, more poignantly, and in terms of the concern about "crowding out" of the demand of the poor: Will China starve the world?

The preponderance of evidence produced by those who have seriously addressed this debate clearly favors the viewpoint that China will essentially be able to feed itself even though imports of grains most likely will rise over the next several decades. For example, Yang and Tyers (1989) have forecast that China will import around 50 million metric tons (MMT) of grains per year in the late 1990s. Garnaut and Ma (1992) argue that China will face up to a 90 MMT shortfall in grain production in the twenty-first century. Rozelle, Huang, and Rosegrant (1996) predict that China will need up to 40 MMT of grain imports annually to meet domestic needs in the first two decades of next century. While China will need to import substantially more grain than in the past, most international food trade and production specialists believe such a rise in demand can be met by current suppliers, with only a modest rise in long run prices.

Only the most controversial of recent attempts to gauge China's future import demand for grains has been able to produce for the long run a tale of widespread disaster. Using somewhat opaque methodologies, Lester Brown (1994, 1995) has predicted that rising consumption and stagnating supply could force Asia's fastest growing economy to import more than 200 MMT of grain annually two or three decades into the next century. Brown's argument is that China's emergence as a large importer will drive up world grain prices. A price spike in the world grain market may temporarily divert trade flows away from less competitive, but more needy nations - which according to Brown could suffer food shortfalls and massive starvation. Within China, some researchers have noted that the nation's own poor may also be facing the same threat. Low income households, without access to entitlements and few liquid capital assets, may find their subsistence demand for food crowded out in times of high prices and may suffer nutritionally as a result (Ye, Park and Rozelle, 1994).
Brown's sensational prediction has been countered by those who claim it does not factor in basic political and economic principles. At the policy level China's government is likely to respond with interventions in agricultural investment ex ante and in food distribution ex post. In the domain of economics Brown ignores the price response of world producers who will supply more at higher prices and of consumers who will demand less. On the side of political imperatives, Brown's argument may also be ignoring China's own ideology, which historically has placed great priority on grain self-sufficiency. Over the long run, China's government almost certainly would take actions to prevent the loss of its hard-gained status of near self-sufficiency.

There are several factors, however, that these studies, including Brown's, do not consider. The studies forecast long-run, average outcomes of China's food economy for the typical consumer. Projection models do not deal with the probability - which may be rising - that the world (or China) might be facing one or more years of food shortages and spiking prices. Increased volatility in prices is assumed away in formal models. However, projection analysts concur that a systematic trend of a "longfall in demand" and of a "shortfall in supply" cannot be dismissed out of hand, given China's vigorous economic growth which indulges improvement in diets, and an international environment of liberalization in agricultural trade where food reserves are pared down. In this setting, China's domestic markets and the world's grain trade will most likely be significantly tighter on average in years to come. Any happenstance of an abnormal weather cycle, be it in China or in important agricultural producing countries, could bring a serious shortfall in food supplies and might easily exacerbate a bad situation.

By itself, a brief period of food shortfall could be tolerable for most people in China: in a growing economy, the average consumer who is enjoying increasing income can bear the burden of acute price spikes from time to time. The problem arises when incomes grow inequitably and it impacts the most disadvantaged segment of the population that is mired in poverty - whether in China or in other countries that rely on imported grain. Those with meager endowments, no significant assets, and limited exchange entitlement mappings may find themselves in a position where they can not afford sharply higher prices, even though the periods of abnormally short supplies and of price spikes are expected to be of limited duration (Sen, 1981). Hence, it is fair to say that in the long run, and on average, China's predicted need for greater grain supplies and its movement into international markets almost certainly will not starve the world at large (or most residents in China itself). In the meantime, tighter markets and unequal patterns of income growth may put some segments of society at a temporary food security risk and could create the preconditions for food crises or even famines. Therefore, policymakers and academics concerned about food security in general and about famines in specific should be interested in the factors that may make grain markets tight: the factors that will shrink and constrain supply and those that will expand demand. Of most concern are those factors which may cause sudden shifts in supply or demand, generating pronounced price spikes, since they can take their toll on the poor before they can be effectively addressed on a large scale by policy (Sen, 1981).
Unfortunately, previous studies are mostly based on historical data, extrapolate from past structural relationships, and rely on the environment of the world food economy which existed in the 1960s, 1970s, and 1980s. Meanwhile, both China's domestic economy and the world food situation are changing rapidly. Post-GATT policies (e.g., those allowing fewer public grain reserves or those that outlaw many production-stabilizing programs) have undermined the world's ability to increase supplies in international markets in times of stress. The structure of China's own economy also is changing rapidly. Urbanization, marketization, and technological change, create new pressures on the Chinese food economy and transform the basic elements of supply and demand.

While the influence of some of these factors on food supply, demand, and trade has been analyzed recently (e.g., Rozelle, Huang, and Rosegrant, 1996), the impact of one other major factor has not. Yotopoulos (1985) has emphasized how changes in the contours of the demand for food, especially as they relate to rapid growth in incomes with pronounced inequality, can potentially have a sharp impact on world food balances. Entitled the “new food-feed competition,” his argument focuses on “longfalls in demand” by those who enjoy rapidly growing incomes and the “crowding out” of the poor whose money incomes have not benefited from economic growth. At low levels of income, the income elasticity of demand for food is low since most of income goes to purchase food grains: expenditures on food grains increase less than the rate of increase in income, as many empirical studies have shown. At higher levels of income, however, consumers begin to switch from directly consuming food grains to eating livestock products (which is really indirect demand for grain). The impact on demand of the general graduation of consumers from poor to middle class is twofold. First, the income elasticity for livestock products is higher than for food grains (which means as incomes rise, more grain is demanded). Second, the switch in classes, from one with a food grain-based diet (and low consumption of grains) to another with a higher level of consumption of grain-intensive livestock products, also creates a large jump in total demand for grains. The size of the additional demand depends on the number of people who graduated to improved diets and on the difference between the old standard at which they were consuming and the new. While the income elasticity of demand is normally accounted for in demand projections, the graduation effect of the switch in classes is routinely overlooked. The dynamic of these two factors may lead economies in early stages of development to experience the type of large surges in cereal demand (a “longfall” in demand) that can generate spikes in prices. Price volatility, in turn, can set off pressures in food markets which can crowd out the food security requirements of large parts of the population whose real incomes shrink.

The purpose of this paper is to revisit the debate on the impact of China's development at home and in the world. The study will systematically explore the implications of China's rapid growth of income, the structure of that income growth (or the pattern of inequality), and the competition of consumers for food and feed. If China is growing fast but inequitably, and if the food-feed hypothesis is correct, it may be that previous studies of future food balances have
underestimated the demand for grain in the medium term. An upward revision of projected demand increases the potential for short-term grain deficits that could lead to abrupt price rises. The concatenation of these events will almost certainly not starve the world; but it is likely to create serious food security problems for those inside and outside China who rely on food markets and who are not in a position to pay high prices for food in the short run.

To meet this goal, the rest of this paper is organized as follows. Sections 2 and 3 examine China's reforming economy, looking at income trends in the whole economy and at the basic forces that affect grain supply, demand, and trade. Section 4 reviews in greater detail the Yotopoulos food-feed hypothesis, and then considers its relevance to the case of China. To more formally examine China's food economy and the impact of the new competition for food and feed, a framework for making projections for future food supply, demand and trade is developed and explained in Section 5. Section 6 compares a baseline scenario (one in which the food-feed competition is not considered) with a scenario in which the interactions among population, income, and food demand are closely scrutinized. The final section concludes and considers the implications that the findings have for China's own domestic policies and how the actions of China's producers, consumers and traders may put greater pressure on world markets.

2. Rising Income and Increasing Inequality in China's Rural Economy

Urban incomes in China have experienced continuous growth since the early 1980s (ZGTJNJ, 1981-1995). The average urban resident has seen real household income nearly triple. Standards of living have likewise rapidly increased. Expenditures on food and other necessities as a share of average household income have dropped, while those for more consumer-oriented goods have continued to grow. These canonical observations do not fully apply to certain pockets of urban society where food security problems are beginning to emerge. A similar caveat is in order for the vast majority of China's poor who live in rural areas. This section focuses on the rural segment of the population as the one at risk. The rural poor may experience the most sudden changes in real income in the future.

