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Can China Continue to Feed its Population?
(First Segment of a Three-part Series)

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China, with one-fifth of the world's population and rapidly rising incomes, is a country which has naturally been open to speculation about its ability to feed itself over the next few decades. Population is projected to grow from 1.34 billion in 2006-2008, to 1.44 billion in 2020, and 1.479 billion in 2030 (Table 1). Simultaneously, per capita income growth will lead to greater demand for animal and aqua products, thus resulting in expanded feedstuffs requirements.

The objective of the research reported on was to determine the extent to which China will be able to maintain its current level of being essentially self-sufficient in animal feedstuffs, animal and aquaculture products, and other foods for humans. The research method used is to calculate all animal and aquaculture requirements and availabilities on the basis of metabolizable energy (ME) and crude protein (CP).

It is concluded that ***technically***, despite human population growth and changes in diet, China can continue to meet, and exceed, its energy requirements for animal and aquaculture feedstuffs if that political oriented decision is made. However, in the basic projections, the

growth in protein deficit will require 48 million tons of soybean equivalent imports in 2015, 58 million tons in 2020 and 55 million tons in 2030.

The projections are based on medium scenario crop yield increases and per capita consumption projections derived from a robust economy in which growth rates moderate over time. Constraints on China's natural resources are taken into account, and the great potential biotechnology will probably have on crop production worldwide is conservatively factored in. It can be expected there will be years in which feedstuffs imports will likely be needed and other years of surpluses due to climatic variations and other factors such as commodity price fluctuations. Human consumption of food from sources other than livestock products (such as crop co-products for example) is taken into consideration in the modeling.

Research Method

A major problem with trade models about China is that, because they are price based, they thus lose their relevance after a few years. The results provided in this article are based on a model especially developed for long-term projections of animal inventories, feedstuffs requirements and feedstuffs availabilities. Originally constructed by Simpson in the late 1980s and early 1990s (Simpson, Cheng and Miyazaki, 1994), this non-deterministic simulation spreadsheet programmed model has been greatly revised and updated several times since then. Suffice it to say that the program is very large and complicated, with more than 5,000 lines of spreadsheet program, 800 variables and more than 2,200 parameters, and success in various previous projections lends credence to reliability of results.

There is a modest gap between requirements and availabilities due to lack of certain data, feedstuffs that cannot be measured such as water plants, roadside grazing, garbage feeding,

misspecifications in the model, errors, etc. (Table 2). Absolute size of the gap 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.

Consumption of Animal and Aqua Products

Per capita projections of demand were primarily derived from cross country analysis and evaluation of other projections. Beef is a high growth meat commodity as per capita consumption (and production) is projected to double from 4.3 kg in 2007 to 7.5 kg in 2030 (Table 3). Poultry also doubles, from 11.6 kg to 20.0 kg in that same period. Pork, already quite high, grows very little, from 34.2 kg to 38.0 kg. China's per capita meat and aqua product consumption is projected to grow from 79.1 kg to 100.5 kg in 2030. As a comparison, the totals in 2007 were 96 kg in Argentina, 100 in Germany, 107 in Japan, 105 in the UK and 146 in the USA (data not shown).

Total production of animal and aqua products from 1989-1991 (mid year of three year averages and last year of two year averages used for simplicity) to 2030 is provided in Table 4. Imports and exports were held constant at 2007 levels in projections to show the effect on domestic feedstuffs requirements and availabilities. Total production of meat and aqua products increases 38 percent in the 23 years from 2007 to 2030. Beef and veal production increases 92 percent, from 5.7 million tons to 11.0 million tons during that 23 year projection period.

Animal Productivity improvement

The remarkable growth recorded in China's livestock product production 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 aspects are taken into account

in the modeling for cattle, pigs and poultry to explain and project animal numbers and feedstuffs requirements. Pigs, for example, are quite complicated, involving 65 variables in the program such as whether they are backyard or commercial, number born per litter, number of litters per year, energy and protein changes by weights, time on feed by stage of feeding, just to give a sampling of the information needed to explain and project technological changes in production. Poultry, in particular, are equally as complex.

