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# China's Pork Imports Rise Along with Production Costs

Fred Gale

## Abstract

China has become a leading importer of pork as its hog production costs have grown. China-U.S. comparisons show that hog producers in China face higher feed and labor costs than U.S. producers, while costs of feeder pigs fluctuate from year to year in both countries. Efficiency of feed use has improved marginally in China, but it remains below that of U.S. farms. Rapid wage growth is spurring China's transition toward larger-scale farms, but labor productivity remains low in hog production. With rising production costs, constraints on land use, and stricter environmental regulations in China, the country is likely to remain a large importer of pork.

**Keywords:** hogs, pork, feed, production costs, efficiency, productivity, imports

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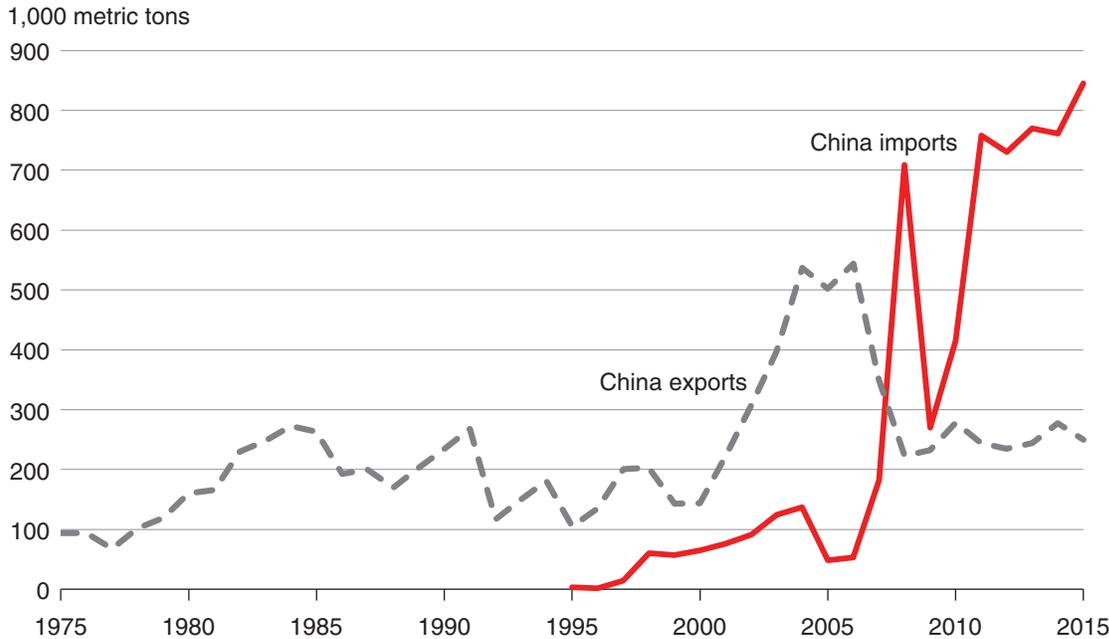
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# China’s Pork Imports Rise Along with Production Costs

## Introduction

China produces roughly half of the world’s pork, but it has nevertheless become a leading importer of the meat. China first emerged as a significant importer of pork during 2007-08 when a swine disease epidemic reduced domestic supply. Imports declined during 2009-10 when China banned pork from the United States—the main supplier at the time—over an alleged disease concern, but imports rebounded after the ban was lifted. From 2011 to 2015, China consistently imported large volumes of pork each year (fig. 1). Imports soared during 2016 as shrinking Chinese pork supplies helped push the country’s pork prices to record levels. China and Hong Kong together now constitute the world’s largest import market for pork. The United States was the leading supplier of China-Hong Kong pork imports during 2007-12, and the United States was the second-leading supplier after Germany during 2013-15.<sup>1</sup>

Figure 1  
**China pork trade, 1975-2015**



Source: Analysis of USDA, Foreign Agricultural Service, Production, Supply and Distribution data.

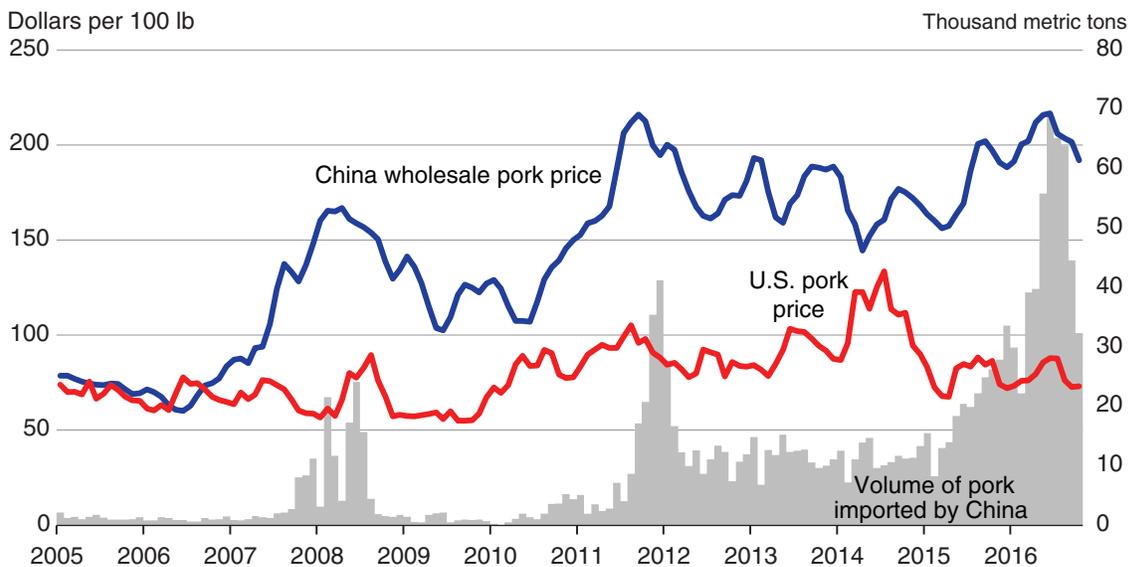
<sup>1</sup>The U.S. share of China-Hong Kong pork imports (Harmonized System code 0203, excluding mainland China exports to Hong Kong), rose as high as 39 percent during 2008 and 2012. The U.S. share fell to 12 percent during 2015.

As the Chinese economy enters a new period of urbanization and labor scarcity, its traditional model of small-scale “backyard” pork production can no longer meet the country’s growing demand for animal protein. Industrialized production models similar to those used in the United States and other developed countries are rapidly displacing backyard producers. A swine industry 5-year plan for 2016-20 by China’s Ministry of Agriculture called for transforming the sector by increasing farm size, raising productivity, and overhauling feed and veterinary drug industries to improve the industry’s international competitiveness (China Ministry of Agriculture, 2016).

Officials in China have taken steps to integrate the country’s meat industry with global markets. An October 2015 circular issued by China’s Administration for Quality, Safety, Inspection, and Quarantine launched an initiative to build designated entry points to receive, inspect, and distribute imported meat. As of September 2016, 56 designated zones had been approved by authorities with laboratories and cold storage where containers of imported meat are inspected and tested before entering distribution channels in China. The swine industry plan for 2106-20 encouraged Chinese companies to collaborate with counterparts overseas to upgrade technology and to compete in international markets.

China’s growth in pork imports corresponds to growth in its pork price. China’s pork imports were negligible during 2005-06 when wholesale pork prices in China and the United States were roughly equal (fig. 2). China became a significant pork importer when its pork price rose to about double the U.S. price in 2008, but imports declined during 2009-10 as China’s price fell.<sup>2</sup> During 2012-15, China’s pork price was often as much as double the U.S. price, and China was a significant importer

Figure 2  
**China and U.S. pork: monthly prices and imports, 2005-2016**



Note: Imported pork is Harmonized System code 020322--frozen swine meat, hams, shoulders, bone-in. U.S. price is wholesale pork cut-out composite price.  
 Source: China Ministry of Agriculture; U.S. Department of Agriculture wholesale prices for the livestock sector (<http://www.ers.usda.gov/data-products/livestock-meat-domestic-data.aspx#26178>); China customs statistics reported by Global Trade Information Services, Global Trade Atlas.

<sup>2</sup>China’s low level of imports largely reflected a ban on U.S. pork for most of 2009 due to purported concerns about transmission of H1N1 influenza.

of pork. Monthly imports soared to a new record during 2016 as the China price rose and the U.S. price fell. If China's high price persists, exporters in the United States and other countries will find sustained market opportunities there.

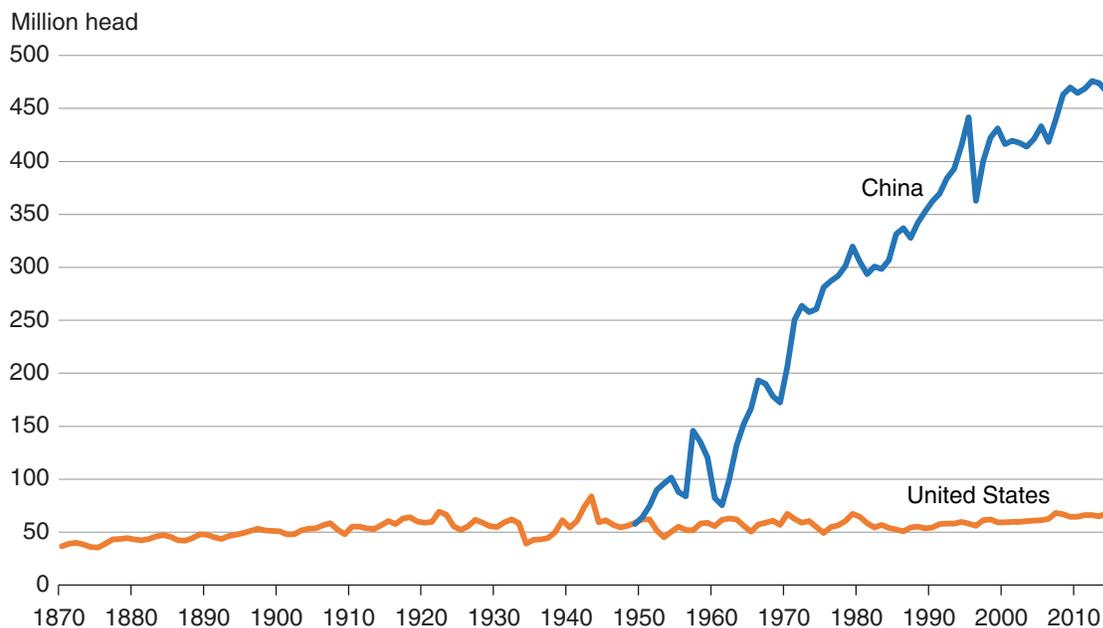
This report investigates the role of rising feed prices, wages, and productivity in China that influence production costs and pork prices in China. The report compares hog farm production costs in China and the United States, and it analyzes trends in feed- and labor-efficiency. The report concludes with a discussion of issues facing China's industry and prospects for future output and trade.

## Background: Expansion and Structural Change

Swine have been an integral part of Chinese agriculture since they were domesticated there thousands of years ago. Devendra and Thomas (2002) explained that mixing swine and crop production on subsistence farms became prevalent in Asia as a means of obtaining adequate calories from intensively cultivated land in densely populated regions.

