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China's Meat Consumption: Growth Potential

Fred Gale and Fengxia Dong

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Abstract

China is a major meat producer, consumer, and importer, but consumption changes are difficult to assess due to inconsistencies in Chinese data. China's population growth is slowing, meat prices are rising, and income is growing at a slower pace than during earlier decades. Disease and other supply-side factors constrain domestic meat supply and imports are a growing share of the supply of each type of meat. Nevertheless, statistical models based on consumer income growth and meat prices suggest China has potential for continued growth in meat consumption. Consumption of poultry, beef, and mutton is growing faster than pork consumption but pork still comprises more than half of consumer meat expenditure in China. Consumption is growing despite rising meat prices in China, and statistical models confirm that consumption is relatively insensitive to price changes. Beef and mutton consumption have risen despite sustained price increases for these meats. Poultry appears to be a substitute for pork.

Keywords: meat consumption, China, livestock, pork, poultry, beef, mutton, Almost Ideal Demand System

About the Authors

Fred Gale and Fengxia Dong are agricultural economists with the USDA, Economic Research Service.

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A report summary from the Economic Research Service *July 2023*

China's Meat Consumption: Growth Potential

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What Is the Issue?

China's emergence as a major meat producer, consumer, and importer may have potential for export opportunities for the United States and other producers. China has become the world's largest meat importer, as growth in its own production has diminished. Growth in China's meat production and consumption has slowed due to decelerating population and income growth, animal disease, scarcity of land for feed and forage, rising production costs, and health concerns. Has China's consumption of meat reached a ceiling, or is there room for more growth? This study investigates trends in China's meat supply and household purchases, discusses data inconsistences, analyzes population, income, and price data that influence consumption, and estimates statistical models to ascertain future growth in China's meat consumption.

What Did the Study Find?

Chinese meat prices have risen faster than other commodity prices since the 1990s, but meat consumption is relatively insensitive to prices.

- ERS analysts looked at beef, mutton, pork, and poultry and found that the relationship between consumption and prices is inelastic (i.e., the demand changed proportionately less than the price).
- Poultry consumption is stimulated by rising pork prices, but substitutability between other types of meats is weak and inconsistent across data sets and estimation techniques.
- Several supply shocks (due to swine disease outbreaks) resulted in large swings in pork prices.
- Poultry consumption decreased during outbreaks of avian influenza when cases in humans occurred.
- Consumption of beef and mutton continued rising despite large price increases.

Imports comprised 9.1 percent of China's meat supply in 2021, up from 1.0 percent in 2000. Meat imports accounted for a growing share of supply, as production growth diminished. In 2021, net meat imports comprised 18.6 percent of China's beef and mutton disappearance, 8.3 percent for pork, and 5.0 percent for poultry.

Data discrepancies still prevent precise analysis of meat consumption trends despite China's revisions of production data and survey methods. Statistics indicate that China's per capita meat supply is about twice as large as consumption reported by a Chinese national household survey. Meat supply statistics indicate an apparent plateau in China's meat consumption after 2014, but the household survey indicates more robust growth in meat consumption.

- Both sources indicate that poultry, beef, and mutton are gradually increasing their share of China's meat consumption spending.
- Pork's share declined but still comprises more than half of consumer meat expenditures.
- For each type of meat, analysis of household survey data indicated greater sensitivity to each meat's own price than did analysis of disappearance data.
- Household survey data indicate a small decline in meat consumption during 2019–20, when China's meat supply declined sharply due to a swine disease. However, the household survey and supply data both indicate a strong consumption recovery in 2021.

China's household income growth averaged 7.6 percent annually during 1985–2021, but income growth fell below this average during most years after 2014.

- Despite rising consumption and prices, meat expenditures comprise a shrinking share of Chinese household budgets.
- Pork consumption is relatively insensitive to income, but poultry, beef and mutton consumption is more responsive to income growth.

Based on past relationships between meat consumption, income, and prices, per capita meat consumption is projected to rise during 2022–31 by 23 kilograms using consumer purchase data and 21 kilograms using disappearance data. Pork consumption is projected to grow slower than the consumption of other meats.

How Was the Study Conducted?

This report analyzes China's meat consumption using two official Chinese data sources: (1) disappearance calculated from meat production and net import data, and (2) household purchases of meat reported by a national household survey. The report discusses the divergence of the two data series, changes in consumption of three major categories of meat, growth in household income, and fluctuation in meat prices. The study estimates relationships between meat consumption, meat prices, and household income, using two methods: (1) first-differenced linear regressions of three categories of per capita meat consumption on inflation-adjusted per capita income and meat prices, and (2) a first-differenced Almost Ideal Demand System for expenditure on three meat categories. Using these estimates, the study calculates predicted meat consumption for 2022–31 based on assumed paths of income and prices.

China's Meat Consumption: Growth Potential

Introduction

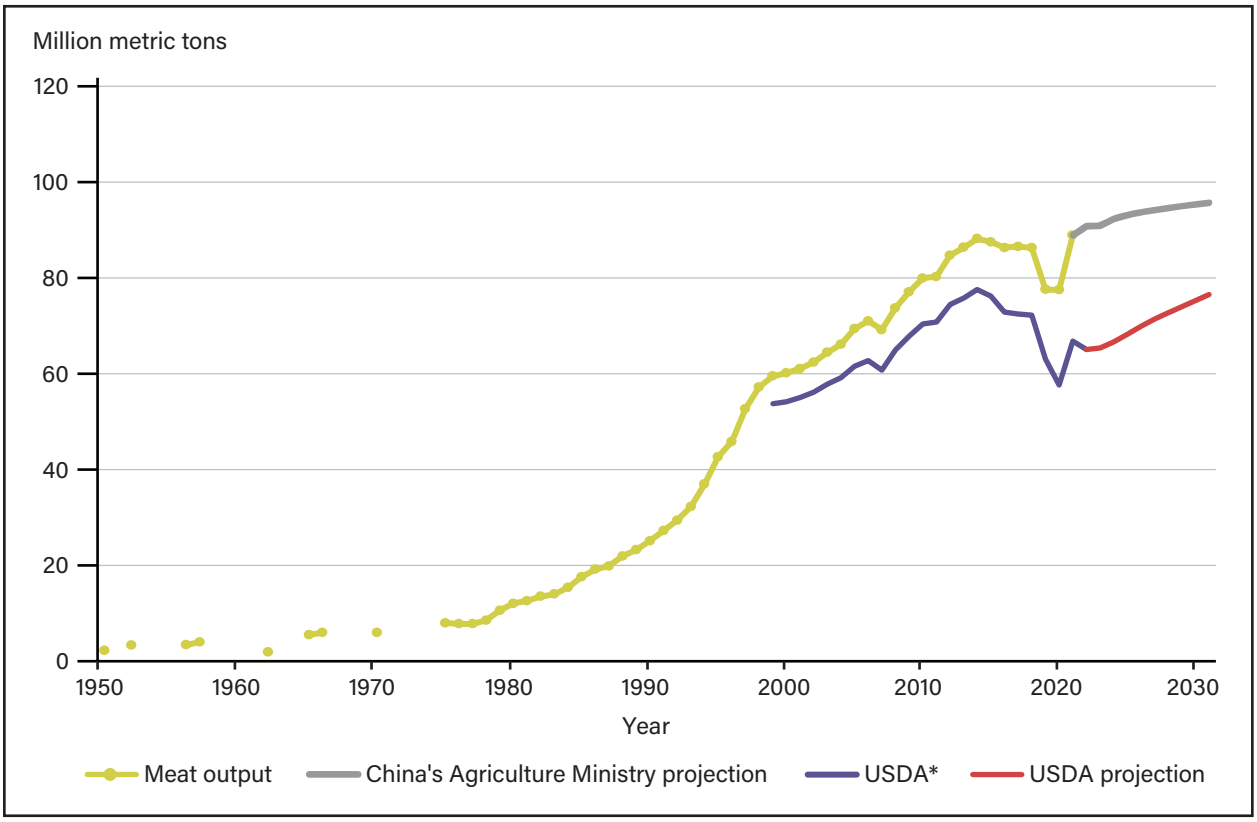
Meat consumption in China was low until the late 20th century. After several decades of rapid growth, China has emerged as a major producer, consumer, and importer of meat. This trend creates new opportunities for exporters in the United States and other countries, but it also poses food security challenges and environmental impacts (Ortega et al., 2015; Yu, 2015; Ortega et al., 2022). In recent years animal disease, scarcity of land for feed production, rising costs, and health concerns have contributed to slower growth. Has China's meat consumption reached a ceiling, or is there room for more growth?

An early 20th-century study of Chinese food and agriculture (Buck, 1937) found that nearly all calories were obtained from plant sources because little land was available to support animal agriculture. Yet, China seemingly overcame this constraint during the 1980s to early 2000s, as its production and consumption of meat boomed. National data show that China's meat output grew from less than 10 million metric tons in the 1970s to 60 million metric tons in 2000, reflecting a vast increase in meat consumption (figure 1). Data from the United Nations Food and Agriculture Organization show that the share of calories supplied by meat in China rose from 4 percent to 19 percent between the 1960s and the 2000s (Ortega et al., 2015).

However, the rate of growth slowed somewhat after 2000 and then abruptly ceased after reaching a peak of 88 million metric tons in 2014. Production dropped to 77.5 million metric tons during 2019–20 due to a severe swine disease outbreak. The data indicate a recovery to a record 89 million metric tons in 2021. China's Ministry of Agriculture and Rural Affairs (China MARA, 2022) projected a resumption of modest growth in meat output that would reach 93.1 million metric tons in 2025 and 95.7 million metric tons by 2031.

The difficulties of assessing China's meat situation—due mainly to concerns about the accuracy of China's data—are illustrated by a comparison with USDA estimates of pork, beef, and chicken output (figure 1; note that USDA data exclude sheep, waterfowl, and other meats such as rabbit and deer). USDA estimates also show a peak in meat output in 2014, but a steeper output decrease from 2014 to 2020 than the Chinese MARA data shows. The USDA estimates show a delayed Chinese recovery from the trough in output in 2020, but output in 2031 is still projected slightly lower than the 2014 peak.

Figure 1
Increase in China's meat output, 1950–2031



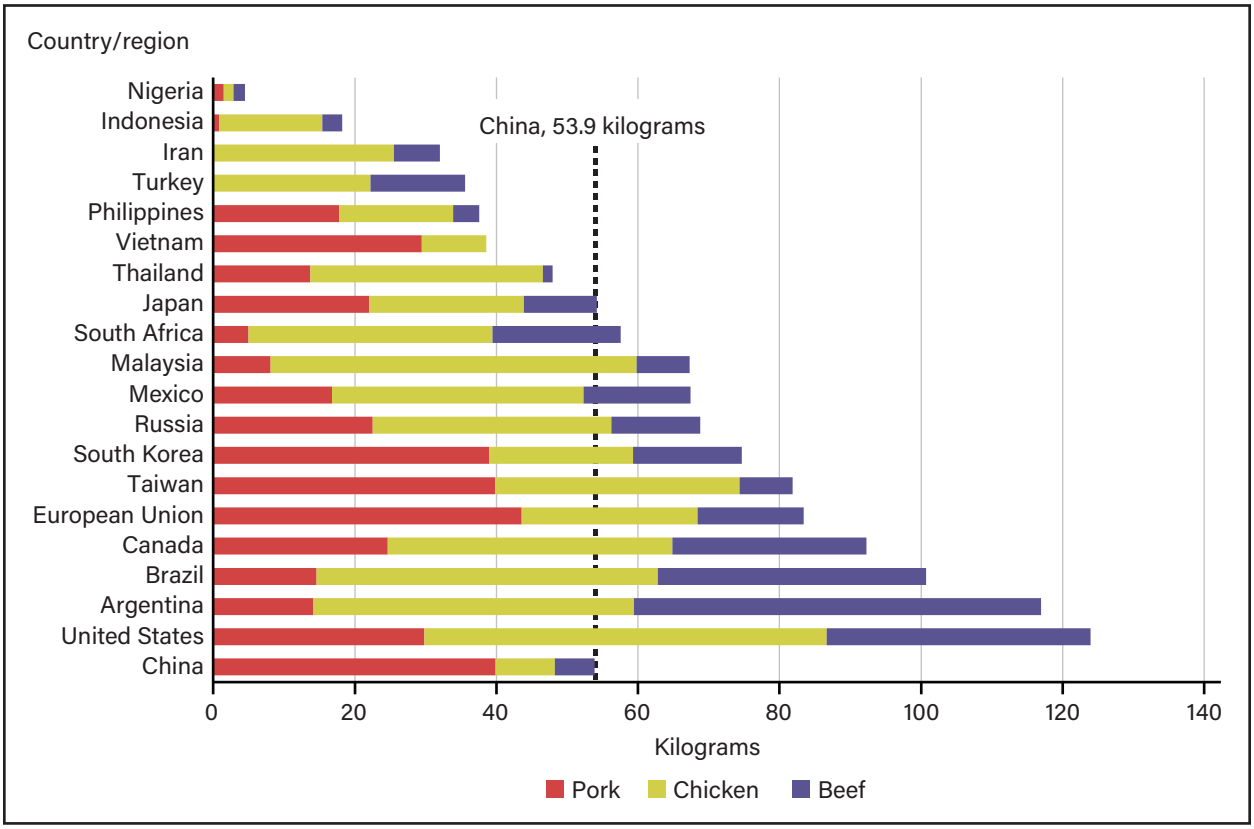
*USDA data include pork, chicken, and beef and exclude sheep, waterfowl, and minor meats such as rabbit and deer.

Note: Output of meat is a carcass weight equivalent for slaughtered hogs, cattle, sheep, and poultry.

Source: USDA, Economic Research Service, based on China National Bureau of Statistics data, China MARA (2022), and USDA data from Production, Supply, and Distribution database and USDA International Projections to 2031.

USDA's Production, Supply, and Distribution database reported that China was the largest producer of pork in 2018, the second-leading producer of chicken, and the third-leading producer of beef. However, China's per capita consumption of meat was lower than in many middle- and high-income countries. According to USDA's international baseline database, China's combined consumption of pork, chicken, and beef was 53.9 kilograms per capita in 2018 (this number excludes sheep and waterfowl that were not included in the USDA data), which is about the same as the meat consumption level in Japan and slightly more than in Thailand (figure 2). Some middle-income regions in Asia (such as Malaysia, Taiwan, and South Korea) had a per capita consumption that exceeded China's by 10 kilograms or more. The United States, Argentina, Brazil, Canada, and the European Union also had a much higher per capita meat consumption than in China. Per capita consumption in the United States and Argentina is about twice the level in China. Meat consumption in China was dominated by pork—China's per capita pork consumption was one of the world's highest, but per capita consumption of chicken and beef in China were low, shown in figure 2.