In contrast to urban incomes, rural incomes have taken a more variable path. Despite the rapid rise in the early 1980s, more than 10 percent annually, real per capita rural income in China did not increase between 1984 and 1990.\(^1\) The growth of income in rural China fell in the mid-

\(^1\) All of the income and output data used in this paper come from standard published sources, and have been used extensively in the literature (e.g., Puttermann, 1992; Oi, 1993; Nee, 1990; Travers, 1992; World Bank, 1992; Ody, 1991). Per capita rural income is from ZGTJNJ (1981-93). The income variable, which is collected and generated by the national State Statistical Bureau (SSB), is designed to capture full household income, including earnings from agriculture and off-farm activities, non-wage sources, remittances and gifts. While it has been shown that SSB figures may systematically understate income (Khan et al., 1992), this study is primarily examining trends over time. There is no reason to expect that any large, new biases have appeared in the data. Real income figures
1980s to an annual rate of 2 percent. After a steep drop in 1989 (and no growth in 1990), the 1989/90 average rural income figure of 336.75 yuan per capita was virtually identical to that in 1984/85 (335.81 yuan per capita). Since 1991, however, average rural per capita incomes have begun to rise rapidly once again (Rozelle et al, 1996). In all but one of the past 5 years, real income growth has exceeded 4.5 percent. Despite the mixed record of income growth in rural China over time, the average farmer has experienced a sharp rise in consumption (Chai, 1992), and a large part of rural populations has moved out of poverty (Travers, 1992).

These aggregate rural income trends mask diverging growth paths for provinces in China's geographical sub-regions. For example, the growth rates of the eastern provinces (except for Anhui) and southern provinces (except for Guangxi) did not decline significantly after 1984. The rural economies in some of these provinces (e.g., Zhejiang) grew at an annual rate of nearly 7 percent between 1984 and 1988. The growth generated by these robust rural areas, however, has been offset by more variable and lower-than-average (or negative) rates of growth elsewhere. Income growth in the northeastern provinces shows the greatest increase in variance. Per capita real income in Heilongjiang's rural sector, for example, alternately grew and fell in each year throughout the late 1980s (and experienced the sharpest fall in 1985, when it fell 18 percent in a single year). The central and northern provinces generally suffered the most severe falls in income. For example, in Hunan average real rural incomes decreased 4 percent per year from 1984 to 1990. The income of rural residents in Shanxi fell for five consecutive years after 1984. Such variable rates of income growth across China's regions have continued in the 1990s. Measures of both interregional and interhousehold inequality that have been rising confirm these divergent income trends (Rozelle, 1996).

Hence, while there is still considerable and even accelerating income growth in China for some, a large class of poor farm households remains (World Bank, 1992; Ye, Park, and Rozelle, 1994). Nearly 100 million persons in China's poor areas are still considered to be in the poverty income category. Although consumption levels are such that there is not pervasive malnutrition, many of these farmers and their families live on incomes below the national poverty line and

are expressed in 1980 yuan and are created by deflating nominal income by the rural retail price index. The rural retail price index is also from ZGTJNJ (1980-93). The gross value of rural social product (GVRSP) comes primarily from ZGNCTNJ (1985-93), and is always expressed in real terms. GRSVP includes output produced in agriculture, industry, construction, transportation, and commerce. It does not contain the value of output from other service sectors of the economy, but given their relatively small size in the rural economy, this omission should not affect the general conclusions of the study. Rural population figures can be found in ZGNYNJ (1981-93). The results here, especially those relating to the analysis of trends over time, are robust to the selection of price index.

2 These real rural per capita income outcomes are supported by trends in consumption, both across time and region. When the by-province income trends are compared to changes in real consumption expenditures (ZGTJNJ, 1980-91), nearly identical contours are found. The findings of Chai (1992) also support this observation. The same provincial consumption trends, when disaggregated by product (in real weight and volume terms), again demonstrate stagnating levels of consumption of individuals in rural households in the provinces that had the slowest growth rates. Conversely, individuals in provinces with fast growing income levels account for the gains in purchases of consumer durables.
their standard of living has not increased in recent years. Moreover, the precarious situation of the situation of the poor has worsened since the reforms by the devolution of the collective and the increasing dependence of many regions on distant markets across China. For example, a system of low-priced relief grains that was in place previously to subsidize the consumption needs of many poor households, has fallen victim to budget cuts. Local budget crises have also severely limited the funds available for welfare and other social programs (Ye, Park, and Rozelle, 1994). Many poor farmers, especially those dependent on markets for grain purchases, are becoming increasingly vulnerable to local and regional shocks to their yields or to market prices (Park, 1996).

3. China's Food Economy in Transition

Total grain production (in trade weight) rose to 385 MMT in the early 1990s, making China the largest producer of cereals in the world (Table 1). The country's farmers produce more rice and wheat than any other country in the world; the country's maize production is second only to that of the U.S. This grain supply is used to meet a number of needs: seed, animal feed, nonfood manufacturing, and direct food grain consumption. Grain used for direct food consumption took up the greatest part of total supply, about 67 percent in the early 1990s. Each resident in China consumed about 225 kg of grain, high even in Asian terms, and almost three times the amount of cereal products directly consumed by the average consumer in the U.S. Feed grain accounted only for 20 percent of utilization (although its proportion has risen rapidly in recent years), and was used to meet China's burgeoning demand for meat. In the early 1990s, China became the largest meat producer in the world, even though per capita consumption of animal products is still below that of Taiwan, Korea, and Japan.

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. Can domestic producers continue to meet most of the demand by China's consumers? What forces will cause current trends to change? If policy makers 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? And, perhaps most importantly for this paper, are there any factors that may cause sharp jumps in demand, which in turn could become destabilizing as they might put unexpected pressures on already tight markets? Any attempt to accurately forecast future supply and demand trends should account for these major economic forces.

Sources of Supply Growth

One-time institutional changes did certainly contribute to the high growth enjoyed by
China's agricultural economy in the early 1980s (McMillan, Whalley, and Zhu, 1989; Lin, 1992). But sustained growth in output must be undergirded by lasting technological advances that increase yields and preserve the fertility of the soils (Figure 1). Further analysis has 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). China's technological base grew rapidly during the pre-reform and reform periods. For example, locally adapted 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 50 percent of China's rice area by 1990. The investment in building a robust stock of research capital has in part been responsible for these dramatic changes. Some observers, however, are concerned that China's research system may be suffering from neglect after more than a decade of reform. Investment into the research system has fallen in real terms (in 1985 prices), from 1.08 billion yuan in 1984 to 0.98 billion in 1992. The ability of China's research system to maintain a constant stream of technical innovations will have an effect on the growth of supply of grains and on the nation's food balance (Fan and Pardey, 1995; Rozelle, Pray, and Huang, 1996).

Investment in agricultural infrastructure, especially irrigation, is another important determinant of China's agricultural growth in recent decades (Nickum, 1995). Irrigation investment and the stock of water control facilities have followed patterns similar to those for research. Since the early 1950s, Chinese agricultural officials have invested heavily in water works, raising irrigated area from 18 percent of cultivated area to nearly one half (State Statistical Bureau, 1993). Real annual expenditures for irrigation rose during the first 25 years of the People's Republic period. Annual irrigation investment, however, has been stagnant since the late 1970s.

The main factor driving his results in Brown's provocative article was identified earlier as the 20 percent drop in production between 1995 and 2030. Brown explicitly states that environmental degradation will be one of the principal causes for the projected decline in grain output. While Brown cites only anecdotal evidence, government data show that there may be considerable stress being put on the agricultural infrastructure; erosion and salinization have increased since the 1970s, although in a somewhat erratic pattern. In a number of recent studies these factors have been shown to affect output of agricultural products and grain (Huang and Rozelle, 1995).

Sources of Demand Growth

The demand side of China's food economy is also transiting through a series of structural transformations (Figure 2). Recent changes in the urban economy, have made urban consumers almost entirely dependent on markets for their consumption needs (Rozelle, 1996). In this
marketized food economy of the urban sector, the fundamental forces driving demand are prices and income changes. With income growth rates among the highest in the world, sharp increases in the demand for food (including the direct and indirect consumption of grain) are inevitable.