Despite its long history, China did not acquire its dominant share of global pork production until the 20th century. In 1950, China and the United States had roughly the same number of hogs and pigs.<sup>3</sup> By 2014, China's inventory had soared to a much larger number than that of the United States (fig. 3 and box, "China's Pork Production May Be Overstated"). The amount of pork produced grew even faster as the time needed to raise a pig to slaughter weight shrank from over a year to a few months. However, China's pork industry appears to have plateaued in recent years. The hog inventory stopped growing after 2008, and Ministry of Agriculture surveys reported a sharp decline in sow numbers during 2014-15 that suggested shrinking production capacity. According to the National Bureau of Statistics, production of pork fell 3.7 percent during 2015, and it fell again during the first half of 2016. The Ministry of Agriculture (2016) 5-year plan set a target of 57.6 million metric tons (mmt) for national pork output in 2020—just 1.6 percent higher than output in 2014. The Ministry's plan called for capping growth in urban areas and regions vulnerable to water pollution, which accounted for 39 percent of production.

Figure 3  
**Hog inventory: U.S. and China**



Source: China National Bureau of Statistics and USDA, National Agricultural Statistics Service.

<sup>3</sup>The only statistics before 1949 are Buck (1937), who estimated a total inventory of 59 million hogs in 19 core provinces. China's 2006 agricultural census reported an inventory of 353 million head in those same provinces.

## China's Pork Production May Be Overstated

Since the 1990s, some analysts have suspected that China's statistics on pork output and hog numbers were substantially inflated by an administrative reporting system that was vulnerable to exaggeration by local officials (Zhong, 1997; Fuller, Hayes, and Smith, 2000). China's first agricultural census found that the actual number of swine was 20 percent less than statistics reported in 1996 (China National Bureau of Statistics, 2000). Swine numbers and pork statistics were revised down following the census, but recent statistics still have discrepancies. The *China Statistical Yearbook 2015* reported national pork output of 56.7 mmt for 2014, which equaled 41 kg per person when divided by the national population. That was more than double the 20 kg per person of pork consumption estimated by household surveys reported in the same yearbook.

Yu and Abler (2013) made adjustments to resolve the discrepancy between production and consumption statistics, but they concluded that pork production and swine numbers were overstated by an average of 25 percent from 2004 to 2010. While China's hog production is almost certainly much larger than that of the United States or any other country, the production and the inventory of animals shown in figure 3 could be significantly overstated. A new agricultural census scheduled for 2017 will provide a new count of swine inventory that could lead to further revisions in the statistics.

Since the 1950s, the role of pork production in China's agriculture and food sectors has evolved with the level of economic development, and officials have taken many policy measures to cope with emerging problems like disease, environmental pollution, and price fluctuations (table 1). Nearly all of the growth in China's pork output came from small-scale, dispersed backyard producers who raised a few swine as a "sideline" activity. At the peak of backyard hog production, China's 1996 agricultural census found that 135 million rural households raised hogs and pigs—70 percent of all agricultural households (China National Bureau of Statistics, 2000).<sup>4</sup> The 1996 census found that 77 percent of those households raised five or fewer swine. According to Zhang (2006), small-scale livestock production became predominant in China because a livestock enterprise could utilize slack labor, land, and feed resources without cash expense while also supplying manure as organic fertilizer for crops.

Livestock production in China began to shift to a more commercialized mode in the 1990s (Fang et al., 2000). Structural change has accelerated as the rising opportunity cost of rural labor and declining birth rates reversed the labor-abundance that favored small-scale production. Moreover, technical change and capital availability spurred investment in larger-scale specialized farms. Growing concerns about water pollution, media reports of carcasses in rivers and canals, and disease control have prompted increased enforcement of regulations banning hog farms near waterways, roads, residential areas, and markets. Enforcement of requirements regarding treatment and disposal of manure raise regulatory compliance costs. Food safety scandals involving meat have also prompted meat companies to vertically integrate livestock production and increase the scale of farms. For example, after a news media outlet revealed the purchase of hogs fed illegal feed additives by a subsidiary of Shuanghui Group—now known as WH Group—the company's

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<sup>4</sup>Buck's (1937) surveys found that 44 percent of households held swine during the 1930s. Unpublished data from China's 2006 agricultural census provided to ERS by China National Bureau of Statistics (2008) showed that 36 percent of rural households raised swine.

Table 1

**China's hog production policies adapted to changing circumstances**

| Year      | Events  |
|-----------|---|
| 1950s     | Mao Zedong urged communal farms to raise pigs as a source of organic fertilizer for grain crops.  |
| 1960s-70s | With tight food supplies, authorities prioritized production of food grains over meat.  |
| 1980      | Livestock was included in market-oriented liberalizations of the centrally planned agricultural sector announced by the Communist Party leadership.   |
| 1983      | Central and local governments launched a set of "lean hog" production bases, setting up breeding farms, feed mills, and disease prevention systems.   |
| 1985      | Hu Yaobang—head of China's Communist Party—urged increased production of pigs to add more protein to the Chinese diet and to supply organic fertilizer for crops.   |
| 1989      | Pork production was a prominent part of a "vegetable basket" initiative to supply cities with vegetables, meat, and fish.   |
| 1994      | China liberalized imports of soybean meal and other high-protein feed ingredients.  |
| 1999      | China liberalized soybean imports, shifting imports from soybean meal to soybeans.  |
| 2001      | Accession to the World Trade Organization reduced import tariffs for pork.  |
| 2006      | A livestock modernization program was launched as part of the 11th 5-year plan.   |
| 2007      | Subsidies for hog producers were introduced: subsidies for artificial insemination, a sow subsidy, subsidized insurance for sows, free vaccinations, a subsidy for construction or refurbishment of large-scale farms, and transfer payments to major pork-supply counties.   |
| 2007      | An epidemic of porcine reproductive and respiratory syndrome constrained supplies of hogs, causing pork prices to soar, which attracted new attention to pork industry policies and investment.   |
| 2009      | A program was launched to stabilize hog prices by buying and selling reserves of frozen pork.   |
| 2011      | A virus caused high mortality among China's piglets, contributing to another surge in pork prices that prompted an expansion of production capacity.  |
| 2011      | News media revealed widespread use of banned feed additives by hog farmers, prompting tighter regulation and pledges by companies to increase vertical integration of pork production.  |
| 2013      | Thousands of dead pigs were discovered floating in Shanghai's Huangpu River, contributing to stricter enforcement of regulations limiting where hog farms may be operated.  |
| 2013      | China's WH Group purchased the U.S. pork company Smithfield Foods.  |
| 2014      | China's State Council introduced regulations limiting waste emissions by livestock farms.   |
| 2015      | China's Minister of Agriculture led a national conference on livestock modernization that encouraged fostering new types of livestock businesses, improved breeds, and strict oversight of feed, slaughter, and veterinary drugs. A target of 52 percent of hogs raised by operations of 500 head or more was set for 2020. |
| 2016      | The Ministry of Agriculture's 5-year plan set objectives of increasing scale of hog farms, utilizing hog waste, shifting hogs away from cities and southern watersheds, improving cold chain, establishing traceability, and increasing vertical coordination.  |

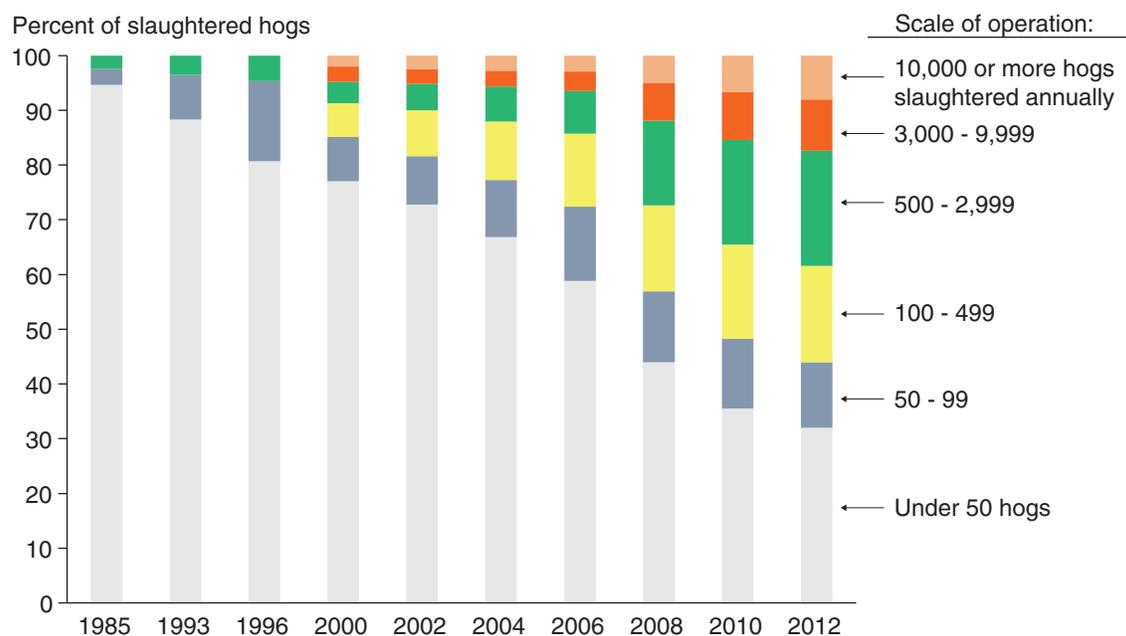
Source: Compiled by ERS from Chinese government reports and news media.

chief executive announced that the company would launch an initiative to build company-operated farms to supply its processing plants (*Henan Daily*, 2011). In 2013, WH Group purchased the U.S. company Smithfield Foods, an acquisition motivated by interest in Smithfield's integration of farming with pork processing (de la Merced and Barboza, 2013). A plan to consolidate pork processors formulated by China's Ministry of Commerce (2013) called for companies to take more control over hog production to address other chronic problems such as slaughtering diseased pigs, pumping water into carcasses, and feeding restaurant waste to pigs.

Zhang (2006) reported that the share of rural households raising hogs and pigs fell from 73 percent in 1990 to only 38.3 percent in 2005. Rae and Zhang (2009) reported that nearly 40 percent of rural households gave up livestock production between 1995 and 2005 as the sector adjusted to excess supply and declining prices. Chen and Rozelle (2005) found that the prevalence of swine production waned in more-developed coastal regions, while farmers in less-developed regions retained a strong inclination to raise swine.

According to Ministry of Agriculture data, the share of hogs raised by small operations producing 50 or fewer hogs per year fell from over 90 percent during the 1980s to 32 percent in 2012 (fig. 4). The declining share reflects a 50-percent decline in the number of small-scale farms raising 50 or fewer head during 2002-12; the number of small farms decreased by 52 million. In contrast, the number of farms raising 50 or more head increased by 1.7 million. Somwaru, Zhang, and Tuan (2003) highlighted household-operated farms with 31-100 head as the most cost-efficient farm size, but most hogs are now raised on farms producing more than 100 head. Somwaru, Zhang, and Tuan identified large-scale farms as primarily state- and collective-owned, but large-scale company- and individually operated farms are now becoming common. The number of Chinese farms producing 5,000 or more hogs and pigs increased from 8,300 to 11,400 during 2009-12.<sup>5</sup>

Figure 4  
**Share of hog slaughter by scale of operation, 1985-2012**



Source: China Ministry of Agriculture, *Livestock Industry Yearbooks*.