Figure 2
Per capita meat consumption, selected countries and regions, 2018

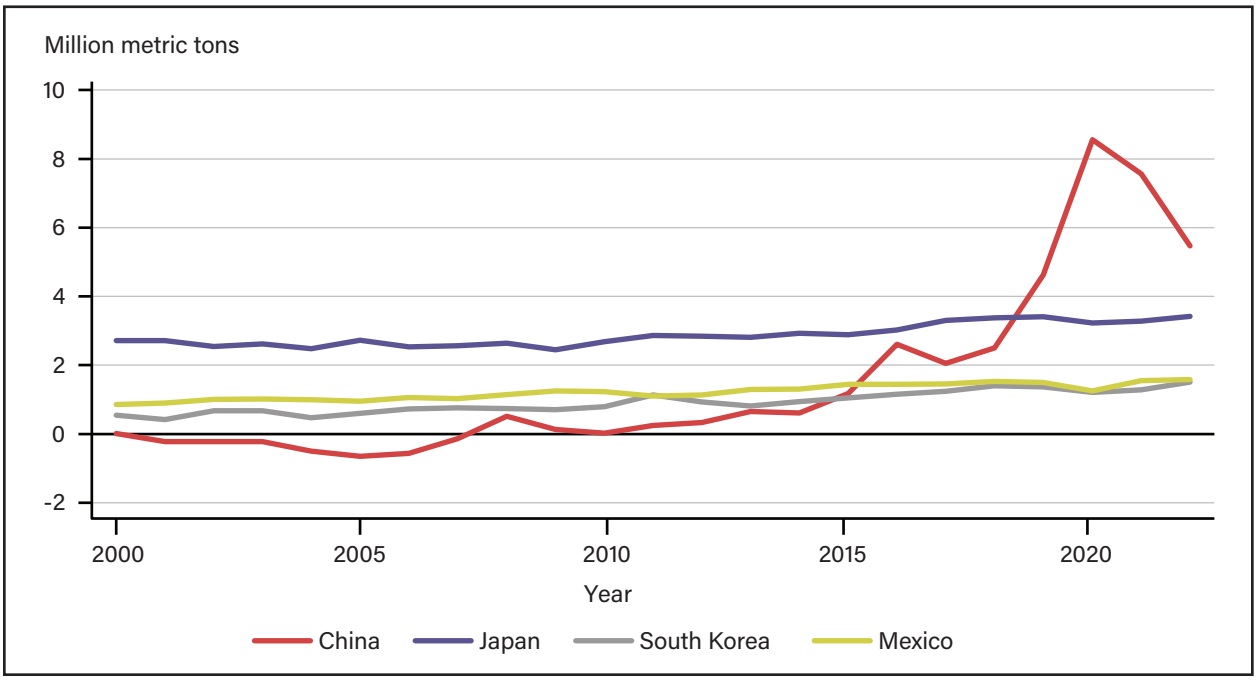


Source: USDA, Economic Research Service based on USDA international baseline database.

China relies on the global market to sustain growth in meat production and consumption. China's meat production created demand for animal feeds that made China the top importer of soybeans and feed grains such as corn, sorghum, and barley (Gale, 2015; Gale et al., 2019). As meat production growth slowed, China began to import meat and now is an important player in global meat markets. USDA estimates show that China's meat imports surpassed those of other top importers (Mexico, South Korea, and Japan) between 2015 and 2019 (figure 3). China was the world's top meat importer by a substantial margin in 2020. China was the top importer in 2022, despite a sharp drop in imports after pork production recovered rapidly in 2021. Future meat imports could remain large or increase if consumption outpaces growth in domestic production.[1] USDA's Baseline projections showed that China's pork imports could reach 6.3 million metric tons in 2031, beef imports could reach 4.0 million metric tons, and chicken imports could reach nearly 1.3 million metric tons.

[1] Beckman et al. (2022) found that nontariff barriers prevented China's pork and beef imports from growing even larger.

Figure 3
Leading meat-importing countries, 2000–22*



*2022 is a forecast.

Note: Net imports = imports – exports. Meat is the sum of pork, beef, and chicken in carcass weight equivalent.

Source: USDA, Economic Research Service analysis of USDA Production, Supply and Distribution data.

The potential for further growth in China's meat consumption is uncertain. While a significant portion of China's population still has nutritional deficiencies that indicate low meat consumption (Liu et al., 2018), rising incidences of obesity, heart disease, and other diet-related diseases have prompted Chinese public health experts to recommend that consumers curb meat consumption (China State Council, 2014; China Nutrition Society, 2021). Additionally, concerns about environmental impacts of livestock production and animal welfare are encouraging consumption of plant-based and lab-grown meats (Ortega et al., 2022).

Income growth is likely to prompt additional spending on meat, but China's income and population growth are slowing. Some studies found that the pace of meat consumption growth slows as consumer incomes reach a higher level (Gale and Huang, 2007; Chen et al., 2016). Land constraints in China identified by Buck (1937) contributed to rising feed costs and the degradation of grasslands. With constraints on Chinese supply and growth in demand, meat prices have been rising faster than inflation. The rise in prices may offset the effects of income growth to some extent.

The report analyzes trends and fluctuations in production, net imports, consumption of meat, meat prices, and consumer income by using data from China's National Bureau of Statistics and Administration of Customs. The analysis disaggregates meat into three main components—pork, poultry, and beef and mutton—and investigates the changing composition of China's meat consumption. The report also discusses inconsistencies between disappearance and household purchase data that cannot be reconciled and conducts parallel analyses of the two data series. In addition, the study estimates the sensitivity of meat consumption to changes in consumer income and the fluctuation in meat prices (based on historical data) and supply-side factors constraining meat consumption are discussed. The report projects future consumption based on moderate income growth and a continuation of the trend toward rising inflation-adjusted meat prices, to ascertain the prospects for continued growth.

Conflicting Measures of Per Capita Meat Consumption

The amount of meat consumed in China is difficult to ascertain since no statistics directly measure China's aggregate meat consumption. Analysts indirectly estimate consumption as "disappearance" using an identity based on the assumption that consumption equals the available supply:

Disappearance = Production + Net Imports – Inventory Change (1)

Disappearance is a residual quantity estimated by adding domestic production and net imports (imports – exports) (shown in figures 1 and 3), plus inventory change (ending inventory – beginning inventory). The calculation assumes that all meat available is consumed. This report assumes that inventory change is a negligible portion of the annual meat supply since inventories of meat—a perishable product—cannot be stored easily and China's national meat reserves are not revealed to the public (see appendix 1, "China's Meat Reserve").

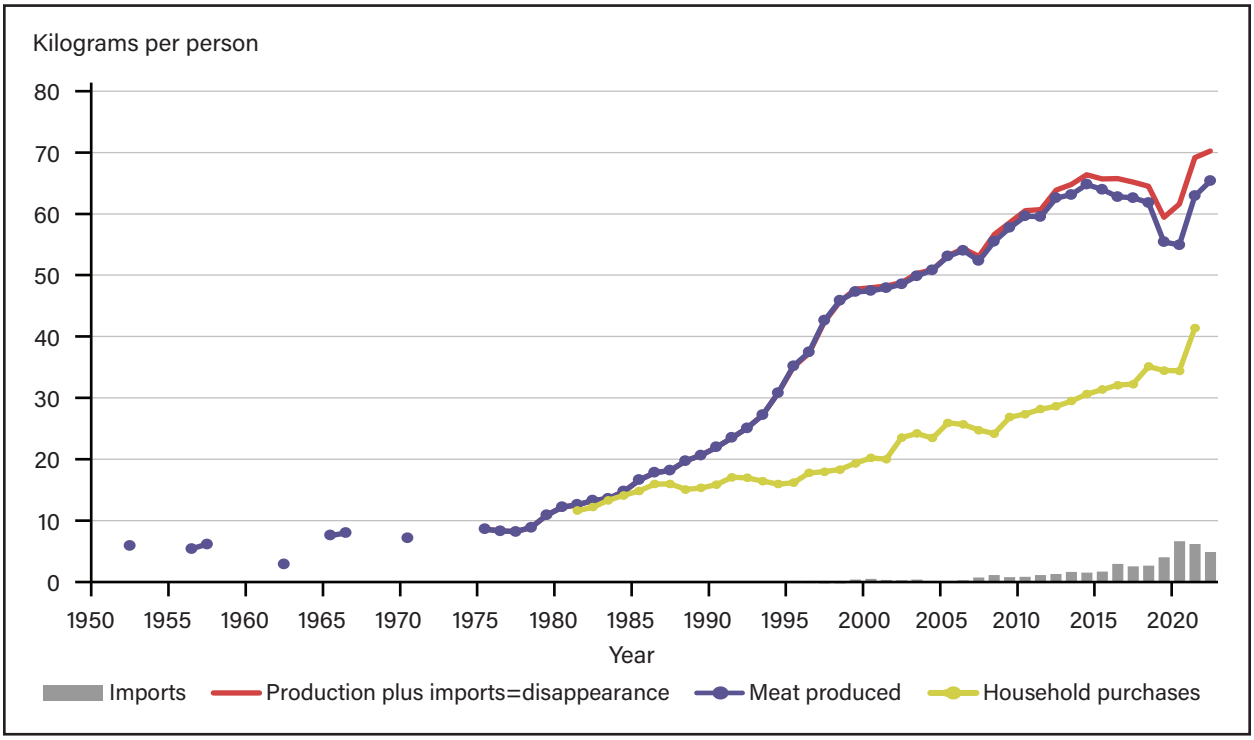
China produced nearly all the meat it consumed until recent years, so meat production is the main statistical indicator available to measure consumption, estimated annually by China's National Bureau of Statistics. The main components are the dressed weights of slaughtered hogs, cattle, and sheep and the final weight of poultry.[2] The accuracy of consumption estimates is also determined by the quality of production data. Appendix 2 discusses the changes in statistical methodology and meat data revisions that raise questions about the accuracy and consistency of these data.

Growth in Chinese per capita meat disappearance is an indicator that consumption has outpaced population growth. Per capita disappearance estimates indicate that China's meat consumption grew from under 10 kilograms/person in the 1970s to 66 kilograms/person in 2014 (figure 4). After 2014, the growth trend reversed, as meat disappearance declined gradually to 64.5 kilograms/person in 2019. Meat disappearance then fell sharply to 58.7 kilograms/person in 2019, reflecting reduced meat supplies resulting from a nationwide outbreak of African swine fever.[3] Net imports grew during 2014–20 but not enough to fully offset the decline in meat output. Official Chinese data indicate that meat disappearance rebounded in 2021, as farms reestablished swine herds and production recovered. With imports added to domestic production, disappearance was at a record-high 69.4 kilograms/person in 2021 and rose to 70.2 kilograms/person in 2022.

[2] Documentation in China National Bureau of Statistics Rural Statistical Yearbooks indicates that its estimates of meat output are the weight of carcasses after removing head, feet, internal organs, and blood. The data are estimated from rural livestock surveys and do not appear to directly measure carcasses produced by slaughter facilities.

[3] The African swine fever virus spread throughout China during 2018–19, causing a large reduction in the pork supply.

Figure 4
Per capita meat disappearance and household purchases per capita in China, 1952–2022



Note: Per capita values are calculated using official population data. Household purchases are the weighted average of rural and urban Chinese consumption of pork, poultry, beef and mutton for 1981–2012 and the national average for 2013–22, reported by China National Bureau of Statistics.

Source: USDA, Economic Research Service, based on China National Bureau of Statistics and China Statistical Yearbook, various years.

Another measure of meat consumption—household purchases of meat per capita—is measured by a household survey conducted by China's National Bureau of Statistics (independent of the surveys used to develop meat production estimates). While the household survey is the only direct measure of consumption, the survey is incomplete because it does not capture meat consumed away from home in restaurants, cafeterias, and institutions. Nor does the household survey fully account for meat used in processed foods or waste and spoilage in the marketing chain. Some observers suspect that the survey sample may not be representative of the national population and discontinuities in the data suggest that the survey may not accurately reflect trends and fluctuations. The issues related to this survey are discussed in more detail in appendix 2.

The per capita amount of meat Chinese households purchased shown in figure 4 is not entirely consistent with the trend in disappearance.[4] Household purchases and disappearance were approximately equal during the 1980s, but they diverged during the 1990s as disappearance rose at a much faster pace, as shown in appendix figure 2. This inconsistency prompted some scholars in China to suggest that the meat disappearance data were inflated by exaggerating production growth while household purchases missed rising consumption of meat away from home (see box, "Inconsistencies in Chinese Meat Data").

Growth in household purchases and meat disappearance were nearly parallel during the 2000s, but per capita disappearance was more than twice as large as household purchases. After 2014, per capita disappearance began to decline, while household purchases continued to grow. The magnitude of the decline in disap-

[4] The chart shows an average of Chinese urban and rural consumption weighted by population for 1985–2012 and the national average reported by China's National Bureau of Statistics for 2013–22.

pearance during 2019 was much larger than the decline in purchases. Both disappearance and purchases increased sharply in 2021. Household purchases grew 7.0 kilograms in 2021, slightly less than the 7.5-kilogram growth in disappearance that year. In 2021, per capita meat disappearance was 69.2 kilograms, still 67.0 percent higher than household purchases that averaged 41.4 kilograms.

Detailed estimates of per capita meat disappearance show the growing importance of meat imports in China's meat supply. Data showed growth in meat imports partially offset falling production during 2014–20 and facilitated record-high meat consumption in 2021 and 2022. Net imports grew 1.1 kilograms during 2000–14, then grew from 1.6 kilograms to 4.9 kilograms during 2014–22. Net imports accounted for 2.3 percent of disappearance in 2014, peaked at 10.9 percent in 2020, and declined to 6.9 percent in 2022. The increase in imports from 2014 to 2022 accounted for nearly all the 3.9-kilogram increase in meat disappearance over that period.

Table 1
Estimates of China's per capita meat disappearance, 2000–22

Year	Production	Net imports*	Meat supply = disappearance	Net imports share of disappearance
	Kilograms			Percent
2000	47.4	0.5	47.9	1.0
2014	64.8	1.6	66.4	2.3
2015	64.0	1.7	65.7	2.7
2016	62.8	3.1	65.8	4.7
2017	62.6	2.6	65.2	4.0
2018	61.8	2.7	64.5	4.2
2019	55.4	4.1	59.5	6.9
2020	54.9	6.7	61.7	10.9
2021	62.9	6.3	69.2	9.1
2022	65.4	4.9	70.2	6.9
Cumulative changes:				
2000–14	17.4	1.1	18.4	1.3
2014–22	0.6	3.3	3.9	85.6

*Net imports = imports - exports, Harmonized System code 02 "meat and edible meat offal."

Note: Calendar year data. Production data reflect revisions made by China's National Bureau of Statistics following agricultural censuses conducted in 2007 and 2017. Per capita values are calculated by dividing national production and import values by total population.

Source: USDA, Economic Research Service calculations using data from the China National Bureau of Statistics and China Customs Administration.

Inconsistencies in Chinese Meat Data

Zhong (1997) first pointed out the apparent exaggeration of meat production statistics and their inconsistency with household survey data. Several studies investigated the inconsistencies and attempted to reconcile the production and consumption data (Xiao et al., 2015). Detailed discussion of statistical methodologies and revisions of China's meat data are in appendix 2, Review of China's Meat Statistics.

Fuller et al. (2000), Ma et al. (2004), and Yu and Abler (2014) attributed the inconsistencies between meat production and consumption data to several factors: incentives to inflate livestock numbers, failure to incorporate consumption of meat away from home, and the exclusion of waste and food processing. Those authors used multiple data sources and assumptions to reconcile the two series.

A downward revision of official livestock data following a 1997 Chinese agricultural census seemed to validate concerns about over-reporting of livestock data. Fuller et al. (2000) explained how inflation of livestock data could have resulted from pressure to achieve production targets and incentives created by the privatization of livestock production and marketing. Xiao et al. (2015) denied any evidence existed of overstated livestock data, yet they suggested that census data revisions following the 1997 and 2007 censuses improved the accuracy of the statistics. Calculations indicate that beef production data was revised downward again by 12.6 percent after the 2017 census, but pork and mutton were revised upward slightly.

Shao et al. (2020) observed that declining inventories of swine—a variable related to pork output—after 2014 was inconsistent with market conditions. As possible causes, they cited environmental regulation and reduced reporting by local officials concerned that inflated data would be exposed by the Chinese agricultural census in 2016. It is unclear, however, why no similar decline was reported by China's National Bureau of Statistics for beef, mutton, or poultry which were also subject to environmental regulation and had also been revised downward in censuses (see appendix table 2). Shao et al. (2020) used hog and feed prices and a machine learning algorithm to adjust monthly swine inventory data reported by China's Ministry of Agriculture and Rural Affairs (MARA), but the study did not analyze pork output directly.