Rural consumers have different consumption patterns and their incomes have grown more slowly than those of their urban counterparts (Figure 2). Rural food markets can fail and can be less complete than urban markets. Farmers in many areas face limited choices in their consumption decisions due to the fact that many of the products that increasingly well-off households desire on a daily basis, such as meat and fresh fruit, are not always available. In a sample of households drawn by the authors from the national Household Income and Expenditure Survey (HIES), a strong and significant correlation was found between the level of consumption of primarily purchased goods (meat and fruit), and the level of market development, holding income and prices constant (Huang and Rozelle, 1995). Discontinuities in free markets, lack of refrigeration, and generally high transaction costs for procuring food in rural areas influence consumption patterns of rural consumers in China. While change in the rural economy has been rapid, in 1992 farmers purchased only 48 percent of the food they consumed (HIES). As markets develop, and the activity in rural consumption markets increases, even apart from changes in income and prices, consumption patterns will be affected.

The structure of China's consuming population is also changing. As urbanization proceeds across Asia, the composition of the diet and the behavior of consumers are found to change quite dramatically (Huang and David, 1993). Urban dwellers consume more wheat and less rice and demand greater quantities of meat, 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. Considering only the officially registered city population, the urban population has grown from 19.4 percent in 1980 to 27.6 percent in 1992. These population shifts have been shown to affect consumption in China (Huang and Bouis, 1995). Given the large potential impact of these forces, as well as the projected urbanization trends for the future, population shifts should be accounted for in any food-forecast exercise.

4. The New Food-Feed Competition

Recent work on China's future food balance has systematically analyzed the impact of the dynamic factors in supply and demand discussed in the previous section. While the trends of rising demand are powerful, the general consensus of most analysts is that under the most likely sets of scenarios, slow-growing but accelerating domestic supplies and other sources of world production can meet the rising demands of China and other developing nations in the future. The rising requirements of China will put new pressures on world markets and very likely will cause real world prices to rise in the long run; but few serious forecasters predict chronic shortfalls of
grains. The appearance of some previously neglected source of demand, however, may caution policy makers to take careful notice. Moreover, most of these supply an demand forces, even the strongest ones, tend to move slowly and are fairly predictable: future population growth rates, for instance, can be calculated by demographers quite accurately, giving ample time for policy reaction; urbanization has built-in control mechanisms limiting the rate of increase in the flow of labor; and so on. In contrast, if a new source of high demand suddenly appeared and made new claims on already tight supplies with few alternative sources (in the short run), prices could rise sharply. With ever-tighter markets, even a one-time shortfall of supply (e.g., some natural- or human-caused disaster), the resulting shortage could make food inaccessible to some or only affordable to those with substantial purchasing power. A deadly food crisis could then be looming. The dynamics of the food-feed competition in the world's more liberalized food economy - factors that have not been considered rigorously until now - may be just that combination of lurking pressures.

The Basic Argument

In his well-noted article, Yotopoulos (1985) outlines the dynamics of the competition for grain that occurs during rapid development. The rise of the middle class creates a voracious appetite for animal protein. The feedgrain needs of the growing livestock sector which evolves to meet this demand is the most important determinant of the rising demand for cereals. This rapid increase in demand is the result of three conjoint factors: first, the income elasticity of demand for indirect grain consumption by the middle-income class is high; second, the recent experience of inequitable distribution of the fruits of economic growth has led to a massive graduation of the beneficiaries of development into the middle income classes; third, and as a result of the previous two factors, the indirect demand for grains by the middle classes is no longer trivial - as compared with the negligible grain-share weight that the large low-income class receives.

The first element is illustrated by Figure 3 that focuses on the relationship between the consumption of grains and income. It is convenient to concentrate on grains when studying the growth in demand for agricultural commodities, given their dominant role in most food economies. By breaking down the demand for grains into direct (food) and indirect (feed) use, one captures the staple commodity for both ends of the income distribution, for the poor and the non-poor. Cereals (wheat, rice, and coarse grains) are the major source of calorie intake at low-income levels. At higher levels of income cereals also feature prominently in the human diet. The only difference is that grains (mostly coarse, but also increasingly soft grains as well) are consumed indirectly in the form of animal protein.

The move from direct to indirect grain consumption as incomes increase represents a move up the food chain and changes the composition of the food basket away from plant and
toward animal protein. This move to higher rungs of the food ladder is common and is fully handled by Engel's Law. The only element added here is the recognition that in the process of changing the food basket mix the total supply of grains available for consumption has greatly shrunk. As consumers add more meat to their diets and the indirect demand for grains escalates, the total grain availability for both direct and indirect use, expressed in calorie equivalent units, decreases. The animal stomach is a rather inefficient converter of protein.\(^3\)

The problem with estimating demand for grains without distinguishing the poor from the rich and as a result neglecting the difference between direct and indirect consumption is precisely that the former is bounded narrowly while the latter is not. Only so much grain can be consumed directly to provide an adequate nutritional intake - approximately 200-250 kg per capita per year. The variance is much higher when indirect grain consumption is also considered, with the average per capita rising to 550 kg per year in Western Europe and 850 kg per year in the United States. The situation is illustrated in Figure 3. Food is consumed directly. At the low income-levels of the poor, grains have the characteristics of the "necessity good." Grains are also consumed by the middle-income classes and the wealthy; but at higher income levels animal protein is substituted for direct consumption of grains. The indirect consumption of feed represents a "luxury-good" consumption for the non-poor. It is captured by the curve having a sigmoid shape in the figure. By ignoring the distinction between the poor and the rich and aggregating the food and feed demand curves, one gets the total demand curve that represents a polynomial of higher order. Such curves, unless broken down to their basic components, are difficult to use for predictions because their turning points cannot be determined with accuracy.

Accurate projections of future food demand require that the second and third elements of Yotopoulos' food-feed competition argument are factored in. The large and rising share of the middle class in the consuming population, or the "graduation effect," must be accounted for. And the non-negligible step-up in demand for total grains that occurs when consumers move from range 1 to range 2 in Figure 3 must be also considered. These factors are incorporated in the following equation:

\[
\check{D} = \sum_i \left( \frac{N_i}{N} \right) \left( \frac{q_i}{q} \right) (\check{N}_i + e_i \check{y}_i)
\]  

Equation 1 is a transformation of the usual formulation for projection purposes that makes total demand for food the product of population and the quantity demanded per capita, with the latter being determined by (prices and) income. The change in aggregate demand over time (\( \check{D} \)) is the sum of the changes that occur within each socioeconomic-class-specific population cell. That depends on the change in population in each class over time (\( \check{N} \)), the

\(^3\) The calorie-equivalent conversion ratio of grains from direct to indirect consumption varies, depending on the type of meat, from 2-to-1 to 7-to-1 (Yotopoulos, 1985).
change in income over time \( (\dot{y}) \), and the class-specific income elasticity of demand for grains \((e_i)\). The weight that each component receives in the sum is the share of the grain demand of each class in the total \((N_i / N)(q_i / q)\).

But equation (1) is actually an aggregation of the consuming habits of many sets of individuals in an economy (or the individuals who belong to different segments of the income spectrum in Figure 3). So, by expansion and several intermediate steps\(^4\), equation (1) becomes:

\[
\dot{D} = \sum_i \frac{N_i}{N} q_i \dot{N}_i + \sum_i \frac{N_i}{N} q_i (e_i \dot{y}_i)
\]  

(2)

which explicitly shows total demand as the sum of the demand relationships of different socio-economic groups. Equation (2) can illustrate the graduation effect. Consider for simplicity a society that consists of three classes, the poor, the middle income, and the rich. People graduate into an income class either as a result of income growth or by being born into that class, and in either case they acquire the incomes (and average consumption) of the parent population. The elasticity of demand with respect to income is crucial in determining the change in total demand, over and above the effect of population growth. If, for example, on entering the middle-income class people shrink grains by a high calorie-equivalent grain-meat conversion rate for consumption of animal protein, the elasticity of demand is high and the share of the middle-income class in total consumption of grains increases. The corresponding increase in demand will be much greater than the population growth rate. The effect will be even larger if the size of the middle-income class to total population increases as incomes grow.\(^5\)

Is the New Food-Feed Competition Important in China's Food Economy?