Pigs also provide a good example of the impact technology adoption can have on production. In 1990 only 67 kg of pork was produced per pig in inventory (Table 5). By 2007 it had reached 106 kg, and is projected at 137 kg by 2030. In comparison, the average in 2007 was 129 kg in Japan, 150 kg in the United Kingdom and 158 kg in the USA. Offtake rates (the percent of pigs going to slaughter compared to inventory) in China are projected to increase from 139 percent in 2007 to 170 percent in 2030. As a point of reference, rates for the above three other countries in 2007 were 167 kg, 191 kg, and 172 kg, respectively (FAO, FAOSTATS).

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 with proper policy formulation focusing on adoption of current technology, productivity stimulation through research and development, China will benefit from those changes as well. The point is that accuracy in projections about China's agriculture depends on a good understanding of its agricultural structure, knowledge, recognition that China's agriculture is a dynamic industry and not a static one, and that in most respects it is more like European agriculture than that of its East Asian neighbors to which it is often, and misleadingly, compared.

Cattle are particularly important in determining whether China can feed itself because total beef production will have to double in order to meet increased demand. Most cattle in China are

found in the cropping areas rather than on rangelands. 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 a true beef industry is quickly emerging in which cows are kept primarily for calf production in both cropping and grassland areas. A variety of growing and fattening operations have sprung up, but U.S. style feedlots will not come into being in the foreseeable future.

Productivity is increasing rapidly in China's cattle industry. In 2007 production per head of inventory was 60 kg, up dramatically from 15 kg in 1990. It is projected to reach 79 kg by 2020 and 96 kg in 2030. These rates are not high for; by comparison, Germany recorded 93 kg in 2007, UK 84 kg and the U.S. 125 kg.

Animal Inventory Projections

Historical data and projections on livestock inventory are given in Table 6. Review of them is very instructive for they reveal the impact from technology adoption and structural change. As an example, despite total production continuing to grow, inventories of pigs and poultry are projected to grow moderately until 2015 and then decline slightly as those industries move to large-scale technologically advanced enterprises that continue to increase their adoption of productivity enhancing technologies. Growth in milk consumption has received considerable attention recently with speculation that the number of milk cows will have to increase dramatically. The milk industry is a nascent one with yield per cow at just 2,800 kg in 2007. It is project to grow to 6,500 kg in 2030. As a result, while great growth in numbers is projected to 2015, they are calculated to remain at 9 million head from then on. The projected decline in non-bovine work

animal numbers from 18 million head in 2007, to 5 million head in 2030 will free up considerable feedstuffs resources for other animals. The bottom line: Focus on technological change and adoption.

Table 1. Population and gross domestic income per capita, China economy robust, 1989-199 to 2030

Item	1989-1991	1994-1996	1999-2001	2006-2008	2015	2020	2030
	Population						
	Million						
Population	1,142.1	1,211.0	1,274.0	1,336.5	1,403.9	1,439.4	1,471.3
	Gross domestic income (GDI) per capita						
	Compound annual growth rate			Base year	Projection years		
	2007-2015	2015-2020	2020-2030	2007	2015	2020	2030
	Percent			$US			
PPP basis	8.0	7.0	5.0	5,900	10,920	15,317	24,949
Exchange rate basis	9.0	5.5	4.5	840	1,674	2,188	3,397
				Yuan			
Exchange rate to dollars				6.8	6.8	6.8	6.8
PPP basis				40,120	74,259	104,153	169,654
Exchange rate basis				5,712	11,382	14,875	23,101

Population: United Nations, January 2010

PPP GDP per capita for 2007 based on 2005 from International Monetary Fund, WWW.Wikipedia. Org , January 14, 2010.

PPP GDP in 2008 based on estimate by the World Bank in 2009 was $5,962 for China.f In comparison it was $34,099 for Japan and $46,716 for the United States. Sourced from WWW.Wikipedia.org/list, by GDP (PPP) per capita, November, 2009.

