Long-term Projections of Livestock, Meat and Feedstuffs in China:

Focus on Beef Production Potential

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Abstract

Projections to 2030 for China using the computer program ANFEEDPROJ include beef consumption supply per capita growing from 3.9 kg in the base period 1999-2001, to 5.5 kg in 2010, 6.5 kg in 2020 and 7.5 kg in 2030. Cattle inventory (including dairy cattle) will increase from 104 million head in the base period, to 123 million in 2010 and 2020, and to 128 million in 2030 under the scenario called "robust" in which it is assumed that the economy grows at 7.0 percent annually from the base to 2010, 5.5 percent annually from 2010 to 2020, and then 4.5 percent annually to 2030.

The major focus in this paper is on structural change in the industry, especially on nutritional aspects, and particularly on types of feedstuffs utilized. A unique aspect is that the computer program is based on animal feed requirements and animal feed availabilities, which are on an energy and protein basis to account for the wide variety of feedstuffs fed in China. Human consumption of food is also included in the model to assure that animal use is properly defined. Results from the current model, completely revised and updated to 1999-2001 as a base period, include all animals except very minor ones, and fish farming. Explanation is provided on China's program for enhancing feeding of crop residues as well as structural aspects related to it.

It is concluded that China can basically meet its cattle feed requirements without additional feedstuffs imports, primarily due to the large proportion of crop residues fed to them. However, while imports of energy feeds for the entire livestock and fish sectors will not be required, potential protein shortfalls point to the need for significant imports if appropriate agricultural sector policy decisions are not taken.

Key words: China, projections, livestock, meat, beef, poultry, pigs, goats, sheep, small ruminants, feedstuffs, nonconventional, by-products, grain feeding

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Beef production has long been a source of contention among those modeling trade with China. Nearly all projections have indicated that China would be unable to produce sufficient feedstuffs to meet requirements for cattle production (as well as other animal and fish products) leading to grain and oilseed imports growing at an increasing rate, necessity of large net beef imports, or a combination of both. The purpose of this paper is to explain why such a scenario has not come to pass, provide projections to 2030 for animals and farm-raised fish with emphasis placed on cattle, and explain why—**technically**—China can potentially meet its long-term beef requirements through domestic production. The term **technically** is crucial as this is not a trade or economics based model.

Research Method

Most trade modelers use an econometric approach, such as the FAO World Food Model, the USDA model, the World Bank model or the IFPRI model. However, models of this nature are quite cumbersome to use, are restricted in use by the organizations, some only project out 10 years or so, and are primarily based on price, a variable that loses meaning after a few years.

A major problem with trade models about China, and perhaps most important, is that they are quite simplistic from a technical viewpoint. On the animal side constant feed/meat conversion ratios are the main variable used, thus masking impacts from technology development and adoption, and structural change. In general, maize is used as the energy source and soybeans as the protein source, a method that works well for the United States but, as will be shown, does not at all capture the considerable role of by-product and nonconventional feedstuffs such as crop residues used in China. On the crop side, trade models provide no detail of reasons for yield growth rates. Rather, past tendencies are the norm. As a result, virtually all projections have been misleading and erroneous about the potential for exports to China, as well as international agricultural trade in general (McCalla and Revoredo, 2001).

The results provided in this paper are based on a model especially developed for long-term projections of animal inventories, feedstuffs requirements and feedstuffs availabilities. Simpson originally constructed it in the late 1980s and early 1990s with the technical assistance of Cheng Xu of China Agriculture University after extensive travel and research in China. After further in-depth fieldwork Simpson, Cheng and Miyazaki provided background, projection methods and results in a 1994 book.

This non-deterministic simulation spreadsheet programmed model was greatly revised and updated using results of China's first agricultural census (Zhu, 2000) for a paper presented in New Zealand by Simpson and Li (2001), which is available online for greater study about the model and rationalizations about preliminary results. Further substantial revision of the model, and updating of data, were made in preparation for this 2003 paper. The program is very large and complicated, with more than 5,000 lines of spreadsheet program, 800 variables and more than 2,200 parameters. The method used is to calculate all requirements and availabilities on the basis of metabolizable energy (ME) and crude protein (CP).

The source of published data is FAO's on-line DATASTATS service rather than directly from Chinese publications because FAO, in line with its international data standards, has a much wider availability of statistics. All FAO data are from official Chinese sources and comparison of original data with FAO reveals no significant difference. Other parameters, like proportion of inventory in backyard versus commercial operations, use of crop residues, yield growth components, animal production parameters, etc., which are not published in official statistics, were ascertained by discussions with specialists, through publications of other authors, and personal survey data collection (e.g. Simpson, et. al., 2000).

On the animal side, per capita supply projections of animal and fish products (including poultry, and all termed animal from here) were multiplied by population to arrive at total production of these products (adjusted by exports and imports). Application of production parameters resulted in verification of inventories for the base period (1999-2001), and projections for 2010, 2020 and 2030. Multiplication of animal numbers by appropriate ME and CP values resulted in total ME and CP requirements. Availabilities include principal crop outputs such as grains, grassland, by-products and nonconventional feed resources such as crop residues. There is a modest gap between requirements and availabilities due to lack of certain data such as roadside grazing, misspecifications in the model, and feedstuffs that cannot be measured such as water plants, non-specified forages, garbage feeding, statistical errors in data, etc. Absolute size of the gap in the base year is not important. Rather, changes in the gap in projection years are the determinant of whether, and how much, imports of feedstuffs will be needed.