Table 2 utilizes a series of China's corn consumption data organized by the Economic Research Service of the United States Department of Agriculture to break down demand into the two components, direct consumption (food) and indirect consumption (feed). The table presents (for the period 1980-93, averages) the numbers for total demand and also for food and feed; and

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\(^4\) See Yotopoulos (1985) for the intermediate steps.

\(^5\) Sen (1980: 618) has described a similar situation where graduation of one population group to fuller diets can lead to price spikes and collapse of the real incomes of the poor — but without the multiplier effects that the feed-for-food substitution entails. “In a poor community take the poorest section, say the bottom 20% of the population, and double the money income of half of that group, keeping the money income of the rest unchanged. In the short run prices of food will now rise sharply, since the lucky half of the poorest group will now fill their part-filled bellies. While this might affect the food consumption of other groups as well, the group that will be pushed towards starvation will be the remaining half of the poorest community which will face higher prices with unchanged money income.”
the share of the last two in total. A number of interesting observations arise from the data.

First, at the aggregate level the importance of corn use for feed is escalating rapidly. Of total disappearance of corn, feed accounted only for 37 percent in 1980, the early years of China's reform program when China's rural population was still relatively impoverished. The rest was consumed directly as food. By 1993, however, the one-to-three relation was reversed with more than 67 percent of corn production going for feed. Extrapolating from these figures for the grain economy as a whole, one can conclude that the proportion of total grain used for feed increased from about 10 percent in the early 1980s to more than 20 percent in the mid-1990s. Hence, by the late reform period, feed for the animal products demanded by China's consumers is playing an increasingly important role in the global picture of grain consumption.

Table 3 utilizes data from the national HIES which is conducted by the State Statistical Bureau (SSB).\(^6\) The data, based on income, illustrate the point that the demand for grains used for direct consumption is different from the demand for grains used for animal feed. At low levels of income, the demand for food swamps the demand for meat (and the grain that it needs for its production). This is especially true for poor rural consumers earning on average 256 yuan annually (in 1990 yuan, expenditure col. 7). On an annual basis, people in these households consume about 118 kg of food grain (not including tubers or soybeans), but only 5.5 kg of pork, 0.4 kg of fish, 0.9 kg of poultry, and 1.1 kg of red meat (beef, mutton, and others). Using standard Chinese grain-meat conversion ratios, this consumption of animal protein by the rural poor corresponds to about 22 kg of grain on an indirect basis, a level of 18.5 percent of their direct food grain consumption.

The richest rural consumers, those in the upper quintile with an annual per capita income of 1522 yuan per year (category V, col. 7) and the average urban consumer, those in the middle income category (last row, col. 7) consumed grains indirectly at a much higher rate. While consuming 200 kg per year of food grains, rich rural consumers add almost 100 kg of indirect grain consumption. Urban residents have an even more livestock-biased diet, consuming indirectly more grain for feed (about 135 kg per capita) than directly for food (123 kg).

The consumption data in Table 3 confirm that the relationship between income and demand for food and feed follows Figure 3. The general increase in food grain consumption as

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\(^6\) Row 1 contains data from 300 poor households in seven counties designated to receive nationally-allocated poverty alleviation funds. These households are assumed to be representative of China’s poorest decile (representing about 100 million people). These data were provided to the authors by the local SSBs as part of the effort of these counties to understand the economic behavior of the poorest households. The methods used to collect the data were identical to the methods used in the national sample. The rest of the table uses data from the national SSB providing a representative picture of China. The reason for not using the data from local SSBs in the poor area is that interviews revealed that frequently the poorest households are left out of the sample due to limited numeracy and literacy capabilities and because they are often less willing to spend the time with the SSB enumerators.
incomes rise decreases proportionally. The percentage change in food grain consumption (from the previous income category) divided by the percentage change in income is given in column 8. All of these percentages are low and decline over the range of incomes. These approximations of income elasticities support the postulated low and falling income elasticities for food grains: consumers become saturated with food grains as incomes rise.

Of even greater interest, however, is the change in the relationship between indirect feed consumption and income (Table 3, rows 1 and 2). Between the two poorest levels of income, for each percentage rise in income there is a fairly low percentage increase in meat consumption (0.67), even considering the low base at which poor residents are consuming (Table 3, col. 7). This would be equivalent to moving from range 1 to the threshold of range 2 in Figure 3. Between the next two income categories (from row 2 to 3), the percentage jump in meat consumption is relatively large (1.23), indicating the consumer has graduated into an income region with high response in meat consumption to changes in income. Beyond income category II, however, the percentage changes in meat consumption to percentage changes in income fall over time (from 1.23 to 1.10 to 0.93 and to 0.14, col. 7). The indirect feed income elasticities of demand are also higher than their counterparts for food grains, as postulated in the Figure.

These descriptive relationships are supported by econometrically estimated expenditure elasticity parameters in various areas of China (Table 4). In some of the poorest areas of China, food grain elasticities are estimated to be 0.52, and the meat elasticities are low, 0.44 (row 1). In average income areas, the food grain elasticities fall somewhat (to 0.48), but the income demand elasticities for meat are much higher (0.91 in row 2). In studies of relatively rich, rural, coastal areas, and urban regions, the income elasticities for food grains are substantially lower, while those for meat are still high and close to one.

This information lends credence to the fact that China has experienced, and may still be facing, the dynamics of the new food-feed competition. In section 2 of this paper it was seen that the incomes of a large segment of China's populations have been growing and continue to grow fast. This growth most certainly is creating a rising middle class. Table 5 demonstrates that there has been a large movement of people out of the poorest income category; about 150 million people in the 1980s alone escaped poverty. Certainly, a good portion of those moved up into some of the lower-middle and middle income categories. Will the trends continue in the future? Rural incomes are still growing fast. And while there are still over 100 million people in officially designated poverty areas, if the government's recent program to alleviate poverty is even partially successful, a large number of new graduates should be expected.

And when they graduate, the information on food and feed consumption behavior (presented above) illustrates that there is good reason to believe these ex-poor will be demanding much higher levels of grain. The sigmoid relationship between food and feed grains and income

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7 The elasticities are approximations because all other things are not held constant.
5. China’s Grain Economy in 2000 and 2020

Projections of Chinese supply, demand, and imports of grain are generated using a framework developed by the authors and their associates. The structure of the model is based on a series of micro- and macro-economic studies conducted over the last several years (Figure 4). The major components of this forecasting framework include a supply model for the rice, other grains, and cash cropping sectors of the agricultural economy. Demand models are specified separately for rural and urban consumers for rice, grain, meat, and six other animal products. Price forecasts are generated by IMPACT, a partial equilibrium global trade model developed by researchers in the International Food Policy Research Institute (Rosegrant, Agcaoili, and Perez, 1995). In addition to income and prices, the modeling framework includes a number of structural and policy variables to account for fundamental forces of transformation in China’s rapidly reforming and modernizing economy.

The Supply Side

The supply model forecasts future trends in China’s grain output utilizing separate equations for rice, other grains, and major cash crops. 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. The full set of results and detailed discussion of the model can be found in Rozelle, Huang, and Rosegrant (1997).

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8 Technology was measured in stock form, and was built by aggregating past government expenditures on research according to a weighting criterion suggested by Fan and Pardey (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 Kaspryn (1994). The environmental variables have been described and analyzed in Huang and Rozelle (1995) and Rozelle, Huang, and Rosegrant, (1997). The severity of erosion is measured as a ratio of eroded area to cultivated area (which can exceed one since eroded area includes both cultivated and non-cultivated area). Salinization is the proportion of total sown area where salinity levels are high enough to affect yields.
The Demand Side

Grain consumption also is projected using a double-log model. Grain consumption is divided into two parts: grain that is directly consumed, and that which 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 used for different projection period: the 1990s; 2000-2010; and 2020. And, most importantly for this analysis (which is concerned with the interaction of income and demography), demand parameters are used for each population cell by income group. Demand is specified as responding to own-price, the price of other major commodities, income, and a variable representing the level of development of rural consumption markets (in the rural demand equations).

Parameter Estimates and Baseline Assumptions

The elasticities and other basic assumptions for the underlying model can be found in Rozelle, Huang, and Rosegrant (1997). All simulations begin from the early 1990s, the base period. Base period data on production and utilization (discussed above) are three-year averages centered on 1992. There are a number of factors that potentially affect the future development of China's food situation. Price movements of key commodities and resources affect both demand- and supply-side trends. Demand-side elements 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 investment policy, as well as changes in the state of the environment. Summaries of the assumptions of the major factors affecting future demand and supply growth are in Rozelle, Huang, and Rosegrant (1997, forthcoming).