Failure to capture Chinese meat consumption away from home is potentially a major source of discrepancy. A survey by Xiao et al. (2015) conducted during 2010 found that 33 percent of meat was consumed away from home, and Bai et al.'s (2020) surveys during 2010–12 found that 28 percent of meat was consumed away from home. Xi et al. (2016) cited several surveys showing that 12–40 percent of poultry was consumed away from home. Yu and Abler (2014) argued that China's National Bureau of Statistics rural household survey understated per capita consumption by counting migrants and students who lived and ate elsewhere as rural household members. A revision of the household survey in 2012 appeared to address the rural migrant data issue by eliminating the rural-urban distinction in the survey and counting migrants based on their actual place of residence.

Yu and Abler (2014) concluded that over reporting of production was the largest contributor to the gap between reported pork supply and consumption but under reporting of consumption also played a role. Xiao et al. (2015) attributed most of the discrepancy in meat statistics to failure to capture meat consumed away from home.

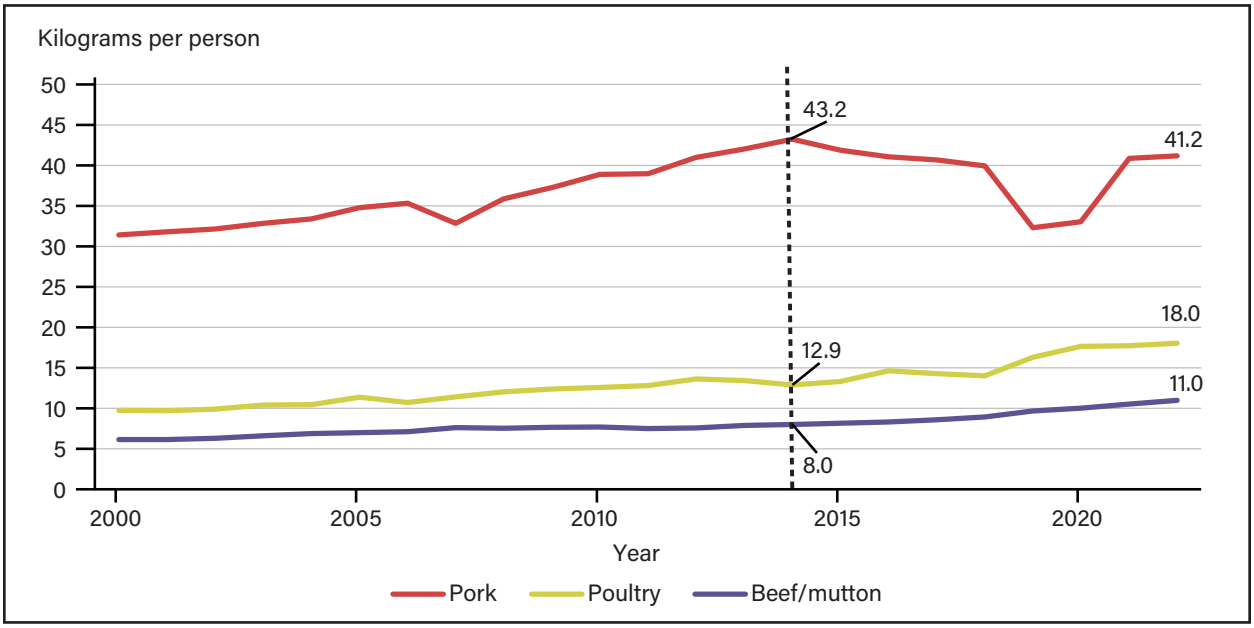
Production data is based on carcass weights and exclude feet, organs, blood, and head of animals (30 percent or more of the liveweight) but these items are often consumed in China. The household survey includes these items in meat purchases (see appendix 2).

Some meat counted in farm production statistics never reaches consumers due to waste and spoilage, thus accounting for part of the discrepancy between production and consumer purchase data. Aggregate supply and demand estimates by China's Ministry of Agriculture and Rural Affairs (2021) included estimates of waste and spoilage equal to 4.7 percent of supply for pork, 3.5 percent for beef, and 3.4 percent for mutton (no waste was reported for poultry). Xiao et al. (2015) cited estimates of meat waste that ranged from 5–20 percent. The only direct measurement of China's food waste, a survey of restaurant waste by Wang et al. (2017), indicated that meat accounted for 17 percent of waste (pork 8 percent, beef 3 percent, and poultry 6 percent). Based on this percentage, the Chinese food waste estimate of 11 kilograms per person per year implied 1.9 kilograms of per capita meat and poultry waste. That total would be less than 3 percent of meat disappearance that year, but does not include waste in processing, distribution, and retail.

Pork has always been the predominant meat consumed in China but its consumption has also been volatile. Pork disappearance peaked in 2014, fell dramatically in 2019, and rebounded in 2021 (figure 5 and appendix table 5). The peak in meat disappearance in 2014 shown in figure 4 appears to reflect the peak in pork disappearance while disappearance of poultry, beef, and mutton continued to grow from 2014 to 2022.

Chinese per capita household purchases of pork were constant from 2013 to 2017 (figure 6 and appendix table 5). Household purchases did not show the decline evident in the disappearance data during those years. Household pork purchases peaked in 2018, fell during 2019–20, then rebounded to a record high in 2021. Purchases of poultry were generally on an upward trend and surged during 2019–20 when pork purchases declined, consistent with Ma et al.'s (2021) finding that poultry is a strong substitute for pork. Beef and mutton purchases were much smaller but rose gradually during 2014–21.

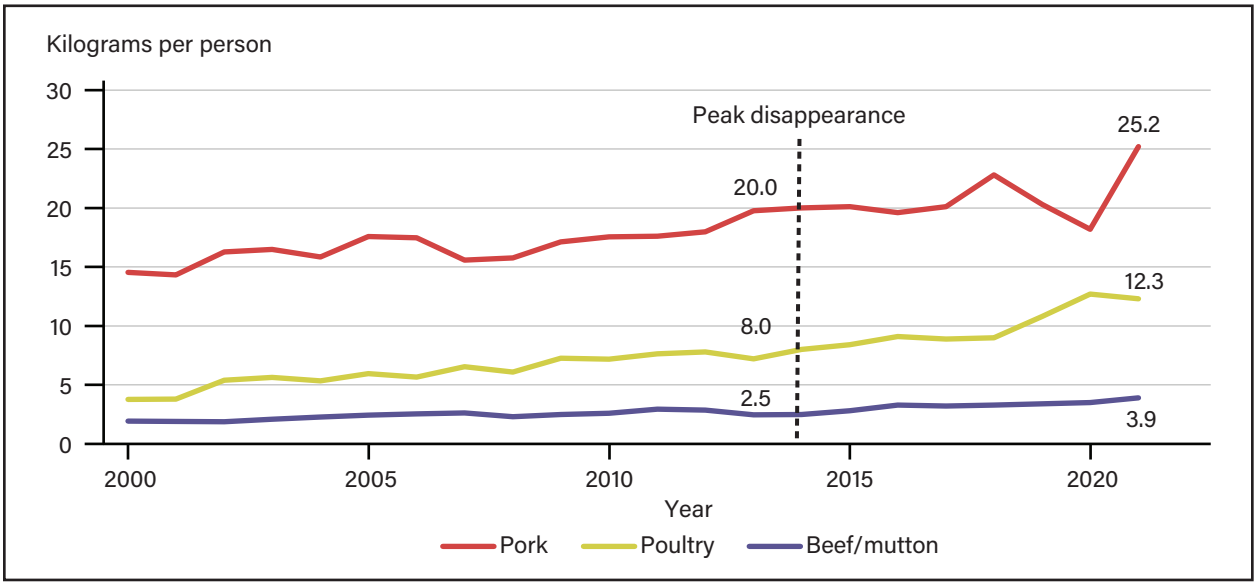
Figure 5
China's per capita disappearance of pork, poultry, and beef and mutton, 2000–22



Note: Disappearance = production + net imports. Net imports of pork (harmonized system (HS) codes 0203, 020630, 020641, 020649), poultry (HS code 0207), beef and mutton (HS codes 0201, 0202, 0204, 020610, 020621, 020622, 020680, 020690, 020629) are calculated from customs data.

Source: USDA, Economic Research Service, based on China's National Bureau of Statistics and China customs data, accessed through the Trade Data Monitor.

Figure 6
China's household purchases of pork, poultry, and beef and mutton, 2000–21



Source: USDA, Economic Research Service, based on data from China's National Bureau of Statistics.

Authors compared the Chinese disappearance and household purchase data series for each of the three meat categories. Disappearance was generally about twice as large as household purchases, but there was a slight tendency for the differences between the two series to narrow after 2014. In particular, pork disappearance was 100–125 percent larger than household purchases from 2000 to 2013 (see appendix figure 2). The difference in the pork data narrowed to 55 percent in 2019 and 2021, as disappearance fell faster than household purchases. For beef and mutton, the difference between disappearance and household purchases was even larger, fluctuating between 150 percent and 240 percent. From 2003 to 2021, poultry had the least difference between disappearance and household purchases. The difference for poultry declined from 75–100 percent during 2003–09 to 45 percent in 2021.

Authors also checked the consistency of year-to-year changes in consumption indicated by the disappearance and household purchase data. The correlation between changes in disappearance and household purchases for pork was 0.70 but the correspondence between the two data series deteriorated after 2014 (see appendix table 9). During 2000–13, the correlation for pork data was a relatively high 0.87 but the correlation for pork data during 2014–21 declined to a low value of 0.29. In contrast, the correlations between changes in disappearance and household purchases were higher for other meat categories: 0.98 for poultry and 0.95 for beef and mutton, and the correlations were also relatively stable between time periods.

Net imports comprised a growing share of disappearance for each of the three Chinese meat categories. Per capita net imports in 2010 were 0.6 kilograms for pork, 0.3 kilograms for poultry, and less than 0.1 kilograms for beef. These net import values were 2.0 percent or less of disappearance for each of the three meat categories. Pork net imports rose to 2.1 kilograms per person in 2016 and 2019, then reached 3.9 kilograms in 2020 and 3.4 kilograms in 2021 before they fell to 2.0 kilograms in 2022. Net imports comprised 11.9 percent of pork disappearance in 2020, then fell to 4.7 percent in 2022. Beef and mutton net imports rose to 19.9 percent of disappearance in 2022. Poultry net imports were generally between 1 percent and 2 percent of disappearance until they rose to 5 percent in 2020 and 2021 and 4.1 percent in 2022.

Table 2
China's net imports of pork, poultry, and beef and mutton per capita, 2010–21

Year	Net imports per capita			Net imports share of disappearance		
	Pork	Poultry	Beef and mutton	Pork	Poultry	Beef and mutton
	Kilograms			Percent		
2010	0.6	0.3	0.0	1.5	2.0	0.5
2011	0.9	0.2	0.1	2.4	1.2	0.8
2012	1.0	0.2	0.1	2.3	1.8	1.7
2013	1.0	0.3	0.4	2.3	2.1	5.3
2014	0.9	0.2	0.4	2.2	1.4	5.4
2015	1.1	0.1	0.5	2.6	0.9	6.3
2016	2.1	0.3	0.6	5.1	1.8	7.0
2017	1.7	0.2	0.7	4.2	1.1	8.0
2018	1.5	0.2	1.0	3.7	1.4	11.0
2019	2.1	0.4	1.5	6.6	2.5	15.3
2020	3.9	1.0	1.8	11.9	5.4	17.7
2021	3.4	0.9	2.0	8.3	5.0	18.6
2022	2.0	0.7	2.2	4.7	4.1	19.9

Note: net imports = imports – exports for pork (harmonized system codes 0203, 020630, 020641, 020649), poultry (HS code 0207), beef and mutton (HS codes 0201, 0202, 0204, 020610, 020621, 020622, 020680, 020690, 020629). Per capita values are calculated from population data. Disappearance = production + net imports.

Source: USDA, Economic Research Service calculations using data from China customs administration accessed through the Trade Data Monitor and China's National Bureau of Statistics.

Factors Affecting Meat Consumption

Population and Urbanization

Population growth affects aggregate consumption of meat. China's population grew 1.0 percent to 1.5 percent annually during the 1980s and 90s, contributing to rapid growth in aggregate meat consumption (figure 7). Population growth decelerated to 1.0 percent in the 2000s, coinciding with slower growth in meat disappearance. The one-child policy adopted in 1979 was replaced with a two-child policy in 2016 and then a three-child policy in 2021. Population growth nevertheless fell to near zero in 2021 and during 2022, according to official data. The United Nations projected a peak Chinese population of 1.425 billion and population declines of -0.1 percent to -0.3 percent annually during 2025–40. The United Nations projected a decline in China's population to 1.38 billion by 2040.

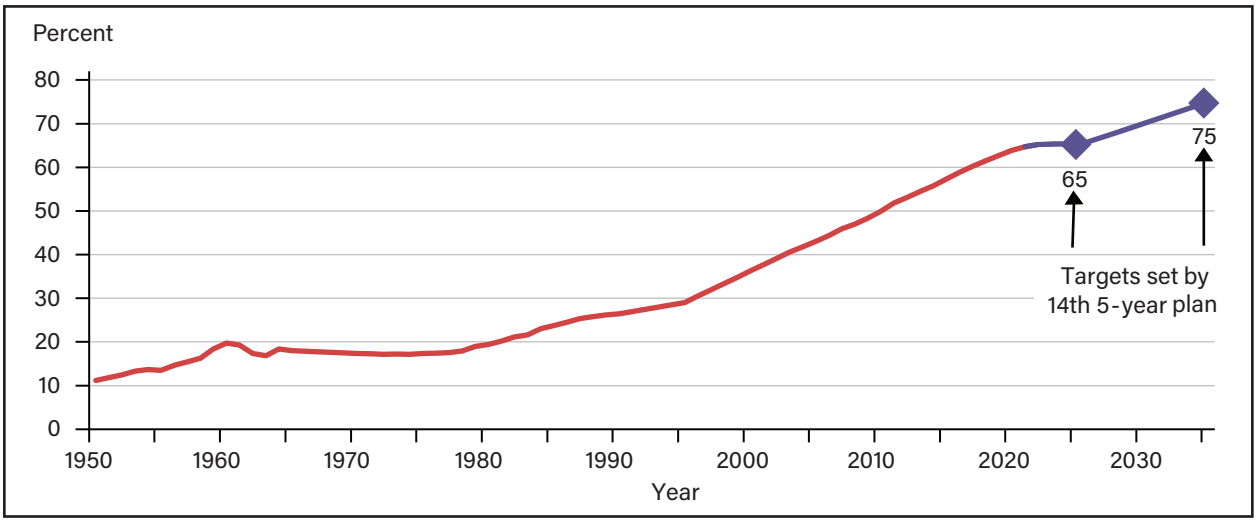
Figure 7
China's population growth, 1950–2040

Note: Reflects population data following revisions from the 2020 population census. Projections for 2022–40 are from the United Nations World Population Prospects 2022.

Source: USDA, Economic Research Service calculations using data from China's National Bureau of Statistics web site.

Urbanization of the population is another factor that contributes to rising meat consumption around the world (Regmi and Dyck, 2001) and in China (Zheng et al., 2019). China's urban population was less than 20 percent of the total during the 1970s. Urbanization grew to 27 percent in 1990, 36 percent in 2000, and 50 percent in 2010 (figure 8). China continued to urbanize during the 2010–20 decade, reaching 64 percent in 2020 and 65 percent in 2022. China's 14th 5-year plan set a target of 75 percent urbanization in 2035.

