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Feeding China's Pigs

Implications for the Environment, China's Smallholder Farmers and Food Security

By Mindi Schneider

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All photographs taken by Mindi Schneider in China from 2009–2010.

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Executive Summary

Starting in 1979, pork became the most produced and consumed meat in the world. The reason for its ascent to the top of the global meat heap is simple: China. In 2010 alone, farmers and companies in China produced more than 50 million metric tons of pork, virtually all of which was sold and consumed domestically. This Chinese pork boom, which today accounts for half of all the pork in the world, is the result of a set of policies and trade agreements that liberalized and industrialized Chinese agriculture and enabled enormous production increases.

In the quest to feed 21 percent of the world's population on nine percent of its arable land, Chinese central authorities prioritize ensuring a steady supply of low-priced pork as an important component of food security (China maintains a strategic pork reserve, the only one of its kind in the world). In the more than 30 years since Deng Xiaoping introduced the first major set of reforms to liberalize China's economy in 1978, policies and investments have worked together to shape and implement a model of agricultural development that privileges industrial agriculture and increased meat production and consumption. While some of these measures have played a role in decreasing the number of hungry in the country, the crises of industrial agriculture are emerging, with serious implications for the environment, public health, smallholder farmers, and questions of food security. This paper focuses on the pork sector in particular—including the feeding of swine—as it relates to these pressing issues and challenges.

Long before "Reform and Opening," pork was critically important in Chinese agriculture and diets. Pigs were domesticated in China some 10,000 years ago, and for millennia, virtually every rural household in China raised at least one or two pigs each year. Smallholders defined the structure of pig raising in China all the way up until the early 1980s, when industrial forms began to emerge. Today, smallholder farmers struggle to survive in the new market agro-economy, while specialized household producers and large-scale commercial operations are actively supported by policy and investment. A small number of vertically integrated, and predominantly domestic, agribusiness firms are claiming an ever-increasing share of pork production, processing and marketing. Changes in swine feeding and China's feedstuffs imports are at the heart of this shift. The industrialization of pig farming in China has taken place in concert with the development of a multi-billion dollar (USD) feed industry.

Soybean imports are keeping the swine industry in China afloat. In order to overcome the limitations of domestic production for feeding millions of pigs, authorities enacted a series of measures to liberalize China's soy trade, including those required by World Trade Organization (WTO) accession protocols, starting in the early 1990s. Imports quickly overtook both soy exports and domestic production, and today, China is the world's leading soybean importer. In 2010, more than 50 million metric tons of soybeans came into China, mostly from the United States and Brazil. These imported beans accounted for 73 percent of soy consumption in China, and were used exclusively in the production of soybean meal for livestock feed and soy oil for cooking (meal and oil are coproducts in the soy crushing process). In stark contrast to the pork industry, which a handful of domestic companies dominate, transnational agribusiness firms including Archer Daniels Midland, Bunge, Cargill, Louis Dreyfus (together, ABCD) and Wilmar own about 70 percent of the soybean crushing industry in China. In recent years, China has enacted measures to cool the dominance of foreign firms in support of domestic operations. Whether or not these moves will be effective remains to be seen.

Soy is particularly important in commercial pig feed mixes, but for smallholder and specialized household farmers, corn is the most used feedstuff. Corn is protected as a "strategic crop for food security," primarily because of its role as a staple food for human consumption. Recently, however, corn is also being used in the manufacture of industrial products, and increasingly in commercial livestock feed. In 2010, China was a net corn importer for the first time since 1995. The buyers, a state-owned conglomerate and a private agribusiness firm, used the corn to produce feed. Authorities claim that 2010 was an anomaly, but 2011 looks to be another record corn import year for the Middle Kingdom.

The consequences of these changes in pig production and pig feeding have wide-ranging impacts. In terms of environmental degradation, agriculture in general—and livestock farming in particular—are the most important sources of pollution in China. Livestock farms produce more than 4 billion tons of manure annually, much of which contributes to nutrient overload in waterways and subsequent eutrophication and dead zones. Globally, as more and more land is converted to intensive monocrop production of soybeans and corn (and others in a narrow range of industrial feed crops), pesticide and fertilizers pollute waterways, biodiversity declines, natural carbon sinks are destroyed, and greenhouse gases are emitted in all stages of intensive feed production and transport.

Industrial pig feeding also carries a range public health concerns. China is becoming increasingly infamous as a site of food safety scandals, most of which stem from feed additives such as hormones and growth regulators ending up in meat and livestock products. On top of this, the prophylactic administration of antibiotics in confined animal feeding operations (CAFOs) has resulted

in antibiotic-resistant and disease-causing organisms emerging in China, just as in the United States and Europe. Other threats to public health include the emergence of so-called diet-related diseases of affluence, including Type 2 diabetes, coronary heart disease, obesity and a range of cancers. At the same time, the current model of agricultural development has failed to close the gap in dietary and income inequalities that continue to plague China, especially in the form of differences between rural and urban populations.

Beyond environmental and health impacts, increased liberalization of agriculture is taking a toll on China's rural population. Smallholder farmers struggle to access markets, meet new market standards, cover costs of production and maintain an adequate farm labor force. In the context of mass urban migration, many young, and especially male, rural residents are flooding China's cities as migrant workers, leaving the elderly, women and children to tend their households and farms alone.

For its people, environment and penchant for self-sufficiency, a reassessment of the actual impacts of industrial pork production and pig feeding on China's population and environment is needed. Redirecting research and subsidies from industrial systems to locally embedded systems, while maintaining food reserves, are steps in the right direction toward serving national food security, development and environmental needs.

I. Introduction

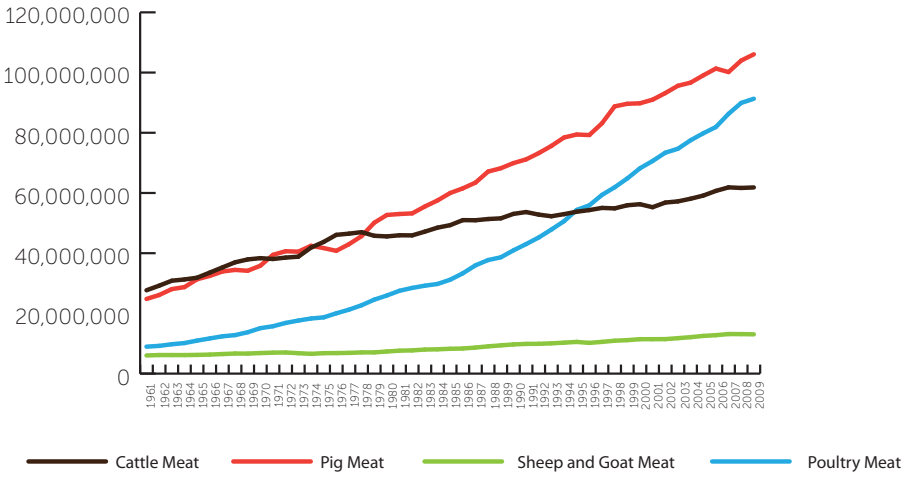
In 1978, Deng Xiaoping introduced a program of economic reforms in China that began to move the country in the direction of becoming a market economy. The following year, pork started on the path to global domination as the world's most produced and consumed meat. These two trajectories are intimately linked. While pork had been a key source of protein in China for thousands of years, it was only in the context of de-collectivizating the countryside, liberalizing agricultural markets, and adopting industrial production technologies and ideologies that China's pork sector began to shift global statistics. Today, 30 years after Deng's market reforms began, pigs—and what pigs are eating—in China have become big news and big business. The world, it seems, is watching.

The numbers that accompany the assent of China's pork industry are impressive. In 2010, farmers and companies in China produced 50 million metric tons of pork from a domestic swineherd of 660 million head. This is twice the amount of pork produced in all 27 EU countries combined, five times the amount in the United States and almost half of the global total of 101.5 million metric tons. On the chopstick side of this food system sector, domestic consumption matches domestic production: In 2010, people in China ate 50 million metric tons of pork at an average rate of 37.1 kg per person[1]. Presently, pork imports and exports are negligible, and consist largely of trade in select body parts and products. Chinese importers, for instance, buy offal (organ meat) from foreign companies, and Chinese exporters sell cooked pork products to foreign traders.

China's high level of pork self-sufficiency is a point of national pride and political significance. When Lester Brown published the book *Who Will Feed China?* in 1995, for example, he was met with a resounding response from China's research and political institutions that, "We will feed ourselves!" Since at least the 1980s, food security through self-sufficiency had been a key concern of the central government, with the legacies of famine and isolation from the not-so-distant past serving as powerful motivations. Through a combination of food reserves, price guarantees, rural credit, input subsidies, support for agricultural research and extension, and political incentives, China has been successful in large measure in achieving food self-sufficiency, improving agricultural production, and raising living standards. But when livestock are involved, particularly livestock raised in confined/concentrated animal feeding operations (CAFOs), sources of feed must be included in the calculus of self-sufficiency. In China, the stories of the pig industry and the feed industry are interdependent, and include farmers in North and South America, farmers throughout China, agricultural imports, foreign investment, and both domestic and transnational agribusiness firms.

This report considers some of the implications of the industrialization and liberalization of pig and feed production in China. It expands the questions of "Who will feed China?" and "Who will feed China's pigs?"[3] to questions of *how* will China feed its pigs, who will decide, and what will these choices mean for the environment, Chinese diets and food security, and domestic small-scale farmers? Answering these questions involves first understanding the structure and politics of pig and feed production in China today, and how these two industries are emerging together and contributing to similar challenges and crises in the food system.

Figure 1. World Meat Production by Sector: 1961–2009 (tonnes)



Source: FAOSTAT

II. From farm to factory: The structure of pig farming in China

Pork is a central component of Chinese agricultural systems, food security policy and diets. One reason for this is the long history of raising swine in the country. Pigs were domesticated from wild boars in southern China as early as 10,000 years ago, and more extensively throughout other parts of the country 6–7,000 years ago. Millennia of animal husbandry produced a genetically diverse range of locally adapted indigenous pig breeds with characteristics such as high prolificacy (large litters) and juicy, flavorful pork.[4] When the Chinese Academy of Agricultural Sciences undertook the first national survey of indigenous livestock in 1960, researchers found more than 100 indigenous pig breeds, which ranged from the extreme northeast of modern day Heilongjiang Province, to the Tibetan Plateau, and all the places in between.[5]

This means that for virtually all of China's agricultural history, local people raised local pigs and ate them in local (geographic, cultural, social, dietary) contexts. Dispersed swine husbandry and consumption was dominant in China all the way up until the end of the 20th century, when policies and markets began to change dramatically, and three distinct scales and forms of pig production emerged.

China and World 2010 Pork Statistics at a Glance[2]			
	China 2010	World 2010	China as % of World Total
Pork Production (1,000 metric tons)	50,000	101,507	49%
Pork Consumption (1,000 metric tons)	50,050	101,126	49%
Pork Imports (1,000 metric tons)	350	5,645	6%
Pork Exports (1,000 metric tons)	250	6,052	4%
Swine Production (1,000 head)	660,000	1,202,550	55%

A. Backyard farms

For thousands of years, small-scale farmers raised all of the pork in China. As recently as 1985, these so-called backyard farmers (后院式饲养场) who raise fewer than five pigs per year, in addition to crops and other livestock on about a half acre of land, produced at least 95 percent of the country's pork. They did so using indigenous pig breeds, locally occurring or produced feedstuffs, and centuries of accumulated agricultural knowledge and practice.[6] Pigs in these smallholder systems played key agroecological roles, particularly in the conversion of weeds, crop residues and kitchen scraps into nutrient-rich manure that would fertilize crop fields. Mao Zedong wrote that, "The pig is a fertilizer factory on four legs,"[7] and a low-input, low-pollution, low-carbon factory at that. Pigs also provided a vital source of protein for rural people who raised them largely for self-consumption.[8] Before the 1980s when the government liberalized agricultural markets, farmers generally produced two pigs each year: one to slaughter and eat starting at Spring Festival (Chinese New Year), and one to sell to government purchasing stations in local areas at prices set by the state.[9]

Today, smallholder farmers, mostly women and elderly villagers who remain in the countryside while men migrate to China's cities in search of employment, produce pigs for self-consumption and for markets.[10] They raise pigs on a wide array of self-produced feedstuffs, and sometimes purchase commercial feed and feed supplements to use at key moments in the production cycle. They produce both meat pigs and breeding stock, and sell them to local butchers or local dealers. Meat is sold at wet markets—also called "traditional" or "open" markets where fresh meat and/or animals are sold—either in villages or in nearby cities. In China, wet markets can be roadside butcher stands, village markets where animals are butchered and sold, or fresh meat markets in cities.