Income Elasticities, the Structure of the Population and Graduation to Middle Class

The expenditure behavior of the population cells in each income group is the critical parameter for this study. Table 6 contains the expenditure elasticity estimates for livestock products used in the forecasts by period, rural-urban, and income category. The matrix of elasticities is largely based upon the econometric work done by the authors in a series of demand studies, and most importantly, conforms closely with patterns of consumption behavior illustrated in Tables 3 and 4.

9 Ultimately the quantities of animal products were converted into income (expenditure) elasticities for feed by using the appropriate conversion ratios.
The two top rows of Table 6 incorporate the assumption that all residents in all income categories enjoy rises in income in both scenarios: 3 percent per year for rural residents and 3.5 percent for urbanites in the baseline variant; and 2 percentage points higher for all residents in the high growth scenario.

The food-feed competition is captured through two factors in the elasticity matrix of Table 6. First, diets change because consumers enjoy the benefits of widespread increase in incomes. The *improvement in diets* is clearly seen by reading along the columns for the Poor category, where as incomes grow through the three periods the income elasticities of demand increase. The second factor captured in the table is the growth out of poverty and into the Middle Income class, and beyond into the Well-off. This factor alone is attributed to the *graduation effect*. A very conservative assumption has been incorporated at this point: income elasticities of demand for animal protein peak at the Middle Income class and at income levels not much different from the incomes of the Poor (e.g., last three categories in the Middle Income class). At the Well-off level of income the elasticities decline sharply showing the saturation point to most food consumption, including livestock products.

The population growth rate is the United Nations medium projection (1990-2000 at 1.238 percent per annum). The assumptions on the structure of the population between rural-urban and by income category, as well as the dynamics of this structure over time appear in Table 7. In the top third of the table, the baseline population figures are given for rural and urban populations by income category. By assumption, the poorest 20 percent of China's population are categorized as "Poor," 60 percent as "Middle Income," and 20 percent as "Well-off." The percentage assigned to the "poor" is higher than the official figures for "those in poverty" (World Bank, 1992), but it is widely believed that there are many poor outside of the officially designated poor areas, and there is a rising number in urban areas also (Travers, 1992). Twenty percent of the population were put into the highest income category since this is approximately the number of rural residents living, working, and prospering in the most advanced of the coastal areas (e.g., in the Yang-tze Delta region, the Pearl River Delta, Fujian, parts of Shandong, and the farmers in the suburban regions of Beijing, Tianjin, and Shanghai). While people in all of these categories enjoy rising incomes and as such will demand more food, there is no way to capture in the baseline scenario the sharp changes in diet structure seen to occur through the graduation effect of the new food-feed competition.

The assumptions used in the alternative scenario try to explicitly account for the changes in diet as people move out of poverty. The middle four rows of Table 7 show the number of people that are assumed to be graduating out of poverty and into the Middle Income class (columns 4-7), and those that are graduating into the Well-off category (columns 8-9). The figures in the bottom panel of Table 7 show the demographic structure of China's population during the mid-point of the decades (i.e., in the year 2000 for the period 1995-2004, etc.).
The numbers in the table are generated by the assumption that one half of China's poor will be alleviated from poverty in the 1995-2004 decade and the other half will move into the incomes of the middle category between 2005 and 2015. The graduation process may seem optimistic. But the graduation rates are certainly attainable if one considers the previous record of China, the experience of other rapidly growing Asian neighbors, and the power of China's overall income growth to spill over into all areas of the economy. The hypothesized movement out of poverty is more conservative than the one pronounced by the leadership in China who has recently made it a national priority to eliminate poverty by year 2000. The graduation rate to the high income category occurs more slowly reflecting the increasing difficulty of regions to enter the high-income, industrialization stage (Rozelle, 1996).

6. Projections with the Food-Feed Competition

Improvement in Diets: Low-Uniform Income-Growth Scenario

Consistent with the elasticities for food grains in Table 6, per capita direct grain consumption in China is projected to have hit its zenith in the late 1980s and early 1990s. From a high of 225 kg in the early 1990s, food grain consumption per capita falls over the forecast period. This is the result of the baseline income growth assumption (3.0 and 3.5 percent per year for rural and urban residents, respectively) that leads to an improvement of diets and shift toward animal products. Although consumption of food grains by the average rural resident will increase through the year 2000, before falling off in the first decade of the next century, urban demand for food grains is nearly at a point where it will fall early with further rises in income. Expected population shifts from rural to urban areas will compound the decline in food grain consumption. In contrast, per capita demand for red meat is forecast to more than double by 2020. The projected rise in demand for meat and other animal products will simultaneously put pressure on aggregate feed grain demand, raising the proportion of feed grain in total utilization from 20 percent in 1991 to 38 percent in 2020.

Baseline projections (i.e., without considering the dynamics of the food-feed competition) of the supply of grain show that China's production sector will not be able to keep up with the escalating demand. Aggregate grain supply is predicted to reach 410 MMT (in trade weight) by the year 2000. Constrained by a technological base that has weakened after more than 10 years of falling investment, grain output will increase only about 7 percent during the 1990s, a figure far below the more optimistic estimates given in recent years by MOA officials who had hoped to meet the target of 455 MMT by 2000 (or 500 MMT in nontrade weight figures). The poor grain harvest of 1994 was followed by a record 465 MMT in 1995.
investment in agricultural research within the next few years.

Under the authors' most plausible scenario, total grain consumption will rise at 1.72 percent per year in the 1990s, 1.28 percent from the rise in population and 0.44 percent due to increasing per capita grain demand, mostly in the form of feed. Grain production during this period will grow at an annual rate of only 0.64 percent. At these growth rates, the gap between the forecast annual growth rate of production and demand will mean a rising deficit. Projected imports to cover this deficit are shown for the baseline case at the bottom line of Figure 5. They are expected to increase the fastest in the 1990s, reaching 29 MMT by 2000 (as compared to net imports of 3 MMT on the average in 1990-92). This represents a level of imports nearly twice as great as China's historic high. Imports are projected to have stabilized by 2010 at 32 MMT.

Graduation Effect: Low-Uniform Income-Growth Scenario

Given the income distribution among the Poor, uniform slow growth is bound to propel the upper end of the distribution into the Middle Income class. There they adopt middle class elasticities of demand for livestock products (cols. 3 and 4 of Table 6) and the demand for grains (especially indirect) steps up above the baseline projection with improved diets alone (Figure 5, top line). Nearly all of the additional rise in demand (about 95 percent) is in the form of indirect grain used to feed livestock. With the increase in demand, imports rise by nearly 20 percent to 38 MMT in the year 2002 (Figure 5, top line) with an additional 9 MMT contribution by the graduation effect alone. By 2010 the graduation increment has decreased to 3 MMT since by assumption uniform low-growth scenario rates persist and the income elasticities of demand for livestock products decline as middle class incomes increase.

High-Uniform Growth Scenario

But the true effect of the new food-feed competition does not show fully until the high growth scenario is run. When urban consumers are enjoying annual increments in income of 5.5 percent (at or below the average for the past 10 years) and rural consumers of 5 percent (above average for the past 10 years, but about average for the past 5 years), the pure improvement-diets effect (without the graduation effect, the middle line, Figure 6) is shown to be very significant, with imports more than double the levels of the baseline scenario (bottom line). By year 2000, for example, high growth and the new appetite for feed grains could force China to import as much as 50 MMT, which grow to 68 MMT by year 2010. Superimposing on the improvement of diets the graduation effect adds another 20 MMT by the middle of the next decade (the gap between the lines in Figure 6), a volume exceeding 10 percent of the world's current level of trade in grains. The food-feed competition (with both effects considered) under the high-income growth scenario makes imports grow to 65 MMT in year 2000 and to 90 MMT
in 2010. The latter figure is nearly 40 percent of the world's current market for grain. Feeding that level of imports into the IMPACT module of the underlying global model results in world price increases for grains at a rate of 2 percent per year at a minimum.