China's Feedstuffs Requirements and Availabilities

Population and gross domestic income per capita are provided in Table 1 to assist in understanding the demand side. Population is expected to grow from 1.28 billion in 1999-2001 (hereafter, this three year average base year is termed 2000) to 1.37 billion in 2010, to 1.46 billion in 2020, and 1.49 billion in 2030. These constitute 7, 14 and 16 percent increases from the base period, respectively. Per capita income on a Purchasing Power Parity (PPP) basis is calculated to grow from

$3,940 in 2000, to $20,560 in 2030. As a point of reference, the PPP in 2000 for Japan was about $23,000, and $33,000 for the USA.

The model is quite robust and, in fact, the original projections for 2000 using 1989-91 as the base period are quite close to what actually happened in 2000, thus lending credence to reliability of the results reported in this paper. It is concluded that ***technically***, despite human population growth and changes in diet, China can continue to meet its energy requirements for animal and fish feedstuffs. However, protein requirements are projected to exceed the base period of 1999-2001 domestically produced availabilities by 13 percent in 2010, 32 percent in 2020 and 37 percent in 2030 (Table 2). These projections are based on quite conservative crop yield increases taking into account constraints on China's natural resources, and without consideration of the great potential biotechnology will probably have on crop production worldwide. Additional in-depth studies on China are available at the USDA briefing room website (USDA, n.d.) and the Western Coordinating Committee project "Assessing China as a market and Competitor" website (WCC-101, n.d.). Implications for trade are provided at the end of this paper.

Beef Production Model Inputs and Results

<u>Consumption of Animal and Fish Products</u>

Per capita projections of meat, milk, fish and eggs were obtained from an unpublished cross-country consumption analysis by Simpson and Li (2000), building on the method of Simpson and Ward (1995). An average 1996-98 per capita consumption for each commodity was used for each of the 10 countries included and results regressed against purchasing power parity data for the year 1998. Results were then used as a basis for initial selection of parameters. Projections used in six other models were reviewed and consideration given to lifestyle changes of Chinese to obtain the final parameters. Selection of this method may not be optimal, but the parameters chosen (Table 3) are in line with other projections for China.

Beef is the largest growth meat commodity in China; per capita production nearly doubles, from 3.9 kg in the base year, to 7.5 kg in 2030 (Table 3). Total meat and fish consumption was 92 kg in 2000, and is projected to reach 118 kg in 2030. As a comparison, the totals in 2000 were 115 kg in Japan, 142 in the USA, 101 kg in Germany and 117 kg in Taiwan.

Total production of animal and fish products from 1985 to 2030 is provided in Table 4. Imports and exports were held constant at 2000 levels in projections to show the effect on domestic feedstuffs requirements and availabilities. Total production of meat and fish increases 49 percent in the 30 years from 2000 to 2030. Beef and veal production increases 127 percent, from 4.9 million tons to 11.2 million tons during the 30-year projection period.

<u>Productivity improvement</u>

Remarkable growth has been recorded in China's livestock product production, and it is projected to continue for the foreseeable future primarily because there is still great latitude for further progress in production efficiency and productivity. A multitude of technical variables such as dressing percent, live weight, milk production and offtake rates are taken into account in the model for cattle, pigs and poultry to explain and project animal numbers and feedstuffs requirements. Pigs, for example, are quite complicated, involving 65 variables such as whether they are backyard or commercial, number born per litter, number of litters per year, weaning weights, time on feed by stage of feeding, and death loss, just to give a sampling of the information needed to explain and project technological changes in production. Poultry are equally as complicated.

Pigs provide a good example of the impact technology adoption can have on production. In 1985 only 54 kg of pork was produced per pig in inventory (Table 5). By 2000 it had reached 95 kg, and is projected to reach 145 kg by 2030. In comparison, the average in 2002 was 150 kg in Germany, 136 kg in the United Kingdom and 138 kg in the USA (FAO DATASTATS). Offtake rates (the percent of pigs going to slaughter compared to inventory) in China are projected to increase from 124 percent in 2000, to 170 percent in 2030. As a point of reference, rates for the above three other countries ranged from 144 to 195 percent in 2000 (data not shown in tables). It is important to realize that productivity will continue to increase in other countries over the next three decades covered in the projections, and that China will benefit from future technological development influencing those changes as well as adoption of current technology, not to mention great structural changes that have been taking place (see for example Fang, Fuller, Lopez and Tuan, 2000). The point is that accuracy in projections about China's agriculture depends on a good understanding of its agricultural structure (including policy, research, education, etc.), knowledge about international agriculture and technology, recognition that agriculture is a dynamic industry and not a static one, and that in many respects China is more like European agriculture than its East Asian neighbors to which it is often, and misleadingly, compared.

Most cattle in China are found in the cropping areas. Originally they were mainly used for draft and transport, with milk and beef as by-products from aged animals that had to be culled. As the rural areas have begun to mechanize, and national per capita incomes have increased, demand for beef has also grown so that, although there is still a substantial portion of cattle used for work, a true beef industry is quickly emerging in which cows are kept primarily for calf production in both cropping and grassland areas (Simpson and Li, 1996). A variety of growing and fattening operations operations have sprung up. Most are small ones somewhat akin to those in the U.S. before and shortly after WWII. Some larger scale enterprises of several hundred head to several thousand head have developed, but U.S. style feedlots will not come into being in the foreseeable future. Space does not permit a detailed description of industry structure. As such, readers are encouraged consult the authoritative 2001 book *Beef in China: Agribusiness Opportunities and Challenges* by Longworth, Brown and Waldron for further information.

Productivity is increasing rapidly in China's cattle industry. In 1985 just 6 kg of beef was produced per head of cattle (including dairy cattle) in inventory (Table 5). By 2000 it had reached 47 kg. It is projected to reach 61 kg by 2010, then 77 kg in 2020, and 87 kg in 2030. In comparison, Germany recorded 91 kg in 2000, Japan 111 kg and the U.S. 124 kg (Table 6).