Backyard farmers account for about 27 percent of national pork production (Figure 2), though the smallholder share is much higher in some regions of the country. In Sichuan, the historic heart and current national leader in pork production, backyard farmers raise 70 percent of the pigs in the province, while specialized households account for 25 percent, and large-scale commercial farms have only 5 percent.[11] This in contrast to the roughly 20 percent share held by backyard farmers in Guangdong Province, the national feed industry leader and overall largest livestock (pigs and chickens) producing province.

Harvest time in a Sichuan Village. These smallholder farmers are cleaning corn, paddy rice and millet. They will use most of the corn as feed for their pigs.

B. Large-scale commercial farms

Large-scale commercial farms (大型商业养殖场) are increasing in both number and in pork market share in China. In the wake of Deng Xiaoping's economic reforms in 1978, methods of selling, eating and producing pork began to change. These reforms broke up Mao-era collectives, permitted entrepreneurs to launch private businesses and allowed foreign investment to flow into China. Industrial modes of production came on the scene, kicking off the trend toward large-scale commercial pig raising that continues today. Before 1979, "factory farms" that raise thousands of hogs together in enclosed structures using CAFO technologies were nonexistent in China.[12] In 1985, these farms accounted for just 2.5 percent of the country's total pork production, but by 2007,

their share had grown to 22 percent.[13] By way of comparison, large-scale farms (500–50,000 pigs per year) accounted for 97 percent of all the hogs produced in the United States in 2010.[14]

A small village in Sichuan Province. In addition to rapeseed for oil production and sale, farmers are growing a wide variety of herbaceous plants for use as pig feed. The crop in the foreground is Niupicai, which is grown exclusively for pig feed.

Most large-scale commercial pig farms in China today are domestic enterprises. They may be state-owned, privately owned through sole proprietorship or partnership, joint ventures between Chinese and foreign firms, or between private and state-owned firms.[15] They are supported by central and provincial government subsidies, in addition to state and private investment. Commercial farms breed, feed, rear, slaughter, process, and market pigs and pork. They do so in a variety of ways, from being specialized in one particular phase of production, to being vertically integrated in some or all phases, to managing contracts with other farms and companies to produce and sell an end product. Commercial farms often own their own retail brands, and "industrial pork" is sold almost exclusively in urban supermarkets. The scale of production on these farms ranges from 500 to 50,000 pigs per year, but is rapidly increasing. It is not uncommon for a single firm to produce 100,000 hogs in one year, either through contracts with other farms, or in a single production facility.

One of the most salient features of the commercial pig industry in China is the trend toward vertical integration. Most of the major players are domestic firms with operations in more than one stage of production, including meat processing. The largest pork packers currently operate with a large degree of unfulfilled slaughter capacity. In an effort to fill this gap, many packers are building their own pig breeding and feeding facilities, and are poised to become the country's largest pig producers. Some of the leading commercial pork companies are briefly outlined below.

AGFEED INDUSTRIES is one of the largest independent commercial hog producers in China. Founded in 1995 by five animal nutritionists from Jiangxi Province, it is now a U.S. public company (NASDAQ: FEED) with operations in the U.S. and China. AgFeed is in the process of becoming a "fully integrated hog production system," with operations in animal nutrition (feed), hog production and harvesting (slaughter, processing and marketing). The company operates five feed mills in Southern China that produce premixes, feed concentrates and complete feeds, predominantly for hogs. They own 31 hog farms with a total annual production capacity of 550,000 head. With two new breeding and feeding farms projects underway in Jiangxi and Guangxi Provinces, annual production capacity will increase to 850,000 head by 2012. The company intends to produce 2 million hogs per year by 2015. AgFeed acquired M2P2, a U.S.-based hog production and industry management company in 2010.[16] It also entered into a joint venture with Hypor the same year in order to expand hog breeding operations in China. Hypor is a subsidiary of Hendrix Genetics, which is the second largest pig breeding company in the world.[17]

An urban wet market in Chengdu, Sichuan Province.

COFCO (China National Cereals, Oils and Foodstuffs Corporation) (中国粮油食品集团有限公司) is the largest edible oil and food producer in China, and the largest agricultural import/export firm. It is a state-owned enterprise that is publically traded. Specific information and statistics about COFCO's operations are difficult to find, though two large hog production development projects have been in the press in recent years. In 2007, COFCO launched a pig-breeding program in Wuhan, the provincial capital of Hubei Province. By 2012, the

This worker is processing sausage at a vertically integrated company that owns hog production, slaughter and processing facilities, in addition to owning its own retail market outlets.

project will be a base for 500,000 breeding sows and 10 million meat pigs per year, one million of which can be slaughtered on-site.[18] In 2009, COFCO invested $588 million USD in a pig production and processing complex in Tianjin to serve the Tianjin and Beijing markets. It will produce 2 million live hogs and 150,000 tons of pork per year after its completion in 2014.[19] COFCO bought a five-percent share in Smithfield Foods in 2008, and purchased Maverick Food, a joint venture between Smithfield and Belgian Artal Group in 2009.[20]

THE XINCHENG JINLUO GROUP (新程金锣肉制品集团有限公司), the commercial brand of People's Food Holdings Limited,[21] is the largest pork slaughter and processing company in China, and a leading meat product producer. The private company was founded in Shandong Province in 1994, and now has operations in Shandong, Heilongjiang, Jilin, Inner Mongolia, Hunan, Henan, and Sichuan Provinces, and export branches in Hong Kong, Singapore and Japan. Jinluo has more than 17,000 specialty shops and over 9,000 franchise retail outlets. The group produces two million tons of meat products every year, and has an annual slaughter capacity of 22 million hogs. The company is currently investing in breeding and feeding operations, in addition to feed production facilities, in order to fill their slaughter capacity.[22]

NEW HOPE GROUP[23] (新希望集团有限公司) is the largest wholly-owned private agricultural firm in China. The group has holdings in agribusiness and food, chemicals and resources, real estate and infrastructure, and finance and investment. New Hope is the largest livestock feed producer in China, and is quickly consolidating the meat, poultry and dairy sectors as well. In 2009, New Hope slaughtered 1.7 million pigs, and sold 162,400 tons of chilled pork.[24] Hog slaughter and processing capacity is 10 million head, and the company is developing breeding and feeding production bases in cooperation with Hendrix Genetics to help fill their slaughter production-capacity gap.[25] New Hope has close to 400 subsidiaries and 60,000 employees. They have joint ventures with Chinese state-owned enterprises, and also have private holdings in China and overseas. The company is actively pursuing the central government's "Going Global Strategy," which encourages Chinese firms to invest abroad.[26]

THE SHINEWAY GROUP (双汇集团) is another of the largest pork processors in China, with annual slaughter capacity of more than 30 million pigs. This state-owned company was established in 1994 in Henan Province, and sales of fresh and frozen meat and livestock products exceeded 50 billion RMB ($ 7.6 billion USD) in 2010.[27] Goldman Sachs bought a 10-percent share in Shineway in 2006, but sold half of those shares to

CHINA'S STRATEGIC PORK RESERVE

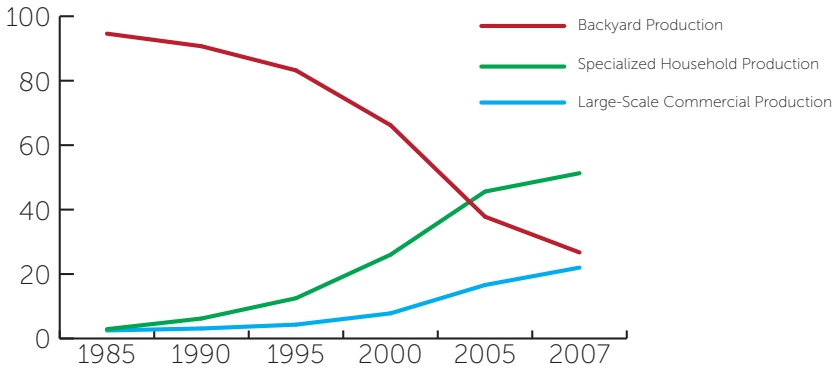
What do pigs have to do with social and political stability in China? Plenty. In a country where most of the population spends a large share of their household income on food, and where pork is the staple protein source, when the price of pork rises, discontent is often not far behind. In an attempt to quell potential protest that could threaten state power, central authorities created a strategic pork reserve to control pork prices and to signal the need for shifts in policy. This is the only reserve of its kind in the world today.

The strategic pork reserve consists of two different parts. The Ministry of Commerce initiated a live hog reserve that started operating in earnest in 2007 when the inflation rate in China hit 6.5 percent, and the price of meat and poultry surged 49 percent from the previous year.[35] The live hog reserve had been in existence before this price crisis, but was quite small and rather ineffective at regulating price. Today, it consists of a stock of a few million pigs that are rotated every four months on 200 to 300 commercial farms.[36]

The 2007 food price hikes also spurred central authorities to initiate a frozen pork reserve that year. Pork stocks in China were suffering from the PRRS (Porcine blue-ear disease) outbreak in 2006 that killed millions of pigs, as well as a production downturn from high feed prices. COFCO, China's state-owned and publically traded agribusiness conglomerate, signed a deal with U.S.-based Smithfield Foods, the world's largest pork producer, for the purchase of 60 million pounds of pork in 2007 for the frozen reserve. To fulfill the contract, Smithfield scaled up production and added 250 workers at their Sioux City, Iowa plant, expecting that this deal signaled the opening of a promising market for pork exports.[37] When the Ministry of Commerce released frozen pork from the reserve in 2008 to calm high market prices, it was Smithfield pork that found its way into Chinese kitchens. In 2009, however, authorities decided that only domestically produced pork would be used for the reserve in the future. Today, the frozen pork reserve is administered through domestic packing plants, most of which also have pig production facilities.[38]

The specifics of how the strategic pork reserve operates are tightly held state secrets. According to a pork industry expert in China, COFCO has a monopoly on both the live hog reserve and frozen pork reserve.[39] COFCO also has a minority share in Smithfield Foods,[40] and in 2009, bought Smithfield out of its joint venture in Maverick Food.[41]

Figure 2. Share of Total China Pig Production by Farm Type: 1985–2007 (%)



Source: Informa Economics and National Grain and Oil Information Center, 2009

CDH Investments, a Chinese private equity fund, in 2009.[28] Shineway is currently investing in its own hog production facilities, and hopes to produce 4 million hogs by 2015.[29]

THE TANGRENSHEN GROUP[30] (唐人神集团) is a shareholding enterprise founded in 1995. The China Agricultural University, the China Meat Products Research Center and Hong Kong Tai Sang Feeds Company are the three joint investors. The group has 45 subsidiaries with business in pig breeding, feed production and meat processing, and also sells animal health products and owns chain store and retailing operations. Tangrenshen slaughters 2.6 million pigs a year, produces 40,000 metric tons of meat products and 3.2 million tons of livestock feed. The group plans to invest $342 million USD to expand pork production to 10 million pigs per year in partnership with Whiteshire Hamroc, a U.S.-based pig breeding company.[31]

THE WEN'S FOODSTUFFS GROUP[32] (温氏食品集团) is a leading private agricultural company in China that operates through a family of 15 member companies and more than 80 subsidiaries. Wen's is the largest broiler producer in China, and also has operations in feed production, livestock equipment, hog production, poultry and hog breeding, cattle and dairy production, vegetable production, pharmaceuticals and processed meat products. In 2009, Wen's produced 3.5 million pigs, both in company-owned and run production facilities, and through contracts with specialized household pig farmers.