In order to place in perspective the new projections of demand for grain in China that incorporate the food-feed competition it is worth noting that, if anything, they are likely to err on the conservative side. First, regarding the general improvement in diets, most analysts (e.g., Alexandratos, 1995; Garnaut and Ma, 1992) have forecast that as incomes rise consumers in all income categories (even those represented by the Well-off group in this study) will demand greater quantities of livestock products (and of feed grains) and often greater quantities of food grains also. In contrast in this study income elasticities of demand for food grains turn negative at an early stage, and those for feed grains decline drastically at higher levels of income. Second, the graduation effect which has been ignored by previous researchers is also calibrated to produce conservative estimates. In effect it incorporates two components: the fact that income elasticities for livestock turn from negligible to high after a certain income threshold; and also the number of consumers that cross that threshold at a given time. The econometric estimates of the elasticities adopted for this study show a small only step-up of income elasticities as one moves from the Poor to the Middle Income category and reach a peak early thereafter; they are deliberate underestimates. Also, assigning the largest share of the population (60 percent) to the Middle Income group and only 20 percent to the Poor means that the graduation has already taken place for most of the people and will not show up in the results. Third, and as in Sen's example,11 the food-feed competition leads to more certain "crowding out" of the poor the more inequitable growth is. The assumption of uniform growth (varying only among the urban and the rural sector) endows even the poorest with increasing money incomes and this muffles to a certain extent the impact of the food-feed competition.

7. Conclusions and Policy Recommendations

The debate about the world food balance – and the food situation in China, in specific – focuses on whether there will be adequate food supplies to feed the growing population. As Sen (1981:1) has remarked, however, “Starvation is the characteristic of some people not having enough food to eat. It is not the characteristic of there being not enough food to eat. While the latter can be the cause of the former, it is but one of the many possible causes.”

This paper focuses on there not being enough food to eat - both for the middle-income classes (indirectly) and for the poor (directly) - which often results in poor people not having enough to eat. The mechanism of the crowding out of the poor is the food-feed competition that can cause a price spike in grains leading to the collapse of the real income of the poor. While the

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11 See footnote 5 above.
supply side and the food availability question is also treated (from secondary sources), the contribution of this paper lies on the demand side - in fine-tuning the additional grain requirements by the graduation of those whose incomes have increased into more feed-intensive diets.

One piece of probative evidence that "there is not enough food to eat" in China is a trend of increasing domestic prices and of increasing imports. For a number of reasons that are more or less conventional (and that have been adequately covered in the literature cited) China's grain imports could become "too large." One policy solution to this situation is to increase the supply of grains so that there is enough of both food and feed to eat.

On the supply side, the level of China's forecasted deficit is predicated on several key assumptions, which if not met might lead to a ballooning of the gap shown in Figures 5 and 6. Rozelle, Huang and Rosegrant (1997, forthcoming) have shown at baseline demand assumptions (i.e., without considering the dynamics of the food-feed competition) that a breakdown in the productivity of the Chinese agricultural investment could lead to import levels as high as 100 MMT. To avoid such high level of imports, China's leaders need to step up the annual investment in the agricultural research system to 4 percent per year, from the current level of 3 percent. Moreover, the impact of the research investment on creating new yield-increasing breakthroughs, as well as the ability of the system to encourage farmers to adopt new technology, must remain unflagging. Fiscal problems, however, have caused concern among agricultural research administrators and scientists that the government may not be able to maintain its commitment to research, nor will have the resources to resurrect the extension system (Rozelle, Pray, and Huang, 1996). Interviews by the authors with Chinese scientists have also revealed skepticism that "in-the-pipeline" technologies have the same potential of generating yield increases as in the past. If Chinese farmers were unable to get access to new higher-yielding technologies (either from the nation's own research system or from international channels), the combined effect of falling supply and the new food-feed competition could contribute to the long-run pressures on the world food economy.

The approach in this study is from the demand side and focuses on structural characteristics that mark a period of rapid growth, as the one now transpiring in China. While the improvement of diets that accompanies an increase in incomes has been accounted for in previous studies, the impact of the sequential graduation of cells of the population to higher income levels, and the weight that their numbers attach to the improvement of diets, has escaped past projections. Considering both effects, the additional demand for grains in the first decade of the next century rises to between 50 and 90 MMT per year. The graduation effect alone accounts for 20 percent of that annual increase.

How can demand-oriented policies smooth the price increase in grains and avert the crowding out of the poor?
Prices are rationing mechanisms and price increases can have the desirable effect of limiting the indirect feed consumption of the middle classes. It is ironic, then, that price increases are part of the problem in this case instead of the solution. The reason is that grains for food and grains for feed are in most cases one and the same commodity, and in any event they trade in a linked market. Under the circumstances, the outcome of the competition between the poor, who try to increase their direct consumption, and the rich who shrink grains for indirect consumption as animal protein, will be decided by their respective price and income elasticities of demand. The more inelastic with respect to price is the demand of the rich for indirect consumption,\(^\text{12}\) the greater the price increase that will be required to limit their use of cereals for animal feed. In the meantime, in a linked market the price increase in feed grains will be reflected in the food market also by diverting food grains to feed and driving their price up. That same price increase causes a decline in the real income of the poor (whose main purchase is food grains) and an attendant decrease in the quantities of food demanded. In the extreme case, and as a result of the operation of the respective price and income elasticities of demand, the animals for the consumption of the rich may crowd out the direct demand for the subsistence of the poor.

This undesirable effect of price increases in a linked market can be obviated by delinking the two markets. One mechanism for that is imposing a tax on meat consumption in place of a price increase for animal feed. But targeted increases of taxes (and of prices) may be difficult to impose politically, especially in agriculture, and they can be hard to administer, more so in the rural areas of China. Rationing of meat consumption, by declaring, e.g., meatless days when no meat can be traded, is a tax-substitute measure. It can be reasonably effective only in the urban areas. The limiting case of this approach is changing people's tastes away from meat - through political indoctrination or religion (vegetarianism?).

Price discrimination is another mechanism that can effectively delink the two markets. Commodity targeting can favor the prices of the grains consumed by the poor. In Bangladesh, as an example, sorghum was sold at ration stores at half the price of wheat and rice. The rural poor bought sorghum, while the urban poor in Dacca paid double the price and bought rice or wheat (Yotopoulos, 1985). The question that arises is whether cheap sorghum went to feed the animals as well.

As in the previous example, rationing is a decisive mechanism for delinking markets. Group targeting directs the grains to the poor by issuing rations and coupons or by distributing them at fair price shops or at soup kitchens. The government often bears the entire cost of such programs, or else it can partly defray it by increasing the price of grains to the non-poor. But rationing can be incendiary in a commercialized economy. It certainly has an ominous reputation in China dating from the period when 15 percent of the budget was absorbed by

\[^{12}\text{The smaller the share of a consumer's income that goes to meat consumption, the lower is the price elasticity of demand for animal feed.}\]
rationing operations. After liberalization of the economy and the austerity imposed in the public sector, fiscally reallocating meaningful amounts of funds to rationing may be out of the question.

The domestic market link between food and feed has been discussed so far. In a global economy with free trade there is also an intercountry market link that can be used to increase the supplies - with the impact of crowding out possibly transferred to other, and weaker, parts of the global economy. One recent application is the case of Chinese maize. China has been very successful in wresting the South Korean feed-maize market away from the U.S. (Tuan, 1994). As domestic prices started increasing, however, China imposed trade restrictions on exports of maize for the purpose of increasing domestic supplies.

Even under the most optimistic supply-side scenarios, if the Chinese average annual deficit of grains increases to a level between 50 and 90 MMT due to the food-feed competition alone, the potential for a severe food crisis in any one year will rise significantly. At such high levels of demand the welfare of China's own poor depends on the nation's steady access to food. If China's food supply faltered (even for a year or two from, say, a major disaster) China would have to make up the deficit from world food sources.

To protect their own consumers, China's leaders would likely take strong actions to relieve domestic shortfalls by turning aggressively to international markets. This is already underway as imports have grown from nearly zero in 1993 to over 20 MMT of grain in 1995. Designed to dampen domestic price rise, these purchases helped drive up international prices by more than 40 percent. High price spikes and temporary market shortfalls could put other less-favorably-endowed food importing countries at risk. While most countries could cope with a gradual increase in prices even on the projected 2 percent level that is forecast to accompany a deficit of about 90 MMT (see discussion above), in any one year that rise could be much greater. The poor food-deficit nations that have no adequate stocks of grain at home nor access to deep foreign exchange reserves would be left with few options in the face of stiffly rising prices beyond reducing food imports. In many of these cases a short-run access problem could have severe global consequences. At the international level this would amount to "China starving the world."