Purchasing power parity (PPP) is the equivalent buying power in different currencies: a way of estimating national income by showing the number of currency units required to buy the same amount of goods and services in another country as one currency unit would buy at home

Table 2. Metabolizable energy and crude protein requirements and availabilities, animals and aquaculture, China economy robust, 2006-2008 to 2030

Item	2006-2008	2015	2020	2030
		Metabolizable energy (1)		
		Million Mcal		
Animals and aquaculture				
Requirements	1,652,518	1,837,055	1,888,200	2,131,242
Availabilities (include net imports entered in model)	1,605,259	1,890,811	2,049,793	2,413,230
Requirements over availabilities	47,258	-53,756	-161,593	-281,988
Additional requirements over base year	--	-101,014	-208,851	-329,246
		Percent		
Gap in requirements over availabilities	3	-3	-9	-13
Additional requirements over base period gap (include net imports specified)		-214	-442	-697
Increase over base year				
Requirements	--	11	14	29
Availabilities	--	18	28	50
		Crude protein		
		1,000 MT		
Animals and aquaculture				
Requirements	76,459	92,950	102,305	116,654
Availabilities (include net imports entered in model)	68,705	82,244	91,758	108,623
Requirements over availabilities	7,754	10,705	10,547	8,031
Additional requirements over base year	--	2,951	2,793	277
		Percent		
Gap in requirements over availabilities	10	12	10	7
Additional requirements over base period gap (include net imports specificied)		38	36	4
Increase over base year				
Requirements	--	22	34	53
Availabilities	--	20	34	58

Source: Simpson, modeling results.

(1) One megacalorie (Mcal) is equivalent to 1,000 kilocalories (Kcal, and also written with a large "C" found on food labels).

Table 3. Projections of per capita supply of animal and aqua products, China, economy robust, 2007 to 2030

Item	Compound annual growth rate (2)			Per capita projections (1)			
	2007-2015	2015-2020	2020-2030	2007	2015	2020	2030
	----------Pct ----------			----------Kg----------			
Beef and veal	3.07	3.40	1.44	4.32	5.50	6.50	7.50
Pork	0.66	0.55	0.27	34.15	36.00	37.00	38.00
Mutton, lamb and goat	-0.19	0.70	0.17	2.84	2.80	2.90	2.95
Mutton and lamb	-0.06	0.66	0.32	1.51	1.50	1.55	1.60
Goat meat	-0.34	0.76	0.00	1.34	1.30	1.35	1.35
Buffalo meat	0.27	-4.78	-6.70	0.23	0.23	0.18	0.09
Total red meat	0.87	0.90	0.41	41.54	44.53	46.58	48.54
Poultry meat	1.47	4.24	2.26	11.56	13.00	16.00	20.00
Total meat	1.01	1.70	0.91	53.10	57.53	62.58	68.54
Aqua products (cultivated)	0.93	1.39	0.65	26.00	28.00	30.00	32.00
Total meat and aqua products	0.98	1.60	0.83	79.10	85.53	92.58	100.54
Milk							
Cow	-0.67	3.71	2.92	25.86	25.00	30.00	40.00
Goat meat	-1.08	0.00	0.00	0.20	0.18	0.18	0.18
Buffalo meat	-2.24	-2.33	-1.33	0.22	0.18	0.16	0.14
Eggs, hen	-0.03	0.18	0.03	16.34	16.30	16.45	16.50
				----------Percent----------			
Beef and veal				5	6	7	7
Pork				43	42	40	38
Mutton, lamb and goat				4	3	3	3
Mutton and lamb				2	2	2	2
Goat meat				2	2	1	1
Buffalo meat				0	0	0	0
Total red meat				53	52	50	48
Poultry meat				15	15	17	20
Total meat				67	67	68	68
Aqua products				33	33	32	32
Total meat and aqua products				100	100	100	100

Source: Simpson, modeling results.

(1) Calculated

(2) Entered

Table 4 Total production of animal and aqua products, China, economy robust, 1989-1991 to 2030