THE YURUN GROUP[33] (雨润集团) is a private food company that was founded in Nanjing in 2001, and listed on the Hong Kong Stock Exchange in 2005. Operating through four retail brands, the company processes and retails chilled and frozen pork, in addition to canned foods, vegetables, spices and imported food items. They have a pig slaughter capacity of 28.55 million head, but slaughtered only 7 million head in 2010. The group is investing in land in Nanjing to establish a base for pig production.[34]

C. Specialized household farms

The number of commercial pig farms is certainly increasing, but in China there is an important middle scale of production that central and local governments have aggressively supported through favorable policies and subsidies. Specialized household farms (专业化的家庭式养殖场) encompass operations with annual pig production from 10 to 500 head, with the range of 50–200 head as the most common.[42] These farms, which accounted for 51 percent of all the pigs in China in 2009, may be run by individual families or by several backyard farmers who have come together to focus on pig raising more exclusively, sometimes with the help of government subsidies for housing (humans and hogs) and for animal stocking. In this system, farming is a professional endeavor based on production of pigs for sale instead of self-consumption, though the "backyard"—an average land holding of half an acre per household—remains the primary site of operation.[43]

	Pre-reform (before 1978) Traditional Backyard Production	Post-reform Specialized and Commercial Production
Farmers	The majority of the population works as farmers, using unpaid household labor to produce food.	Pig raising is a paid occupation, including business executives, scientists, farmers and workers.
Pork & Human Diets	Meat eaten primarily in the spring when pigs were slaughtered for Spring Festival, marginally throughout the rest of the year. Pork had a higher fat-lean ratio. Meat was peripheral in diets.	Meat consumption more frequent in rural and urban areas, but dietary inequalities persist by class and residence. Pork is leaner. Meat more central in diets.
Pork Uses & Markets	Most production was for household consumption, and later for local wet markets and state provisioning.	Pork is grown and sold through contract agreements or dealers; is retailed at wet markets, or increasingly at super- and hyper-markets in cities.
Production Scale	Small-scale, dispersed production was situated in localities throughout China.	Mid- to large-scale, using confinement technologies and concentrating around major metropolises.
Pig Productivity	Low productivity on a per-animal basis, production cycle of 10–12 months.	Highly productive with time-to-market requirement of only 5–6 months.
Pig Breeds	More than 100 indigenous breeds.	Three major exotic breeds: Duroc, Landrace, Yorkshire.
Pig Feeding	Locally occurring or produced weeds, table scraps, crop residues, vegetables, grains, tubers and agricultural byproducts.	Globally sourced oilseeds and grains manufactured into complete feeds with vitamins, minerals and other feed additives. Antibiotics and other growth promoters commonly used.
Manure	Essential source of nutrients for crops (fertilizer).	Waste that must be managed to prevent water and soil pollution.

Changes in feeding practices and materials have accompanied the scaling-up and industrialization of pig production. Some specialized household swine farmers produce under contract with large commercial farms, while others sell piglets and meat pigs to local dealers who then sell pigs to slaughter, processing, and retail companies. The specifics of production contracts vary considerably by place and arrangement, but feeding is almost always a part of the agreement. Like large-scale commercial farms, specialized household farms use purchased feedstuffs for hog feeding.[44] Some specialized farmers rely on purchased feed exclusively, while others use it as a supplement to self-grown feedstuffs. Taken together, these two models of production, which today account for the majority and growing share of pigs in China (73 percent in 2007) involve a profound shift in feeding practice from locally occurring and produced feedstuffs, to the long-distance transport of processed feed, made largely from globally sourced oilseeds and grains.

The table on page 9 summarizes pig production practices before and after the 1978 reforms. Modern day backyard farms look similar to the "traditional" category, but with differences in the pig breeds used and in terms of labor and livelihoods.

Smallholders struggle to compete with the shorter production cycles, high levels of capitalization, easier adherence to meat quality and safety standards, and market control enjoyed by large-scale commercial farms. Specialized household farmers, on the other hand, occupy an insecure middle ground, straddling the worlds of "traditional" and "modern" farming. Through government subsidies and production contracts with large farms and firms, they are steadily being brought under the umbrella of the highly integrated, capital- and input-intensive pig industry that is booming in China today. This boom is linked to the large-scale commercial feed industry that took off in China during the same post-reform period.

III. The feed industry in China

Before 1975, a Chinese pig's lips would never have touched processed feed. Grains and oilseeds were cultivated for human consumption, while livestock were raised on weeds, grass, crop residues, kitchen scraps or any of a number of other readily available feedstuffs. In an effort to speed up the conversion of plant materials into meat, from 1976 to 1985 China's leaders supported rapid development of a milling industry that would provide compound livestock feeds, as well as employment opportunities in rural areas. These changes would in turn increase meat consumption in the country, improving diets and food security, and moving the population beyond the famines and meat rationing of the past. Through a combination of market reforms and government financial support, China's feed industry went from practically nothing before 1975 to becoming the world's second largest feed producer by 1995. Pig feed was the first boom in the 1980s, followed by chicken feed in the 1990s.[45]

Today, China has a multi-billion dollar (USD) livestock feed industry. Its 2008 gross output value was 425.8 billion RMB ($62.3 billion USD), an 8.5 percent increase from 2007. Of that total, 381.29 billion RMB was from formula feed, 28.66 billion RMB from feed additives, 6.96 billion RMB from animal-derived feed, and 8.88 billion RMB from feed machines and equipment.[46] For the past 10 years, domestic feed demand has been rising by about eight percent each year, making China home to one of the largest feed industries in the world, and poised to pass the U.S. as global leader in the coming decade.

Since its inception, the ownership and management structure of the feed industry has changed dramatically. During the first two decades after reform, government agencies such as the Ministry of Agriculture (MOA) and the Ministry of Finance and Commerce (MOFCOM) managed most feed mills. Farmers cooperatively owned some mills through arrangements called township and village enterprises (TVEs), generally under MOA supervision. At the same time, private ownership increased, and central authorities also started to encourage foreign firms to invest in joint venture mills. Before the turn of the century, private and public/private operations accounted for 30 percent of all mills, and foreign investment in 66 joint ventures totaled over $200 million USD.[47]

Currently, private enterprise, both of the domestic and transnational agribusiness variety, defines much of the sector. This is particularly true in soybean crushing. One analyst estimates that 69 percent of the active soybean crushers in China are privately owned.[48] Of the 31 percent state-owned share, several operations also have foreign and domestic private investors.

A. Soybeans

Soybean, a plant that was domesticated in China 5,000 years ago, is the current feed industry star. Similar to pigs, the millennial-scale cultivation of soy has produced around 6,000 domestic varieties and a rich associated knowledge about soy production, processing, and uses. But whereas China continues to be largely self-sufficient in pork as an end-product food category, centuries of soy self-sufficiency came to an end in the mid-1990s, with soy import dependency following in subsequent years. After being a leading soy-exporting country for decades, China became a net importer in 1996, and by 2003, had taken over as the world's largest importer of soybeans. In 2009 and again in 2010, China's imports accounted for more than half of the total global soy market.[49]

Given that soybeans are touted as the ultimate source of protein in modern feed mixes for shorter-cycle, leaner pork production, these developments might seem natural or expected. Surely, most all of the rapid growth in soy imports is in response to increased domestic demand to feed the ever-growing national swineherd, but the shift to imported soy and the associated changes in China's feed industry are not because of the so-called invisible hand of the market. Rather, they are the direct result of a set of policies, agreements and conflicts—some quite visible, and others less obvious—involving a diverse set of Chinese and international actors. For its part, the Chinese central government has enacted measures aimed at ensuring China's food security on a limited amount of land, supporting increased consumption of cheap pork, liberalizing the soy sector, and anticipating and abiding by WTO regulations. From the perspective of soybean-exporting countries and transnational agribusiness firms (and the institutions that regulate international trade), China was, and remains, a key site for investment and profit and a central component of future development plans. With soybeans, what is at stake is nothing less than control of the flow of soybeans into the country and throughout the food system.

1. Liberalizing and industrializing soy

To increase meat consumption for 1.3 billion people on only 120 million hectares of arable land, something's got to give. For China's central authorities, a key "something" has been soybeans. Recognizing that domestic soy output would not be able to keep up with the massive growth planned for the livestock industry, the government moved to liberalize the soy sector starting in the 1990s, allowing imports to overtake both exports and domestic production. Officials used a number of methods to open this market.

Central authorities implemented the Value Added Tax (VAT) system in 1993 to encourage production and export of certain products,[50] and as a key source of state revenue. For food and agricultural goods, the VAT rate is generally 13 percent.[51] In 1995, to spur the livestock industry and to get around limitations in domestic soybean crushing, the government lifted the VAT on soybean meal. As a result, meal imports surged to 3.6 million tons in 1996–1997, making China the world's largest soybean meal importer that year, and then to 4.2 million tons in 1997-1998. This increase in supply depressed domestic soy prices, reduced domestic crushing margins and discouraged producers from planting soybeans during those years. As domestic crush fell, so too did soy oil production, since soybean meal and soy oil are co-products in the crushing process. Several sources report edible oil smuggling in the country as a result of the shortfall.

In an attempt to correct these imbalances, the central government reimposed the 13-percent VAT on all imported soybean meal in 1999, a move that favored the import of unprocessed soybeans instead. Consequently, soybean meal imports dropped from 4.2 million tons in 1997–1998 to 0.1 million tons in 2000–2001, while soybean imports soared from 3.8 million tons in 1998–1999 to 10.1 million tons in 1999–2000.[52] Domestic soybean meal prices rose, crushing margins improved, employment increased and edible oil smuggling stopped. To this day, China's soy import strategy is focused on whole, unprocessed soybeans, not soybean meal.

WTO and bilateral trade agreements were also important drivers of soy sector liberalization. In 1996, the government reduced the import tariff on soybeans from 40 percent to 3 percent in anticipation of accession to the WTO in 2001. The tariff rate on soybean meal was set at 5 percent, while soy oil was 9 percent.[53] In 1999, China and the U.S. became closer trade partners when the two countries signed a bilateral trade agreement that contained a tariff-rate quota for soy oil (that would later turn into a bound 9-percent tariff rate), but excluded soybeans and soybean meal.[54] In 2003, Brazil came on the scene when China accepted the country's soy export application.[55] These agreements defined the terms of trade and China's major trading partners for the next several years.

Changes in how soybeans and soybean meal are defined and regulated were also key policy maneuvers with important consequences for trade and domestic production. In 2002, in order to raise domestic soybean meal prices after supplies exceeded demand, central authorities defined soybean meal as an industrial, rather than agricultural, product. This language changed the tax structure of soybean meal, giving it a 13 percent export tariff refund to encourage exports and to relieve excess supply on the domestic market.[56] Redefining soy in this way was related to the government's more general reclassification of it as a "non-strategic" crop for food security. Upon accession to the WTO in 2001, China's overall strategy was to focus food security policy on maintaining strategic reserves of rice, corn and wheat—crops considered important for direct human consumption—while liberalizing the markets for other non-staple crops in order to honor accession protocols and commitments. At that time, authorities liberalized soybeans from strict state control, and removed so-called trade-distorting mechanisms.[57] According to experts within China, the main reason that soy was "cut loose" was to ensure adequate supplies of feed for industrial pork production.