From the Chinese perspective also resorting to massive imports may be an expensive operation. Even "low" international prices of grains can be no bargain for developing countries that have currencies under pressure for chronic depreciation; in terms of domestic resource cost such imports can still be very expensive (Yotopoulos 1996). Moreover, in a worst case scenario the imports that China would require are not marginal. They amount to 40 percent of the current volume of grains that enters world trade. Such an increase in the volume of imports of grain requires heavy investment in infrastructure with ample lead time: investment into facilities, such as ports and bulk handling silos and warehouses, and investment in institutions, e.g., more commercialized grain trading systems. To the nation's over-stretched transportation network and
infrastructure, that could prove a formidable barrier to moving grains through the country, one could add ideologically-driven import restrictions, or world-wide embargoes (let alone global short supplies due to a synchronous negative supply shock). If grains are kept from flowing to demand points, domestic prices of food in China could easily skyrocket leaving those with low incomes and weak purchasing power at risk.

The final conclusion is that the Chinese ideology of near self-sufficiency in food may not be totally misplaced, not even in an era of liberalization of trade and of markets and of globalization in the world economy. Moreover, 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.
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Table 1. Average Annual Grain Production and Utilization in China, 1990-1992 (million metric tons, MMT)

<table>
<thead>
<tr>
<th>Grain</th>
<th>Production</th>
<th>Change in Stocks</th>
<th>Net Import</th>
<th>Total Supply</th>
<th>Disposal of Available Supply</th>
<th>Per Capita Food Consumption&lt;sup&gt;b&lt;/sup&gt; (kg)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Seed</td>
<td>Animal Feed</td>
<td>Nonfood Manufacturing</td>
<td>Waste</td>
<td>Food</td>
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<tr>
<td>Total Grain</td>
<td>385</td>
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<td>3</td>
<td>386</td>
<td>16</td>
<td>76</td>
<td>19</td>
<td>15</td>
<td>260</td>
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<td>-1</td>
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<td>4</td>
<td>11</td>
<td>3</td>
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<td>Other Grain</td>
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<td>-- Wheat</td>
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<td>0</td>
<td>11</td>
<td>110</td>
<td>4</td>
<td></td>
<td>4</td>
<td></td>
<td>105&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>-- Maize</td>
<td>97</td>
<td>-4</td>
<td>-9</td>
<td>84</td>
<td>56</td>
<td></td>
<td>28&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td>24&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Note: Rice in milled form (trade weight).
<sup>a</sup> A negative number indicates an increase in stocks, which reduces the total grain supply.
<sup>b</sup> Includes direct home consumption, grain purchased and consumed outside of home, and processed foods. Does not include grain used to feed livestock and converted to meat.
<sup>c</sup> Includes all non-feed grain use.

Source: Computed by authors except those for wheat and maize which are from ERS.
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<tr>
<th>Year</th>
<th>Feed</th>
<th>Food</th>
<th>Total</th>
<th>Feed Disappearance</th>
<th>Food Disappearance</th>
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<td>25</td>
<td>43</td>
<td>68</td>
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<td>27</td>
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<td>0.56</td>
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<tr>
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<td>33</td>
<td>62</td>
<td>0.47</td>
<td>0.53</td>
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<tr>
<td>1983</td>
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<td>34</td>
<td>64</td>
<td>0.47</td>
<td>0.53</td>
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<td>35</td>
<td>31</td>
<td>66</td>
<td>0.53</td>
<td>0.47</td>
</tr>
<tr>
<td>1985</td>
<td>42</td>
<td>25</td>
<td>67</td>
<td>0.63</td>
<td>0.37</td>
</tr>
<tr>
<td>1986</td>
<td>44</td>
<td>30</td>
<td>74</td>
<td>0.59</td>
<td>0.41</td>
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<td>31</td>
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<td>0.59</td>
<td>0.41</td>
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<td>47</td>
<td>29</td>
<td>76</td>
<td>0.62</td>
<td>0.38</td>
</tr>
<tr>
<td>1989</td>
<td>48</td>
<td>30</td>
<td>78</td>
<td>0.62</td>
<td>0.38</td>
</tr>
<tr>
<td>1990</td>
<td>50</td>
<td>31</td>
<td>81</td>
<td>0.62</td>
<td>0.38</td>
</tr>
<tr>
<td>1991</td>
<td>51</td>
<td>34</td>
<td>85</td>
<td>0.60</td>
<td>0.40</td>
</tr>
<tr>
<td>1992</td>
<td>55</td>
<td>32</td>
<td>87</td>
<td>0.63</td>
<td>0.37</td>
</tr>
<tr>
<td>1993</td>
<td>60</td>
<td>30</td>
<td>90</td>
<td>0.67</td>
<td>0.33</td>
</tr>
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</table>

Table 3. Per Capita Grain Consumption for Food and Feed by Expenditure Groups, 1992

<table>
<thead>
<tr>
<th>Expenditure Group</th>
<th>Food Grain (kg)</th>
<th>Indirect Feed Graina (kg)</th>
<th>Pork Meat (kg)</th>
<th>Pork Feedb (kg)</th>
<th>Poultry Meat (kg)</th>
<th>Poultry Feedb (kg)</th>
<th>Expenditures (1980 yuan)</th>
<th>Percent Change in Food Grain Consumption for a Percentage Change in Expenditures6</th>
<th>Percent Change in Indirect Feed Grain Consumption for a Percentage Change in Expenditures6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Households in China’s Poor Counties</td>
<td>118</td>
<td>22.0</td>
<td>5.1</td>
<td>19</td>
<td>0.42</td>
<td>1.05</td>
<td>256</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Rural Income Category I</td>
<td>134</td>
<td>25.9</td>
<td>6.0</td>
<td>22</td>
<td>0.51</td>
<td>1.3</td>
<td>323</td>
<td>0.52</td>
<td>0.67</td>
</tr>
<tr>
<td>Rural Income Category II</td>
<td>163</td>
<td>39.8</td>
<td>8.9</td>
<td>33</td>
<td>0.90</td>
<td>2.2</td>
<td>464</td>
<td>0.49</td>
<td>1.23</td>
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<tr>
<td>Rural Income Category III</td>
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<td>51.5</td>
<td>11.4</td>
<td>42</td>
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<td>3.3</td>
<td>588</td>
<td>0.39</td>
<td>1.10</td>
</tr>
<tr>
<td>Rural Income Category IV</td>
<td>194</td>
<td>66.0</td>
<td>14.2</td>
<td>53</td>
<td>1.81</td>
<td>4.5</td>
<td>766</td>
<td>0.26</td>
<td>0.93</td>
</tr>
<tr>
<td>Rural Income Category V</td>
<td>204</td>
<td>95.7</td>
<td>18.8</td>
<td>70</td>
<td>3.56</td>
<td>8.9</td>
<td>1522</td>
<td>0.05</td>
<td>0.14</td>
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<tr>
<td>Urban Median</td>
<td>123</td>
<td>135</td>
<td>22.8</td>
<td>84</td>
<td>4.30</td>
<td>10.8</td>
<td>1580</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Note:

a Indirect Feed Grain is calculated from livestock product and fish consumption, including pork, poultry, beef and mutton, fish, eggs, milk, etc. In this table, column 2 (total feed use) equals columns 4 (feed used for pork) plus column 6 (feed used for poultry) plus the feed used to produce the rest of livestock products.

b Pork feed consumption is calculated by multiplying meat consumption by 3.7. Poultry consumption is calculated by multiplying meat consumption by 2.5.

c Figures in columns 8 and 9 are estimates of income elasticities derived by dividing the percentage change of grain demand between two income categories by the percentage change of income. They differ from true elasticities, however, since other things are changing between income groups. See Table 4 for estimated elasticities.