China's 6 percent cattle offtake rate in 1985 had climbed to 22 percent by 2000. It is projected to reach 29 percent in 2010 and then remain at about 30 percent. This may seem low compared to the U.S., which had 38 percent in 2000, but is reasonable because there are significant structural, management, and feeding differences between the two countries. The rate was 30 percent in Germany and 27 percent in Japan.

Carcass weights are another indicator of technology adoption, breed and management improvement, and feeding strategy, among other factors. The average for cattle in China grew from 106 kg in 1985 to 174 kg in 2000. It is projected to reach 293 kg in 2030, which would bring it in line with Germany, the UK and the USA in 2000 (Table 6). The heavy carcass weight in Japan (409 kg) reflects slow, long time feeding for their specialized dishes. Carcass weights in China are much lower, but the long, slow feed approach is becoming an accepted practice and fits their cuisine very well.

<u>Inventory projections</u>

Livestock inventory projections and historical data are given in Table 7. Inventories of pigs and poultry are projected to grow moderately this decade and then decline as the industry shifts from backyard and small production units to large-scale, technologically advanced enterprises that will continue to increase their adoption of production enhancing technologies. Sheep and goat numbers are expected to increase only modestly due to minimal increases in per capita consumption of meat and milk, conflicting use of natural resources, and relatively small potential for technology development and adoption.

Non-bovine work animal numbers are projected to decline from 24 million head in 2000, to 7 million head in 2030. There was an increase in their numbers until 1990 as farmer's income grew. The 1990s represented the beginning of the era of mechanization, including contracting heavy farm work such as land preparation and harvesting. As a result, non-bovine work animal numbers declined 13 percent in that decade.

Buffalo are also used for farm work. They are separated from other large animals because milk is a joint product of them, although most it is fed to calves in China. Their numbers are also projected to decline significantly, from 23 million head in 2000, to 7 million in 2030. Non-bovine work animal and buffalo numbers are projected to collectively decline by 33 million head, which will free up considerable feedstuffs for other animals and farm-raised fish. Projections of these two categories are based on anticipated structural and farm management changes that will take place as the country modernizes.

Draft/beef cattle numbers (termed beef cattle from now on) increased from 42 million head in 1985, to 99 million in 2000. They are projected to grow to 117 million head in 2010 and then remain at that level through 2020, reaching 123 million in 2030. In brief, beef cattle inventory more than doubled in the 15-year period to 2000, and is expected to grow 24 percent over the next 30 years. One big reason cattle numbers will increase dramatically, while non-bovine work animals and buffalo will decline, is that cattle are a major source of human food while the others are not. Another reason is that while there is moderate scope for improvement in cattle productivity, it is not as great as in poultry and pigs.

Efficiency and Utilization of Feedstuffs

There is a strong relationship between body condition and feed consumption. Animals on a maintence diet consume relatively small amounts of energy and protein, but production per head of inventory is also low. Most animals in China have traditionally been poorly fed. As time has passed a variety of management practices commensurate with improved diets and intake have been adopted that have increased production efficiency. Pigs and poultry in particular have benefited by improved quality and quantity in their diet. Sheep and goats have traditionally been small and poorly fed, and improvement will be slow in coming. Energy and protein requirements for cattle will increase for the next 10 or 15 years as heavy culling takes place, body size increases, and they are fed at a higher plane of nutrition. Once an adequate level of nutrition is reached commensurate with the feeding strategy, the amount of ME and CP per kg of beef produced will decline. In brief, each animal species is different in the way they are raised and consequently the feed requirements also vary.

Beef cattle accounted for 22 percent of all ME requirements by animals and pond raised fish in 2000 (Table 8). Projections are for cattle to account for 28 percent in 2030. Pigs utilized 41 percent of all ME in 2000 and that proportion is projected to be 40 percent in 2030. Protein utilization by beef cattle will increase from 20 to 23 percent of national requirement by 2030. Nutrition, including type of feedstuffs, is central to understand the extent to which China can meet the great increases projected in livestock commodity and fish production to meet changes in demand for them.

Types of Feedstuffs Produced

Each country feeds its animals according to resource availabilities and legislation concerning product quality, food safety desires, and comparative advantage in production of feedstuffs. This is a key point in understanding and projecting China's beef cattle structure. The United States is an anomaly in world beef production by its almost total finishing of beef in large feedlots and almost exclusively on grain. This system has developed because of grading standards that essentially preclude fattening on forages or crop residues even though such a practice is often lower cost per kg of beef produced. The reason is that the sale price of forage finished animals is much lower than grain finished ones due to grading standards. Americans have come to believe their beef is the standard for quality beef, and that animals raised under other conditions are lower quality. Consequently, it is also believed that China will inexorably move toward a U.S. style, high average daily gain, grain-based fattening system. This way of thinking leads to the conclusion is that China will thus require substantial feedstuffs imports. I believe, as do the Australians Longworth, Brown and Waldron (2001), that such a structure will not evolve, and the projections in this paper reflect that.

About 1.2 trillion Mcal of feedstuffs were calculated to have been produced in China in 2000 (Table 9) although, as described earlier, that is below the actual amount due to lack of data on availabilities. Of that, 9 percent was by-products, i.e. feedstuffs apart from principal crop production that enter international trade such as oilseed and other meals (cakes), and commonly sold products within a country such as spent brewers grains. Another 13 percent was from grasslands. The principal output of crops such as grains accounted for 42 percent of all ME. Principal crop outputs will increase continuously as a proportion of all ME produced, and are projected to reach 55 percent by 2030.