As a result of this sectoral restructuring, soybean imports have been soaring since the late 1990s at an average annual growth rate of about 26 percent. From 2009–2010, China imported just over 50 million tons of soybeans, representing 58 percent of all soybean imports worldwide.[58] Imported soy is crushed domestically to produce livestock feed (soybean meal) and soy oil. Between 2000 and 2007, soy crushing in China increased 72 percent, from 19.77 million tons to 34

China: Soy Figures 2009–2010[54]	
Soybean imports	50.34 million tons
Soybean production	14.7 million tons
Soybean meal production	39 million tons
Soybean oil production	8.7 million tons
Soy imports as % of total soy consumption	73%
GM soy imports as % of total imports	90%
Soybean import tariff rate	3%
Value of imported soybeans as a percentage of the value of all imported agricultural products	35.8%
Imported volume of soybeans compared to imported volume of all grains/other oilseeds combined	13.5 times
Value of imported soybeans compared to the total value of all imported grains/oilseeds	20.8 times

million tons, at an 8.1 percent average annual increase.[59] In 2009–2010, China produced more than 38 million tons of soybean meal, and in 2010–2011, is expected to produce 42 million tons. As for soy oil, production in 2009–2010 was more than 8 million tons, and more than 10 million tons are expected in 2010–2011.[60]

These figures make China the world leader in both soybean meal and oil production, but it is important to remember that this output comes overwhelmingly from imported beans. In 2009, 73 percent of the soybeans consumed in China were imported.[61] The United States and South America (Brazil and Argentina[62]) are seasonal complimentary soybean suppliers for China. Because of the "opposite" growing seasons in these two global locations, South America soy imports dominate from June to October and United States imports from November to May.[63] This system means that U.S. beans are in direct competition with Chinese domestic beans because they share the same growing season.

2. Soybean wars and foreign crusher dominance

The dominance of foreign firms in the Chinese soybean industry is one the most contentious issues in China soy policy and production circles. The situation is reported in the Chinese media as "Soybean Wars," "Battle of the Beans," and "Foreign Companies Eat Up Our Country's Soybean Industry," suggesting the conflict between transnational agribusiness firms and domestic crushers and producers. While foreign enterprises started to enter the Chinese feed industry in the 1980s through joint ventures with domestic mills, it was only after the soy crusher defaults in 2004 that these companies were able to take control of 80 percent of Chinese soy crushing, ushering in a new era of foreign domination.

After the 13 percent VAT on soybean meal was reimposed in 1999, there was an unprecedented crushing boom in China to accompany the surge of whole soybean imports. Investment in the sector soared and crush capacity expanded beyond production. At the same time, toward the end of 2003, China and the U.S. were on the brink of a trade war because of the U.S.'s growing trade deficit. Chinese Prime Minister, Wen Jiabao, made a trip to the U.S. and promised to send delegates the next year to purchase agricultural products, primarily "non-strategic" soy and cotton. The monthly average soybean future price on the Chicago Board of Trade (CBOT) at the time of Prime Minister Wen's visit was $7.70 USD per bushel. In March and April of 2004, when Chinese buyers arrived in the U.S. to make the bulk of soy purchases as per the previous agreement, the price of soybeans had skyrocketed to $9.82 and $9.89 USD per bushel respectively. Average April prices in 2003 and 2005 were $6.04 and $6.23 USD per bushel respectively, so the almost $10 USD per bushel price was an anomaly.[65]

When deliveries and payments came due from the Chinese buyers in June, July and August of 2004, the price of soybeans had tanked to $5.93 USD per bushel. Rather than incur losses from the radically different per-bushel price at the time of purchase and the time of delivery, many Chinese importers defaulted on their contracts. Angry traders took the case to arbitration at GAFTA (Grain and Feed Trade Association) in London. Because price fluctuations are perfectly legal under the international pricing system based on CBOT futures, but defaulting on trade contracts is not, the final ruling was against the Chinese crushers. They were required to fulfill their contracts and pay for soy shipments at the abnormally high March and April prices. A Chinese Academy of Science study estimated that Chinese crushers overpaid for this soy by a margin of at least $1.5 billion USD.[66]

The immediate result was that many Chinese crushers were forced into bankruptcy and had no choice but to sell to foreign firms. Predictably, the firms that made the most market headway after the crusher defaults were already leaders in the global soy trade.[67] ADM, Bunge, Cargill and Louis Dreyfus (together, ABCD) bought over 70 percent of the shut-down Chinese crushers, and Singapore-based Wilmar also increased its market share at that time.[68] It is important to note, however, that New Hope Group, a private domestic firm with annual feed production capacity of over 20 million metric tons,[69] is the largest feed producer in the country.

Official statistics on the number and type of feed enterprises in China also illustrate the continuing and growing prominence and concentration of foreign firm ownership. According to Ministry of Agriculture figures, there were 13,612 feed enterprises in 2008. This was 11.5 percent lower (1,764 fewer operations) than in 2007, and recorded the third consecutive year of diminishing numbers. The only enterprise categories that saw an increase in the number of operations were foreign-funded and joint-stock enterprises. All other categories declined.[70]

Livestock feed is the main driver in the soybean crushing industry but soy oil is also becoming increasingly important. Before industrialization of pig and feed production, small-scale farmers cooked their meals with fat from the pigs they slaughtered in the spring, or pressed a small amount of cooking oil from crops produced locally. Today, edible oils have also been largely commercialized, and soy oil is now the leading cooking oil in China, accounting for 40 percent of national use.[71] While there is regional variation in household edible oil consumption, with rapeseed, palm and peanut oil dominating in some parts of the country, soy oil is gaining more and more of the market. According to a scholar at a leading Chinese agricultural university, virtually all restaurants in China today—from street vendors to upscale eateries—use soy oil for cooking.[72] It has completely taken over the restaurant sector.

Foreign firms have an important presence in soy oil production, with several operating under their own brands within China. Jinlongyu (金龙鱼) has 30–40 percent of the total market for all edible oils in China, and is an important soy oil brand. Its parent company, Arwana, is owned by Kerry Oils and Grains, which was just purchased by Singapore-based Wilmar. Bunge started the Douweijia (豆维家) brand of soy oil in Nanjing in 2007. ADM and Wilmar have a joint venture in the Jinhai brand (金海) of products, including the Sania (莎妮雅) soy oil brand. Through a joint venture with China National Cereals, Oils and Foodstuffs Corporation (COFCO), ADM and Wilmar also own five companies of crushers and refiners. On its website, ADM notes that, "A key part of ADM's Asia strategy today is our strategic ownership interest in Wilmar International Limited."[73] Cargill and Dreyfuss don not presently have their own retail soy brands, but instead sell unrefined oil to local refiners or to ADM enterprises.

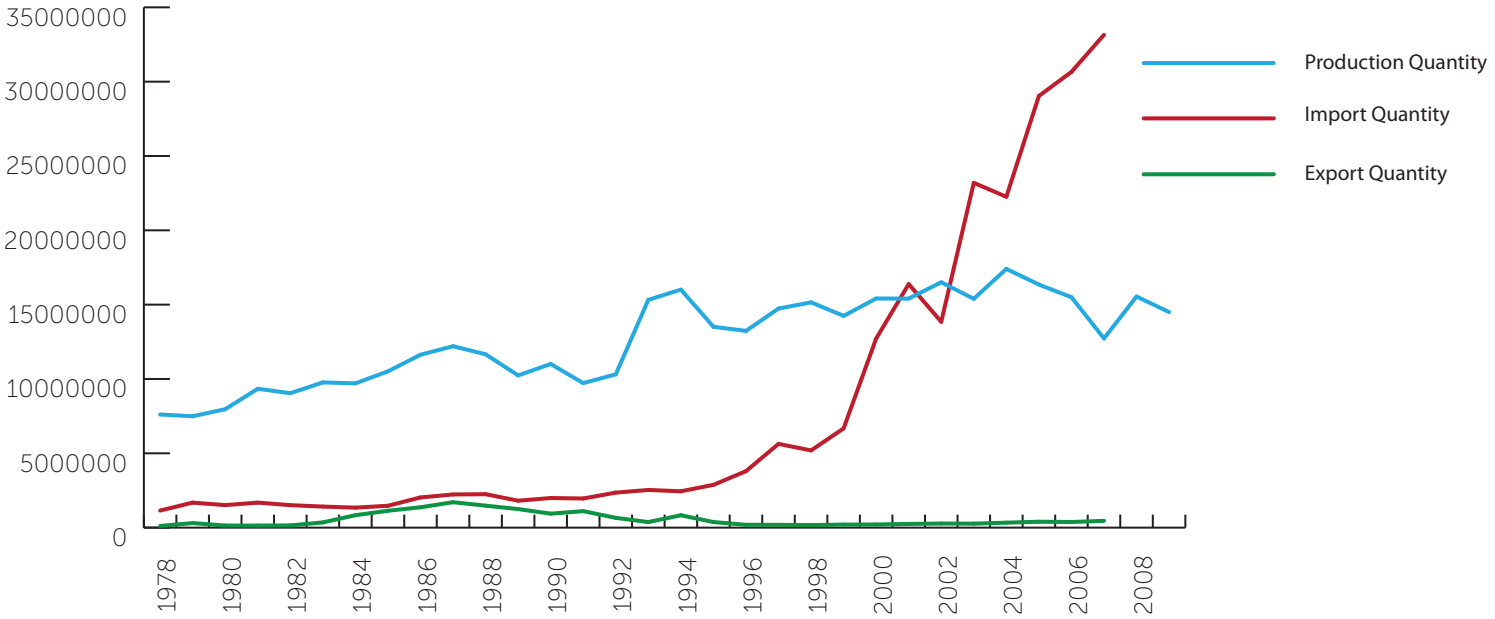
As a result of the crusher defaults in 2004, on top of crusher buyouts, half of all domestic soy oil refineries were forced to close. Transnational agribusiness corporations now control 80 percent of soybean crushing, and control 60 percent of China's soy oil refining.[74] This means that the same firms that control soybean exports to China from production centers in the U.S. and South America are also the major importers that control the flow of soy through the Chinese food system.

3. Protecting domestic soy

Changes in the feed industry, including ever-increasing soybean imports and the dominance of foreign firms, have had definitive impacts not only on domestic soy crushing and oil refining, but also on domestic soy production and farmers. In 2009, Chinese farmers produced 16 million tons of soybeans on 9 million hectares, or 7.5 percent of the country's total arable land.[75] Liberalization of the sector has meant that surging soy imports have dramatically outpaced domestic production, and more and more farmers are opting out of planting soy (Figure 3).

Soy experts in China estimate that there are 25 million smallholder soy farmers in the country today.[76] So while large-scale soy production is increasing—with groups like Beidahuang,[77] a state-owned conglomerate working to scale-up and mechanize production to increase per-acre productivity—smallholders play a vital role in the soy sector, acting

Figure 3. China Soybean Production, Imports, and Exports: 1978-2009 (tonnes)



Source: FAOSTAT

both individually and through cooperatives. The real story behind domestic soy production, therefore, is the story of the struggles of smallholders whose livelihoods are endangered by changes in the soy industry and in soy pricing.

There are several reasons why farmers move out of soy production in China. One important factor is that the market price of imported soybeans is cheaper than that of domestic soy. A complex mix of commodity programs, agricultural policies, and pricing schemes in the United States and South America keeps the market price of soybeans (and other agricultural commodities) below the cost of production. This is a well-documented phenomenon that has led to unfair competition and dumping on world markets for decades.[78] When domestic farmers are undercut by cheap imports, one immediate result is that those farmers can no longer make a living from their crops, and are often forced out. On top of this, the foreign firms that control 80 percent of crushing and 60 percent of refining in China have the ability to import soybeans from their own production centers around the world at a price much cheaper than what domestic soybeans can sell for. In 2010, imported soybeans in China were 300 to 600 RMB cheaper per ton than domestic beans.[79] This situation means that not only are domestic soy prices depressed, but that both foreign-owned and domestic crushers are buying more imported beans in order to increase profits, or in some cases, to stay in business. Tian Renli, the president of Heilongjiang Jiusan Oil and Fats Company said, "It's not that the processors don't want to use domestic soybeans, but we can't at current prices."[80] Domestic crushers can buy soy from local farmer co-ops, but increasingly they are getting soy supplies from the same foreign firms that control the vast majority of the processing sector.