<sup>5</sup>In comparison, U.S. agricultural census data showed that the United States had 46,747 farms holding hogs and pigs during 2012, including 6,953 farms that sold 5,000 or more head. Those 5,000-head farms accounted for over 90 percent of hogs and pigs sold in the United States.

The increase in scale of farms reflects rising labor costs and economies from specialization and size as the nature of the industry changes. Increased scale and use of modern inputs has also been encouraged by government officials through various subsidies and other initiatives. Beginning in the 1980s, officials encouraged imports of “lean-type” swine breeds and adoption of commercial feeds that shortened the production cycle and increased the proportion of muscle meat on carcasses. A livestock “modernization” initiative launched during the 2006-10 5-year plan included subsidies for building large-scale livestock farms, artificial insemination with semen from improved breeds, subsidies for productive sows, subsidized insurance for sows and finishing hogs, and free vaccines. Transfer payments to major hog-producing counties helped fund local assistance, including subsidized loans and support of rural veterinary services (Tan, 2015). The China Ministry of Agriculture’s 5-year plan for hog production during 2016-2020 continues the modernization initiative. The plan calls for enlarging the scale of farms in order to raise productivity and to make China’s hog producers more internationally competitive (China Ministry of Agriculture, 2016).

The increased scale of operations is concurrent with a change in composition of feed materials. In place of large volumes of coarse fodders and wastes, hog producers are using feeds that contain corn and soybean meal as the chief ingredients. Liberalization of soybean imports supplied large volumes of soybean meal as the main source of protein in feed, while domestic corn production expanded to supply energy to feed (Gale, 2015). Larger-scale farmers are more inclined to adopt these new breeds, feeds, and other technologies than are backyard producers.

## Analysis of Production Cost and Productivity Data

This study analyzes trends in production cost and productivity of feed and labor inputs using data from a cost of production survey conducted by China's planning commission (CNDRC, 2015). The survey reports average income and expenses, average weights of piglets and finished hogs, days on feed in the finishing stage of production, quantity of feed concentrates, and labor input for thousands of hog producers nationwide. Average costs per head, live weights, feed, and labor input have been reported annually for small backyard households and "above-scale" producers since the early 1980s.

The CNDRC data are often used for analysis of China farm costs, including Rae et al.'s (2006) study, which reported rapid growth in livestock productivity. However, there are few details provided about the data. The sample size has not been reported since the 2002 report revealed that hog data were based on records submitted by 2,603 backyard farms and 1,192 above-scale farms. No standard errors are published, so statistical testing is not possible. The sample appears to be chosen in an ad hoc manner by county price bureau offices that are instructed to choose a few farms that are representative of different types of farms in their local area.

Surveyed farmers record their sales, income, and expenses for the year on a form submitted to the county office. The data are compiled at the county, provincial, and national level and then published by CNDRC once a year.<sup>6</sup> The data from the 1980s and early 1990s fluctuate widely, which could reflect errors or misreporting, but data for 1998-2015 appear to be relatively consistent. This report analyzes data for 2000-15 in order to discern recent trends. The analysis includes data for backyard and above-scale farms and reports the weighted average of several productivity indicators for the two farm types to illustrate how the shift toward larger-scale operations affects overall performance of the sector.

The analysis begins by summarizing trends in Chinese pork prices and costs from 2000 to 2015. Trends in average unit values of hogs, feed, piglets, and wages calculated from the CNDRC data characterize the growth in input and output prices in China during the years when it became a pork importer. A second part of the analysis compares major components of hog production costs in the United States and China from 2000 to 2015. This analysis is based on similar U.S. and China hog-production cost estimates from CNDRC data and the USDA Agricultural Resource Management Survey (ARMS) reported by U.S. Department of Agriculture (2016).

The third part of the analysis tracks several indicators that reflect production efficiency and changes in production systems from 2000 to 2015. Indicators were calculated separately for above-scale and backyard farms, and weighted averages were calculated to assess how structural change from backyard to larger-scale production systems affects the sector's performance. Indicators were compared with estimates from a large sample of U.S. producers tracked during 2007-14 by Stadler (2015).

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<sup>6</sup>Some county and township offices prepare brief reports on an ad hoc basis based on small local samples, which are available at <http://www.npcs.gov.cn> and local government websites.

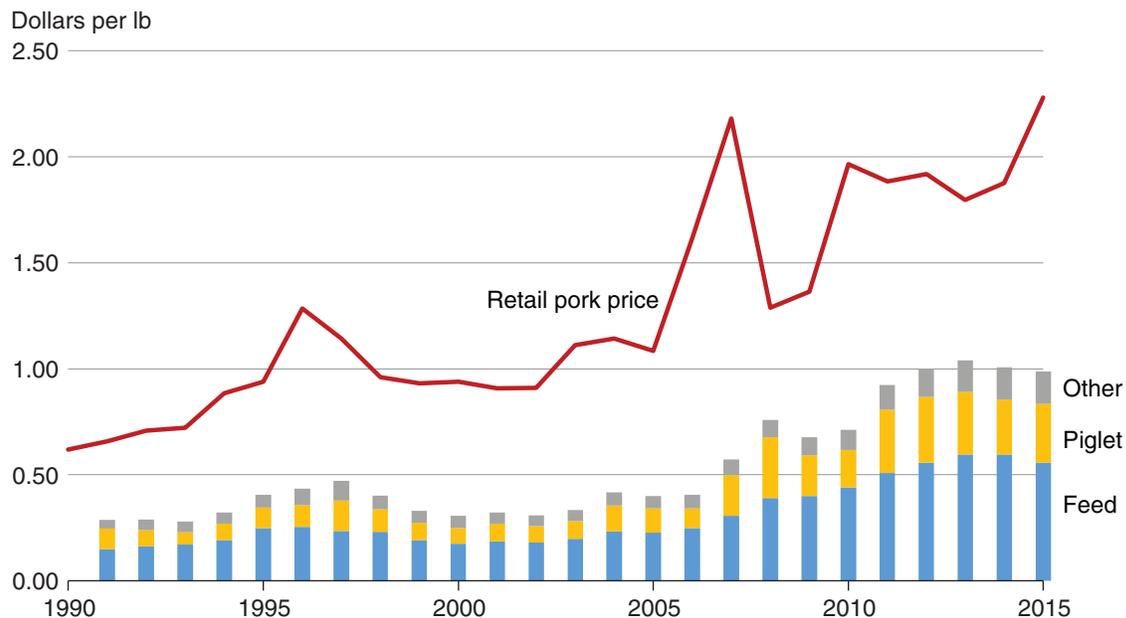
## Prices and Production Costs

The average Chinese retail pork price for 2000-16 is compared with CNDRC hog production costs per pound of live weight for 2000-15 to illustrate the relationship between pork prices and production costs (fig. 5). The main cost components for producing a live hog are shown separately: the costs of a piglet, labor, and feed. Per-head costs were divided by average weight of a finished hog. The difference between the retail pork price and hog production cost reflects profits/losses by farmers, margins added by processors and traders, and the removal of low-value parts of the live animal such as bones, skin, and offal that are not included in the retail price. All values were converted to U.S. dollars at the official exchange rate.

The chart shows that the retail price of pork and the production costs of hogs have fluctuated from year to year since 2000, but a rising trend is evident in both. Hog production costs constitute about 50-60 percent of the retail price of pork. Escalating costs place a rising floor under the cyclical fluctuations, as the low point of each price cycle moves steadily higher (Gale, Marti, and Hu, 2012). The retail price rose to a record high during 2016 (production cost data are not yet available for 2016).

Feed is the largest component of hog production cost in China. The cost of feed per pound of hog live weight equaled about 35 to 40 percent of the retail pork price from 2009 to 2015. Feed's share of the cost of producing a market hog is actually somewhat higher than reported here. Although the feed cost of producing piglets in the farrowing and nursery stages of production should be reflected by the cost of the piglet, the cost of feed in that stage of production is not shown explicitly in the

Figure 5  
**China pork price and hog production cost**



Note: Hog production costs are for above-scale farms reported by production cost surveys. 2016 retail pork price is January-November average.

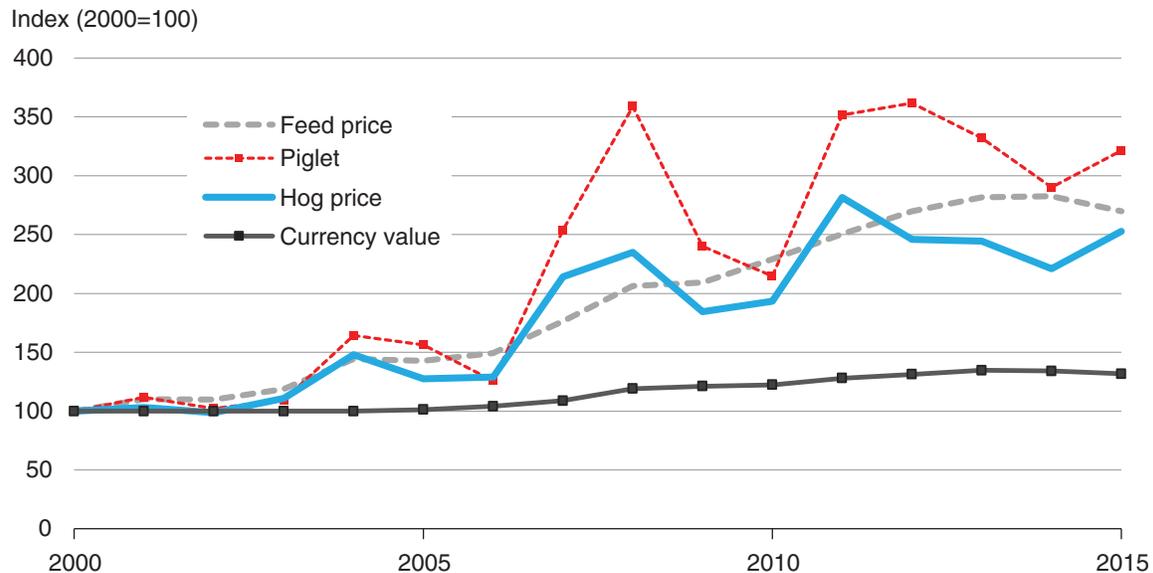
Source: USDA, Economic Research Service analysis of data from CNDRC and National Bureau of Statistics.

CNDRC data.<sup>7</sup> Labor—including the imputed opportunity cost of unpaid operators and hired labor expense—accounts for a relatively small share of production cost for above-scale producers, but labor’s share is higher for labor-intensive backyard producers, as will be discussed below.

The contribution of rising input prices and appreciation of China’s currency were investigated by calculating indexes based on unit prices of hogs, feeder pigs, feed, and labor derived from CNDRC data. Indexes for these indicators were calculated using their values for year 2000 as a base. These indexes were calculated using prices in Chinese currency. A separate index showing the value of the Chinese currency against the U.S. dollar was calculated to show the impact of currency appreciation on the U.S.-dollar price of Chinese pork. Figure 6 displays indexes of the hog price, piglet price, feed price, and currency value for 2000 to 2015. A hog-farm wage index was calculated, but it is not displayed in the chart because it grew so much faster than the other indexes.