Nonconventional feedstuffs (NCFR) are really the heart of China's draft and beef cattle industry, as well as for other ruminants and non-bovine work animals. To a lesser extent they play a role in backyard poultry and pig units. NCFR, made up of crop residues such as maize and sorghum stover, straw, vegetable and other crop and processing waste, and vines of vegetables, potatoes, etc. constituted a whopping 36 percent of all ME produced in 2000 although it is expected to fall to 26 percent in 2030. Twenty six percent of all crude protein produced in China is calculated to have been derived from NCFR in 2000. That proportion is expected to decline to 22 percent in 2030.

Residues and Silage Fed to Animals

Most of the parameters in the model fall within rather definable limits as they are quite technical in nature. A few, such as the feeding of residues, are much more open to speculation as they depend so much on government policy. Thus a very conservative approach was taken with these variables and if anything, the amount fed will increase more than projected. It is estimated that 795 million MT of residues and silage were produced in 2000, and it is projected to reach 1.0 billion MT in 2030 (Table 10). Residues accounted for 85 percent of the total in 2000 but, despite modest growth in production of them, that proportion will decline to 75 percent in 2030 as silage production will increase even more quickly.

About 346 million MT of residues and silage were fed in 2000 of which residues accounted for 66 percent. All silage produced is fed which, combined with considerable growth in production, leads to the proportion of silage fed of all residues and silage growing from 34 percent in 2000, to 50 percent in 2030.

The largest part of NCFR is simply crop residue waste that is burned in the field after harvest, plowed back into the ground, used in other activities such as paper making, or used for cooking and heating by farmers. The rest is fed to animals. Twenty three percent of vines produced are estimated to have been fed in 2000, along with 34 percent of straw and 40 percent of stover. Also, 34 percent of all residues were fed that period, and 44 percent of combined residue and silage production (Authors calculations based combined with those of Tingshuang, Sanchez and Peiyu, 2002). The proportions of residues will be about the same in 2030 (34 percent), but the total will increase (from 44 to 50 percent) due to a greater proportion of maize and sorghum being ensiled rather than being harvested for grain.

An important part of China's animal policy is to increase use of treated as well as untreated residues (Tingshuang, Sanchez and Peiyu, 2002). Stover is the preferred crop residue for feed due to higher feeding values. Rice straw has 1.43 Mcal/kg and 2.9 percent CP. In contrast, maize stover has1.87 Mcal/kg and 5.4 percent CP, i.e., considerably more than straw. China embarked on a crop residue improvement program in the mid 1980s. FAO and UNDP then provided considerable financial and technical assistance from 1987. By 2000, 13 prefectures and 380 counties had programs, including demonstration sites.

There are a number of ways to treat residues (and silage), but ammonia has become the most common. The benefits are that the lignin is broken down thus improving digestibility, and ME and CP content are increased. As an example, ME in maize stover can nearly double, from 1.87 Mcal/kg to 2.50, and CP from 5.4 to 8.0 percent. There is relatively little increase in ME by treating straw although CP increases from 2.9 to 4.3 percent, a modest gain. It is estimated that about 45 percent of all crop residues fed were treated in 2000 (including 49 percent of straw and 51 percent of stover fed). Government programs especially target residue treatment and the projection of reaching 64 percent of all residues fed in 2030 reflects this policy decision (Table 10).

Impact on Trade

The projections are that beef production (consumption) will grow from 3.9 kg in 2000, to 5.5 kg in 2010. Using those figures, as well as the other data presented in previous tables, the result would be a CP shortfall of 2.2 million MT in 2010. ME and CP are a useful way to quantify very different feedstuffs, but they're also an abstract measure. Consequently, the additional requirements over the base year (1999-2001) have been converted to a soybean equivalent (SBE) basis using a 40% crush rate, and resultant meal set at 43 percent CP. That converts to an equivalent of 12.9 million MT of additional soybean imports in 2010 as shown in the first (and projected) scenario of Table 11. To place this in perspective, the USDA baseline import projection for China in 2007 is 5.3 million MT of soybeans, which is an additional 1.5 million MT over imports in 2000. Clearly, there are other sources of protein based feeds such as oilseed and fish meals. The soybean example is used because it is easy to visualize. Consider the year 2030. If projections for that year of 36.1 million MT SBE were realized, and all imports were soybeans, that amount would nearly reach the equivalent of total world soybean imports in 2000 (40 million MT).

A natural question is about sensitivity of the projections. It turns out that changes in crop yields and sown area do have an impact, and since the projections are based on moderate yield increases, additional response rates from further development and adoption of research results would have a mitigating impact on the shortfalls. As pointed out, beef is the principal commodity of concern in projections since cattle production utilizes such a large amount of feedstuffs. The government program to foster feeding and treatment of crop residues is very important because only modest increases in feeding residues, particularly treated ones, do have a major impact on CP shortfalls. Consider, for example, just one commodity, maize stover. If the proportion of maize stover production in the base scenario that is treated and fed were increased from the projected 25 percent in 2010 to 35 percent, just 4.9 million tons of additional SBEs (rather than 12.9 million MT) would be needed to cover the shortfall (Table 11). An increase to 60 percent in 2030 from the projected 35 percent (while simultaneously untreated residues fed falls from 20 percent in 2010 to 5 percent in 2030) means just 13.6 million tons of additional SBE (a reasonable amount) would have to be imported rather than 36.1 million MT.