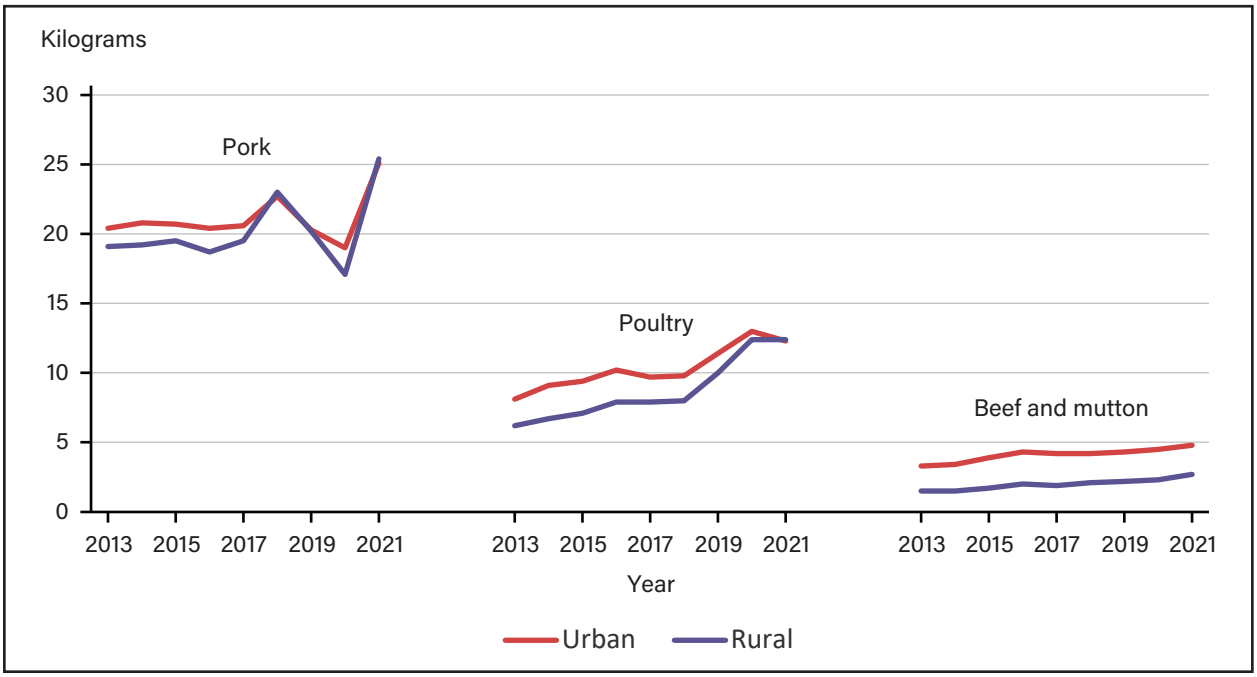
Figure 8
Urban share of China's population, 1950–2035



Source: USDA, Economic Research Service, calculated from China's National Bureau of Statistics data and China's 14th 5-year plan for social and economic development.

Per capita meat consumption is typically higher for urban than for rural residents in China—as the migration of rural Chinese workers to cities increases income, alters lifestyles, and gives migrants access to a greater variety of foods in urban markets and in workplace cafeterias and restaurants (Zheng et al., 2019). Urban and rural per capita household purchases of pork, poultry, and beef/mutton for 2013–21 indicate that urban-rural differences in pork and poultry have diminished (figure 9). The urban-rural difference in consumption largely disappeared in 2018 for pork and in 2020 for poultry. In contrast, an urban-rural difference in beef/mutton consumption of about 2.0 to 2.3 kilograms persisted, as both values rose in parallel over time.[5] Urban and rural values of pork and poultry purchases also displayed similar year-to-year fluctuations during 2017–21.

Figure 9
Per capita purchases of pork, poultry, and beef and mutton, China urban and rural households, 2013–21



Source: USDA, Economic Research Service analysis of data from China's National Bureau of Statistics, China Statistical Yearbook.

Regional Differences

China's regions have distinctly different meat consumption patterns that are obscured in national averages. The patterns reflect the different types of livestock traditionally predominant in these regions as well as income differences. The persisting differences across provinces are illustrated by fluctuations in per capita purchases of pork, poultry, and beef/mutton in five diverse regions (Beijing, Guangdong, Henan, Sichuan, and Xinjiang) during 2015–21 (figure 10). The national average for each year is also shown for comparison.

Per capita pork consumption is highest in southwestern Chinese provinces like Sichuan, where swine raising has historically been widespread, even though incomes are not high in those regions. According to China's National Bureau of Statistics household purchase data, per capita pork consumption in Sichuan exceeded the national average by 70 percent in 2018 (figure 10). In contrast, per capita pork consumption in Henan Province was consistently about 40 percent less than the national average despite also being a major pork-

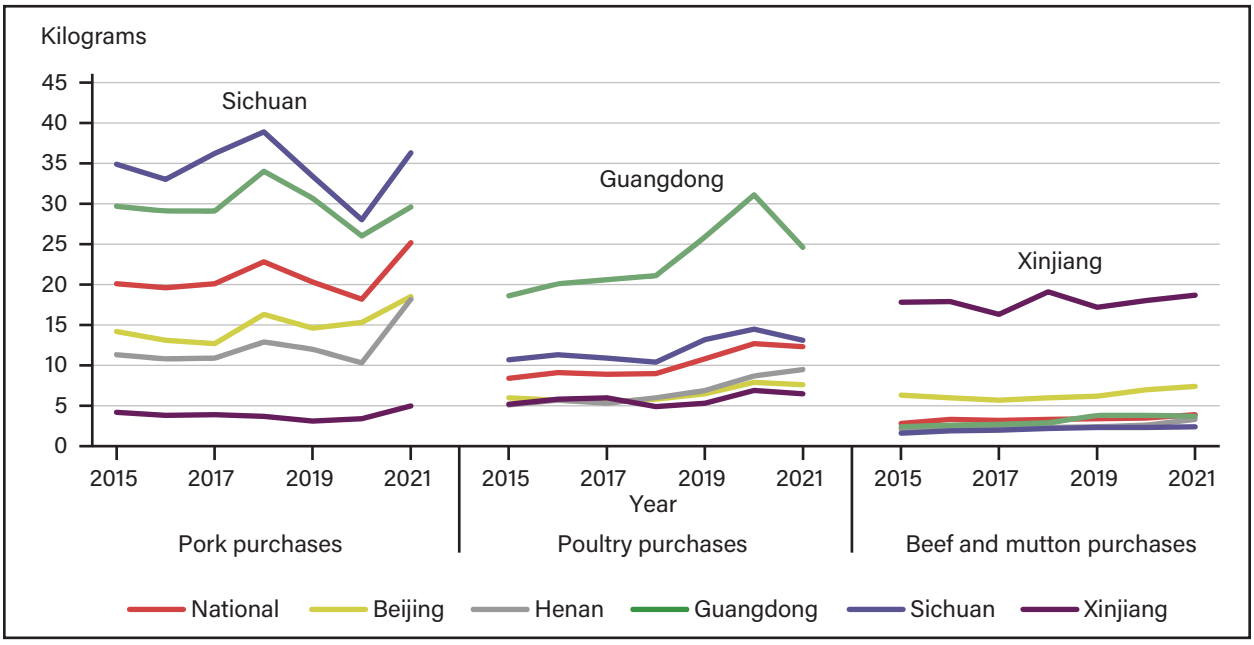
[5] Appendix 2 notes that a change in survey methodology in 2012 may have reduced the Chinese urban-rural difference in consumption by adjusting their classification of migrants in the household survey.

producing region. In Xinjiang, a region where much of the population is Muslim, pork purchases were about 80 percent below the national average. The large pork-consuming provinces of Sichuan and Guangdong had the largest fluctuations in pork purchases during 2019–21. The fluctuation in the national average was muted by much smaller fluctuations in regions like Beijing and Xinjiang.

Guangdong's per capita purchases of poultry were more than double the national average. Sichuan's poultry purchases were also slightly above the national average. Other regions shown (Beijing, Henan, and Xinjiang) had poultry purchases 3 to 4 kilograms below the national average. Fluctuations in the national average appear to reflect mainly fluctuations in Guangdong's and Sichuan's poultry purchases.

Conversely, beef and mutton consumption was highest in regions of western China, where grasslands historically supported pastoral grazing as a primary food source and the Muslim faith proscribes consumption of pork. Xinjiang's beef and mutton purchases far exceeded the national average, peaking at more than 19 kilograms per capita in 2018. Beijing's beef and mutton purchases were also about double the national average. Other regions shown in figure 10 had very low beef and mutton purchases, but the purchases tended to increase over time. For example, Henan's beef and mutton purchases rose from 2.1 kilograms to 3.3 kilograms between 2015 and 2021. Guangdong had low beef and mutton purchases, despite having a relatively high income, reflecting regional preferences for poultry and pork.

Figure 10
Chinese per capita household purchases of pork, poultry, and beef and mutton in selected provinces, 2015–21



Source: USDA, Economic Research Service analysis of household purchase data from the China National Bureau of Statistics.

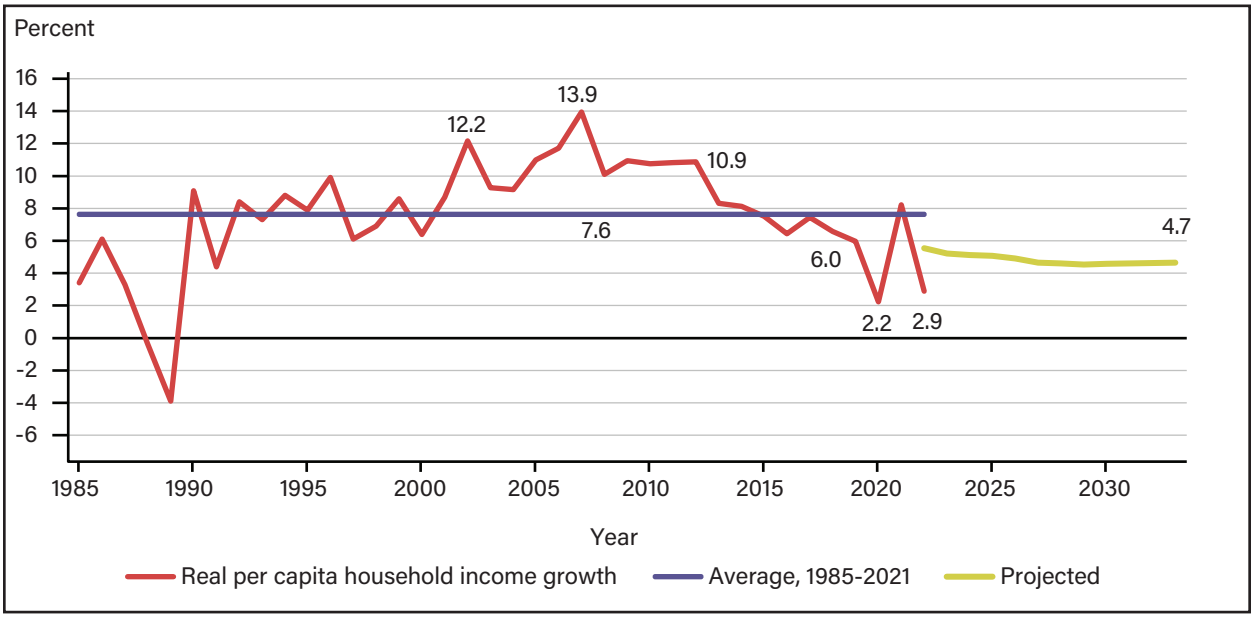
Income and Prices

Many previous studies found that meat consumption tends to rise with income and decline as meat prices rise but results varied in magnitude. Meta-analysis of 85 studies released between 1987 and 2012 found that income elasticities of demand for pork, beef, and mutton averaged about 0.6 but elasticities varied widely from negative values to elastic values of 1.5 (Chen et al., 2016; Zhou et al., 2020). Poultry income elasticities averaged 0.85 but also ranged widely from 0.14 to 3.5. Studies found meat and poultry price elasticities of demand that averaged -0.6 to -0.8, but they also varied from highly elastic values of -2.5 to some positive values. Demographic characteristics, like age of the household head, had minor effects (Chen et al., 2016). Most studies of food consumption in China analyzed cross sections of the per capita household purchase data. Studies used data produced prior to the revision of the household survey in 2013 discussed in appendix 2. A more recent study using rural and urban data for all provinces for 2000–12 found (unconditional) price elasticities above -0.7 for urban meat and poultry, -0.48 for rural pork, -0.38 for rural beef, and -0.28 for rural poultry (Zheng et al., 2019). Zheng et al. (2019) noted that their study excluded data after 2012 due to the survey revisions. Ma et al. (2021) estimated a price-flexibility model using time-series disappearance data for 1991–2018 to assess impacts of African swine fever on China's pork market. Their findings indicated that pork demand is price inelastic and that pork and poultry are strong substitutes. A recent analysis of time series data on meat demand in other Asian countries found results similar to those of the China studies (Rathnayaka et al., 2021).

USDA, ERS estimates that growth in China's real per capita household income averaged 7.6 percent per year from 1985 to 2021 (figure 11). Income growth exceeded the 7.6-percent average each year from 2001 to 2014, peaking at 13.9 percent in 2007. Income growth fell below the long-run average during 2015–20, slowing to 6 percent in 2019 and 2.2 percent during the Coronavirus (COVID-19) pandemic year of 2020. Income growth exceeded the long run average during 2021 (8.2 percent) but growth slowed to 2.9 percent during 2022 when many cities were under extended lockdowns to prevent spread of COVID-19. Meat consumption—especially away from home—was likely curtailed by restrictions on travel and reduced consumption in cafeterias and restaurants during intermittent city lockdowns during 2020–22. Projected Chinese per capita gross domestic product (GDP) growth of 4 to 5 percent annually for 2022–33 suggests that income growth may also remain at a rate well below the historical average.[6]

[6] Income growth data for 2022 was announced after the 2022–33 projections were made.

Figure 11
Growth in China's per capita disposable income



Note: Chart shows annual change in per capita disposable income. Real income growth was calculated by subtracting the change in the consumer price index each year. Projected values for 2022–33 reflected the projected per capita gross domestic product (GDP) from the USDA, Economic Research Service, International Macroeconomic Database.

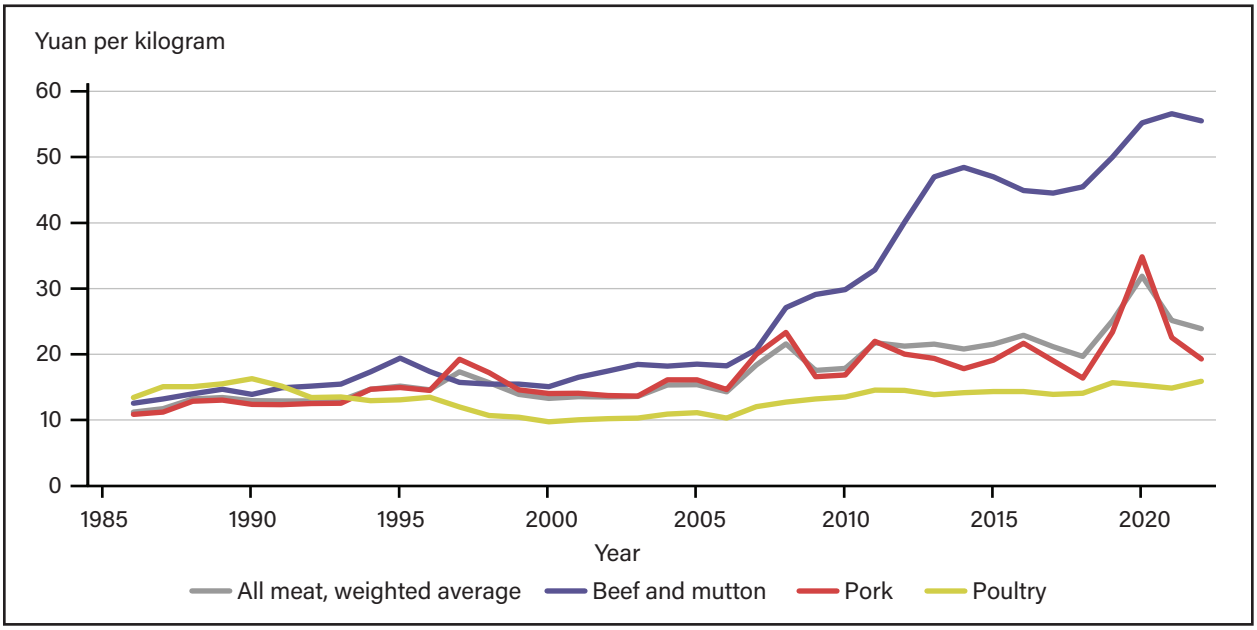
Source: USDA, Economic Research Service calculations using data from China's National Bureau of Statistics "cha shu" database.