The GM issue, which is highly controversial in China, further complicates soybean pricing. Currently, the central government prohibits commercial planting of GM food crops, but unlike most other countries with similar bans, allows imports.[81] In 2009, 90 percent of soy imports were GM.[82] Given that 73 percent of the soy consumed in China in 2009 was imported, and that 90 percent of imports were GM, that means that 81 percent of all soy was GM. Clearly, this is a challenging market situation for domestic producers who grow non-GM soy that should fetch a premium price, but instead creates a barrier for them when they are faced with buyers who want (or need) the cheapest beans possible. There is little incentive for crushers to buy domestic non-GM soy because, on the other side of processing, the price of GM and non-GM soybean meal and soy oil is largely the same.

Farmers are having a hard time breaking even from planting soy, and for smallholders in particular, who have an average annual income of about $690 USD (4,616 RMB), the implications are especially serious. Experts estimate that 30 percent of soybean farmers have already left their homes and families to become migrant workers in China's coastal cities. Liberalization of the soy sector, including the mass influx of cheap soy imports and domination by foreign processors, is linked to urban migration in complex ways (Read more in the final section).

The mix of low soy prices for domestic farmers, cheap GM soy imports, foreign domination of soy crushing and oil processing, and the exodus of soy farmers to labor in the cities has led to a domestic sector in trouble. In response, central authorities have taken measures to protect the soy industry, and experts have advised on alternative markets and strategies. 2008 was a particularly active year for soy regulation. On August 22, China's National Development and Reform Commission (NDRC) issued a directive on the future direction of the domestic soy sector. Some of the key provisions included policies to further concentrate soy production and processing in the Northeast and in Inner Mongolia, to scale-up and further industrialize the sector, to develop and improve the domestic soybean futures market, to establish a soybean reserve system for commercial circulation, and to develop soy industry standards. The aim of these measures was to support domestic production and maintain a consistent supply of soy.

Also in 2008, the central government imposed new restrictions on foreign investment in soy processing to limit the expansion of foreign control, and to try to level the playing field for domestic firms. By these provisions, foreign firms are not allowed to expand existing operations, invest in new operations, or have a controlling share (more than 50 percent) in new joint ventures.

To help alleviate downward price pressure on farmers in 2008, the central government started buying domestic soy at a minimum purchase price. At that time, international futures markets fell because of the financial crisis, initiating a flood of even cheaper soy into China.[83] The state minimum purchase and storage price for 2008–2009 was 3.7 RMB per kg, and 3.74 RMB per kg for 2009–2010.[84] Between October 2008 and June 2009, the China Grain Reserve Corporation (CGRC) bought 7.25 million tons of soybeans in Northeast China at 3.7 RMB per kilogram.[85]

Over the past two years, protective purchasing has helped to swell the state reserves in Heilongjiang Province and domestic crushers are now negotiating on the purchase of soy from these stockpiles. The degree to which the minimum pricing scheme has helped smallholders and domestic processors, however, is unclear. Many farmers couldn't afford to transport their beans to state warehouses to collect the higher payments. Additionally, the state reserve only bought the highest quality soybeans, and even at that, couldn't buy

the total domestic harvest. Price alone, therefore, wasn't enough to save all of China's soy farmers. Some domestic processors didn't fare much better. The increased domestic soy price meant that processors' profit margins shrunk.[86] Even after the government provided rebates to processors for buying domestic beans, they were still losing money. Further, protective purchasing in 2008 has been linked to another wave of processing plant closures in Heilongjiang that year, further challenging the ability of domestic producers, especially smallholders, to sell their soy.

The Chinese Soybean Industry Association (CSIA) has proposed alternatives for the soy sector. Along with other experts, the CSIA urges that China should develop new markets for domestic soy so that it doesn't compete directly with cheap GM imports. There are two main proposals on the table. One is to use domestic soy exclusively in the manufacture of foodstuffs such as tofu, soymilk and vegetarian products to be marketed within China. This proposal could also include marketing sustainable soy products to link producers to the growing domestic market for sustainable food products. Presently, there are a handful of Chinese firms using this model. The other proposal is to (re-) develop the export market for non-GM soy to Japan, South Korea and European countries. This would involve improving soy varieties and quality to internationally accepted standards, and implementing local monitoring and certification schemes. Both of these proposals aim at separating the markets for domestic and imported soybeans to benefit Chinese producers and processors. There are similar proposals for labeling and promoting non-GM soy oil.

B. Corn

Soy has a competitor in China's feed industry, and its name is corn. While soy is a native crop, corn was introduced from the Americas only during the Ming Dynasty, sometime in the early to mid 16th century.[87] Corn and soybeans today are prime competitors for land and trade, and increasingly, as components in livestock feed. Considering productive area, both crops are grown primarily in the Northeast—the soy base is Heilongjiang Province, while Jilin Province is the main corn region. If farmers opt out of soy production, they often plant corn instead (and vice versa in some cases). Throughout the 20th century, corn has been more widely planted than soy (Figure 4), but in some places in the Northeast, officials encourage farmers to rotate the two crops. This is the dominant practice in the USA, but is not widely used in China.

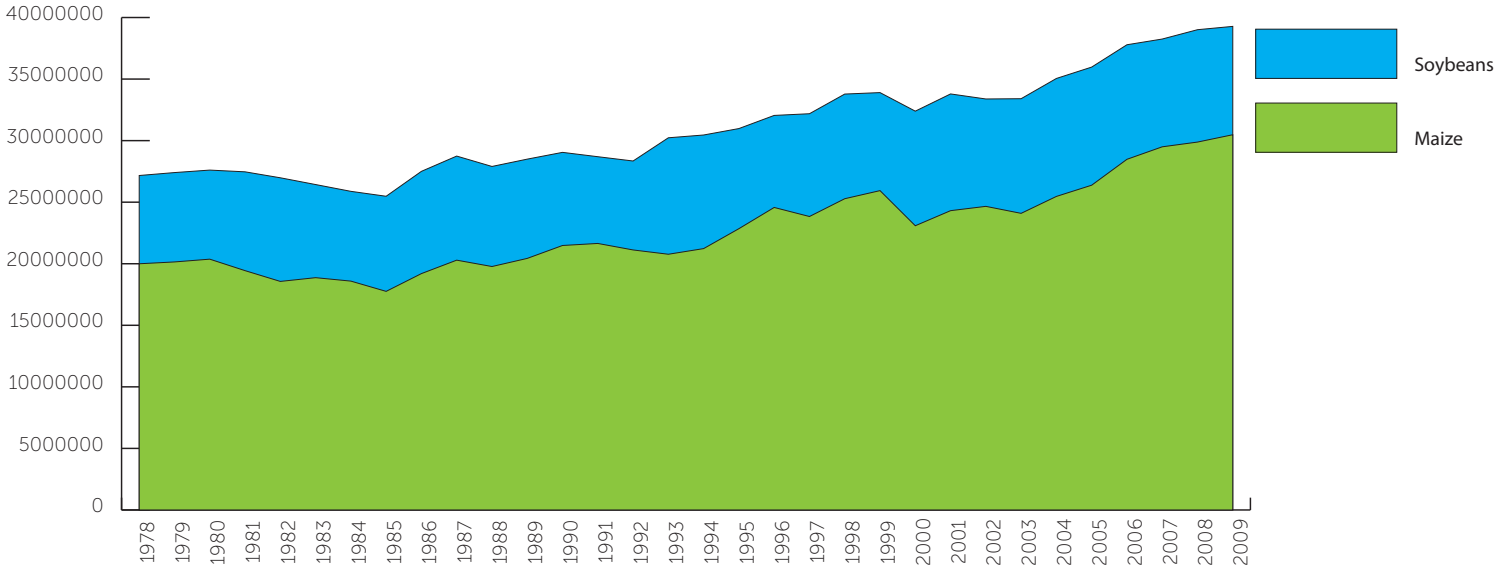
In the early 2000s, corn and soy roughly offset each other in terms of value, largely because of massive soy imports coupled with the need for heavy subsidies for corn production and export. The central government, in other words, has devoted huge amounts of money to these two crops.

1. Regulating and industrializing corn

Unlike soy, corn is considered a strategic crop for food security, and so is more tightly regulated by the central government. China is a world leader in corn production, and is historically a regular net exporter with negligible imports. In the past ten years, however, the situation in the corn sector has started to change dramatically.

The structure of state support for corn production changed in 2001 when China joined the WTO. In order to fulfill commitments, China was required to eliminate export subsidies on

Figure 4. China Harvested Area of Maize and Soybeans: 1978-2009 (hectares)



Source: FAOSTAT

corn and open a 5.85 million ton quota for corn imports at a one-percent tariff rate.[88] These measures were expected to significantly decrease China's corn exports and increase imports, but much to the surprise of analysts and traders, China's corn exports in 2002—the year after WTO accession—were the highest in the country's history. Corn imports in 2002 were also insignificant, meaning that in its first year as a WTO member, China remained, and even increased, its global position as a net corn exporter. In 2003, corn exports were even higher, supported not by the WTO-forbidden direct export subsidies, but by a package of measures aimed at boosting corn sales to promote the livestock industry and domestic meat consumption. These measures included subsidies for corn sales from state grain reserves, railroad tax and grain shipment waivers, subsidies for port fees, and a VAT rebate for exported corn.

The above policies were so successful in promoting production that throughout the early 2000s, corn supply in China persistently exceeded demand, exports boomed and corn prices rose steadily throughout the first years of the new millennium. In 2007, central authorities began to encourage and support industrial corn processing as a way to deal with excess supply. In the 2007-08 market year, about one fourth of the country's total corn use was in industrial products such as corn starches, sweeteners, alcohols, amino acids and citric acid. China also began exporting these products, changing its corn export profile from trading mostly in unprocessed corn, to exporting mainly industrial products. Industrial corn exports are now three times as high as unprocessed corn exports.[89]

2. From leading corn exporter to net corn importer

Perhaps the most profound change in the corn sector over the last decade is the 1.3 million tons of corn that China imported from the United States in 2010. While this amount is small relative to China's total corn production (158 million tons in 2009–2010, and expected 168 million tons in 2010–2011), it accounted for 1.4 percent of the total global corn trade.[90] This was the first time since 1994–1995 that China was a net corn importer. At that time, central authorities cut off exports of corn and other grains because of widespread concerns about grain shortages and inflation.[91]

The reasons for 2010's amped up imports are related to high domestic corn prices, though among analysts and officials there is disagreement about what drove prices up in the first place. Government officials at the National Grain and Oils Information Center urge that rising corn prices were not the result of falling domestic supplies or reserves, but that market speculation was to blame.[92] Central authorities seem to be arguing that once they crack down on illegal activities that force prices up (i.e., hoarding), China will return to being a net exporter, and corn self-sufficiency will be preserved.[93] They insist that the country will not continue to import significant amounts of corn in the future, despite the USDA's prediction that 2011 imports will top 1 million tons.

Analysts at the United States Grains Council (USGC) agree that market speculation played a role in increasing corn prices, but argue that drought in 2009 coupled with cool and wet conditions at spring planting in 2010 also contribute significantly to the high price situation, as did increased processing demand for the livestock industry.[94] These analysts, along with global grain traders, predict that China will continue to import corn, mostly for feed, and will remain a net importer into the foreseeable future.[95] Hanver Li, the Chairman of Shanghai JC Intelligence Co, a Sino-U.S. joint venture agro-commodities investment advisor, went so far as to say that, "A new era of China importing corn is here," calling the present moment a "turning point" at which China will become a regular corn buyer. Li and other experts predict that China's annual corn purchases will reach 15 million tons by 2015.[96] Traders are also anxious for China to continue purchasing corn to help recover low international prices, and trade groups like the USGC are excited by the market opportunities. Thomas Dorr, USGC president, said, "There is evidence that [China's] demand for high-quality proteins is going to require added energy for livestock rations and we believe it's an excellent opportunity for the U.S. to provide those corn supplies as needed."[97]

As for the mechanics of the 2010 corn imports, COFCO was the top buyer, and the New Hope Group was number two. COFCO didn't release plans for how it would use the imported corn, but the New Hope Group stated publically that it would use purchased corn in the manufacture of pig feed.[98] Some imports will likely go to restore state stockpiles that were drained through auction to cool local prices earlier in 2010. From April 13 to May 25, the state sold 4.67 million tons of reserve corn, mostly to traders in the Northeast who quickly shipped it to Guangdong Province for livestock feed processing.[99] After six rounds of sales, corn futures on the Dalian Commodity Exchange rose to 1,984 RMB ($302 USD) per ton on May 24, a two-year high. By opening the door to corn imports, the central government used the international market to stabilize the domestic market.