Like the retail pork price, China’s hog and piglet prices fluctuated from year to year, but they also followed a rising trend from 2000 to 2015. In 2015, the average hog price was 253 percent of its value in 2000. The hog price never fell below its value in the base year. The index peaked in 2011 at 281 percent of the 2000 level. The piglet price fluctuated to an even greater degree. Piglet prices tend to rise sharply when the industry is expanding faster than the industry can supply them in the short run—due to biological constraints. Piglet prices can also fall sharply when breeding programs are not immediately curtailed when demand slows. The piglet price index rose to 350 percent of its 2000 value during 2008, 2011, and 2012. It was 321 percent during 2015.

Figure 6  
**China hog farms: feed, piglet, and hog price indexes, 2000-2015**



Note: Unit values in Chinese currency for expense items were derived from production cost estimates. Indexes were calculated by dividing by values for year 2000. The currency value reflects the U.S.-dollar value of the Chinese yuan using the official exchange rate.  
 Source: ERS calculations using data from China National Development and Reform Commission and People’s Bank of China.

<sup>7</sup>China has no comprehensive statistical data on costs of farrowing and nursery stages of swine production.

The average price of feed—the largest component of production cost—increased each year during 2000-14 before falling slightly in 2015. The 2014 feed price was 280 percent of the price in 2000. Most of the growth in feed price occurred from 2006 to 2013. Rising feed prices place a rising floor under hog prices, since more costly feed raises the break-even price for hog producers. Nevertheless, during 2012-14 hog prices in China fell each year while feed prices continued to rise.

Wages grew much faster than hog prices. The daily wage paid to hired laborers by hog farms in China rose eight-fold during 2000-15. In view of the difference in labor intensity and higher labor expense for small farms, the rapid rise in wages is consistent with the rapid withdrawal of labor from backyard production.

China's hog and piglet prices rose faster than the rate of general inflation in China. The consumer price index (CPI) in China rose an average of 2.2 percent annually during 2000-15.<sup>8</sup> Growth in the CPI exceeded 5 percent only 2 years—2008 and 2011 (which were also years of rapid growth in retail pork prices). The cumulative increase in China's CPI was approximately 42 percent from 2000 to 2015. By comparison, the average hog price rose 153 percent during 2000-15. The hog price in U.S. dollars grew even faster—233 percent—after factoring in the cumulative 32-percent appreciation of the Chinese currency during 2000-2015.

Wages in rural China remain very low compared with U.S. wages, despite their rapid rate of growth. In 2000, Chinese above-scale hog farms paid hired workers the equivalent of just \$0.15 per hour, while the wage for hired farm labor in the United States averaged \$8.10 per hour that year (table 2). Chinese wages reported by hog farms doubled every 4 years from 2000 to 2012 and grew 33 percent from 2012 to 2015. Still, the average Chinese wage reached only \$1.76 per hour in 2015. The average wage for U.S. hired farmworkers grew to \$12.54 per hour in 2015, so the difference between U.S. and Chinese farm wages appears to have grown even wider.

In contrast, China's feed ingredient prices are much higher than in the United States. The difference between China and U.S. prices for corn and soybean meal (the main ingredients in hog feed) was calculated for each year from 2000 to 2015. Prices are from regions in each country that produce hogs, corn, and soybean meal (Shandong, China; Illinois, United States). China's price of soybean meal was consistently 20- to 40-percent higher than in the United States (fig. 7). The higher price of soybean meal in China reflects the cost of importing soybeans--the predominant raw material used to produce soybean meal in China. The difference in prices is consistent with the cost of freight, a 3-percent import duty, and a 13-percent value-added tax assessed on imported soybeans.

The China-U.S. difference in corn prices was larger and more variable. China has a quota that limits imports of corn, and the price of corn in China varies independently of international prices. In many years, the China corn price was 30-40 percent higher than in the United States. The difference widened to 120 percent in 2013 and 180 percent in 2014 when U.S. prices fell but China supported prices at a relatively high level. The difference narrowed to 140 percent in 2015 as China reduced its support price for corn that year. These price comparisons confirm that hog producers in China face much higher feed costs than producers in the United States.

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<sup>8</sup>Average growth in China's industrial producer price index was even lower, averaging 1.7 percent during 2000-14.

Table 2

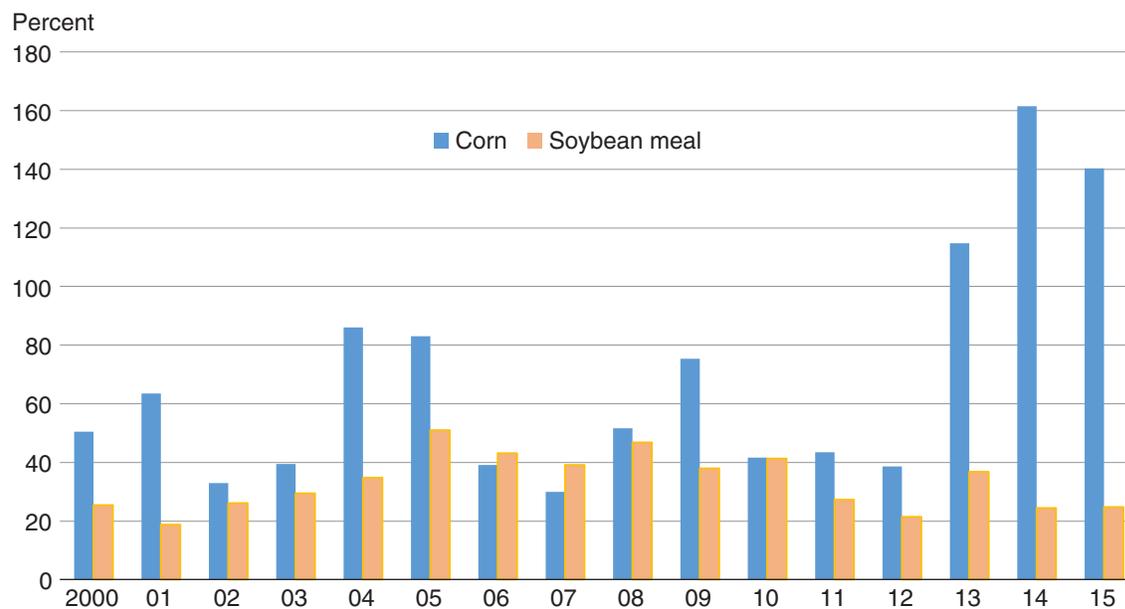
**Hired farm labor wages, China and United States, 2000-2015**

| Year                    | China | U.S.  | Difference |
|-------------------------|-------|-------|------------|
| <i>Dollars per hour</i> |       |       |            |
| 2000                    | 0.15  | 8.10  | -7.95      |
| 2001                    | 0.16  | 8.45  | -8.29      |
| 2002                    | 0.17  | 8.81  | -8.64      |
| 2003                    | 0.17  | 9.08  | -8.91      |
| 2004                    | 0.30  | 9.23  | -8.93      |
| 2005                    | 0.31  | 9.50  | -9.19      |
| 2006                    | 0.38  | 9.87  | -9.49      |
| 2007                    | 0.50  | 10.23 | -9.73      |
| 2008                    | 0.65  | 10.60 | -9.95      |
| 2009                    | 0.73  | 10.83 | -10.10     |
| 2010                    | 0.86  | 10.95 | -10.09     |
| 2011                    | 1.12  | 11.07 | -9.95      |
| 2012                    | 1.32  | 11.51 | -10.19     |
| 2013                    | 1.52  | 11.87 | -10.35     |
| 2014                    | 1.67  | 12.07 | -10.40     |
| 2015                    | 1.76  | 12.54 | -10.78     |

Note: U.S. wage is for all farm laborers; China is wage paid by above-scale hog farms.

Source: USDA, National Agricultural Statistics Service; China National Development and Reform Commission.

Figure 7

**Difference between China and U.S. feed ingredient prices, 2000-15**

Note: Chart shows percentage difference between China and U.S. price for each commodity. China prices are wholesale corn price and ex-factory soybean meal price in Shandong Province; U.S. prices for Illinois.

Source: ERS analysis of data from China National Grain and Oils Information Center; USDA, National Agricultural Statistics Service and Agricultural Marketing Service.

## China-U.S. Production Cost Comparison

In this section, the three main components of hog production costs are estimated over 2000-2015 for China and U.S. hog farms. Changes in production costs reflect changes in input prices as well as the productivity of inputs.

The CNDRC costs were converted to U.S. dollars at the official exchange rate to compare with U.S. hog production costs during 2000-15. U.S. estimates derived from the USDA Agricultural Resources Management Survey were obtained from the USDA, Economic Research Service (McBride and Key, 2013; U.S. Department of Agriculture, 2016). No adjustments for inflation were made to data from either country. Since the CNDRC survey focuses on the finishing stage of hog production in which a 15- to 17-kg feeder pig is raised to a market weight of 100-120 kg, the CNDRC data were compared with costs for U.S. “feeder-to-finish” farms.<sup>9</sup>

The CNDRC expenses were converted to values per 100 lb of weight gain in the finishing stage for comparability with the U.S. estimates. The following formula was used for calculations:

$$Cost\left(\frac{\$}{100-lb}\right) = \frac{Production\ expense}{Finished\ hog\ weight - Piglet\ weight} \times 100$$

The costs of feed, piglets, and labor—the predominant cost components—were compared for China and U.S. feeder-to-finish hog farms each year from 2000 to 2015. The comparisons used data for above-scale producers (30 or more head) Chinese farms which now account for most production in China.<sup>10</sup>

Consistent with the growth in feed prices observed above, Chinese feed costs steadily rose above those of U.S. farms from 2002 to 2014 before declining in 2015 (fig. 8). Feed cost for China’s hog farms more than doubled from \$21 to \$70 per 100 lb during 2006-2014. U.S. costs rose at a slower and more variable pace. U.S. feed costs increased from about \$17 to \$40 per 100 lb during 2006-2014. Feed costs declined slightly in both countries during 2015, but the Chinese feed cost was still 75 percent higher than the U.S. feed cost that year.