Average annual meat prices adjusted for inflation rose faster than the general level of prices during 1985–2021 (figure 12).[7] The weighted average of meat prices largely reflected the price of pork, the predominant type of meat produced and consumed in China. Pork prices fluctuated from year to year, with prominent peaks occurring in 1997, 2008, and 2020. The inflation-adjusted pork price (in constant 2000 yuan) more than doubled from 10.9 yuan in 1986 to 22.5 yuan in 2021. One of the most severe meat price increases occurred during 2019–20, when the African swine fever epizootic reduced pork supplies. The pork price peaked at 34.82 yuan in 2020, before dropping to 22.75 yuan in 2021.

Beef and mutton prices clearly grew faster than other meat prices. The fastest growth occurred during 2007–14, when beef and mutton prices diverged from pork and poultry prices. Beef and mutton prices grew again during 2018–21. The average inflation-adjusted beef and mutton price in 2021 was 57.1 yuan, nearly five times higher than the 1986 average. Poultry prices grew at a slower pace than other meat prices. Inflation-adjusted poultry prices declined during the 1990s, then grew moderately during 2005–11 and displayed no clear trend during 2011–21. The average inflation-adjusted poultry price in 2021 was about the same as in 1990.

[7] Price data without inflation adjustment are available in appendix table 7.

Figure 12
China's average meat prices, 1986–2022 adjusted for inflation



Note: See box, "Calculating Annual Meat Prices" for an explanation of the data. Annual averages are calculated from monthly data, deflated to constant 2000 Chinese yuan with China's consumer price index. Prices in current yuan in 2021 were 36.15 yuan for pork, 21.71 yuan for chicken, and 85.6 yuan for beef and mutton.

Source: USDA, Economic Research Service calculations using data posted online by the China National Development and Reform Commission (2000–09), China National Bureau of Statistics (2010–14), and China Ministry of Agriculture and Rural Affairs (2015–21).

Calculating Annual Meat Prices

China has no continuous data series measuring meat prices over 1985–2022. USDA, ERS authors constructed a price series for Chinese pork, chicken, beef, and mutton by combining retail price data reports posted online by China's National Development and Reform Commission (NDRC, 1999–2017) and National Bureau of Statistics (NBS, 2013–17) with wholesale market prices posted by China's Ministry of Agriculture and Rural Affairs (MARA, 2006–22). ERS authors also calculated average annual Chinese prices for 1986–90 from expenditures and quantities reported in the household surveys for those years (see appendix table 7 for 2000–21 price data).

Monthly series were compared to verify that levels and fluctuations were consistent during years when multiple series were available. Annual average prices were calculated from monthly and weekly prices. Prices from household survey data represented 1986–2000. USDA, ERS selected the NDRC data to represent 1999–2008, NBS for 2009–2017, and MARA for 2018–22. An average retail-wholesale margin was added to the wholesale prices for 2018–22 to approximate the retail price. The margin was calculated as the difference between retail and wholesale prices for 2009–17 when retail and wholesale data were both available.

An average overall Chinese meat price was calculated by weighting the price of meat in each category by production of that type of meat. China's consumer price index, with a fixed base of 1978, was used to deflate prices. The CPI was adjusted to reflect constant yuan for year 2000.

Consumer Budget Shares Devoted to Meat

The change in the Chinese share of consumer spending devoted to meat is an indication of income elasticity and the sensitivity of consumer purchases to price changes. Zheng et al. (2019) showed that overall food spending's share of household expenses declined over time. USDA, ERS estimated meat household expenditures from 1986 to 2021 as the product of average household purchases and the weighted average meat price. Estimated meat expenditure was divided by total household expenditures and household food expenditures reported by the National Bureau of Statistics in the China Statistical Yearbook to ascertain the importance of meat in consumer budgets. The estimates indicate that the share of meat in Chinese consumers' overall budgets had shrunk by half since the 1990s, despite growth in meat consumption and rising meat prices (figure 13). Meat's share of all household expenditures fluctuated in the range of 11 to 13 percent during the 1980s to mid-1990s, then fell to 4 to 6 percent during 2012–18. The share rebounded to near 7 percent in 2020 due to high pork prices following the African swine fever epizootic. The meat share declined slightly to 6.3 percent in 2021 when pork prices fell but quantity consumed increased sharply.

The share of meat spending in consumers' food budgets fluctuated between 20 percent and 25 percent from 1986 to 2005. The meat share of food spending fell to 15 percent in 2014 and below 15 percent in 2017–18. The meat share of food spending rebounded to 22 percent in 2020 due to high pork prices that year, similar to the share during the 1990s. The share of food spending remained at a relatively high level of 21.1 percent in 2021.

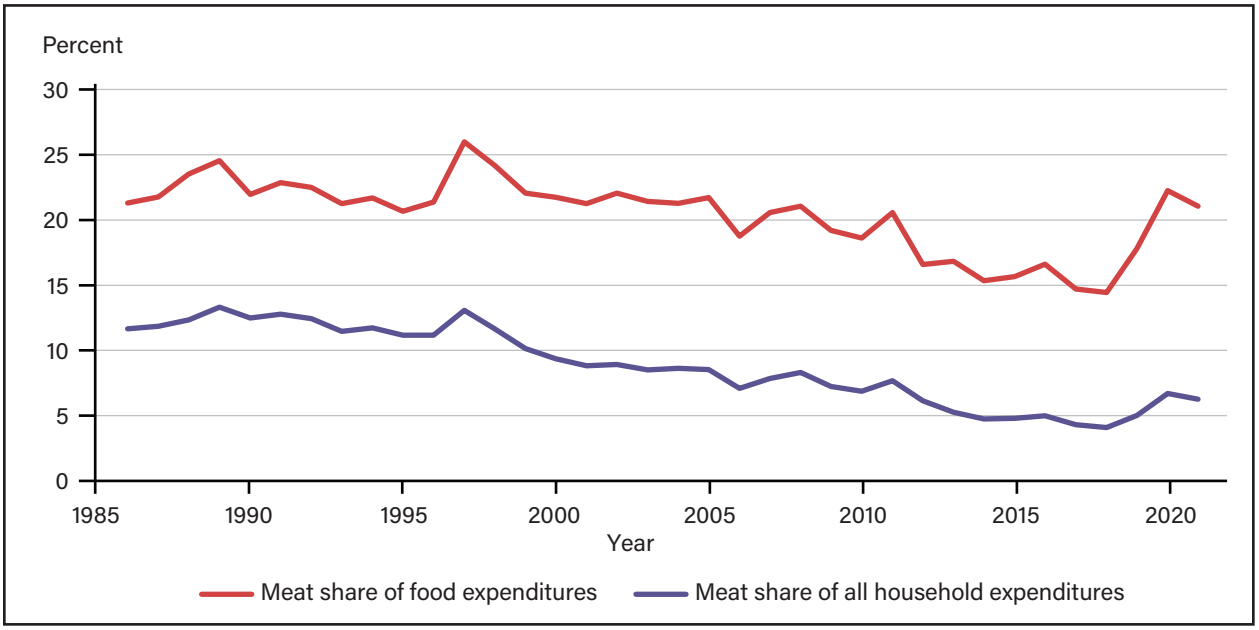
The long-term downward trend in the meat share of household expenditure is the result of Chinese households' faster spending growth on nonfood items. Most of the shrinkage in meat's share of the food budget occurred from 2011 to 2018 when average inflation-adjusted meat prices were relatively steady. Temporary increases in the meat budget share correspond to surges in pork prices during 2007–08, 2011, and 2019–20. Each of these increases occurred after a major swine disease event. The downward trend in meat budget share was reversed by the increase in meat prices during 2019–20. The increase in household meat consumption during 2021 sustained the meat budget share at a relatively high level.[8] Still, meat comprised just 6 percent of all household spending in 2021. Economic theory suggests that a small budget share reduces the relative impact of meat prices on consumer budgets.[9] A smaller budget share, therefore, tends to reduce consumers' sensitivity to meat price changes.

Chinese consumers' shares of spending on different types of meat indicate that pork is the predominant component of meat spending. The large share of pork reflects traditional consumption habits, the use of pork in recipes and, in turn, the widespread raising of pigs by Chinese households in past decades. Calculations indicate that pork accounted for 70–80 percent of Chinese consumers' meat spending during the 1980s and 1990s (figure 14). At that time, poultry accounted for 12–15 percent of meat spending while beef and mutton accounted for less than 10 percent.

[8] Chinese household purchases increased for nearly every food item in 2021. The ratio of food spending to household expenditure was nearly constant in 2020–21 at about 30 percent. Increased at-home purchases of all foods, combined with an unchanged overall food expenditure share, might reflect increased consumption of food at home and less spending on food consumed away from home during COVID-19 lockdowns.

[9] The "Slutsky equation" (derived in many economics textbooks) decomposes the effect of price changes on consumption into a substitution effect and an income effect that depends on the good's income elasticity of demand and its share in a consumer's budget.

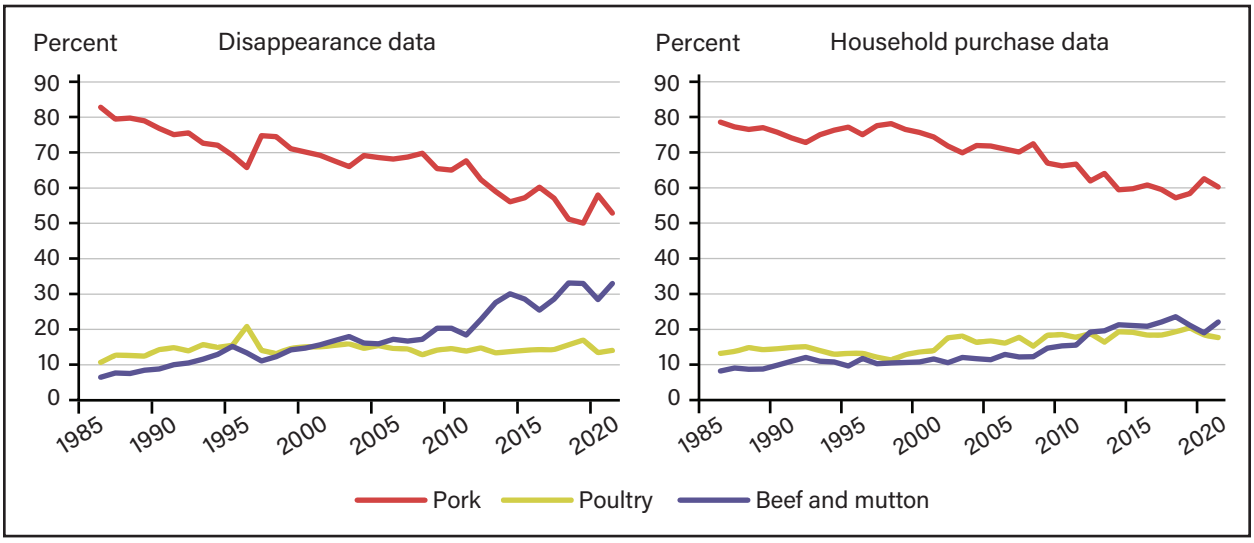
Figure 13
Estimated meat spending share of Chinese consumers' household budget, 1986–2021



Note: Expenditures on meat are the product of average per capita household purchases and weighted-average meat price. Budget share is calculated as the ratio of estimated meat expenditures to per capita total household expenditure.

Source: USDA, Economic Research Service analysis of data from China's National Bureau of Statistics, National Development and Reform Commission and Ministry of Agriculture.

Figure 14
China meat budget shares, 1986–2021



Note: USDA. Economic Research Service estimated Chinese expenditures on pork, poultry, and beef-mutton as the product of per capita disappearance and household purchases and average price for each meat. Budget shares are the ratio of each type of meat to total meat expenditure. Shares add to 100 for each year.

Source: USDA, Economic Research Service calculations using data from China's National Bureau of Statistics, National Development and Reform Commission, and Ministry of Agriculture.

Pork's dominance gradually declined as other meats gained popularity. Pork's share of meat spending fell to 60 percent during 2014–17, then fell to 57 percent in 2018, before rebounding to 63 percent in 2020.[10] Shares of expenditures on beef, mutton, and poultry gradually increased. Beef and mutton's share grew to a peak of 24 percent in 2018 and fell to 19 percent in 2020. The growing beef-and-mutton share reflected both rising purchases and higher prices for these meats. While poultry purchases rose in volume, the price of poultry did not grow as fast as the prices of other meats. Consequently, poultry's share of the meat budget remained roughly steady at 16–20 percent during 2002–20.

Supply Side Factors

Supply-side factors indirectly affect meat consumption through their impact on production costs and prices of livestock, and the supply of meat. Disappearance estimates show that rising Chinese imports have allowed meat consumption to exceed domestic production. However, China's meat consumption is not entirely independent of its domestic supply, since growth in meat imports is limited by tariffs and nontariff barriers, which prevent imports from rising enough to equilibrate Chinese and international prices (Beckman et al., 2022). Consequently, sustained growth in domestic livestock prices led to rising consumer prices that constrained growth in consumption.

China overcame its land scarcity constraints to produce more meat than Buck (1937) thought possible during the 1980s and 90s, when rapid expansion by small-scale operators was facilitated by abundant rural labor resources, utilization of low-cost feeds like food waste and milling by-products, and the use of crude housing for animals. More recently, livestock supply has become constrained by rising off-farm wages and barriers to entry that raised capital requirements. Land scarcity continues to restrain growth—reflected by rising prices for feed, degraded grassland, and shortage of fodder crops.

Authors investigated historical events and compared Chinese trends in livestock production costs with the rise of corresponding meat prices to gain insight about supply side factors. *China Animal Husbandry and Veterinary Yearbooks* revealed that animal diseases disrupted markets in recent years. Reduced pork supplies due to swine diseases corresponded to prominent surges in pork prices: the "blue ear disease" epizootic during 2007, the porcine epidemic diarrhea virus (PEDv) in 2011, and the African swine fever epizootic in 2018–20. These swine disease outbreaks reduced pork supplies by killing many animals and prompting widespread culling of additional animals to stop the spread of the diseases. These swine diseases did not directly affect pork demand since the diseases do not spread to humans.[11] China also had numerous strains of avian influenza constantly circulating in the poultry population (Su et al., 2015). Widespread outbreaks in 2004, 2005, 2013, and 2014 reduced demand for poultry due to the risk of diseases spreading to humans. Poultry sales dropped 50 to 70 percent during an outbreak in 2005 that spread to humans (Jiang, 2006). *Workers Daily* (2013) said demand for poultry had "fallen off a cliff" during H7N9 avian influenza outbreaks that began in March 2013. Xi et al. (2016) attributed reduced demand during 2013–14 to a panic that was set off by news media reports.

Cattle and sheep diseases are a less-publicized problem that likely constrained beef and mutton supplies. In 2011 a meeting of Chinese academicians described the cattle disease issue as "grim," with new diseases appearing and a resurgence of diseases like brucellosis, foot and mouth disease, and bovine tuberculosis (*Xinhua*

[10] Expenditures on each of these meats accounted for a declining share of total household expenditures.