Aside from worries in Beijing that China will no longer be self-sufficient in grain, there are several other concerns associated with the possibility that China's corn imports might continue into the long run. First, in terms of global food supplies, if China becomes a major importer, there are fears that price fluctuations in global markets will become increasingly dramatic, as the world relies on an even narrower set of countries to supply corn. Jay O'Neil, an agricultural economist at Kansas State University in the United States, said, "This

means there are fewer countries supplying the needs of a growing world and the potential for crop production shortfalls is a greater risk to everyone."[100]

There are also important climate and environmental concerns, particularly in terms of the deepening relations between pig production in China and soybean and grain production in South America. Tom Philpott argues that increased corn demand from China can only result in more land being cleared in South America for large corn plantations.[101] Already, deforestation has claimed 528,000 square kilometers of the Brazilian Amazon as cattle grazing and large-scale soybean fields have taken over. Soy production in Brazil quadrupled between 1995 and 2009, and almost half of all exports went to China for the feed industry.[102] At the same time, almost half (1 million square kilometers) of Brazil's Cerrado, the most biologically diverse savannah in the world, has been burned for use as cattle pasture, sugarcane fields for ethanol production, and large-scale soybean and corn cultivation, primarily for export and the manufacture of livestock feed.[103]

This conversion of mass tracts of land to intensive monocrop agriculture has threatened the livelihoods of many smallholder Brazilian farmers who are forced to move. At the same time, both the processes and long-term impacts of removing forest and burning grasslands contribute to climate change, as CO2 stores are released and sinks are lost. On top of that, transporting massive amounts of feed around the globe, from Brazil to China for instance, further strains fuel demand and contributes even more GHG emissions. If South American countries pursue monocrop corn plantations that mirror the way soy has been developed there, these impacts will be even more serious.

Inside China, there are concerns around the GM issue, given that 60 percent of the corn imported in 2010 was genetically modified.[104] That said, in 2009 China's central government approved the first strain of homegrown GM corn to be grown for research purposes only.[105] It also approved 11 varieties of GM corn for import. While the official stance on GM crops may be changing and perhaps moving toward acceptance, even if the general public continues to have reservations.

Finally, if corn goes the way of soy in China, and imports become a regular occurrence, what are the costs to China's small-scale producers? How will their livelihoods be affected? What will they grow if they can't compete with low market prices for either corn or soybeans? Similarly, how do these changes in the structure of the corn industry affect food security, given that 64 percent of corn is being used as livestock feed, 25 percent for industrial uses and only 11 percent as edible grain?[106] Because corn is now primarily used for livestock feed, the central government is considering a revision to current trade policy, such that corn would no longer be regulated in the same way as grains intended exclusively for human consumption.[107]

The focus on developing a domestic corn processing industry, allowing GM imports, and the possibility that the central government will reclassify corn as a "non-strategic" crop, makes this sector sound quite similar to the soy sector. A feed mill executive in Guangdong Province said, "We think corn will follow soy, and imports will become a normal practice whenever there is need."[108] COFCO officials maintain that corn imports will always be a supplement to domestic production, and that the central government is committed to regulating this sector. Corn planting is expected to increase in 2011 to help decrease imports, but international industry and trade groups are focused on creating more regular corn trade with China in the future. The battle, so to speak, seems poised to rage on.

Feeding China's pigs: Challenges and issues

The feed industry in China can be classified as operating through a combination of local and transnational agribusiness firms that use mostly domestically produced grains and mainly imported oilseeds (soybeans), together with additives manufactured in China and abroad, to produce feed for the rapidly industrializing livestock sector. There are other commercial feed crops and ingredients, but today soybeans and corn account for the lion's share. The vast majority of pigs raised each year in China are eating commercial feed at some point in the production cycle, and as the scale of pig production continues to increase, so too will the scale and extent of the feed industry. Trends in industrial pig feeding seem to inevitably point to additional soybean and corn imports in the future, further narrowing the range of feedstuffs used to produce pork.

Central policies and subsidies, and so-called market signals for increased (lean) meat demand, have been used to define the slower growth cycle and fattier pork output from smallholders as "backwards." It is highly unlikely, therefore, that "traditional" feeding, which happens to be a highly environmentally sustainable and near carbon-neutral activity, will be promoted or supported as part of China's agricultural development model. Instead, industrial feeding will continue to be relentlessly promoted as the most modern, efficient, and safe method for further increasing pork production and consumption in China. This will have serious implications for the environment, for Chinese diets and public health, for smallholders and for food security.

A. Environmental challenges and issues

The Food and Agriculture Organization (FAO) stated in 2006 that, "The livestock sector emerges as one of the two or three most significant contributors to the most serious environmental problems, at every scale from local to global."[109] To put this statement more bluntly, it is the livestock industry, including intensive animal feeding and feedstuff production, that is the overwhelming cause of these problems. Issues such as water pollution, greenhouse gas emissions, reduced genetic and species diversity, and the emergence of antibiotic-resistant disease-causing organisms are increasing both in scale and global relevance. In China, the rush to increase meat consumption is implicated in these and a number of other environmental problems. The effects have both domestic and global reach.

1. Water and soil pollution

In February of 2010, the Chinese government released results of the first national pollution census[110] (全国污染源普查). The most startling finding of this nearly three-year, 737 million RMB ($110 million USD) investigation was that agriculture today is a bigger source of water pollution in China than industry. Researchers found that farming was responsible for 44 percent of chemical oxygen demand (COD—the main measure of organic compounds in water), 67 percent of phosphorus discharges, and 57 percent of nitrogen discharges into bodies of water. The Ministry of Agriculture immediately recognized that these findings were the direct result of the shift to intensive farming methods over the past 30 years. The Ministry's Wang Yangliang said:

> Fertilizers and pesticides have played an important role in enhancing productivity but in certain areas improper use has had a grave impact on the environment. The fast development of livestock breeding and aquaculture has produced a lot of food but they are also major sources of pollution in our lives.[111]

Fertilizer- and pesticide-containing runoff from crop fields (vegetables, grains, oilseeds, cotton, etc.) is an important source of this water pollution. Greenpeace estimates that China uses 35 percent of the world's fertilizer, and pesticide use is increasing every year. In 2006, Chinese farmers used 1.2 million tons of pesticide on approximately 300 million hectares of farmland and forest. In 2009, China was the world's largest pesticide producer. Output volume was 2.23 million tons, export volume was 0.51 million tons and leftover pesticide demand was 400,000 tons.[112] As a result of increased fertilizer and pesticide application, at least seven percent of arable land is polluted from improper use, in addition to significantly increased water pollution levels throughout the country.[113]

Manure is an even more important source of pollution. Experts warn that the massive increase of animal waste from the livestock industry is the main source of water pollution in China today. According to Ministry of Agriculture statistics, in 2000, China's livestock produced 3.8 billion tons of manure, and by 2008, the figure was 4.8 billion tons.[114] The sheer volume of manure shifts it from being a valuable resource, to a waste-management problem with severe ecological consequences. Such massive amounts of manure contribute to nutrient overload on land and in waterways. This is particularly evident in the rapidly increasing incidence of blue-green algae outbreaks in China's lakes and streams. Eutrophication results when intensive livestock farms, which generally lack effective water treatment methods to deal with the rivers of manure coming out of them, deposit excessive amounts of phosphorus and nitrogen in nearby bodies of water.[115] The problem is exacerbated when inland water flows to coastal areas. As a direct result of runoff containing excess nutrients from fertilizers and manure carried by the Changjiang (Yangtze) and Huanghe (Yellow) Rivers, a dead zone has developed in the East China Sea.[116] This has serious consequences for ecosystem functioning. Because the government has failed to institute regulations to strictly manage manure runoff from industrial operations, pig farms are not being forced to internalize the environmental costs of manure treatment.

2. Greenhouse gas emissions

Globally, the livestock industry contributes 18 percent of anthropogenic greenhouse gas (GHG) emissions.[117] There are three main GHGs that come from the livestock industry in significant amounts: carbon dioxide (CO_2), methane and nitrous oxide. Carbon dioxide is emitted at virtually every stage in the production and transportation of livestock products and feed, accounting for nine percent of all human-made CO_2 emissions globally. Methane, a gas that is 23 times more potent in the atmosphere than CO_2, is emitted from enteric fermentation (flatulence in ruminants) and from manure. The livestock industry is responsible for 37 percent of all human-made methane emissions globally. Manure also accounts for 65 percent of all global human-made emissions of nitrous oxide, which is 296 times more potent than CO_2.[118]

At the same time that China's livestock industry is growing, so too are the country's GHG emissions. China passed the U.S. in 2008 as the world's largest emitter, with current emissions that account for 17.3 percent of the global total.[119] This is a dramatic shift from the carbon-absorbing economy that defined China for thousands of years, before it began to industrialize its agricultural (and other) sectors.[120] The further increase in industrial livestock feeding will exacerbate the above GHG emissions figures and the problems associated with them, both inside China and internationally.[121] Already, erratic weather (linked to climate change) is wreaking havoc

Blue-green algae bloom in a waterway outside of a large-scale commercial pig farm in Sichuan Province.

on agricultural production and communities in China, as evidenced by severe drought in 2009 and 2010, followed by rampant flooding in 2010. Experts predict these patterns will continue, and intensify in the coming years.[122]

3. Genetic and species diversity

The focus on a narrow range of crops and livestock to meet dietary needs has led to a global reduction in genetic and species diversity. The cases of soybeans and pigs in China illustrate this trend. The more than 6,000 varieties of soybeans that Chinese farmers have developed over thousands of years account for 90 percent of all the soybean varieties in the world. Today, only a few varieties make up the core of the soybean industry; experts fear that if GM soy production is allowed in China, most wild types will be wiped out.[123] The conversion of mass tracts of land to monoculture crop production in the country's Northeast and elsewhere will further reduce overall agroecosystem species diversity.

Swine breeds have already been significantly reduced. The "modern industrial hog," prized for quickly converting feed into lean pork, has taken over. Presently, just three exotic breeds, namely Duroc, Landrace and Yorkshire (DLY) have replaced the more than 100 indigenous pig breeds in China. Farmers at all scales of swine production, from the backyard to the CAFO, raise these breeds either in pure or hybrid form. Indigenous breeds are now maintained on conservation farms and in the national gene bank, but very few (less than 5 percent of China's total swine production) are raised by farmers for pork.[124] Consequences of relying on a narrow range of intensively bred livestock breeds include the loss of genetic traits such as prolificacy or fertility, increased vulnerability to disease and extinction of local breeds. At the same time, reliance on industrial swine breeds, especially to the degree currently seen in China, is coupled with horizontal and vertical integration of ownership by a handful of agribusinesses.[125] PIC (the Pig Improvement Company) and Hendrix Genetics are already major players in providing breeding stock in China, as they are globally.