What about beef consumption increasing at a much faster rate than projected, say from 7.5 to 10.0 Kg in 2030? The answer is that, with the base scenario of 35 percent of maize stover being treated and untreated falling to 5 percent of residues produced (analogous to the first example in Table 11), the SBE increases to an almost unimaginable 82 million MT. If the treatment percent were to increase to 60 percent, the SBE would still be an inconceivable 60 million MT. But, bear in mind that maize residue is just one of many residues covered by the government program. If feeding levels of many or most of residues and treatment of them were to expand in line with government programs, it is likely that protein shortfalls, or at least most of them, could be met with reasonable levels of protein oriented imports. The point is that relatively simple solutions are available to meet projected shortfalls in protein requirements, they are in place, and they are an important component to meet feedstuffs requirements.

Conclusions

It can be concluded that **technically** China will be able to meet its demand for beef as well as other animal and freshwater fish products over the next several decades. In all likelihood, although protein based feedstuffs imports will continue to grow to meet the varied requirements of the entire food chain, it should be able to meet its energy feedstuffs requirements, particularly for beef production. There will be imports and exports of beef to meet specialized needs such as certain parts of the hotel trade and some cuts for home use, but relative to China's size they will be small provided government adopts appropriate policy measures. One principal reason, as highlighted in this paper, is that crop residues and silage will remain as mainstays of cattle feedstuffs needs, and relatively little grain will be fed.

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TABLE 1. POPULATION AND GROSS DOMESTIC INCOME PER CAPITA, CHINA, ECONOMY ROBUST, 1984-86 TO 2030

ITEM	1984-1986	1989-1991	1994-1996	1999-2001	2010	2020	2030
				POPULATION			
				MILLIONS			
POPULATION	1,075.9	1,161.4	1,226.0	1,282.4	1,374.4	1,455.0	1,494.1
				GROSS DOMESTIC INCOME (GDI) PER CAPITA			
	COMPOUND ANNUAL GROWTH RATE			BASE YEAR	PROJECTION YEARS		
	2000-2010	2010-2020	2020-2030	2000	2010	2020	2030
	PERCENT			$ US			
PPP BASIS	7.0	5.5	4.5	3,940	7,751	13,239	20,560
	0.0						
EXCHANGE RATE BASIS	7.0	5.5	4.5	840	1,652	2,823	4,383
				YUAN			
EXCHANGE RATE TO DOLLARS				8.28	8.28	8.28	8.28
PPP BASIS				32,623	64,175	109,620	170,236
EXCHANGE RATE BASIS				6,955	13,682	23,371	36,294

SOURCE: BASE YEAR PPP AND EXCHANGE RATE BASIS FROM WWW.rieti.go.jp/en/China/02080901.html
POPULATION FROM FAO DATASTATS.

TABLE 2. METABOLIZABLE ENERGY AND CRUDE PROTEIN REQUIREMENTS AND AVAILABILITIES, ANIMALS AND FISH, CHINA, ECONOMY ROBUST, NO CHANGE IN TRADE FROM BASE LEVEL, 1999-2001 TO 2030

Item	AVG 99-2001	2010	2020	2030
		METABOLIZABLE ENERGY		
		MILLION Mcal		
ANIMALS AND FISH				
REQUIREMENTS	1,595,970	1,896,705	2,124,963	2,272,334
AVAILABILITIES	1,211,936	1,517,321	1,756,966	1,967,125
REQUIREMENTS OVER AVAILABILITIES	384,034	379,384	367,997	305,209
ADDITIONAL REQUIREMENTS OVER BASE YEAR	--	-4,650	-16,037	-78,825
		Percent		
REQUIREMENTS OVER AVAILABILITIES	24	20	17	13
DIFFERENCE FROM BASE PERIOD (PERCENT)	--	-1	-4	-21
DIFFERENCE FROM PREVIOUS PERIOD (PERCENT)	--	-1	-3	-17
ANIMALS AND FISH INCREASE OVER BASE YEAR				
INCREASE OVER BASE YEAR				
REQUIREMENTS	--	19	33	42
AVAILABILITIES	--	25	45	62
		CRUDE PROTEIN		
		1,000 MT		
ANIMALS AND FISH				
REQUIREMENTS	69,742	83,576	96,155	106,145
AVAILABILITIES	52,961	64,576	73,972	83,150
REQUIREMENTS OVER AVAILABILITIES	16,782	19,000	22,183	22,995
ADDITIONAL REQUIREMENTS OVER BASE YEAR	--	2,218	5,401	6,213
		Percent		
REQUIREMENTS OVER AVAILABILITIES	24	23	23	22
DIFFERENCE FROM BASE PERIOD (PERCENT)	--	13	32	37
DIFFERENCE FROM PREVIOUS PERIOD (PERCENT)	--	13	17	4
ANIMALS AND FISH OVER THE BASE YEAR				
INCREASE OVER BASE YEAR				
REQUIREMENTS	--	20	38	52
AVAILABILITIES	--	22	40	57

SOURCE: SIMPSON, MODELING RESULTS.