[11] Government publicity campaigns during 2018 sought to assure consumers that African swine fever (ASF) is not transmitted to humans by eating pork. Opinion polls and news articles indicated that some consumers did avoid pork after the first ASF outbreaks.

News, 2012).[12] The meeting linked disease problems to a state of decline in the beef cattle industry and rising beef prices. More recently, a team of China Agricultural University scholars attributed growing outbreaks of cattle and sheep disease epizootics to scaled-up farming and growth in international trade (Wang et al., 2020).[13] These diseases included a resurgence of zoonotic brucellosis and anthrax in pastoral regions. A rising trend in beef prices began in 2007, concurrent with a widespread outbreak of foot and mouth disease that year, noted by Wang et al. (2020).

A public health program to reduce the incidence of schistosomiasis among humans in provinces along the Yangtze River reduced the use of cattle and water buffalo as draft animals in several provinces (Wang et al., 2021).[14] A "substitute machinery for cattle" program that began around 2007 subsidized up to 50 percent of purchase costs for tractors and other machinery to replace bovines that are carriers of snails that transmit schistosomiasis to humans (*Farmers Daily*, 2011). Much of the beef in the region had traditionally come from butchering cattle and water buffalo no longer fit for field work, so this program's elimination of cattle may have reduced beef supplies.

The 2013 edition of the *Animal Husbandry and Veterinary Yearbook* summarized chronic problems facing livestock farmers in China. The yearbook cited rising prices for feed and increasing wages for hired workers as factors that directly raise production costs. Feed is generally the largest component of production cost for hogs and poultry and labor costs are the largest component for cattle and sheep. Gale (2017) found that feed was the main component of rising hog costs in China. Gale and Arnade (2015) found that rising chicken prices in China were linked to increases in corn and soybean meal prices, as well as increases in wages. The yearbook noted that large numbers of small-scale "backyard" farmers quit the industry to pursue off-farm work or to specialize in another enterprise, consistent with exits from the sector documented by Rae and Zhang (2009). An influx of larger-scale commercial farms are replacing smaller farms, but the larger farms' entry is constrained by other problems cited by the yearbook: difficulty gaining access to land and credit, and costs of complying with environmental regulations (Gale, 2017). Beginning in 2014, a series of environmental decrees and regulations ordered local officials to ban or limit livestock farms near residential communities, bodies of water, scenic areas, roads, and markets, another initiative that may have reduced meat supplies.

The especially rapid growth in beef and mutton prices may be traced to concerns raised in the 2013 yearbook about the failure of cattle and sheep production to keep pace with growth in demand for beef and mutton. Decline in cattle numbers occurred faster than statisticians realized, reflected by sharp downward revisions of beef cattle inventories after a 2017 agricultural census.[15]

Cattle and sheep were raised predominantly by extensive-margin grazing on grasslands, hillsides, and other spaces unsuited for row-crop farming, including public spaces like roadsides and railway rights-of-way. During the 2000s, cattle and sheep herds were reduced by grazing bans and a series of programs that resettled herders or paid them to remove animals from degraded grasslands.[16] In major farming regions, quality pasture and forage are scarce since nearly all land is used for row crops or vegetables. Industry analysts blamed the long cycle for cattle production as a deterrent to Chinese farmers seeking quick returns on investment.

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[12] These diseases are spread among cattle by bacteria and viruses. Brucellosis and tuberculosis can be spread to humans, but their main impact on beef markets is to restrain supplies through deaths and culls of infected animals.

[13] The authors cite the grassland program that shifts animals from extensive grazing to fenced pasture, and confinement housing and transmission of diseases by imported livestock or animal products.

[14] Schistosomiasis is a disease spread to humans by parasitic flatworms.

[15] Beef cattle numbers in revised data for 2016 were 14 percent less than estimates for the same year released in the 2017 edition of the *China Statistical Yearbook*, before the census data had been incorporated. Dairy cattle numbers were also revised downward, which may have also contributed to reduced beef supplies.

[16] The "退牧还草" (reduce grazing, restore grassland) program began in pastoral provinces in 2004.

By 2009, a Ministry of Agriculture grassland monitoring report said animal stocking density on grasslands exceeded capacity by 34 percent.[17] A grassland protection program initiated in 2011 paid pastoral families to reduce herds and subsidized planting of improved grass varieties, fencing of pastures, and construction of barns for animals. Expansion of corn production during 2008–15 (incentivized by a price support for corn) displaced grassland and fodder crop production. In 2016 the corn price support program was ended and a grain-to-fodder program encouraged farmers to replace field corn with alfalfa and other fodder crops in pastoral regions.[18]

In 2020, an assessment of beef supply problems by China's Academy of Agricultural Sciences raised concerns about the long cattle cycle, outdated beef production methods, poor fodder management, and high production costs (Tang and Zhang, 2020). China's MARA (2021c) blamed similar problems for high beef and mutton prices when MARA issued a 5-year action program for developing beef and mutton production, citing the failure of supply to keep up with growing consumer demand.

The authors calculated the average production cost and sale price per kilogram of live hogs, chickens, cattle, and sheep using annual farm production cost data from various editions of the *Compilation of Agricultural Commodity Production Costs and Income*, published by China's National Development and Reform Commission. These farm-level values are compared with corresponding retail meat prices in figure 15.

Inflation-adjusted production costs rose over time—to varying degrees—for each type of livestock. Hog production cost rose 135 percent from 2000 to 2021 while sheep costs rose nearly 250 percent and beef costs rose threefold over the same period.[19] Chicken cost rose at the slowest pace: 40 percent from 2000 to 2021. The three main components of production costs were feed, labor, and feeder stock. Feed costs are prominent for hogs and chickens, but cattle and sheep typically graze on pastures or public areas and consume straw and fodder gathered by farmers. Labor is the chief cost for sheep and cattle. The fluctuating price of piglets causes hog production costs to vary cyclically.

Livestock and meat prices generally rose along with production costs. Hog prices rose above production costs in some years—often during a disease epizootic—and fell to a point slightly above production costs in other years. Pork prices were higher than hog prices, but fluctuations of hog and pork prices were similar. Chicken prices tended to rise slightly faster than chicken production costs and chicken prices fluctuated less from year to year than pork prices. Beef and mutton prices rose even faster than their production costs. Inflation-adjusted beef prices rose by 300 percent during 2000–21 and mutton prices rose 230 percent over that period.

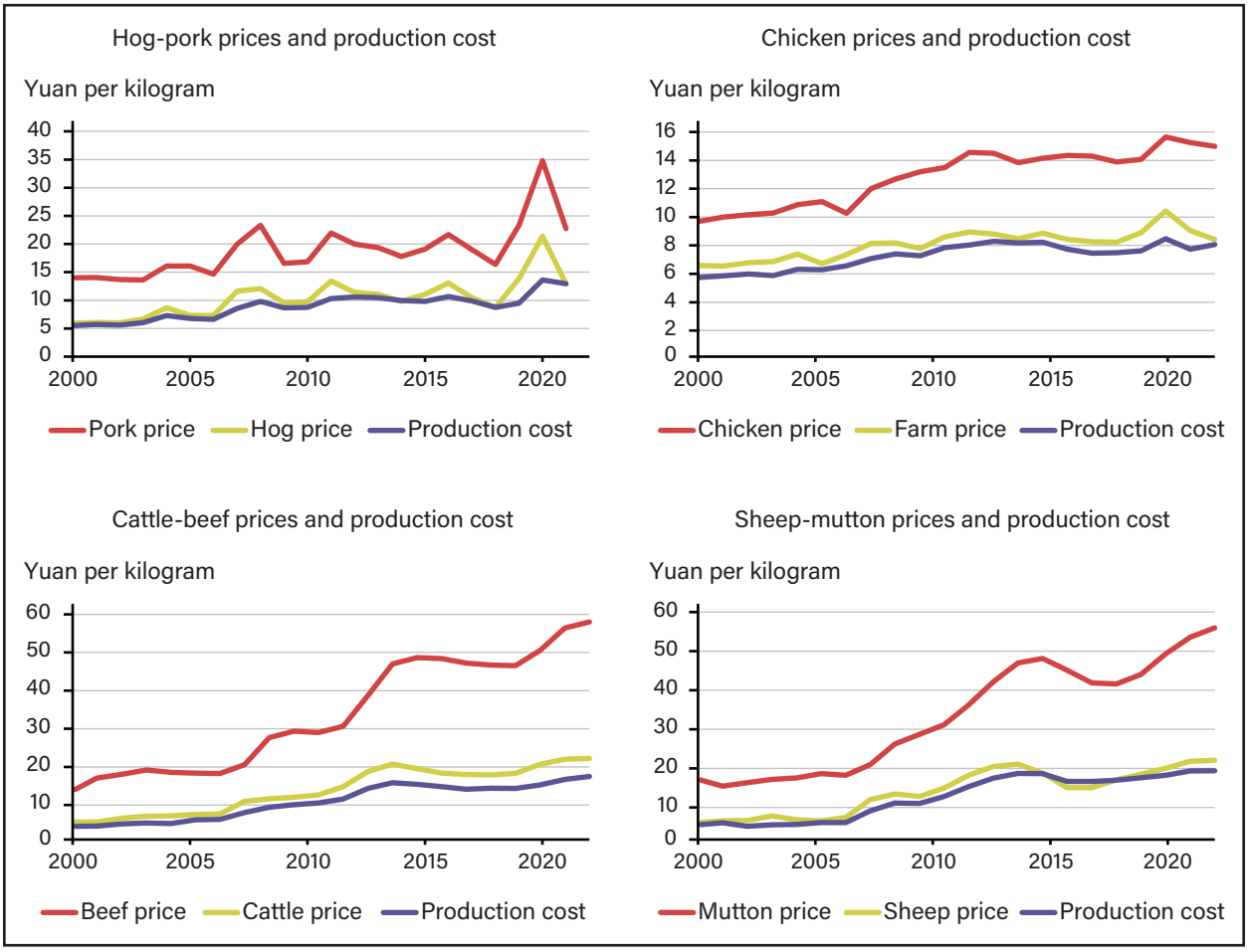
These data suggest that production costs have a role in determining the prices of meats. Prices of live animals rarely fall below production costs, so increases in costs tend to result in higher prices. Mutton and beef (the meats with the highest production costs) have the highest prices. Pork (the most consumed meat) has a lower cost than beef or mutton but a higher cost than chicken. The close link between prices and costs for pork and chicken suggests that costs are a major factor determining their final prices. However, beef and mutton prices have risen much faster than their production costs, suggesting that growth in demand was outpacing production and consequently driving up prices.

[17] A grassland monitoring report in 2019 said grasslands were still overstocked by 10 percent.

[18] In 2016, the 5-year "粮改饲" (grain to fodder) initiative began subsidizing farmers who planted fodder crops, beans, and minor grains in place of corn.

[19] This comparison excludes the 40-percent rise in hog production costs during 2020 due to a surge in feeder pig prices during the recovery from the African swine fever epidemic.

Figure 15
Rising meat prices reflect farm prices and production costs for four types of meat, 2000–21



Note: Data are in constant 2000 yuan, adjusted for inflation, using China's consumer price index. Costs are a ratio of production cost per head to weight. The farm price is from production cost data.

Source: USDA, Economic Research Service, based on data from China National Development and Reform Commission, compilation of materials on agricultural production costs and returns, Beijing: Statistics Publishing House.

Estimating Sensitivity to Personal Income and Meat Prices

ERS authors estimated the relationship between Chinese meat consumption, income, and meat prices by fitting two types of statistical models to annual data from 1999 to 2021: (1) a set of linear models that regressed quantities of meat consumed on average prices and income, and (2) a meat demand system that estimated how household meat budget shares for the three meat categories were related to prices and expenditure. The models were estimated separately with disappearance data and with household purchase data.

Linear Consumption Models

First, authors estimated a set of linear demand equations for three meat categories using the three meat prices and per capita disposable income as the main explanatory variables. Augmented Dickey-Fuller tests suggest that several data series were "non-stationary"—they did not have a constant mean and variance over time. Regressing data series that have strong time trends—for example poultry and beef/mutton consumption—on another series with a time trend—household income—could lead to a spurious result. The models were therefore estimated in first differences to avoid incorrect conclusions due to such spurious relationships.

Authors estimated the following linear demand models:

$$\Delta Q_i = a_i I_{AI} + \sum_{j=1}^{3} b_{ij} \Delta p_j + d_i \Delta Y + e_i, \; i\text{=pork, poultry, beef/mutton} \quad (2)$$

Here, Q_i is the quantity demanded for meat i; p_j is the price of meat j with j ranging from 1 to 3 representing pork, poultry, and beef/mutton, respectively; Y is per capita income; and Δ is the difference operator; a_i, b_{ij}, and d_i are parameters to be estimated; and e_i is the error term. A dummy variable I_{AI} captures the direct effects of major avian influenza outbreaks on poultry consumption due to fears of transmission to humans. I_{AI} takes a value of 1 in years when major avian influenza outbreaks occurred with reported human contractions (i.e., in years 2004 and 2013); 0 otherwise.[20] Impacts of swine diseases on consumption were indirect—through contractions of supply that drove up prices (see box: "Case Study of a Meat Supply Shock"). Therefore, the model does not include a swine disease variable. Similarly, no beef/mutton disease indicator is included since impacts were mainly indirect.

The analysis used inflation-adjusted per capita household disposable income data and average annual meat prices (see figures 10 and 11 above). Income and prices were deflated to constant 2000 currency values, using China's consumer price index. Based on Akaike's Information Criteria (AIC) and the Bayesian Information Criteria (BIC), researchers concluded that a model without a constant term is preferred over a model with a constant term. The models are estimated by seemingly unrelated regression with robust standard errors. The constant was excluded from the linear models based on the AIC and BIC criteria. More details about the estimation and related tests are provided in appendix 3. The regression results are presented in appendix table 2.

Price and income elasticities estimated at mean are presented in table 3. Income elasticities of each type of meat with both data sets are between 0 and 1, suggesting that the demand for each type of meat increases (decreases) less than 1 percent when income increases (decreases) 1 percent. The inelastic response of China's meat consumption to income changes is consistent with the declining budget share of meat calculated above.

Pork disappearance has an insignificant relationship to income, suggesting that pork disappearance consumption does not respond to an income change. Estimates using both data sets indicate that pork's income elasticity is much smaller than the income elasticities estimated for poultry, beef and mutton, suggesting that consumption of poultry, beef and mutton is more sensitive to income growth than pork. The relatively small income elasticities for pork suggest that this category of meat can be classified as a "necessity" that varies little with income. This finding is consistent with pork's role in traditional Chinese diets and the declining share of pork in meat spending.

The magnitude of income elasticities obtained from the disappearance data, 0.41 for poultry and 0.33 for beef and mutton, is inelastic (less than 1.0). The household-purchase income elasticities for poultry, beef

[20] Major disease outbreaks were identified by consulting China Animal Husbandry and Veterinary Yearbooks and a review of the poultry industry by Xin et al. (2016).

and mutton are larger in magnitude than the ones estimated from disappearance data but still inelastic. The income elasticities suggest a slow shift in the composition of meat consumption from pork to other meats as income rises (holding prices constant). The shift is especially slow for disappearance data.

Both data sets indicate that pork consumption is slightly sensitive to changes in its price. Analysis of both data sets yields a negative own-price elasticity that is inelastic: -0.16 for disappearance data and -0.37 for household purchase data. The inelastic price response suggests that a relatively large change in pork price is needed to induce consumers to change their consumption of pork. This finding is consistent with market events in several recent years. When swine disease reduced pork supplies, large increases in pork prices occurred to restore equilibrium between demand and supply (see box, "Case Study of a Meat Supply Shock").