Source: All data from State Statistical Bureau’s (SSBs) annual household income and expenditure survey. Data for row one directly from local SSBs. Data for rest of table from national SSB in Beijing. Food grain does not include tubers or soy beans.
Table 4. Estimates of Food Grain and Meat Demand Income Elasticities by Expenditure Groups in China

<table>
<thead>
<tr>
<th>Expenditure Group</th>
<th>Food Grains</th>
<th>Meat</th>
<th>Pork</th>
<th>Fish</th>
<th>Poultry</th>
<th>Annual Per Capita Expenditures (Sample Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Rural: Rural households in</td>
<td>0.52</td>
<td>0.44</td>
<td>0.40</td>
<td>0.81</td>
<td>0.65</td>
<td>243</td>
</tr>
<tr>
<td>China's poor counties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Rural: From national</td>
<td>0.48</td>
<td>0.91</td>
<td>0.85</td>
<td>1.50</td>
<td>n.a.</td>
<td>601</td>
</tr>
<tr>
<td>representative rural sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Richer Rural: From Zhejiang and</td>
<td>0.26</td>
<td>0.58</td>
<td>0.49</td>
<td>0.64</td>
<td>n.a.</td>
<td>1225</td>
</tr>
<tr>
<td>Hebei's suburban rural Communities</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Urban: From national</td>
<td>0.07</td>
<td>0.88</td>
<td>0.79</td>
<td>1.34</td>
<td>1.79</td>
<td>1582</td>
</tr>
<tr>
<td>representative urban sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: All estimates by authors using data from State Statistical Bureau (SSB) annual household income and expenditure survey. Data for row one directly from local SSB branches in seven poor counties (300 households). Data for row three directly from local SSBs in six advanced counties in Zhejiang and Hebei suburban counties (330 households). Data for the rest of the table from national SSB in Beijing.
Table 5. Numbers and Percent of Poor* in Rural China, 1978 to 1989

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The Poor in China</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of rural Residents (Millions)</td>
<td>260</td>
<td>194</td>
<td>140</td>
<td>123</td>
<td>89</td>
<td>96</td>
<td>97</td>
<td>91</td>
<td>86</td>
<td>103</td>
</tr>
<tr>
<td>Percent of total population</td>
<td>33.0</td>
<td>24.3</td>
<td>17.4</td>
<td>15.2</td>
<td>11.0</td>
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<td>11.9</td>
<td>11.1</td>
<td>10.4</td>
<td>12.3</td>
</tr>
<tr>
<td>Number Graduating Out of Poverty (Millions)</td>
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<td>66</td>
<td>54</td>
<td>17</td>
<td>34</td>
<td>-7</td>
<td>-1</td>
<td>6</td>
<td>5</td>
<td>-17</td>
</tr>
</tbody>
</table>

Notes:
* Poverty line based on minimum cost of consumption of 2150 kcals per day.
** Number graduating out of poverty is calculated by subtracting the number of poor in period "t" from the number of poor in period "t-1." Negative numbers indicate that the number of poor increased.

Table 6. Income Growth and Income Elasticities by Commodity, 1990-2020, and Income Group Used for Projection Analysis by Class

<table>
<thead>
<tr>
<th></th>
<th>The Poor</th>
<th></th>
<th>Middle Income</th>
<th></th>
<th>The Well-off</th>
<th></th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Rural</td>
<td>Urban</td>
<td>Rural</td>
<td>Urban</td>
<td>Rural</td>
<td>Urban</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>Income growth rate (%)</td>
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<td></td>
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</tr>
<tr>
<td>Baseline</td>
<td>3.0</td>
<td>3.5</td>
<td>3.0</td>
<td>3.5</td>
<td>3.0</td>
<td>3.5</td>
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<td>5.0</td>
<td>5.5</td>
<td>5.0</td>
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<td>Food grain income elasticity</td>
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<tr>
<td>1990-2000</td>
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<td>0.10</td>
<td>0.08</td>
<td>0.03</td>
<td>-0.05</td>
<td>-0.10</td>
</tr>
<tr>
<td>2000-2010</td>
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<td>0.025</td>
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<td>-0.05</td>
<td>0.05</td>
<td>-0.15</td>
<td>-0.16</td>
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<tr>
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<td>0.66</td>
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<td>0.85</td>
<td>0.80</td>
<td>0.60</td>
<td>0.50</td>
</tr>
<tr>
<td>2000-2010</td>
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<td>0.76</td>
<td>0.80</td>
<td>0.76</td>
<td>0.55</td>
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<tr>
<td>2010-2020</td>
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<td>0.75</td>
<td>0.70</td>
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<td>Beef and Mutton Income Elasticity</td>
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<td>Poultry Income Elasticity</td>
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<td>0.95</td>
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<tr>
<td>2000-2010</td>
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<tr>
<td>2010-2020</td>
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<td>0.50</td>
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<td>0.76</td>
<td>0.80</td>
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<td>2000-2010</td>
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<td>1.00</td>
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<td>1.05</td>
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<td>0.90</td>
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</table>
### Table 7. Structure of Population and Graduation Out of Poverty Into Middle and Upper Income Categories: Assumptions for Baseline and Alternative Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Population, Aggregate for China</th>
<th>The Poor</th>
<th>Middle Income</th>
<th>The Well-off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Rural Urban</td>
<td>Rural Urban</td>
<td>Rural Urban</td>
<td>Rural Urban</td>
</tr>
<tr>
<td>(1)  (2) (3)</td>
<td>(4) (5)</td>
<td>(6) (7)</td>
<td>(8) (9)</td>
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</tr>
<tr>
<td><strong>Baseline Population (millions)</strong></td>
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<td></td>
</tr>
<tr>
<td>1991</td>
<td>1161  847  304</td>
<td>109  61</td>
<td>508  182</td>
<td>109  61</td>
</tr>
<tr>
<td>2000</td>
<td>1200  854  436</td>
<td>171  87</td>
<td>512  262</td>
<td>171  87</td>
</tr>
<tr>
<td>2010</td>
<td>1389  804  585</td>
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<td>161  117</td>
</tr>
<tr>
<td>2020</td>
<td>1482  744  738</td>
<td>149  148</td>
<td>447  443</td>
<td>149  148</td>
</tr>
<tr>
<td><strong>Graduates Out of Poverty and Into Middle and Well-off Income Categories: Assumptions for Alternative Scenarios</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(millions)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>1991-1994</td>
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<td>0  0</td>
<td></td>
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<td>2005-2014</td>
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<td>80  59</td>
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</tr>
<tr>
<td>2015-2020</td>
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<td>147  148</td>
<td>74  74</td>
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</tr>
<tr>
<td><strong>Population Shares Used in Baseline and Alternative Scenarios</strong></td>
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<td></td>
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</tr>
<tr>
<td>Alternative Population (millions)*</td>
<td>169  61 (20) (20)</td>
<td>508  182 (60) (60)</td>
<td>169  61 (20) (20)</td>
<td></td>
</tr>
<tr>
<td>Baseline 1991-1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1995-2004</td>
<td>85  44 (10) (10)</td>
<td>572  292 (67) (67)</td>
<td>196  100 (23) (23)</td>
<td></td>
</tr>
<tr>
<td>2005-2014</td>
<td>0  0</td>
<td>563  409 (70) (70)</td>
<td>241  176 (30) (30)</td>
<td></td>
</tr>
<tr>
<td>2015-2020</td>
<td>0  0</td>
<td>521  517 (70) (70)</td>
<td>223  222 (30) (30)</td>
<td></td>
</tr>
</tbody>
</table>

*Population figures for alternative scenarios based on estimates of number of people who move between income categories during the specified decade. The numbers in parentheses are percentages of total sectoral population.

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Figure 1. Key determinants of China grain output

Source: Rozelle, Huang, and Rosengrant (1997)
Figure 2. Forces affecting demand for grain in China

Source: Rozelle, Huang, and Rosengrant (1997)
Source: Yotopoulos (1985)

Figure 3. Demand for grains, total, direct, and indirect, according to income
Figure 4. Conceptual framework for China’s grain supply, demand, and import projections
Figure 5. Comparison of projected grain imports under low growth (baseline) scenario with food-feed competition
Figure 6. Comparison of projected grain imports under baseline and high growth scenarios with food-feed competition


396. William Poole, "When is Inflation Low?," March 1994. This paper was presented at the CEPR conference, "Monetary Policy in a Low Inflation Regime," March 4-5, 1994.