Item	1989-1991	1994-1996	1999-2001	2006-2008	2015	2020	2030
	----------	----------	----------	1,000 MT	----------	----------	----------
Beef and veal	1,167.7	3,054.7	4,745.5	5,730.4	7,681.5	9,316.1	10,994.8
Pork	24,061.9	33,009.7	40,768.7	46,244.0	50,640.4	53,357.8	56,009.4
Mutton, lamb and goat	1,070.6	1,681.9	2,642.7	3,759.4	3,889.9	4,133.3	4,299.3
Mutton and lamb	550.7	893.3	1,445.3	1,972.0	2,065.9	2,191.1	2,314.1
Goat meat	519.9	788.6	1,197.3	1,787.4	1,824.1	1,942.2	1,985.3
Buffalo meat	165.1	274.6	368.8	300.8	313.2	252.6	129.5
Total red meat	26,465.4	38,021.0	48,525.6	56,034.5	62,524.9	67,059.7	71,433.0
Poultry meat	3,863.4	8,213.9	12,324.5	15,045.8	17,850.7	22,630.4	29,026.0
Total meat	30,328.8	46,234.9	60,850.1	71,080.3	80,375.6	89,690.1	100,459.0
Aqua products (cultivated)	6,078.0	13,531.0	22,269.7	29,484.6	32,000.0	35,000.0	38,000.0
Total meat and aqua products	36,406.8	59,765.9	83,119.8	100,564.9	112,375.6	124,690.1	138,459.0
Milk							
Cow	4,411.4	6,090.2	8,915.9	34,561.8	35,097.5	43,182.0	58,852.0
Goat meat	1,906.7	2,200.0	2,643.3	2,883.3	2,566.9	1,971.7	950.0
Buffalo meat	162.6	192.4	232.5	262.4	252.7	259.1	264.8
Eggs, hen	6,700.6	13,912.0	18,858.5	21,839.2	22,883.6	23,678.1	24,276.5

Source: Simpson , modeling results.

Table 5. Production per head of inventory, China, economy robust, 1989-1991 to 2030

Item	1989-1991	1994-1996	1999-2001	2006-2008	2015	2020	2030
	----------	----------	Kg of meat per head of inventory	----------	----------	----------	----------
Sheep	4.9	7.5	11.2	13.6	12.7	13.1	13.8
Goats	5.4	6.2	8.2	12.4	10.8	10.8	11.1
Cattle	14.7	31.5	46.3	60.2	65.6	78.8	95.8
Buffalo	7.7	11.9	16.3	13.2	16.1	17.6	19.5
Pigs	66.7	80.8	94.6	105.7	112.9	122.4	136.5
Poultry	1.5	2.1	2.8	2.7	2.9	3.6	5.0
Chickens	1.3	1.8	2.4	2.4	2.7	3.5	5.1
	----------	----------	Kg of milk per head of inventory	----------	----------	----------	----------
Goats	1.7	1.5	1.6	1.8	1.5	1.4	1.5
Milk cows	1,563.6	1,543.8	1,836.7	2,776.9	3,600.0	5,000.0	6,500.0
Buffalo	89.0	95.5	116.6	126.3	132.0	137.5	143.0
	----------	----------	Kg of eggs per chicken hen in inventory	----------	----------	----------	----------
Eggs	8.7	10.2	9.9	9.1	10.7	14.0	16.2

Source: Simpson , modeling results.

Table 6. Livestock inventory, China, economy robust, 1989-1991 to 2030

Item	1989-1991	1994-1996	1999-2001	2006-2008	2015	2020	2030
	1,000 Head						
Non-bovine work animals							
Asses	11,128	10,853	9,378	7,409	4,498	2,423	694
Goats	470	360	330	258	129	69	20
Horses	10,338	10,025	8,889	7,141	4,994	4,080	3,509
Mules	5,417	5,480	4,647	3,337	2,127	1,414	767
Total, non-bovine	27,353	26,718	23,244	18,145	11,748	7,986	4,989
Cattle							
Milk cows	2,821	3,945	4,854	12,446	9,749	8,636	9,054
Draft/beef	76,463	93,029	97,611	82,745	107,358	109,537	105,770
Total cattle	79,284	96,974	102,465	95,191	117,107	118,173	114,824
Buffalo	21,412	23,028	22,678	22,831	19,446	14,340	6,644
Total cattle, buffalo	100,696	120,002	125,143	118,022	136,553	132,513	121,467
Total, large animals	128,049	146,720	148,387	136,167	148,301	140,500	126,457
Sheep	112,299	118,919	129,491	144,597	162,678	167,609	167,450
Goats	95,615	126,432	146,672	144,674	169,649	180,635	178,274
Total small ruminants	207,913	245,350	276,164	289,271	332,328	348,244	345,724
Pigs							
Commercial				188,055	246,779	305,152	348,713
Backyard				249,282	201,910	130,779	61,538
Total pigs	360,543	408,782	430,848	437,337	448,689	435,931	410,250
	Million birds						
Total poultry	2,556	3,920	4,407	5,568	7,923	8,055	7,533

Source: Simpson , modeling results.