Poultry has an insignificant own-price elasticity for both disappearance and household purchase data, suggesting that poultry consumption is not responsive to changes in poultry price. Beef and mutton have an inelastic negative own-price elasticity for household purchase data, indicating a decline in beef and mutton consumption following a rise in beef and mutton price. The own price elasticity of beef and mutton for disappearance data is insignificant, possibly due to the growing disappearance of beef and mutton but reduced/restrained supply. The analysis found that the disappearance of beef and mutton had grown at a robust pace in past years, despite large increases in prices.

Most cross-price elasticities are insignificant, indicating that consumption of meats is not very sensitive to prices of other types of meats. However, elasticities estimated from both datasets indicate that poultry is a substitute for pork. That is, the coefficients suggest that poultry consumption rises when the pork price goes up. In contrast, there is no statistically significant effect of poultry price on pork consumption. The insignificant own price elasticity of poultry, but significant cross price elasticity of pork price can be explained by the dominant role of pork in China's meat consumption. The positive beef/mutton price elasticity for pork estimated from household purchase data suggests that higher beef/mutton prices lead to higher pork consumption, but this elasticity estimated from disappearance data was not statistically significant.

Table 3
Estimates of price and income elasticities for Chinese meat consumption

Demand elasticities estimated with disappearance data				
Consumption of:	Pork price	Poultry price	Beef/mutton price	Income
Pork	-0.163** (0.078)	-0.232 (0.239)	0.201 (0.131)	0.058 (0.147)
Poultry	0.165*** (0.039)	-0.106 (0.182)	0.027 (0.098)	0.411*** (0.145)
Beef/mutton	0.021 (0.019)	0.030 (0.092)	-0.006 (0.049)	0.334*** (0.055)
Demand elasticities estimated with household purchase data				
Consumption of:	Pork price	Poultry price	Beef/mutton price	Income
Pork	-.374*** (0.085)	0.136 (0.268)	0.183* (0.100)	0.305* (0.162)
Poultry	0.276*** (0.057)	-0.076 (0.201)	0.002 (0.198)	0.706*** (0.164)
Beef/mutton	0.078 (0.076)	0.219 (0.240)	-0.730*** (0.144)	0.926*** (0.206)

Note: Standard errors are in parenthesis. ***, **, and * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Elasticities are estimated at the mean. Regression results are presented in appendix 3, "Meat consumption regression estimates."

Source: USDA, Economic Research Service estimates based on data from China's National Bureau of Statistics.

Case Study of a Meat Supply Shock

During 2018, China had a severe outbreak of African swine fever that significantly reduced the country's meat supply during 2019 and 2020. Millions of pigs died of the disease, were culled to prevent the spread, or were sent to slaughter early by farmers to forestall infection of their herd (Ma et al., 2021). According to official Chinese data, China's pork production dropped about 21 percent in 2019. Output of poultry, beef and mutton increased, and imports of all types of meat increased, but these increases did not fully offset the loss of domestic pork supplies. Authors' calculations indicate that China's per capita output of meat declined 9.2 percent in 2018–19; disappearance of meat decreased 7.6 percent.

With less meat available, prices rose. China's consumer price index (CPI) for meat rose 29.1 percent during 2019, tenfold faster than the 2.9-percent increase in the overall CPI. Thus, meat prices rose 26.2 percentage points faster than the general rate of inflation that year. The increase in meat prices net of inflation was more than three times the 7.6-percent drop in meat disappearance. The ratio of the -7.6-percent decrease in meat quantity to the +26.2-percent increase in real meat price implies a price elasticity of about -0.3.

Pork accounted for most of the increase in meat prices, but prices of other meats increased as well. According to the monthly CPI report released November 2019 (when meat prices were at their 2019 peak), consumer meat prices were up 74.5 percent from a year earlier, including increases of 110.2 percent for pork, 22.2 percent for beef, and 14.3 percent for mutton (the CPI does not report poultry prices as a separate category.) The CPI report estimated that meat prices accounted for 3.27 percentage points of the 4.5-percent year-to-year increase in the overall CPI that month.

Household data showed a relatively small 1.7-percent decrease in per capita meat purchases in 2018–19, much smaller than the 7.6-percent decrease in meat disappearance that year. The decrease in household purchases reflected an 11-percent decrease in pork purchases, a 20-percent increase in poultry purchases, and a 3-percent increase in beef and mutton purchases.

The small reduction in Chinese household meat purchases seems inconsistent with the much larger decline in pork disappearance and raises questions about the validity of the data. For example, it is possible that the Chinese national household survey gives less weight to rural regions (figure 9) and to regions like Sichuan and Guangdong (see figure 10) that experienced sharper declines in pork consumption than did Beijing. The small change in household purchases might be consistent with the change in disappearance data if nearly all the reduction in meat consumption occurred in restaurants or food processing that is not counted by the household survey.

Almost Ideal Demand System (AIDS) Model for Meat

ERS authors estimated an Almost Ideal Demand System (AIDS) that is commonly used to estimate food demand relationships to analyze changes in demand among different meats. While the linear demand models above analyzed meat consumption and consumers' income, this model analyzes how consumers allocate their meat expenditure across the three categories of meat (pork, poultry, and beef/mutton), and the model assumes that this allocation can be analyzed separately from a consumer's overall budget decision. Figure 13 showed that meat expenditure comprised 4 to 6 percent of household expenditure during 2012–18.

The shares of meat expenditure for the three meat categories are represented by $w_i = \frac{p_i Q_i}{E}$, where E is expenditure on meat and p_i and Q_i are the price and quantity of meat category i with i = pork, poultry, and beef/mutton. Note that $\Sigma_i p_i Q_i = E$, and $\Sigma_i w_i = 1$. These correspond to the budget shares shown in figure 14.

The budget shares shown in figure 13 followed trends over time with no steady or constant mean. Consistent with this observation, augmented Dickey-Fuller tests could not reject the null hypothesis that the shares of meat consumption, wj, have a unit root, but the differenced data was stationary. ERS authors, therefore, utilized a first-differenced AIDS to estimate meat demand relationships (Deaton and Muellbauer, 1980; Eales and Unnevehr, 1993; Ortega et al., 2009).

Three equations were estimated with dependent variables, Δwj, corresponding to the three meat categories with a set of explanatory variables that include each of the three meat prices and meat expenditure.

$$\Delta w_i = c_i + b_i I_{AI} + \sum_{j=1}^{3} \beta_{ij} \Delta lnp_j + \gamma_i \Delta \ln\left(\frac{E}{P}\right)$$

Here ln(P) is a Stone's price index defined by ln(P) = $\sum_{i=1}^{3} w_i lnp_i$ and Δ ln(P)= $\sum_{i=1}^{3} w_i \Delta lnp_i$. c_i, b_i, β_{ij}, and γ_i are parameters to be estimated. Based on AIC and BIC tests, the constant term c_i was retained in the model. All prices and expenditures were normalized by their means before taking logarithms (Moschini and Meilke, 1989). More details about the estimation and related tests of the first-differenced AIDS model are presented in appendix 3. Parameter estimates are presented in appendix tables 3 and 4.

The expenditure elasticities shown in table 4 were calculated from the parameter estimates. These elasticities are "conditional" on the level of overall meat expenditure, representing the tendency to allocate expenditures across the three meat categories, as overall meat expenditure rises. However, the presence of constant terms in each of the first-differenced AIDS models (see appendix tables 3 and 4) means that the elasticities are also conditional on long-term trends indicated by the constants. Since the data are expressed in differences, negative constants for pork indicate a declining trend in its budget share, while positive constants for beef/mutton indicate rising trends. These trends in budget shares appear to be independent of the expenditure and price variables in the model. Thus, the expenditure and price elasticities are interpreted as short-run deviations from the long-run budget share trends.

The expenditure elasticity estimates with disappearance data show that only the expenditure elasticity for pork is elastic, suggesting that the consumption of pork increases (decreases) more than 1 percent when the meat expenditure grows (declines) 1 percent. Inelastic expenditure elasticities for poultry and beef/mutton (with disappearance data) indicate that the consumption of those meats is not influenced by meat expenditure growth. The household data has elastic expenditure elasticities for pork and poultry but no statistically significant expenditure elasticity for beef/mutton. The negative trend in pork and positive trends in poultry and beef and mutton seem to dominate the expenditure effects. Thus, the trend in shifting budget shares

away from pork to poultry, beef and mutton seems to be independent of expenditure growth and could reflect some other unobserved factor, such as change in tastes.

The results shown in appendix 3 also confirm that avian influenza reduced the consumption of poultry during years of widespread outbreaks. The two data sets indicate differing cross-commodity impacts of avian influenza outbreaks. During years of AI outbreaks, the poultry expenditure share shifted to pork with household purchase data, while the shift was to beef/mutton with disappearance data (see appendix tables 3 and 4).

Uncompensated price elasticities reflect effects of price changes on meat consumption, including both a substitution effect and an income effect. The first-differenced AIDS model estimates indicate that own-price elasticities are negative for each meat category, although that for beef and mutton estimated with disappearance data is not statistically significant. Estimates with disappearance data suggest that pork consumption is more sensitive to its own price change than are the other two meats. In contrast, estimates with household purchase data suggest that poultry consumption is the most sensitive to changes in its own price. The first-differenced AIDS model with household purchase data suggests that beef and mutton are complements for pork. This may reflect an income effect due to pork's large share of the meat budget (recall that pork accounted for 60 to 80 percent of consumers' meat budgets during 2000–20). An increase in the pork price not only increases the price of pork relative to substitute meats, but it also tends to reduce the quantity of all meats purchased by reducing the amount of meat that can be purchased with a given expenditure. For example, the pork share of the meat budget rose during 2019–20, as the 120-percent increase in pork price offset the proportionately smaller decrease in pork; the beef and mutton share of the meat budget declined, as the available budget for them became less. Similarly, the negative uncompensated cross price elasticities for pork with disappearance data indicate that pork consumption increases when both poultry and beef/mutton prices go down due to an income effect and the large share of pork in consumer's meat budgets. Lower prices for poultry or beef/mutton may free up more funds from a consumer's meat budget to spend on pork, the largest component of meat spending. In contrast, the estimates indicate that beef/mutton and poultry are substitutes. Both datasets indicate that an increase in poultry prices leads to an increase in beef/mutton consumption and the household purchase data indicates that an increase in beef/mutton prices leads to an increase in poultry consumption. The effect of beef/mutton prices on poultry estimated from the disappearance data also indicates that the two meats are substitutes, but the elasticity is not statistically significant. The apparent substitute relationship between poultry and beef/mutton is surprising since poultry is considered to be a low-priced meat option and beef and mutton are considered to be more of a luxury item. The low expenditure elasticities for beef/mutton also contradict the perceived luxury role of these meats. The positive time trend for the beef budget share suggests that beef consumption also has a rising trend that is independent of overall expenditure/income and prices. It is also surprising that the estimate for the avian influenza indicator from disappearance data also suggests that the beef/mutton budget share tends to increase during avian influenza outbreaks.

Table 4
Estimates of uncompensated price and expenditure elasticities from the Chinese meat demand system

Elasticities estimated with disappearance data				
Consumption of:	Pork price	Poultry price	Beef/mutton price	Expenditure
Pork	-1.070*** (0.048)	-0.180*** (0.023)	-0.376*** (0.026)	1.626*** (0.089)
Poultry	0.230 (0.155)	-0.371*** (0.100)	0.120 (0.109)	0.022 (0.278)
Beef/mutton	0.051 (0.083)	0.103** (0.051)	-0.002 (0.070)	-0.153 (0.151)
Elasticities estimated with household purchase data				
Consumption of:	Pork price	Poultry price	Beef/mutton price	Expenditure
Pork	-0. 877*** (0.052)	-0.059 (0.053)	-0.141*** (0.022)	1.078*** (0.105)
Poultry	-0.196 (0.201)	-1.095*** (0.233)	0.259** (0.111)	1.032*** (0.404)
Beef/mutton	-0.294*** (0.067)	0.345*** (0.112)	-0.698*** (0.084)	0.647*** (0.134)

Note: Standard errors are in parenthesis. *** and ** indicate statistical significance at 1 percent, and 5 percent, respectively. Calculated from parameters estimated with a first-differenced Almost Ideal Demand System (AIDS) and estimated at mean. "Expenditure" refers to expenditure on meat. These are uncompensated price elasticities that include effects of changes in relative prices and the impact of a price change on the purchasing power of a consumer's meat budget.

Source: USDA, Economic Research Service estimates based on data from China's National Bureau of Statistics.

Table 5 shows "compensated" price elasticities, calculated from the first-differenced AIDS model.[21] These elasticities exclude the impact of a price change on the purchasing power of a consumer's meat budget, solely measuring the substitution effect. Consequently, the compensated own-price elasticities are negative and smaller in magnitude than the uncompensated elasticities. For example, the compensated own-price elasticity for pork (estimated with disappearance data) is -.04, compared with its uncompensated own-price elasticity of -1.07. All compensated own-price elasticities are inelastic (absolute value is less than 1). With exclusion of the income effect, poultry is the most sensitive to changes in its own price with both data sets. Positive compensated cross-price elasticities (estimated with household purchase data) indicate substitution effects among all three meats. Those estimated with disappearance data suggest the substitution effect between pork and poultry, as well as beef/mutton and poultry, but the relationship between pork and beef/mutton is not statistically significant. The compensated own-price elasticities for disappearance data are smaller in magnitude than those for household data.

[21] Parameter estimates are presented in appendix table 4.

Table 5
Estimates of "compensated" price elasticities for Chinese meat consumption

Compensated demand elasticities, estimated with disappearance data			
Consumption of:	Pork price	Poultry price	Beef/mutton price
Pork	-0.040** (0.020)	0.056*** (0.014)	-0.016 (0.011)
Poultry	0.244*** (0.062)	-0.368*** (0.088)	0.124* (0.073)
Beef/mutton	-0.046 (0.032)	0.081* (0.048)	-0.036 (0.048)
Compensated demand elasticities, estimated with household purchase data			
Consumption of:	Pork price	Poultry price	Beef/mutton price
Pork	-0.161*** (0.039)	0.128*** (0.039)	0.033*** (0.012)
Poultry	0.490*** (0.150)	-0.916*** (0.185)	0.426*** (0.094)
Beef/mutton	0.136*** (0.050)	0.457*** (0.101)	-0.593*** (0.082)

Note: Standard errors are in parenthesis. *** and ** indicate statistical significance at 1 percent, and 5 percent, respectively. Calculated from parameters estimated with a first-differenced Almost Ideal Demand System (AIDS) and estimated at mean. These are compensated price elasticities that measure pure substitution effects among meat by excluding the impact of a price change on consumers' purchasing power.

Source: USDA, Economic Research Service estimates based on data from China's National Bureau of Statistics.

Predicted Meat Consumption Growth, 2022–31

ERS authors calculated predicted values from the estimated linear meat demand models to evaluate the potential for future growth in per capita meat consumption, based on a scenario of slowing income growth and rising meat prices.

Predicted values were calculated for years 2022–31 using projected growth in income and meat prices. Future per capita disposable income values were calculated using per capita GDP growth rates for China from the USDA, ERS "International Macroeconomic Database" (available online from the ERS web site). Annual Chinese income growth was projected to fall gradually from 5.5 percent in 2022 to 4.6 percent in 2031, reflecting growth below the historical 7.6-percent average growth rate.

ERS authors created a rising meat price scenario that assumed annual growth in real prices during 2022–31 will be the same as that in the last 10 years: 4 percent for pork, 5.8 percent for beef and mutton, and 2.4 percent for poultry. Predicted values from the disappearance and household purchase data (based on the linear demand models) are shown for each of the three meat categories in figures 16 to 18. Predicted values were calculated using historical data for 1999–21 for both disappearance data and household purchase data. Predicted values for future years to 2031 were calculated using income growth and price-increase assumptions. The sum of pork, poultry, and beef/mutton values are shown in figure 19.