The cost of a feeder pig was calculated by dividing the piglet’s purchase cost by the weight gained in the animal’s finishing stage as it grows to market weight (fig. 9). From 2000 to 2006, China’s feeder pig cost was consistently less than the feeder pig cost for U.S. producers. The apparent cost advantage for China’s feeder pigs until 2006 is consistent with an assessment by Fabiosa et al. (2005) that low wages might give Chinese farms a cost advantage in this labor-intensive segment of production. However, the China feeder pig cost rose above the U.S. cost during 2007 and 2008 after a disease epidemic curtailed supplies of feeder pigs in China. Since then, neither country has had a clear cost advantage as feeder pig costs became more volatile in both countries. Chinese feeder pig costs rose as high as \$35 per 100 lb in 2008 but fell to \$20 per 100 lb in 2010. The China feeder pig cost returned to \$75 during another disease epidemic that reportedly caused high piglet mortality in 2011 and remained at a similar level until falling to \$30 per 100 lb in 2014. U.S. feeder

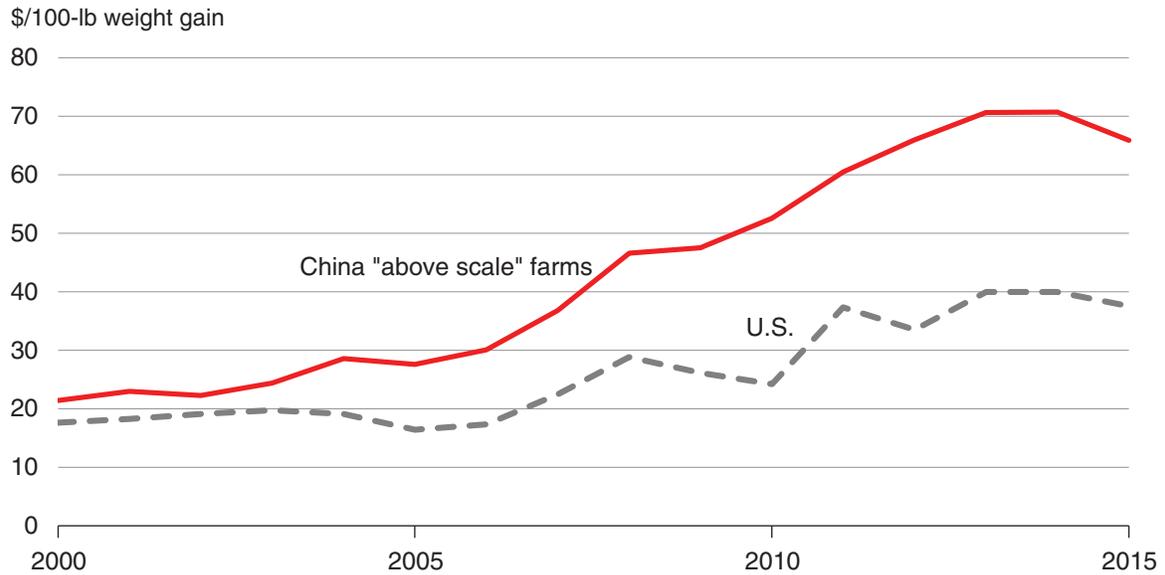
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<sup>9</sup>The farrowing and nursery stages are focal points for concern in discussion of productivity problems in the Chinese industry. However, no statistical information was available to analyze those stages of production.

<sup>10</sup>Note that USDA’s survey excludes hog operations with fewer than 25 head in inventory, a scale comparable to China’s backyard producers. According to the U.S. agricultural census, these farms supplied less than 1 percent of U.S. hogs and pigs in 2012. In China, operations selling less than 50 head supply over 50 percent of hogs.

Figure 8

**Feed costs per 100-lb weight gain: China and U.S. hog farms**

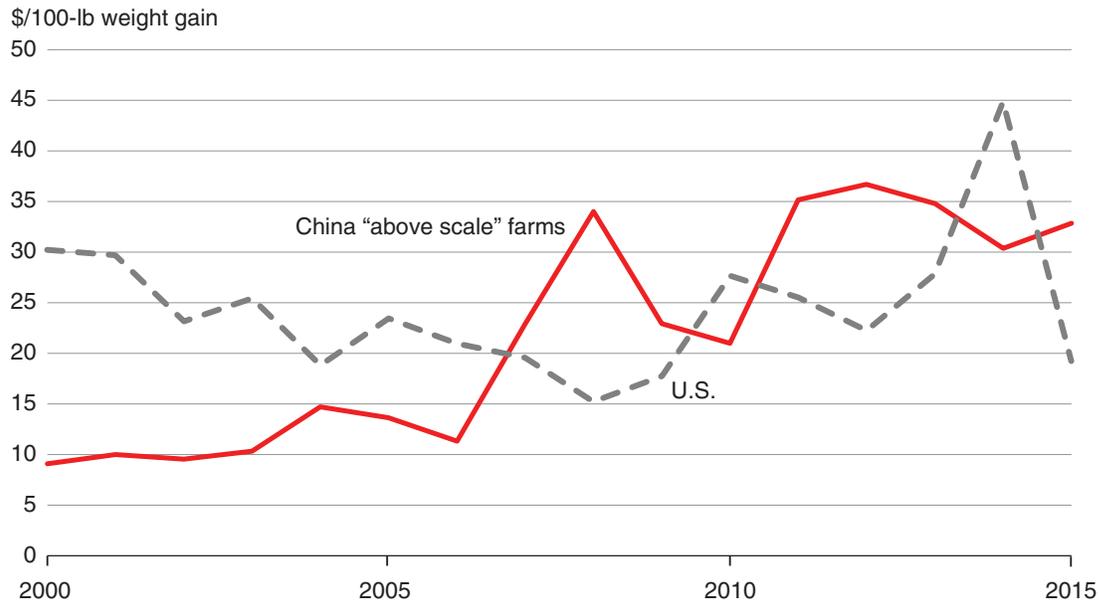


Note: China costs are calculated based on raising feeder pigs from 16-17 kg to finished hogs of over 100 kg. China cost converted to dollars per 100 lb at official exchange rate. Feed expense includes purchased feed, farm-supplied feed, and milling charges. Above-scale farms have an inventory of 30 or more hogs. U.S. data are for operations with an inventory of 25 or more hogs (see McBride and Key, p. 1).

Source: China National Development and Reform Commission; USDA, Economic Research Service (2016).

Figure 9

**Feeder pig costs per 100-lb weight gain: China and U.S. hog farms**



Note: Chart shows ratio of feeder pig cost to weight gained in finishing stage of production.

Source: China National Development and Reform Commission; USDA, Economic Research Service (2016).

pig costs surged to near \$45 per 100 lb during 2014 due to a U.S. epidemic that curtailed piglet supplies. U.S. feeder pig costs declined to less than \$20 per 100 lb in 2015 after the epidemic was curtailed. China's feeder pig cost rose to \$33 that year.

Despite low wages in China, labor costs per unit of output for China's hog farms are now much higher than in the United States because labor productivity is also very low. From 2000 to 2003, China's above-scale and U.S. farm-labor costs per unit of weight gain were similar, at about \$3-4 per 100 lb (fig. 10). Labor costs in the two countries diverged beginning in 2004. U.S. labor cost fell slightly to \$2-3 per 100 lb during 2004-2015—reflecting growth in labor productivity—but China's labor cost soared to \$16 per 100 lb in 2014-15. The labor cost of China's backyard farms was even higher than that for above-scale farms shown in fig. 10.<sup>11</sup>

The share of hog production cost attributed to feed, feeder pigs, labor, and other items was calculated for China and U.S. farms for 2000-2015 to show the differing composition of costs in the two countries (fig. 11).<sup>12</sup> Feed was the predominant component of cost for Chinese hog producers, accounting for an average of 57.2 percent of hog production cost. In the United States, feed accounted for 40.1 percent of hog production cost, much lower than the share in China. In both countries, the feeder pig was the second-largest component of cost for a finishing hog.<sup>13</sup> The feeder pig cost share was 28.2 percent in China and 35.7 percent in the United States. Labor contributed more to cost in China than in the United States, but labor accounted for a relatively minor share of cost in both countries. Labor accounted for 7.8 percent of cost in China and 4.3 percent in the United States. Finally, "other" cost played a larger role in U.S. hog production than in China, reflecting larger investment in facilities, capital, and equipment on U.S. farms. However, anecdotal reports suggest that many large-scale, capital-intensive farms are being constructed in China that have facilities similar to those in the United States and Europe.

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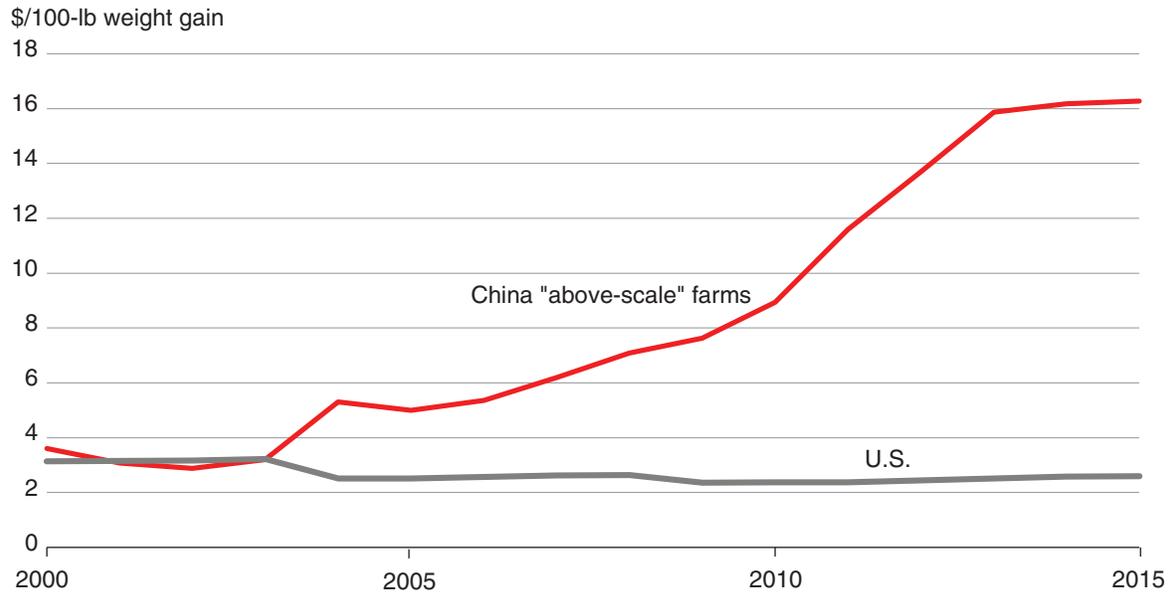
<sup>11</sup>The labor cost for backyard farms was over \$37 per 100-lb weight gain during 2012-15.

<sup>12</sup>Feed and feeder-pig cost shares varied from year to year, largely due to fluctuations in feeder pig prices. China's "other" cost share and the U.S. labor-cost share both declined from 2000 to 2014.

<sup>13</sup>The share of feed cost is understated since feed is also a cost of producing feeder pigs. However, no data were available to estimate the composition of costs for feeder pig production.