TABLE 3. PROJECTIONS OF PER CAPITA MEAT AND FISH SUPPLY, CHINA, ECONOMY ROBUST, 1999-2000 TO 2030

	COMPOUND ANNUAL GROWTH RATE CALCULATED			PROJECTION PER CAPITA ENTERED			
	2000-2010	2010-2020	2020-2030	1999-2001	2010	2020	2030
	PCT			KG			
BEEF AND VEAL	3.6	1.7	1.4	3.9	5.5	6.5	7.5
PORK	0.4	0.6	0.5	32.6	34.0	36.0	38.0
MUTTON AND GOAT	0.8	0.2	0.0	2.1	2.3	2.4	2.4
MUTTON AND LAMB	0.7	0.4	0.0	1.1	1.2	1.3	1.3
GOAT	0.9	0.0	0.0	1.0	1.1	1.1	1.1
BUFFALO MEAT	-2.2	-2.7	-6.7	0.3	0.2	0.2	0.1
TOTAL, RED MEAT	0.8	0.7	0.6	38.9	42.0	45.0	47.9
POULTRY	3.5	2.5	1.6	9.9	14.0	18.0	21.0
TOTAL MEAT	1.4	1.2	0.9	48.8	56.0	63.0	68.9
FISH,FRESH	1.3	0.4	0.7	11.8	13.5	14.0	15.0
TOTAL MEAT & FISH	0.8	0.9	0.8	92.1	99.5	109.0	117.9
MILK							
COW	1.4	4.1	5.2	7.0	8.0	12.0	20.0
GOAT	-0.1	0.0	0.0	0.2	0.2	0.2	0.2
BUFFALO	-1.7	-3.4	-7.3	2.1	1.7	1.2	0.6
EGGS, HEN	0.8	0.1	0.0	15.1	16.3	16.5	16.5

SOURCE: SIMPSON, MODELING RESULTS.

TABLE 4. TOTAL PRODUCTION OF MEAT AND FISH, CHINA, ECONOMY ROBUST, 1984-86 TO 2030

SPECIES	1984-1986	1989-1991	1994-1996	AVG 99-2001	2010	2020	2030
	1,000 MT						
BEEF AND VEAL	406	1,168	3,054	4,944	7,559	9,458	11,206
PORK	17,322	24,062	33,010	41,811	46,730	52,380	56,776
MUTTON AND GOAT	601	1,071	1,682	2,731	3,161	3,419	3,511
MUTTON AND LAMB	307	551	893	1,438	1,649	1,819	1,868
GOAT	294	520	789	1,292	1,512	1,601	1,644
BUFFALO MEAT	127	165	275	369	317	256	131
TOTAL, RED MEAT	18,456	26,465	38,021	49,855	57,767	65,513	71,624
POULTRY	2,092	3,855	8,279	12,671	19,242	26,190	31,376
TOTAL MEAT	20,548	30,321	46,300	62,526	77,009	91,703	103,000
FISH,FRESH		5,263	10,475	15,175	18,554	20,370	22,412
TOTAL MEAT & FISH		50,337	86,083	118,069	136,795	158,633	176,211
MILK							
COW	2,619	4,411	6,090	8,916	10,995	17,460	29,882
GOAT	144	163	194	234	247	262	269
BUFFALO	1,627	1,907	2,200	2,633	2,377	1,787	859
EGGS, HEN	4,225	6,701	13,912	19,390	22,403	23,935	24,653

SOURCE: HISTORICAL DATA FROM FAO DATASTATS. PROJECTIONS FROM SIMPSON, MODELING RESULTS.

TABLE 5. PRODUCTION PER HEAD OF INVENTORY, CHINA, ECONOMY ROBUST, 1984-86 TO 2030

	YEAR						
SPECIES	1984-1986	1989-1991	1994-1996	AVG 99-2001	2010	2020	2030
	KG OF MEAT PER HEAD OF INVENTORY						
SHEEP	3	5	8	11	11	12	13
GOATS	5	5	6	9	9	9	10
CATTLE	6	15	31	47	61	77	87
BUFFALO	6	8	12	16	16	18	19
PIGS	54	67	81	95	103	130	145
POULTRY (JAN 1 INV)	1	2	2	3	4	6	7
	KG OF MILK PER HEAD OF INVENTORY						
GOATS	1	1	1	1	1	1	1
MILK COWS	1,475	1,453	1,436	1,680	2,046	3,255	5,580
BUFFALO	83	89	96	116	121	123	128

SOURCE: SIMPSON, MODELING RESULTS.

TABLE 6. INTERNATIONAL COMPARISON OF CATTLE DATA

	CHINA	ARGENTINA	GERMANY	JAPAN	UK	USA
	KG					
PRODUCTION PER HEAD OF INVENTORY						
1979-1981	5	53	91	101	80	90
1984-1986	6	52	95	117	88	101
1989-1991	15	54	104	117	83	109
1994-1996	31	52	90	119	75	112
1999-2001	47	54	91	111	61	124
2010	61					
2020	77					
2030	87					
CARCASS WEIGHTS						
1979-1981	100	201	257	337	260	271
1984-1986	106	207	264	254	271	272
1989-1991	146	215	286	395	383	299
1994-1996	140	210	296	400	272	310
1999-2001	174	220	310	409	296	326
2010	221					
2020	270					
2030	293					
	PERCENT					
OFFTAKE RATES						
1979-1981	5	26	36	30	31	33
1984-1986	6	25	36	33	32	37
1989-1991	10	25	36	30	29	37
1994-1996	22	25	31	30	28	36
1999-2001	22	25	30	27	21	38
2010	29					
2020	30					
2030	31					

SOURCE:FAO DATASTATS AND AUTHORS PROJECTIONS.