4. Antibiotic resistance

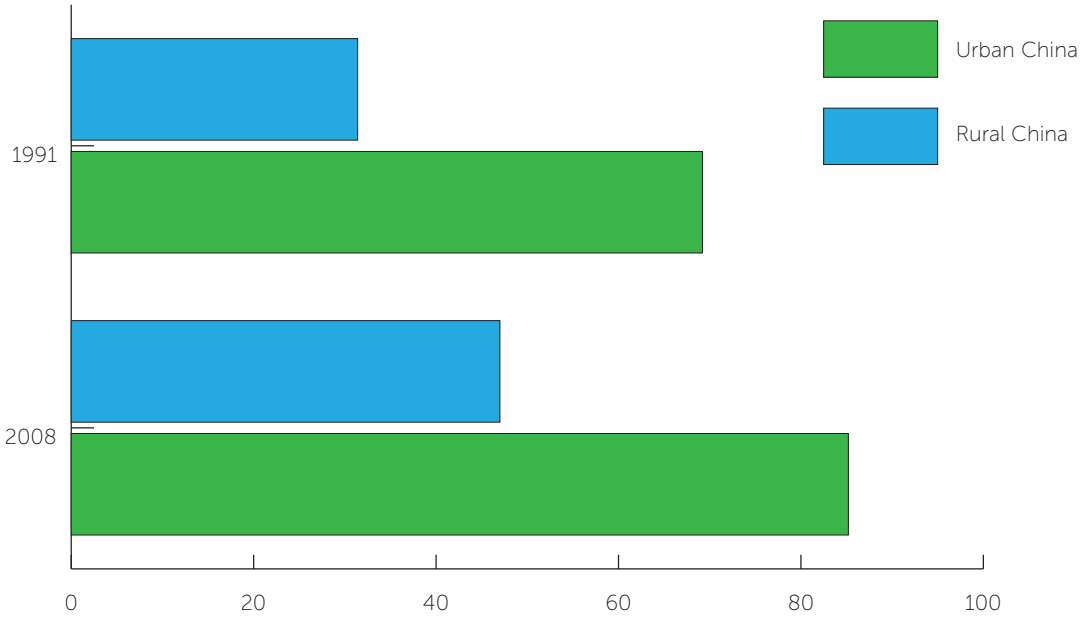
Industrial livestock feeding generally includes administering constant "subtherapeutic" doses of antibiotics throughout the production cycle. This is done to prophylactically prevent disease and to promote growth by making the conversion of feed to weight gain more efficient. As a result of such overuse, antibiotic-resistant strains of disease-causing organisms (mostly bacteria) have rapidly emerged, compromising the ability of medicines to treat disease in both humans and other animals.[126] This phenomenon is expected, and has serious public health implications:

> Through evolutionary adaptation, disease-causing organisms (e.g., E. coli) almost always develop resistance to substances that humans exploit to kill them. In other words, they acquire the ability to thwart the toxicity of medicines designed to control them. The widespread and routine use of antibiotic drugs accelerates this evolutionary process, to the point where the declining effectiveness of antibiotics is now considered a serious public health crisis, expressed in the rising incidence of drug-resistant infections.[127]

There are three primary ways that antibiotic-resistance is conferred in the livestock industry. Drugs fed to animals are excreted in manure, and are then carried into the environment via runoff from feeding operations. The antibiotics kill susceptible microorganisms in soil and water, leaving bacteria with rare resistance to the drugs to flourish. This same selection process can also take place in animals' digestive tracts, and when manure is applied to soil as fertilizer, resistant bacteria in the manure can transfer resistance to bacteria in the soil. Disease-causing organisms can also share genes that encode resistance to antibiotics. Similarly, gene sharing can occur across different species, for instance through fecal bacteria found in meat products.[128]

In the U.S. and Europe, antibiotic-resistant disease-causing organisms are found in meat and poultry products, including multidrug resistant E. coli and organisms resistant to broad-spectrum antibiotics such as penicillin, tetracycline and erythromycin.[129] These organisms were recently discovered in China as well. According to Zhu Yongguan at the Chinese Academy of Sciences, "In China and elsewhere, large amounts of antibiotics are used in the animal industry to promote growth."[130] Professor Zhu and his colleagues released a study in 2010 that showed soils contaminated with manure from livestock farms "are major reservoirs of antibiotic-resistance

Figure 5. Per Capita Meat, Poulty, Aquatic, and Animal Products Consumption, Rural and Urban China: 1991 and 2008 (kg/person/year)



Source: 2009 China Agricultural Development Report, Ministry of Agriculture, PRC

genes in the environment."[131] Researchers identified bacteria with tetracycline resistance in soil samples taken from feedlots near Beijing, Tianjin and Jiaxing. These findings will have implications for both animal and human health.

B. Health and dietary challenges and issues

The co-development of China's livestock and feed industries over the past 30 years has raised the level of meat output and consumption to record and world-leading levels. Meat consumption has quadrupled in China since 1980 to its current level of 54 kg (119 pounds) per person per year. Pork consumption alone has doubled in the past two decades, such that the average Chinese person now eats 39.6 kg of pork in a year, compared to 20 kg in 1990.[132] These profound production gains have meant that hundreds of millions of people are eating more protein today than perhaps at any other time in their lives, helping to reduce the prevalence of undernourishment in the Chinese population to 10 percent, or 130.4 million.[133] While these changes are certainly impressive, they have come with a host of new food system issues related to diets and public health. These problems warrant concerted policy attention.

1. Food safety

There are a number of food safety issues associated with industrial livestock feeding, and China has been in the spotlight over the past few years for several particularly severe offenses. While the highly publicized melamine scandals and animal feed recalls are most well known, there are a host of other food safety issues that haven't reached scandal proportions, but that are potential public health crises in the making. All are related to the endless pursuit of producing more meat in shorter periods of time—the "efficiency" upon which industrial agriculture is based.

Livestock feeders in China (and elsewhere) use growth hormones, antibiotics and growth promoters, such as copper sulfate and arsenicals, to speed up the conversion of feed to meat.[134] As a result, these substances end up in the environment via manure runoff and in the meat and animal products made from livestock. In 2010, reports linked growth hormone residues from livestock feeding found in milk formula, to babies in central China under 15 months old growing breasts.[135] Hormones are not yet regulated in the livestock industry in China. Heavy metal residues are frequently found in meat, coming from contaminated feed and water sources, and from metals used as growth promoters.[136] Add to these problems the pesticide and myotoxin residues from feed that end up in food products, and it becomes clear that food safety issues are endemic to today's livestock industry.

2. Dietary inequality and meat dreams

The processes of meat sector development and accompanying changes in diet have been uneven. The figure below shows per capita meat and animal products consumption in rural and urban China, comparing 1991 and 2008 levels. Despite across-the-board increases and some progress toward narrowing the gap, urban residents still eat almost twice as much meat and animal products as rural residents.

Dietary inqualities mirror other rural-urban disparities. In 2008, the average per capita urban income was 11,299 RMB ($1,688 USD), while the rural level was 4,761 RMB

($712 USD).[137] The urban-rural income ratio in 2010 is 3.33 to 1, growing from 2.56 to 1 in 1997.[138] Urban annual 2008 food expenditures (4,260 RMB, or $636 USD) were almost three times as high as in rural areas (1,599 RMB, or $239 USD), though rural residents spent a larger share of their income on food (43.7 percent of rural income, versus 37.9 percent of urban income).[139] There is also, of course, inequality within rural and urban areas. These data indicate that in terms of diet and income, inequalities are persistant and systemic.

Another form of dietary inequality is the recent emergence of so-called diseases of affluence in China. In the 1930s, 97 percent of calories in the average Chinese person's diet came from grains and vegetables, compared to 63 percent in 2002.[140] Today, a process that Tony Weis calls the "meatification" of diets is proceeding at a rapid pace.[141] Meat is moving from the periphery to the center of Chinese diets, with differences in degree across the population. At the same time, the fast food industry is booming, with global chains like KFC and McDonalds operating on what seems like every street corner in China's cities. Taken together, Chinese people are becoming increasingly vulnerable to a range of diet-related diseases, including Type 2 diabetes, coronary heart disease, obestity, and a range of cancers. A study in 2008 found that one in every four adults and nearly 20 percent of children under the age of seven in China were overweight. In 2005, China's central government reported that 70-90 million Chinese people were clinically obese, accounting for one-third of the global total.[142] T. Colin Campbell and Thomas M. Campbell outlined the relationship between these chronic illnesses and diets high in animal products in their 2005 book, *The China Study*, which focused on the health benefits of traditional, plant-based diets in China.

A Chinese man in Beijing who grew up during the times of meat rationing in the 1970s said "when I was as a young boy, my dream was to eat meat."[143] Clearly, many in China have realized this dream and moved well beyond the famines and rationing of the past to eat meat everyday, and sometimes at every meal. Others, especially in rural areas, still live in a world where meat is a luxury. Using the $1.25 USD per day poverty guideline, there were 150 million poor in China at the end of 2009.[144] According to Li Xiaoyun, Dean of the Center for Integrated Agricultural Development at the China Agricultural University, an additional 20 to 30 percent of the rural population (140 to 230 million people) are precariously close to slipping back below the poverty line because of sickness, natural disaster or economic recession.[145] This vulnerable population is predominantly smallholder farmers, miles away from affluence and its diet-related diseases, and who may still dream of having more meat to eat.

C. Smallholder challenges and issues

Smallholder farmers living in China's vast rural regions are most vulnerable as a group to livelihood and lifestyle transformation as a result of feed and livestock sector restructuring. In addition to challenges in market access and competition, they face other intense pressures related to broader-scale social change. The rural population is somewhere between 700 and 900 million, depending on how migrant workers are counted. The experiences of more than half of China's population, therefore, need to be carefully considered in constructing policies for agricultural development.

1. Market access and competition

Backyard pig farmers[146] and small-scale soybean farmers consistently struggle in the new market agro-economy. Pig farmers who want to sell their animals are at a severe disadvantage in terms of evolving meat quality standards that favor leaner pork, safety requirements based on international standards and the structure of state subsidy programs. First, the longer production cycle on backyard farms produces pork with a higher fat-to-lean ratio. While many Chinese people prefer the flavor of this meat, market standards within China are increasingly for leaner pork, making it difficult for small-scale farmers to enter into certain markets. Additionally, because they usually cannot pay for the testing or certification schemes that are currently used to verify hygiene standards (increasingly using the International Organization for Standardization (ISO) system), smallholders are excluded in terms of food safety. At the same time, backyard farmers are largely outside of the subsidy arena, as livestock subsidy programs are by and large aimed at industrializing the sector. [For a more complete look at smallholder disadvantages see, Li Jian, The Decline of Household Pig Farming in Rural Southwest China: Socioeconomic Obstacles and Policy Implications," Culture & Agriculture, Vol. 32, Issue 2, pp. 61-77e (2010).]

Small-scale soybean farmers have been losing money in recent years because they can't sell their beans at a break-even price. Cheap GM imports, a struggling domestic crushing industry and infrastructural challenges of getting their harvest to potential markets, combine to create an incredibly difficult situation. As futures markets and hedging become more prevalent in China, smallholders are further challenged by gaps in information delivery. There are currently four futures exchanges in China, with the Dalian Commodity Exchange managing trade in soybean, soybean meal, soybean oil, corn, palm oil and petrochemical futures contracts. Efforts at improving rural price information are underway to help fill these gaps, but there is currently no centralized system in place to communicate price issues to small farmers.

2. Social issues: Migrant labor, livelihoods and lifestyles

Smallholder issues can't be separated from the urbanization trend that is swelling the populations of China's cities. There are currently 240 million workers in China who constitute a "floating population"[147] that moves from the countryside to cities where they work as migrant laborers. Virtually all are classified as rural residents because they hold rural hukou in China's household registration system.[148] Even those who have been away working in a city for a decade or more are still considered rural residents, and so receive social benefits only in their rural homes. This means that they cannot take part in healthcare, education and social insurance benefits that urban residents enjoy in many cities. So while migrant worker wages flow back to rural families, other privileges do not.

This migration, the largest in human history, has created challenging social conditions in the countryside. Half of migrant workers were born in the 1980s, and most are male, though female migrants are also quite common. The result is that in rural areas, "Just like in wartime, women, children, and the elderly make up most of the population."[149] Those who stay behind and continue farming are referred to as the "773861 army," named for elderly residents (i.e., 77 years old), female (mostly married) residents ("38" is March 8, International Women's Day), and children ("61" is June 1 for International Children's Day). This army works the fields, raises the livestock and maintains smallholder farming systems while young family members labor sometimes thousands of miles away from home. Families in this way are split, and the work of agricultural production falls to those with the least amount of education, and perhaps those least adequately equipped to innovate in farming practice and marketing.[150] As agriculture becomes increasingly marketized, this is yet another hurdle for smallholders.