Figure 10

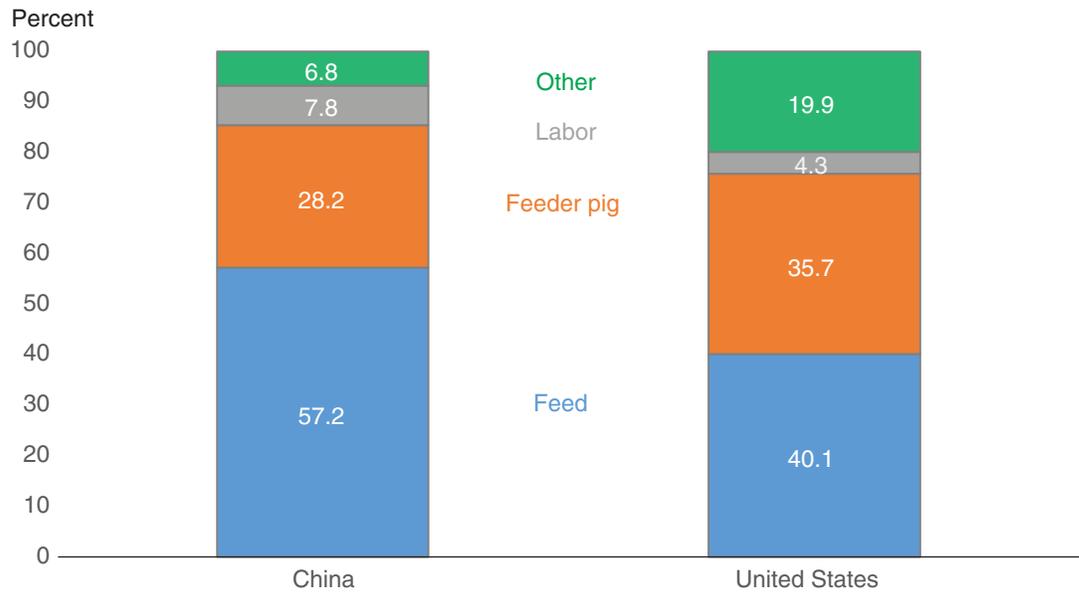
**Labor costs per 100-lb weight gain: China and U.S. hog farms**



Note: China costs are calculated based on raising feeder pigs from 16-17 kg to market weight of over 100 kg. China cost converted to dollars at official exchange rate. Labor expense includes hired labor and imputed cost of unpaid family labor. Above-scale farms have inventory of 30 or more hogs.  
 Source: China National Development and Reform Commission; USDA, Economic Research Service (2016).

Figure 11

**Hog production cost shares, China and United States, 2000-2015 average**



Note: Chart is based on cost per 100-lb weight gain. A simple average was calculated for 2000-2015.  
 Source: ERS analysis of data from China National Development and Reform Commission; USDA, Economic Research Service (2016).

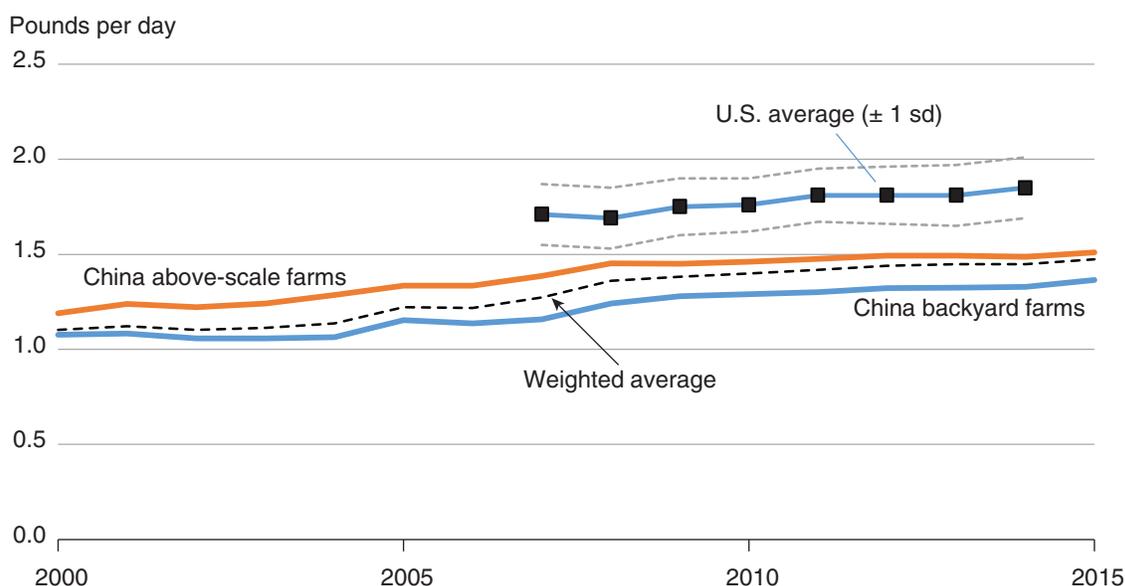
## Efficiency Indicators for China Hog Producers

This section provides further insight about the divergence between China and U.S. hog production costs by assessing indicators of production efficiency for Chinese producers available from the CNDRC data for 2000-15. The indexes are shown for backyard and above-scale farms to show the difference in efficiency between the two types of farms. A weighted average is also displayed for each index as an indicator of how the shift from backyard to above-scale farms has influenced the growth in the sector's efficiency. The indicators were compared with similar indicators from U.S. hog surveys by Stadler (2015) and McBride and Key (2013) where available.

### *Average daily weight gain*

Hogs' average daily weight gain rose during 2000-15 but remained lower than the U.S. average. In 2000, the average daily weight gain of China hogs was 1.1-1.2 lb/day. The weight gain improved to 1.37 lb/day for backyard farms and 1.47 lb/day for above-scale farms by 2015 (fig. 12). The faster weight gain in recent years reflects a shift toward "lean-type" swine breeds that add muscle faster, a diet richer in protein and energy, improved animal health, and better management.<sup>14</sup>

Figure 12  
**Average daily weight gain**



Note: Average daily weight gain = (finished hog weight – piglet weight)/(days in finishing stage). U.S. average is for conventional finishers. The standard deviation reported by Stadler (2015) was used to calculate an interval to show the variation in the U.S. average.

Source: ERS analysis of data from China National Development and Reform Commission and Stadler (2015).

<sup>14</sup>A description in the 1986 *China Agricultural Yearbook* (p. 81) reported that a sample of "lean-type" hogs gained an average of 0.6 kg (1.32 lb) per day. The article claimed that faster weight gain and lower proportion of body fat were achievements of the "lean-type hog production base" initiative.

Faster weight gain corresponds to the shortening of the production cycle. It took about 300 days for backyard producers to raise a pig to a market weight of 100-110 kg in 1980. In 2000, the average production cycle was 181 days for backyard farms and 151 days for above-scale farms. The production cycle was further reduced to 145 days for above-scale producers during 2014-15.<sup>15</sup>

Weight gain for U.S. farms reported by Stadler increased from 1.7 lb/day in 2007 to 1.85 lb/day in 2014. The 2014 U.S. weight gain was 24-percent faster than that of above-scale Chinese producers and 39 percent faster than that of backyard producers. The average weight gain for above-scale Chinese producers was about two standard deviations below the average reported by U.S. producers during 2014.<sup>16</sup> The slower rate of weight gain achieved by producers in China may contribute to their higher feed cost compared with those in the United States shown earlier in figure 8.

### *Feed composition*

One of the factors promoting faster weight gain for Chinese hogs is a shift toward use of feed concentrates in place of coarse fodder.<sup>17</sup> The CNDRC data reports the volume of feed concentrate used per hog and expenses for feed concentrates and fodders (table 3). Concentrates, such as grains, oilseed meals, brans, beans, and commercial feeds, have high concentrations of energy, protein, and other nutrients. Fodders include byproducts of crop production and food processing, food scraps, vegetables, and other materials that add bulk to the diet with lower and varying concentrations of energy and protein. Fodders were traditionally predominant sources of feed for swine in China because they could be procured locally at minimal cost. Use of concentrates has increased as hog production became a more commercially oriented activity with greater emphasis on rapid weight gain. Anecdotal reports in news media suggest that many farmers in China make cyclical adjustments by substituting less-costly fodders for concentrates during periods of low hog prices. No U.S. data on use of fodders is available for comparison; most commercial U.S. hog farms use concentrates as their primary feed.

In 2000, backyard farms used an average of 3 lb of feed concentrates daily per hog, while above-scale farms used 4 lb (fig. 13). The volume used by backyard farms began to increase in 2005, and reached 4.28 lb in 2015. Concentrate use by above-scale farms increased to 4.5 lb per day by

Table 3

#### **Two major categories of swine feeds used in China**

| Type               | Description   |
|--------------------|---|
| Concentrates (精饲料) | Grains, beans, commercial feed, brans, hulls, oilseed meals, and additives  |
| Fodders (青粗饲料)     | Stalks, vines, tubers, aquatic plants, alfalfa, vegetables, silkworm cocoons, food scraps, and byproducts of food processing and distilling |

Source: Compiled by ERS from CNDRC.

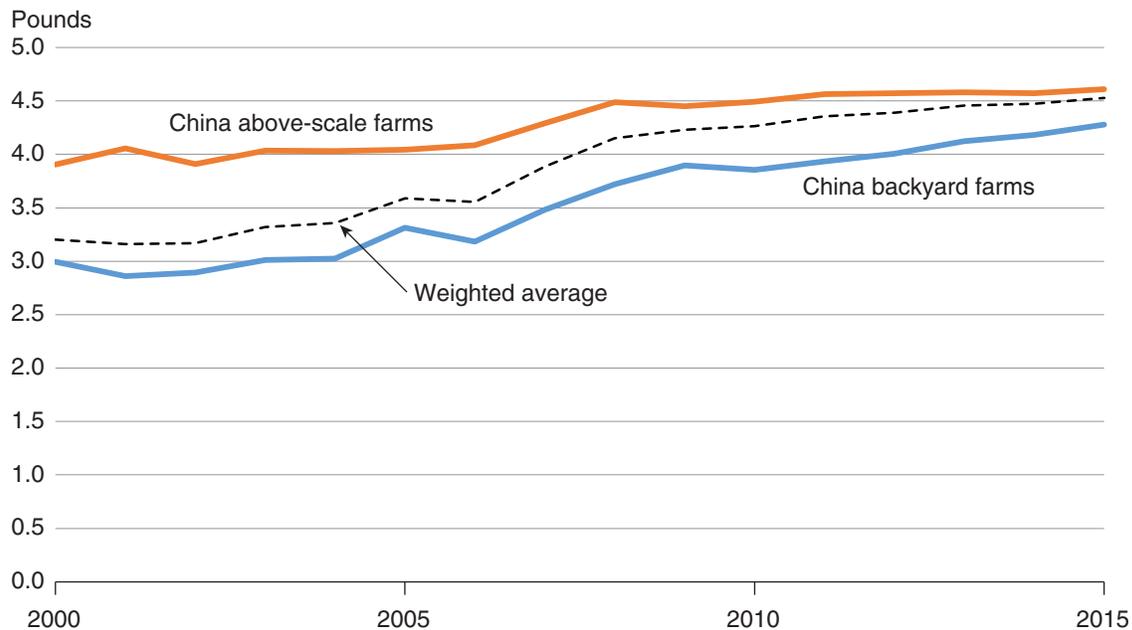
<sup>15</sup>Zhou, Tian, and Liu (1998) reported average days on feed ranging from 130 to 140 in Henan, Jilin, and Zhejiang provinces. They reported a much shorter production cycle of 111 days for backyard producers in Sichuan, which they attributed to the use of relatively heavy feeder pigs in that region.

<sup>16</sup>The CNDRC data does not report standard deviations nor any other measure of variability in the data, so statistical tests cannot be performed.

<sup>17</sup>A study by Fuller et al. (2001) reported that faster weight gain in Shandong (1.03 lb/day) and Jilin (0.95 lb/day) corresponded to a higher proportion of concentrate feeds used in those provinces compared with Sichuan (0.75 lb/day) and Chongqing (0.84 lb/day).