TABLE 7. LIVESTOCK INVENTORY, CHINA, ECONOMY ROBUST, 1984-86 TO 2030

SPECIES	YEAR 1984-1986	1989-1991	1994-1996	AVG 99-2001	2010	2020	2030
	-1,000 HEAD-						
NON-BOVINE WORK ANIMALS							
ASSES	9,942	11,128	10,853	9,906	7,466	4,021	1,151
CAMELS	542	470	360	330	242	197	157
HORSES	10,956	10,338	10,025	8,889	6,236	5,095	4,382
MULES	4,785	5,417	5,480	4,647	2,822	1,876	1,017
TOTAL, NON-BOVINE	26,225	27,353	26,718	23,772	16,765	11,190	6,708
CATTLE							
MILK COWS	1,776	3,037	4,241	5,308	5,374	5,364	5,355
DRAFT/BEEF	41,563	54,835	68,803	98,869	117,813	116,759	123,455
TOTAL CATTLE	43,339	57,872	73,044	104,177	123,187	122,123	128,810
BUFFALO	19,571	21,412	23,030	22,681	19,704	14,530	6,732
TOTAL,CATTLE,BUFFALO	62,910	79,284	96,074	126,858	142,891	136,654	135,542
TOTAL LARGE ANIMALS	89,135	106,637	122,792	150,630	159,657	147,844	142,250
SHEEP	96,108	112,299	118,919	130,539	146,135	151,942	147,592
GOATS	64,521	95,615	126,431	149,245	166,649	170,121	168,669
TOTAL SMALL RUMINANTS	160,629	207,914	245,350	279,784	312,784	322,064	316,261
PIGS							
COMMERCIAL				154,134	204,594	302,370	356,833
BACKYARD				286,248	250,060	100,790	35,291
TOTAL	319,078	360,543	408,782	440,382	454,654	403,160	392,124
	-MILLION BIRDS-						
TOTAL POULTRY	1,586	2,558	3,914	4,410	4,775	4,599	4,298

SOURCE: HISTORICAL DATA FROM FAO DATASTATS. PROJECTIONS FROM SIMPSON, MODELING.

TABLE 8. METABOLIZABLE ENERGY AND CRUDE PROTEIN REQUIREMENTS BY SPECIES GROUPS, CHINA, ECONOMY ROBUST, 1999-2001 TO 2030

SPECIES	TOTAL REQUIREMENTS ME	CP	SPECIES PROPORTION ME	CP
	-Million Mcal-	-1000 MT-	--------PERCENT---------	
AVG 99-2001				
DRAFT/BEEF CATTLE	352,933	14,074	22.1	20.2
OTHER LARGE ANIMALS	134,344	5,407	8.4	7.8
TOTAL LARGE ANIMALS	487,277	19,481	30.5	27.9
SMALL RUMINANTS	124,315	5,678	7.8	8.1
PIGS	660,159	23,534	41.4	33.7
POULTRY	154,003	8,182	9.6	11.7
FISH, FRESH WATER	170,217	12,868	10.7	18.5
TOTAL	1,595,970	69,742	100.0	100.0
2030				
DRAFT/BEEF CATTLE	627,249	23,837	27.6	22.5
OTHER LARGE ANIMALS	90,029	4,262	4.0	4.0
TOTAL LARGE ANIMALS	717,278	28,100	31.6	26.5
SMALL RUMINANTS	154,837	7,103	6.8	6.7
PIGS	909,159	33,781	40.0	31.8
POULTRY	311,544	20,576	13.7	19.4
FISH, FRESH WATER	179,516	16,585	7.9	15.6
TOTAL	2,272,334	106,145	100.0	100.0

SOURCE: SIMPSON MODELING.

TABLE 9. TOTAL METABOLIZABLE ENERGY AND CRUDE PROTEIN PRODUCED BY SOURCE TYPE, CHINA, ECONOMY ROBUST, 1999-2001 TO 2030 (1)

ITEM	AVG 99-2001	2010	2020	2030
	METABOLIZABLE ENERGY			
	MILLION Mcal			
BY-PRODUCTS	110,684	135,808	164,850	195,403
NONCONVENTIONAL	441,711	528,720	524,847	516,587
GRASSLAND	156,511	167,712	171,153	174,435
PRINCIPAL CROP(2)	503,031	685,080	896,117	1,080,700
TOTAL	1,211,936	1,517,321	1,756,966	1,967,125
	PERCENT			
BY-PRODUCTS	9	9	9	10
NONCONVENTIONAL	36	35	30	26
GRASSLAND	13	11	10	9
PRINCIPAL CROP(2)	42	45	51	55
TOTAL	100	100	100	100
	CRUDE PROTEIN			
	1,000 TONS			
BY-PRODUCTS	13,026	16,346	20,177	23,771
NONCONVENTIONAL	13,641	17,247	17,761	18,399
GRASSLAND	5,529	5,931	6,120	6,277
PRINCIPAL CROP(2)	20,764	25,051	29,914	34,702
TOTAL	52,961	64,576	73,972	83,150
	PERCENT			
BY-PRODUCTS	25	25	27	29
NONCONVENTIONAL	26	27	24	22
GRASSLAND	10	9	8	8
PRINCIPAL CROP(2)	39	39	40	42
TOTAL	100	100	100	100

SOURCE:SIMPSON MODELING.

(1) THE ACTUAL ME IS HIGHER, BUT CANNOT BE CALCULATED DUE TO PROBLEMS IN ESTIMATION OF NONPUBLISHED NUMBERS SUCH AS GARBAGE FEEDING, WATER PLANTS, NON-SPECIFIED FORAGES, STATISTICAL ERRORS IN REPORTED DATA, ETC.

(2) INCLUDES SILAGE.