The processes of industrialization of agriculture on the one hand, and the migration of labor from rural to urban areas on the other, are both key components of the central government's current model of development. Experts predict that by 2030, central policies will effectively move hundreds of millions more people to China's cities, leaving only 400 million in rural areas. The 1.4 billion urban residents will need massive amounts of food, which large-scale, vertically integrated farms and companies will largely supply. This model is rigged against smallholders, for whom it becomes more and more difficult to maintain their livelihoods and lifestyles. The annual cost for a soybean farmer, for example, to keep one child in school is one-fifth of their annual income.[151] Migrant labor becomes a necessity for survival, urging more and more people toward the cities where they can earn wages that will support rural households.

Despite the drivers and incentives that are urging rural people to urban areas, not everyone wants to migrate. The Chongqing municipal government recently enacted a policy that allows farmers and other rural residents to become urban citizens by changing to an urban hukou. The program hasn't been as popular as officials expected, as many rural people are opting to remain in the countryside. The primary reason for this seems to be related to rural livelihoods and lifestyle. A rural resident outside of Chongqing told the Global Times, "I am familiar with the rural way of life and I could raise my family by working on my farm. If I become an urban resident, I would be stripped of the right to use my farmland within three years."[152] Rural subsidies, elimination of agricultural taxes, land policies, rising costs of living in urban areas, labor market restructuring, and preference for rural livelihoods and lifestyles are important reasons for people to stay in the countryside. Even in the context of mass urbanization and industrial agriculture, small-scale farming, it seems, will remain a vital part of China's food system well into the future.

V. Discussion: Food security and models of agricultural development

Food security is of the utmost importance to Chinese authorities. In making agricultural development policy, they must consider not only how to feed the country's 1.3 billion people on a limited landbase, but also how to reign in income and dietary inequalities and keep food prices low enough to avoid widespread discontent. In the post-reform period, authorities have been actively promoting large-scale industrial agriculture as the supply source for addressing food security. This model, however, falls short for addressing both land-efficiency needs and food and income inequalities.

China must feed 21 percent of the world's population using only nine percent of the world's arable land. Given these constraints, the argument goes that further industrializing agriculture is the only way to address food needs for a huge and growing population without bringing more land into production. Intensive feed and livestock production are part and parcel of this approach. Raising hundreds of thousands of pigs on imported soy in CAFOs appears on the surface to use much less land than so-called traditional forms of swine husbandry, which involve small farms spread out across the countryside. But industrial pig production is a land-intensive system in at least two ways. First, on the input side, producing one kilogram of industrial pork requires about 13 kilograms of feed.[153] To meet this need, China purchases tens of millions of tons of soybeans and corn from South America and the United States every year. CAFO production, therefore, can appear land-efficient only because livestock have been separated—sometimes by thousands of miles—from sources of feed. Second, on the output side, industrial pork production requires huge

tracts of land to act as a sink for manure. Confining animals at the industrial scale results in more manure than local land, watersheds and air can absorb. As a result, CAFOs pollute, poison, and otherwise degrade land, water and air on a scale that extends well beyond the sites of production.

Industrial agriculture is also proposed as a way to ensure "cheap pork for all," a key to the Chinese conception of food security. Government policies and subsidies support the scaling up of pork production, particularly through highly integrated domestic agribusiness firms. These companies, in turn, sell pork either directly or indirectly to retail markets. Because the middle and upper classes in China live exclusively in cities, large-scale pig farms are situated near urban centers, and most commercial pork is sold there as well. Industrial pork rarely reaches poor and rural areas, and changing markets and market standards erode rural livelihoods. This model of food security turns out to be a model of plenty for those who can afford it, and deficiences for those who cannot.

As a way to get around the problem of limited land, and to increase pork availability, a new method has emerged in recent years. The Chinese government and industry have been "going out" to invest in land in Africa, Latin America and other parts of Asia[154] for feed and food crop cultivation. This move takes development policy beyond just a focus on importing grains and oilseeds for the domestic feed industry, toward state and private ownership and control of resources in other countries. Authorities are pursuing this path in the name of increasing food security, which today means increasing meat consumption, particularly for the upper and middles classes in China's cities who can afford to live the meat dream.

Given the limitations of industrial agriculture as a model of equitable, land- and resource-efficient food security, Chinese policymakers would be well-advised to look for alternative approaches to ensure long-term sustainability. There are such viable alternatives based on small-scale, dispersed, locally-situated agriculture. The World Bank and United Nations–commissioned International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report advocates a multifunctional role for agriculture in reducing poverty and social/gender inequalities, stabalizing rural cultures, reversing environmental degradation and mitigating climate change. Stating that "business as usual is not an option," given the combination of climate, energy, water and food crises, the IAASTD questions industrial agriculture (and GM food) as the solution to the social and ecological crises associated with global agribusiness, on the grounds that markets fail to adequately value environmental and social harm.[155] Policies for models that do a better job of valuing these kinds of harms, as well as multifunctionality, offer more sustainable and equitable ways forward.

IV. Ways forward

Given the still-growing demand for pork in China and the various economic and policy dynamics described above, continuing the current path of industrialization may seem inevitable. But as this report has shown, there are considerable negative social and environmental impacts associated with that path, including pollution, climate and biodiversity-related issues, dietary and public health issues, and rural economy and livelihood issues. This section suggests steps that policymakers in China could take to address the problems associated with the current model of agricultural development, and pursue a more equitable and sustainable path.

1. ASSESS THE FULL SOCIAL, ENVIRONMENTAL AND PUBLIC HEALTH COSTS OF INDUSTRIAL PORK AND FEED PRODUCTION. In the absence of such an assessment, industrial livestock feeding appears to produce relatively cheap and abundant meat in the face of growing consumer demand, and alternatives seem to carry greater costs. Some of the externalized costs of the industrial system that need to be calculated are:

- costs of cleaning up environmental pollution (water, soil, air), including manure and agrochemical runoff and contamination, and livelihood losses that result;
- medical and insurance costs from increased morbidity and mortality associated with pollution, overconsumption of livestock products and diseases of affluence;
- medical and research costs from the emergence and spread of zoonotic diseases associated with intensive livestock feeding;
- medical and research costs associated with the emergence and spread of antibiotic resistant pathogens as a result of non-therapeutic use of antibiotics in pig feed;
- costs associated with greenhouse gas emissions from all stages of industrial livestock production;
- loss of manure as a source of nutrients and organic matter on croplands, and increased costs of manufacturing and using commercial fertilizers;
- economic and food security costs to smallholders and rural communities where household pig raising is undermined by subsidized, industrial operations; and
- costs associated with the loss of domesticated plant and animal diversity.

There is also a whole set of social and environmental costs associated with China's policy of supplying its soy needs through imports. In addition to the implications for domestic small-scale soy farmers, many of these costs are felt outside of the country. The loss of biodiversity and local livelihoods from the conversation of forest or grassland to large-scale soy and corn plantations in Brazil is one important example.

Once all of these currently hidden costs are taken into account, China's industrial pork will not look like such a bargain. Policymakers should adjust incentives and regulations so the market price of industrial pork more accurately reflects its full costs, thereby reducing its competitiveness in relation to pork from more sustainable production systems. They should actively pursue a production system that better balances price, nutrition, rural livelihoods and other environmental and social values.

2. REDIRECT RESEARCH AND EXTENSION FUNDS FROM INDUSTRIAL PRODUCTION TO SUSTAINABLE ANIMAL HUSBANDRY AND CROP PRODUCTION. China is home to more than 6,000 varieties of soybeans and more than 100 indigenous pig breeds that are important sources of genetic diversity. Recent policies and funding structures, however, are systematically replacing these locally adapted varieties with a narrow range of exotic, industrial ones. Research and extension efforts should be focused conserving and utilizing these varieties and breeds, and innovating on sustainable, not industrial, methods of crop and livestock production.

3. REDIRECT SUBSIDIES FROM INDUSTRIAL LIVESTOCK PRODUCTION TO LOCAL FOOD SYSTEMS AND FARMER ASSOCIATIONS. Smallholder agroecosystems and the collective systems of knowledge associated with them are steadily being dismantled in the rush to industrialize and urbanize. Subsidies should be combined with research and extension to support smallholders, local food systems and strong farmer associations.

4. PROMOTE HEALTHY DIETS FOR ALL. In the course of development, many industrialized countries "overshot" the levels of animal protein consumption now recognized as most healthy, and are paying the price in the form of epidemic levels of diet-related disease and mortality. China's policymakers seems bent on blindly imitating the mistakes of the West, despite having a traditional diet identical to that recommended by contemporary nutritionists. Rather than promoting a meat-centric diet, Chinese authorities should promote healthy diets for all, and discourage over-consumption of meat and animal products.

5. MAINTAIN FOOD RESERVES TO ENSURE ADEQUATE SUPPLIES. China should continue to manage domestic food (grain and pork) reserves to avoid shortages and to protect the most vulnerable populations against price volatility. These reserves should be managed in equitable ways.

6. CONTINUE TO PROMOTE HOUSEHOLD METHANE DIGESTERS FOR BIOGAS PRODUCTION, AND REQUIRE LARGE-SCALE COMMERCIAL FARMS TO BUILD BIOGAS PLANTS. Chinese central authorities have been actively promoting household biogas production by providing subsidies to small farmers for methane digesters. Of the 140 million rural households in the country, the Ministry of Agriculture estimates that 35 million currently use digesters to produce cooking gas and fertilizer. On the other hand, less than one percent of the 4.2 million large-scale livestock farms in China employ this method to deal with manure.[156] Authorities should require commercial farms to install large-scale biogas plants in conjunction with their production facilities.

7. ADDRESS THE ROLES OF TRADE POLICIES AND INDUSTRIAL CONCENTRATION IN LIVELIHOOD LOSS FOR SMALL-SCALE FARMERS. The influx of cheap imports and the growing concentration of ownership by a narrow range of vertically integrated agribusiness firms creates an uneven playing field for domestic producers and local products. The government should actively intervene to restrict market concentration and create a fair market environment for small producers. Programs should help smallholders meet changing market and safety standards, compete with cheap imports and industrially produced agricultural products, and cooperate.

8. SUPPORT DIVERSE SCALES AND FORMS OF AGRICULTURAL AND LIVELIHOOD PRODUCTION. Rather than promoting a "one size fits all" model of development with industrial agriculture as the centerpiece, recognize the key role that smallholder farmers play in the country's food and agricultural system, and support these systems as vital parts of future plans for development and sustainability.

Of course, pursuing an alternative path also has its costs. But if fundamental government priorities of supplying ever-increasing amounts of meat while keeping retail prices low don't change, alternative approaches may never receive serious consideration. After all, many of the externalities of the current system are either suffered by economically and politically weak groups such as smallholder farmers, or will be felt most acutely in the future. The pragmatic solution for current leaders may still be to stay the (industrial) course. Meanwhile, the limitations and crises associated with this model—water and soil pollution, increased greenhouse gas emissions, antibiotic resistance, decreased species and genetic diversity, food safety issues, dietary inequalities,

chronic disease, the squelching of smallholder livelihoods, and the ever-widening gap between rich and poor—are already being felt.

VI. Conclusion

Feeding China's nearly 700 million pigs is a massive undertaking. By pursuing an industrial model of agricultural development, based in large part on producing millions of tons of pork from imported feedstuffs, Chinese authorities and policymakers are promoting a paradigm that they believe will ensure the country's food security. They are doing so with the help of trade liberalization, state and private investment, and foreign and domestic agribusiness firms.

Judged against the narrow goal of increasing the country's pork production, they have thus far been successful. But the industrialization of China's pork and pig feed also has mounting social and environmental costs. And while these costs may be harder to quantify than rising production figures, decision-makers would be wise to take them into account and consider whether, in the long term, another path may better serve the nation's food security, environment and development needs.

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