Figure 13

**Daily consumption of feed concentrates per head, 2000-2015**



Note: Chart shows ratio of feed consumed to number of days hogs were fed; thus, the ratio is the average daily consumption over the life cycle of hogs.

Source: ERS analysis of data from China National Development and Reform Commission.

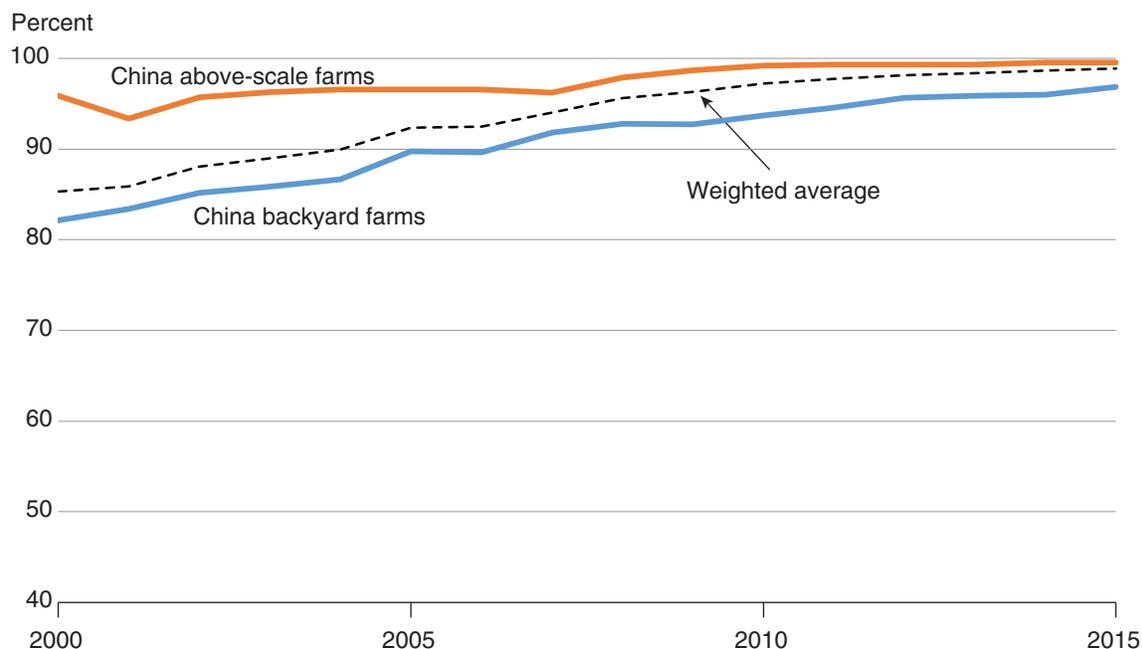
2008 but changed little during 2009-15.<sup>18</sup> The 25-percent difference in daily concentrate feed use between backyard and above-scale farms narrowed to 5 percent in 2015.

The increase in concentrate use by backyard farms reflects largely a substitution of concentrates for fodders. In 2000, concentrates accounted for 82 percent for backyard farms of feed expense for backyard farms; fodder accounted for 18 percent (fig. 14).<sup>19</sup> (Fodder’s share of volume of feed was larger than its share of cost, since fodders have lower prices than concentrate feed—however, no information was available to measure the volume of fodder used.) The concentrate share was already 95 percent for above-scale farms in 2000. The concentrate share of feed expense for backyard farms increased rapidly and surpassed 95 percent in 2012. The concentrate share of feed expense for above-scale farms was near 100 percent during 2010-15.

<sup>18</sup>The acceleration of concentrate use coincided with a Ministry of Agriculture campaign to “modernize” hog production during the 2006-10 five-year plan.

<sup>19</sup>Concentrates accounted for less than 60 percent of feed expense during the early 1980s.

Figure 14  
**Concentrate share of feed expense, 2000-2015**



Note: share = concentrate feed expense/(concentrate expense + coarse feed expense) x 100.  
 Source: USDA, Economic Research Service analysis of data from China National Development and Reform Commission.

### *Feed conversion ratio*

As observed above, weight gain of hogs accelerated over time, but consumption of feed concentrates also increased. The feed conversion ratio (FCR) is an indicator of the efficiency of feed use, which shows the pounds of feed concentrates consumed per pound of weight gained in the finishing stage of production:<sup>20</sup>

$$FCR = \frac{\text{Volume of feed concentrates consumed (lb)}}{\text{Finished hog weight (lb) - Piglet weight (lb)}}$$

A lower ratio implies greater efficiency. The analysis here reports only the feed conversion for concentrates; fodder is not included since CNDRC data do not report quantities of fodder consumed. Fodders have a much higher ratio of feed input to weight gain, so the trend in the concentrate feed conversion ratio may understate the overall improvement in feed conversion due to the increased share of concentrates in feed discussed above.

Other studies found that FCRs vary widely by stage of production and type of feed used. Earlier surveys of China hog farms found values between 3:1 and 4:1 (Zhang and Lu, 1997; Shi, 2003; Zhou, Tian, and Liu, 2003). Studies from the 1970s and 1980s found much higher ratios that reflected less-efficient breeds and use of large volumes of low-value feeds at that time. Zhou, Tian,

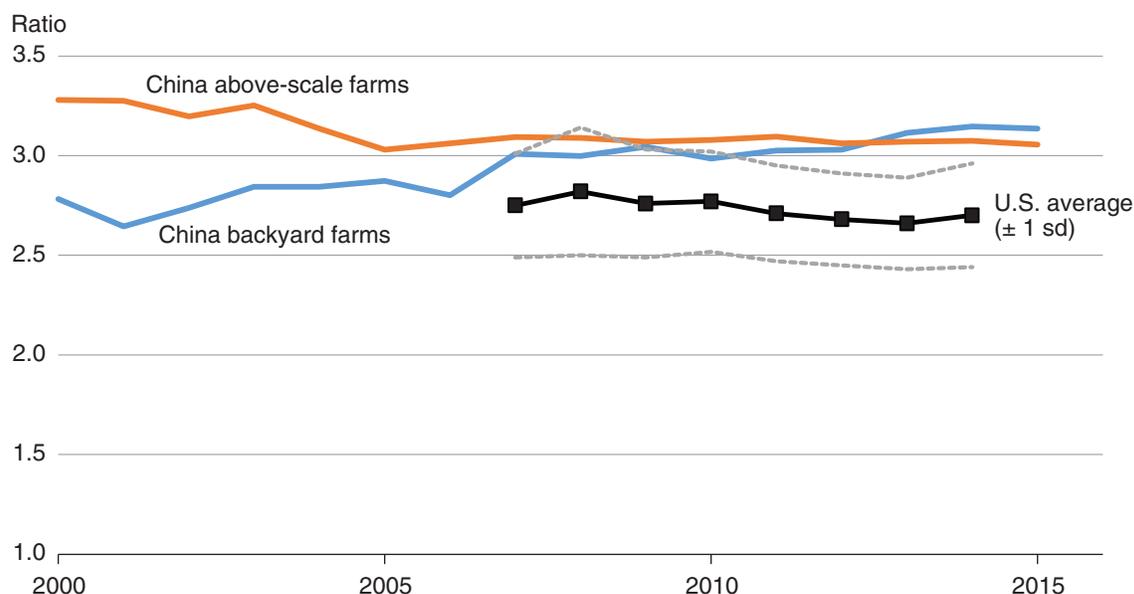
<sup>20</sup>The CNDRC data only reports the average weight of marketed hogs and does not reveal whether feed was used for sows, boars, or gilts. The inventory of animals is not reported either.

and Liu (2003) attributed surprisingly low FCRs for feed concentrates to the use of large volumes of coarse feeds. No previous studies tracked feed conversion ratios over time.

The CNDRC data reveal a decline in the FCR for above-scale farms from about 3.3 in 2000 to 3.0 to 3.1 during 2006-15, which reflects a moderate improvement in the efficiency of feed use (fig. 15). About 7- to 8-percent less feed concentrates are used to produce each pound of weight gain in 2015 than in 2000. In contrast, the feed concentrate FCR increased for backyard farms from 2.6 in 2001 to 3.1 in 2015. During 2007-14, the FCR for backyard farms was nearly identical to that of above-scale farms. The increase in backyard FCR likely reflects the shift in feed composition from coarse fodder to concentrates reflected in figures 13 and 14. Considering that backyard farms supplemented concentrates with more coarse fodder than did above-scale farms, the nearly equal FCR for feed concentrates between the two farm types implies that backyard farms are overall less efficient than above-scale farms.

The FCRs for U.S. producers reported by Stadler (2015) were less than those for Chinese producers during 2006-2014, indicating that U.S. producers are more efficient at converting feed to weight gain than are Chinese producers. The U.S. producers reported slight improvement from 2.82 in 2008 to 2.66 in 2013. In 2008, Chinese FCRs were about 11 percent higher than the U.S. ratios, but the margin between Chinese and U.S. FCRs grew to 14-15 percent in 2013-14. During 2007-10, the average Chinese FCR was within one standard deviation of the U.S. average, but in 2014 the Chinese average exceeded the U.S. average by 1.4 standard deviations. The data suggest that U.S.

Figure 15  
**Feed conversion ratios, 2000-15**



Note: Feed conversion ratio = (feed concentrate used)/(finished hog weight – piglet weight). U.S. average is for conventional finishers. The standard deviation reported by Stadler (2015) was used to calculate an interval to show the variation in the U.S. average.

Source: ERS analysis of data from China National Development and Reform Commission and Stadler (2015).

producers increased their efficiency advantage over Chinese producers in recent years.<sup>21</sup> The 11- to 15-percent U.S.-China difference in FCR is much less than the 24- to 39-percent U.S.-China difference in daily weight gain shown above in figure 12, suggesting that the faster U.S. weight gain is achieved partly by using larger amounts of feed than Chinese farms use.

### *Labor productivity*

Rising labor costs spurred structural change in the North American hog sector during the 20th century (Fredeen and Harmon, 1983; McBride and Key, 2013), and labor costs appear to play a similar role in China’s hog sector. The labor efficiency of hog production in China has increased as production shifted to larger-scale operations with a lower ratio of laborers to hogs.

A measure of labor input per unit of output was calculated from the CNDRC data to gauge the improvement:

$$Labor\ Efficiency\left(\frac{days}{100lb}\right) = \frac{Labor\ per\ hog\ (days)}{Weight\ of\ finished\ hog\ (lb) - Piglet\ weight\ (lb)} \times 100.$$

This measure reflects the average days of labor input during the finishing stage of production. Like the FCR, a lower value reflects higher labor productivity.