TABLE 10. TOTAL RESIDUES AND SILAGE PRODUCED AND TREATED IN CHINA,
ECONOMY ROBUST, 2000 AND 2010

ITEM	AVG 99-2001	2010	2020	2030	AVG 99-2001	2010	2020	2030
	1,000 TONS				PERCENT			
	RESIDUES AND SILAGE PRODUCED							
VINES	130,113	157,218	179,784	201,060	16	17	18	19
STRAW	380,303	380,550	381,106	368,439	48	41	38	36
STOVER	165,887	182,669	197,798	206,022	21	20	20	20
RESIDUES	676,303	720,437	758,688	775,521	85	79	77	75
SILAGE	119,163	197,018	231,879	261,998	15	21	23	25
TOTAL	795,466	917,455	990,567	1,037,519	100	100	100	100
	RESIDUES AND SILAGE FED AND PROPORTION OF TOTAL							
VINES	30,100	41,262	45,391	50,780	9	9	9	10
STRAW	130,495	151,689	145,706	126,377	38	32	29	24
STOVER	66,311	82,715	80,228	83,324	19	17	16	16
RESIDUES	226,906	275,666	271,325	260,481	66	58	54	50
SILAGE	119,163	197,018	231,879	261,998	34	42	46	50
TOTAL	346,069	472,684	503,204	522,479	100	100	100	100
	PERCENT OF EACH RESIDUE AND SILAGE PRODUCED FED							
VINES	30,100	41,262	45,391	50,780	23	26	25	25
STRAW	130,495	151,689	145,706	126,377	34	40	38	34
STOVER	66,311	82,715	80,228	83,324	40	45	41	40
RESIDUES	226,906	275,666	271,325	260,481	34	38	36	34
SILAGE	119,163	197,018	231,879	261,998	100	100	100	100
TOTAL	346,069	472,684	503,204	522,479	44	52	51	50
	INCREASE IN TOTAL FED FROM BASE PERIOD							
VINES					--	37	51	69
STRAW					--	16	12	-3
STOVER					--	25	21	26
RESIDUES					--	21	20	15
SILAGE					--	65	95	120
TOTAL					--	37	45	51
	RESIDUES AND SILAGE TREATED, AND AS A PROPORTION OF THE AMOUNT OF PRODUCTION							
VINES	4,077	8,186	9,434	10,568	3	5	5	5
STRAW	64,437	80,566	83,384	84,440	17	21	22	23
STOVER	33,699	46,181	59,250	71,392	20	25	30	35
RESIDUES	102,212	134,932	152,068	166,401	15	19	20	21
SILAGE	0	0	0	0	0	0	0	0
TOTAL	102,212	134,932	152,068	166,401	13	15	15	16
	RESIDUES AND SILAGE TREATED, AND AS A PROPORTION OF THE AMOUNT FED TO ANIMALS							
VINES	4,077	8,186	9,434	10,568	14	20	21	21
STRAW	64,437	80,566	83,384	84,440	49	53	57	67
STOVER	33,699	46,181	59,250	71,392	51	56	74	86
RESIDUES	102,212	134,932	152,068	166,401	45	49	56	64
SILAGE	0	0	0	0	0	0	0	0
TOTAL	102,212	134,932	152,068	166,401	30	29	30	32

SOURCES: SIMPSON MODELING WITH RECOGNITION OF TINGSHUANG, SANCHEZ AND PEIYU, 2002,
FOR MUCH OF THE BASIC DATA FOR 2000 AND 2010.

TABLE 11. SCENARIOS ABOUT THE IMPACT OF CROP RESIDUES ON SOYBEAN IMPORTS, CHINA, ECONOMY ROBUST, 1999-2001 TO 2030

ITEM	AVG 99-2001	2010	2020	2030
	BEEF CONSUMPTION AT PROJECTED LEVEL			
PER CAPITA BEEF CONSUMPTION (KG)	3.9	5.5	6.5	7.5
PROPORTION OF MAIZE STOVER PRODUCTION				
UNTREATED AND FED TO ANIMALS (PERCENT)	20	20	10	5
TREATED AND FED TO ANIMALS (PERCENT)	20	25	30	35
SHORTFALL IN CP OVER BASE (1,000 MT)	--	2,218	5,401	6,213
ADDITIONAL SOYBEAN IMPORTS (MILLION MT) (1)	--	12,897	31,402	36,122
PROPORTION OF MAIZE STOVER PRODUCTION				
UNTREATED AND FED TO ANIMALS (PERCENT)	20	20	10	5
TREATED AND FED TO ANIMALS (PERCENT)	20	35	50	60
SHORTFALL IN CP OVER BASE (1,000 MT)	--	850	2,428	2,337
ADDITIONAL SOYBEAN IMPORTS (MILLION MT) (1)	--	4,939	14,117	13,590
	BEEF CONSUMPTION AT HIGHER LEVELS			
PER CAPITA BEEF CONSUMPTION (KG)	3.9	6.0	9.0	10.0
PROPORTION OF MAIZE STOVER PRODUCTION				
UNTREATED AND FED TO ANIMALS (PERCENT)	20	20	10	5
TREATED AND FED TO ANIMALS (PERCENT)	20	25	30	35
SHORTFALL IN CP OVER BASE (1,000 MT)	--	3,973	13,699	14,156
ADDITIONAL SOYBEAN IMPORTS (MILLION MT) (1)	--	23,100	79,644	82,301
PROPORTION OF MAIZE STOVER PRODUCTION				
UNTREATED AND FED TO ANIMALS (PERCENT)	20	20	10	5
TREATED AND FED TO ANIMALS (PERCENT)	20	35	50	60
SHORTFALL IN CP OVER BASE (1,000 MT)	--	2,604	10,726	10,280
ADDITIONAL SOYBEAN IMPORTS (MILLION MT) (1)	--	15,142	62,359	59,768

SOURCE:SIMPSON MODELING.
(1) THE AMOUNT ON A SOYBEAN EQUIVALENT BASIS NEEDED TO COVER THE SHORTFALL IN DOMESTICALLY PRODUCED CRUDE PROTEIN AVAILABILITIES. THE FIRST SCENARIO IS SHOWN IN TABLE 2. THE CRUSH RATE IS 40 PERCENT AND THE CP CONTENT OF THE RESULTANT SOYBEAN MEAL IS 43 PERCENT.