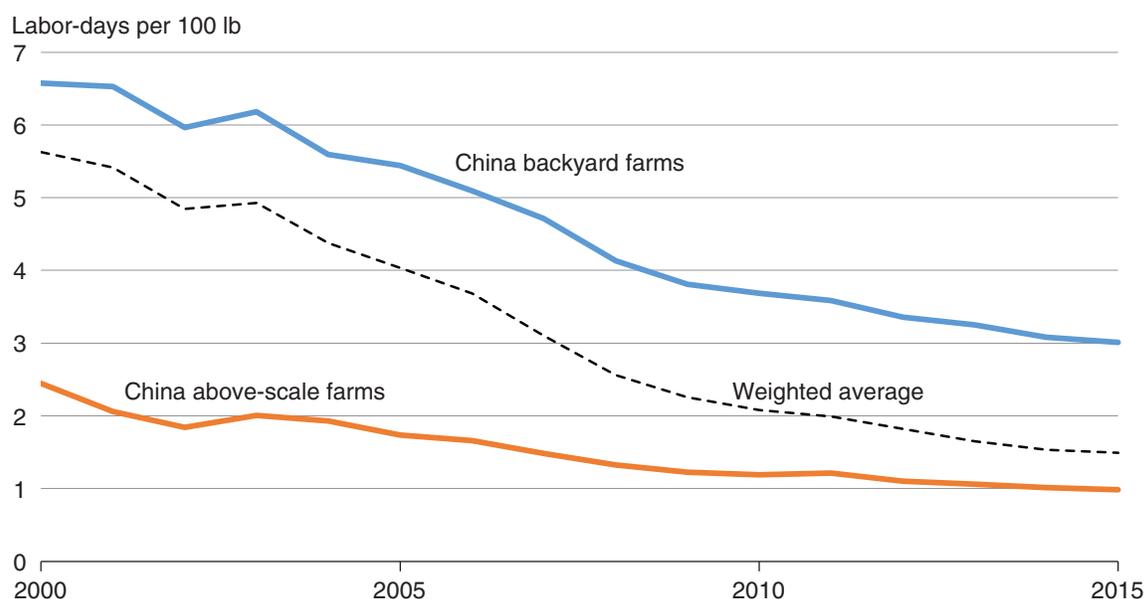
Labor input in Chinese hog production has fallen dramatically. Backyard farms used 6.6 days of labor for each 100 lb of weight gain in 2000, but only 3 days in 2015 (fig. 16). The labor used by above-scale farms dropped from 2.4 days in 2000 to 1 day in 2015. Above-scale farms consistently used less than half as much labor as backyard farms. Thus, the sector boosted overall efficiency of labor use by raising a larger share of pigs on above-scale farms, where labor is more productive than on backyard operations.

Indexes of labor input per 100 lb of weight gain for U.S. hog producers estimated by McBride and Key (2013) were much lower than China’s. McBride and Key estimated that U.S. feeder-to-finish hog producers used only 0.12 hours per 100-lb weight gain in 2009. China’s labor use (assuming 8 hours per labor-day) in 2009 was 9.6 hours per 100 lb for above-scale farms and 30.4 hours for backyard Chinese farms. The difference reflects larger housing facilities and automated equipment on U.S. farms that permit a single worker to handle thousands of hogs (see box, “Verifying Labor Productivity Differences”).

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<sup>21</sup>McBride and Key (2013) reported rapid improvement in FCR and lower values than Stadler (2015). They reported that the FCR for U.S. feeder-finish producers declined from 3.8 in 1992 to 2.07 in 2009.

Figure 16  
**Hog farm labor efficiency, 2000-15**



Note: Feed conversion ratio = (feed concentrate used)/(finished hog weight – piglet weight). U.S. average is for conventional finishers. The standard deviation reported by Stadler (2015) was used to calculate an interval to show the variation in the U.S. average.

Source: ERS analysis of data from China National Development and Reform Commission and Stadler (2015).

## Verifying Labor Productivity Differences

Calculations using other data confirm that the difference in labor productivity on hog farms in China and the United States is quite large.

The 2012 U.S. agricultural census reported that U.S. farms predominantly engaged in swine production produced 179 million hogs and employed 70,800 workers (including both hired and unpaid workers), an average of 2,520 head sold per worker.<sup>1</sup> China has no statistics on employment in hog production. CNDRC data reported an average of 4.8 days of labor was used per finished hog, and China produced 698 million hogs in 2012. That implies labor requirement of 13.4 million full-time-equivalent workers, assuming full-time employment of 250 days of labor per year.

In fact, hog production is predominantly a part-time activity in China, so a much larger number of people are engaged in producing hogs. In 2012, the Ministry of Agriculture reported that China had 55 million farms producing hogs. The national output of 698 million hogs implies less than 13 hogs per farm. Multiplying 13 hogs per farm by the labor requirement of 4.8 days of labor per hog implies an average of 62 days of labor per farm devoted to producing hogs annually.

<sup>1</sup>Data for farms classified in North American Industrial Classification category 1122, “swine farms.”

## Conclusion

China's emergence as a pork importer reflects growing resource scarcity as the nature of hog production there undergoes dramatic change. As China's pork prices rise above global prices, imported pork and other types of animal protein are becoming more attractive to consumers, processors, and food-service buyers in China. Rising production costs prevent Chinese pork prices from declining to become competitive with international prices.

During the 20th century, China became the world's leading pork producer by dispersing hogs in the backyards of rural households, a production model that utilized China's abundant rural labor supply. As economic growth accelerated, labor was drawn out of the countryside, and falling birth rates further tightened the rural labor supply. Improved off-farm employment prospects prompted exit from backyard hog production, and the scale and specialization of hog farms increased. Rapid improvement in labor efficiency on China's hog farms is a reflection of the rising opportunity cost of rural labor. China's hog industry is now in an era of rapid consolidation similar to that experienced by the United States during the 20th century (see Van Arsdall, 1978; Fredeen and Harmon, 1983). Labor efficiency of China's hog farms is still much lower than that of their U.S. counterparts, and McBride and Key (2013) found that labor efficiency on U.S. hog farms continued to improve rapidly from 1992 to 2009. While wages are also much lower in China than in the United States, the withdrawal of labor from hog farming and consolidation of farms in China is likely to continue.

Feed is the largest component of production costs for China's hog farms. Concentrates like grains, oilseed meals, and commercial feeds have now largely displaced low-cost fodders traditionally used to raise hogs. This study found that feed costs for China's hog producers were about 20 percent higher than those incurred by U.S. producers during 2000, but the difference grew to 77 percent in 2014.

As a net importer of feed ingredients, growth in feed demand has prompted China to reduce barriers to imports of oilseeds and several other feed ingredients since the 1990s (Gale, 2015). Nevertheless, China's feed costs are still higher than those of pork producers in countries like the United States, where grain and oilseed prices are lower. The impact of higher production costs on pork prices in China may prompt China to import pork from countries with lower production costs, an outcome anticipated by Hayes and Clemens (1997).

Meade et al. (2016) estimated that shipping soybeans from production regions in the United States and Brazil added 17- to 29 percent to the landed cost of soybeans arriving in China. This differential is consistent with the 20- to 30-percent difference in China-U.S. soybean meal prices found in the current study. China exerts stronger control over corn by limiting imports with a tariff rate quota. A support-price policy prevented domestic corn prices from falling during years of low global corn prices. The China-U.S. differential in corn prices was much larger: 30- to 40 percent in many years and 180 percent in 2014.

Chinese authorities are now allowing China's corn price to decline, a policy change that could reduce cost pressure on the country's hog producers. Feed costs for China's hog producers fell slightly during 2015, when the support price for domestic corn was reduced by 10 percent. During 2016, authorities announced that the country's price floor for corn would be eliminated, and corn prices began to fall as that year's crop was harvested. However, China's feed costs will likely remain higher than in countries with lower grain and oilseed prices despite elimination of the price

floor. For example, China's soybean meal prices remained higher than U.S. prices, despite elimination of a similar floor price program for soybeans in 2014.

Raising productivity to improve the swine industry's competitiveness is one of the themes of the 2016-20 5-year plan for swine production (China Ministry of Agriculture, 2016). The plan calls for increasing mechanization and automation on swine farms, shifting pork production to grain-abundant regions, and upgrading supporting industries that supply breeding stock, feed, and veterinary drugs. The plan set objectives that include raising the share of hogs produced by farms of 500 or more head from 42 percent in 2014 to 52 percent in 2020. Exit of small-scale farms with low productivity and high production costs is likely to continue. Expansion by larger farms with high productivity may be constrained by land scarcity, costs of complying with environmental regulations, and limited supplies of investment capital and skilled farm managers.

This study found rising costs of feeder pigs for Chinese farms in recent years, but it was not able to examine productivity in the important farrowing and nursery stages of production. Commentaries in Chinese animal science publications often emphasize the low ratio of finished hogs to sows in China, which reflects high mortality, short productive lives for sows, and vulnerability to disease in this segment of the production chain.<sup>22</sup> Increasing the number of finished hogs per sow and strengthening disease control and prevention are also objectives of the 2016-20 5-year plan that reflect these concerns. More productive and long-lived sows reduce the cost and feed requirements of supporting a large sow population and holding back female pigs to become replacement gilts. Officials subsidize artificial insemination to upgrade and standardize breeds and reduce the inventory of boars needed to service the sow herd (Tan, 2015).

Other costs may be more significant than they appeared in the data examined by this study. For example, the data showed very low expenses for land and capital investment, but acquiring tracts of land and constructing modern facilities for large farms is clearly much more costly than rudimentary structures used by small-scale producers to house animals. Large farms have greater needs for working capital to finance feed purchases and wages that small farms often finance with cash flow or borrowing from informal sources. Anecdotal information suggests that small-scale farms often invest little in facilities for waste treatment and disposal, but large farms are more likely to make such investments given the volume of waste they produce. Large farms are less able to avoid attention from inspectors and regulators than are small, dispersed farms. More stringent regulation of hog production will reduce external costs of water pollution, disease, and other nuisances, but will raise costs for producers and constrain the expansion of the hog sector.

The 5-year plan specifically targets improvements in feed conversion and labor productivity. Improvements in feed efficiency can be achieved through various measures that include better design of facilities such as better heating, cooling, and ventilation; mixing feed to balance protein, energy, and micronutrients appropriate to the stage of production; reducing mycotoxins and other impurities in feed through better quality control; and better disease management. The large shortfall in China's labor productivity likely reflects more extensive use of labor due to low wages, but low labor productivity could also result from lack of training and high worker turnover. Johnson (2015) and Ellerman (2016) identified several avenues for improving management of Chinese hog farms, such as reducing employee turnover; optimizing temperature, lighting, and sanitation in barns; better

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<sup>22</sup>Zhang (2015) reported that most farms he visited during 2014-15 were experiencing financial losses, but some were profitable because they managed sows well. He advised farms to focus on preventing several diseases and disorders that reduced conception rates, increased stillbirths, and piglet mortality.

monitoring and management of sows; improvements in the way vaccines are supplied and administered; and screening diseased animals.

China's national 5-year plan for 2016-2020 advocates strict controls on use of cropland that may restrain growth of hog production. The 5-year plan orders officials to restrict conversion of cropland to livestock farms and other uses in order to maintain production of staple food crops viewed as essential to national food security. A reform of grain subsidies announced in 2016 calls for withholding subsidy payments for cropland that has been converted to livestock farms (Central Government Web Portal, 2016).

Environmental concerns may also constrain growth in China's hog farms. China's 5-year plan for hog production calls for removing farms from major urban areas and southern regions that are vulnerable to water pollution. The plan targets the northeastern grain-producing region and traditional hog-raising areas of southwestern provinces for growth. The plan may raise costs for Chinese producers by requiring treatment facilities for manure and investment in biogas equipment.

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