The predicted values of pork disappearance and household purchase for past years fit the actual data well. Future predicted values indicate a steady growth that continues into future years. Future disappearance increases roughly 9.47 kilograms/person over 11 years (2021 to 2031). Predicted household purchases of pork

rise a cumulative 9.81 kilograms/person between 2021 and 2031. The stronger trend in household purchases likely reflects the larger income elasticity (0.33 versus 0.05).

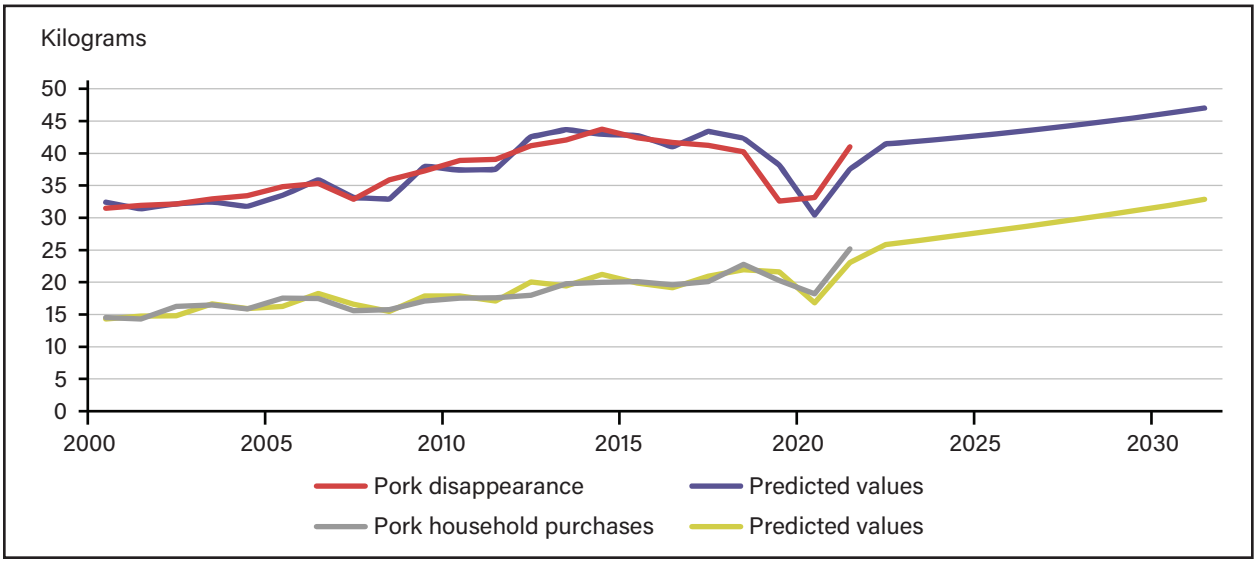
Predicted values for poultry disappearance and household purchases also reflect a clear rising trend that extrapolates past growth (figure 17). Assuming no avian influenza occurrences from 2021 to 2031, predicted poultry disappearance rises about 7.96 kilograms/person. Similarly, predicted household purchases rise approximately 7.21 kilograms/person from 2021 to 2031. The stronger growth in poultry consumption reflects mainly the higher income elasticity (compared with pork), estimated from historical data. This is a best scenario case with an assumption of no avian influenza. If intermittent occurrences of avian influenza continue in the future, poultry consumption could be lower.

Predicted values for beef and mutton disappearance and household purchases also reveal a clear upward trend (figure 18), although the predicted disappearance data show a weaker trend than the predicted household purchase data during 2021–31. Predicted beef/mutton disappearance rises 3.45 kilograms/person or about 33 percent from 2021 to 2031, while predicted household purchases of beef and mutton rises 5.97 kilograms/person or 163 percent over next 10 years.

The predicted total consumption of meat—represented by the sum of predicted pork, poultry, and beef/mutton disappearance and purchases—rises between 2021 and 2031 (figure 19). Predicted meat disappearance rises about 17 kilograms from 2021 to 2031. The sum of predicted household meat purchases rises about 19 kilograms during 2021–31. The changes result from a combination of own-price effects, cross-price effects, and income effects.

Growth of this magnitude could make China's per capita meat consumption among the highest in Asia. While these data are not directly comparable, the comparison of pork, chicken, and beef presented in figure 2 suggests that a 17-kilogram gain in China's meat consumption could put China ahead of Japan, South Africa, and Mexico and close the 20 to 30 kilogram gap with neighbors Taiwan and South Korea. China's meat consumption would likely still be behind levels in the United States, Argentina, Brazil, and Canada.

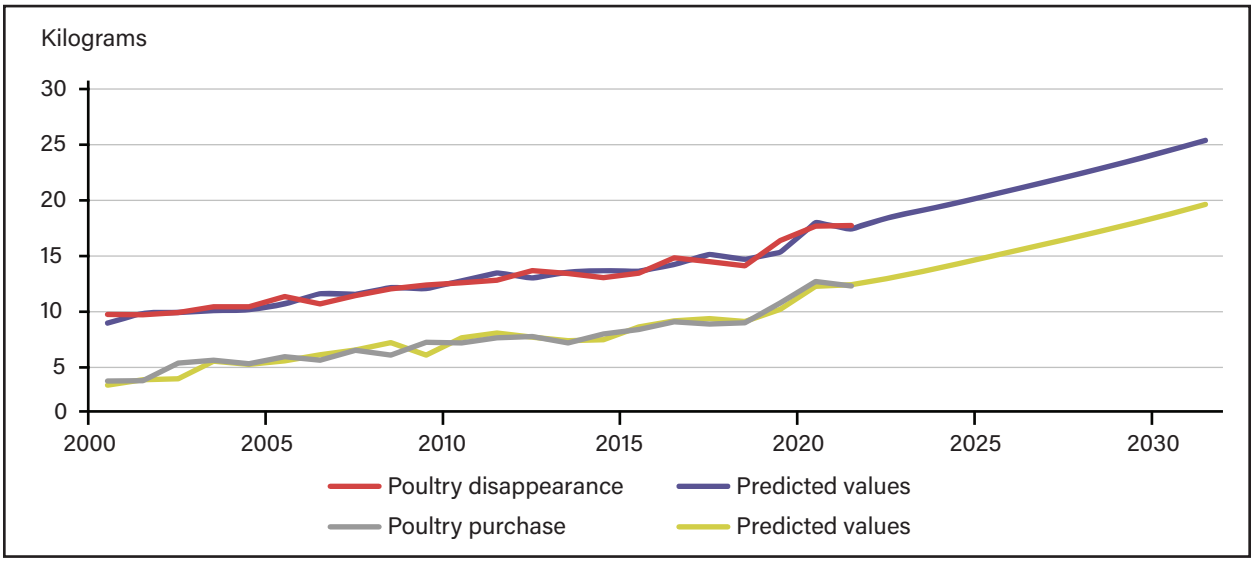
Figure 16
China's per capita pork consumption, actual and predicted



Note: Assumed income values and rising meat prices for 2022–31 are described in the text.

Source: USDA, Economic Research Service based on predicted values calculated from regression coefficients, price, and income data.

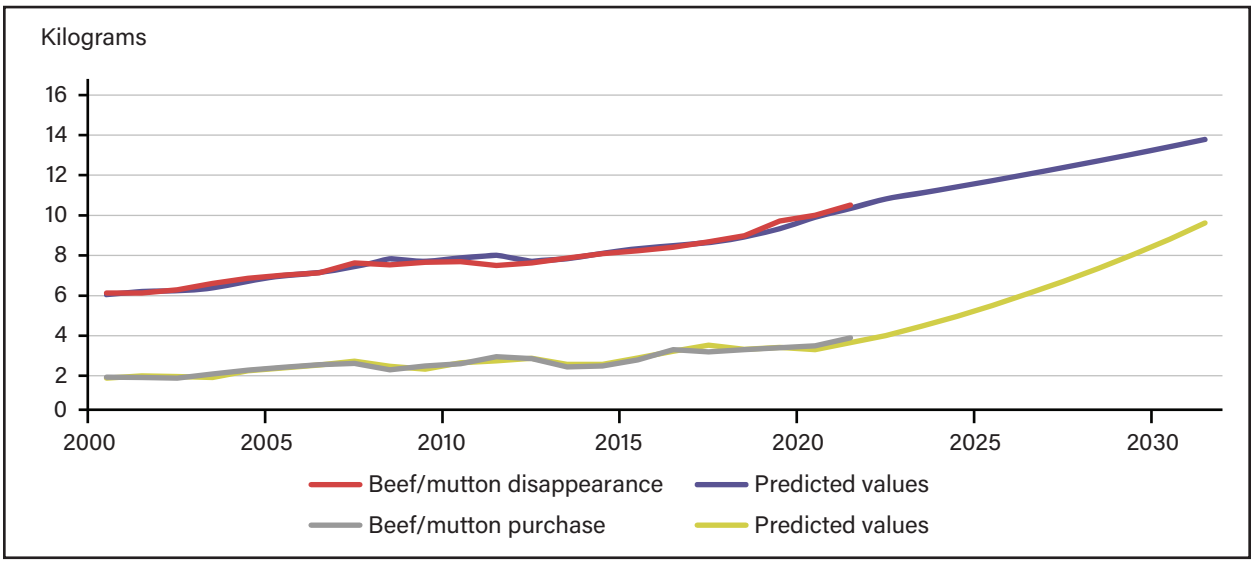
Figure 17
China's per capita poultry consumption, actual and predicted



Note: Predicted values are calculated from regression coefficients, price, and income data. Assumed income values and rising meat prices for 2022–31 are described in the text.

Source: USDA, Economic Research Service, based on predicted values calculated from regression coefficients, price, and income data.

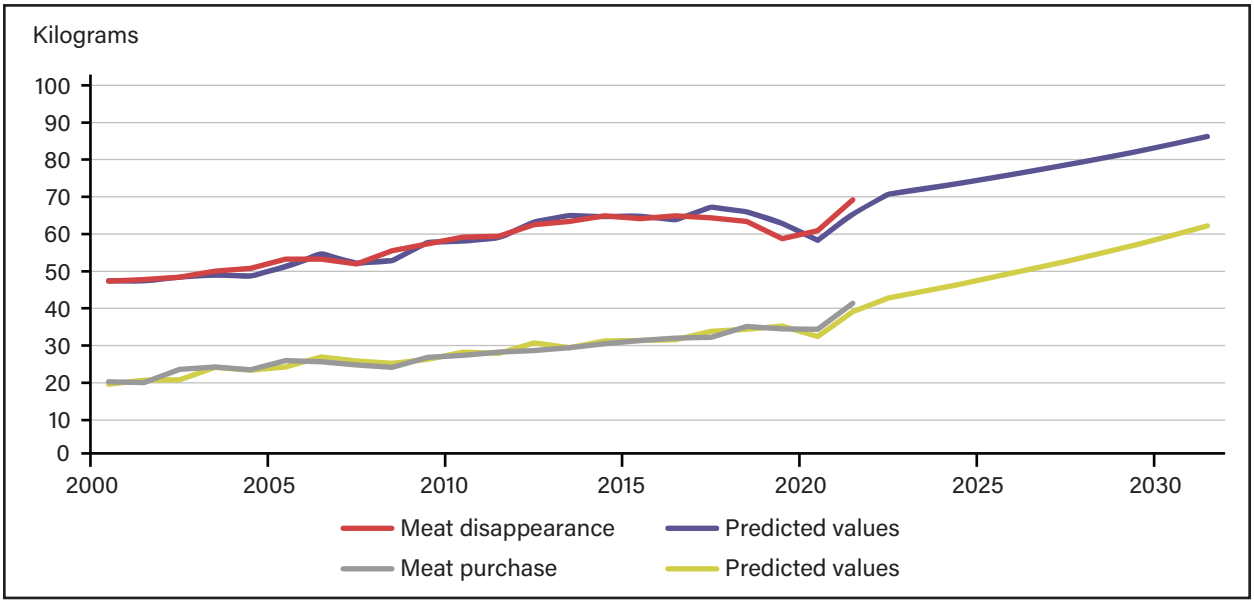
Figure 18
China's per capita beef and mutton consumption, actual and predicted



Note: Predicted values are calculated from regression coefficients, price, and income data. Assumed income values and rising meat prices for 2022–31 are described in the text.

Source: USDA, Economic Research Service, based on predicted values calculated from regression coefficients, price, and income data.

Figure 19
China's per capita meat consumption, actual and predicted



Note: Chart shows sum of predicted values for pork, poultry, beef and mutton shown in figures 16–18.

Source: USDA, Economic Research Service, based on predicted values calculated from regression coefficients, price, and income data.

Discussion of Results

While inconsistencies in China's meat data prevent any strong or precise conclusions, the data indicate that China's per capita meat consumption has potential for further growth. Consumption of each type of meat appears to be growing, but pork has a weak relationship to growth in household income; consumption of beef, mutton, and poultry tends to grow at a little slower pace than the growth in household income. Analysis of Chinese meat budget shares indicates a persistent consumption shift from pork to poultry, beef, and mutton that appears to be independent of expenditure growth and prices. Adjustments in the mix of meat categories consumed are likely to continue.

This analysis found that Chinese household meat purchases were more sensitive to income growth than was the disappearance of meat. This analysis seems counterintuitive, since disappearance includes away-from-home consumption that has a higher income elasticity than at-home consumption. The rapid growth in food service and processed food in China suggests that away-from-home marketing channels are the fastest-growing components of meat consumption. Yet, data on household purchases of meat (which exclude away-from-home consumption) appeared to show faster growth in meat consumption than did disappearance. The results could have been influenced by strong growth in household purchases in the final 2 years of data. A possible explanation is that restrictions on travel and COVID-19 lockdowns during 2020 and 2021 may have resulted in a shift toward at-home consumption.

China's meat consumption appears to be relatively insensitive to price changes. Meat consumption has grown over the years despite increases in meat prices. Consumption of beef and mutton (in particular) grew at a robust pace despite large increases in price. Short-run increases in pork prices (resulting from disease-induced supply shocks) were proportionately much larger than the decrease in consumption, also indicating

price-inelastic demand. Some anecdotal evidence exists of substitution between meats. A noticeable surge in poultry consumption was evident during 2019–20 when pork prices were record-high, but poultry consumption still did not catch up with pork consumption despite the much lower price of poultry meat.

While this study focused on the potential for meat consumption to continue its past growth, supply side constraints may prevent domestic production from rising fast enough to satisfy meat demand. For example, initiatives to address environmental degradation impose new constraints, such as a requirement to invest in manure collection and treatment facilities and reductions in cattle and sheep stocking ratios to restore grasslands.

With rising Chinese demand and slower growth in meat supplies, meat prices tend to rise. The Chinese Agriculture Ministry's 5-year plan cited rising prices for beef and mutton, as well as generally weak international competitiveness, among the challenges facing the sector. A 2020 China State Council "Opinion on promoting high quality livestock development" set self-sufficiency targets for meat. The 5-year plan adopted those targets and warned that growing meat imports led to increased uncertainty and market risk.

In view of the resource constraints on Chinese meat production, the country would not be able to sustain growth in meat consumption without rising meat imports. ERS authors' calculations indicate that the imported proportion of meat in China's disappearance rose from 2.5 percent in 2014 to 9.6 percent in 2021. China's per capita meat imports of 6.7 kilograms in 2021 were higher than those of many neighboring Asian countries but were about one-third of the per capita imports of middle/high-income Asian countries South Korea and Japan. China has opened its markets to more meat suppliers, as Chinese meat price increases indicated constraints on domestic supplies. However, barriers to trade (such as stringent Chinese certifications for foreign exporters, standards and regulations on feed additives and labeling, and bans due to disease concerns) could restrain further growth in meat imports. Beckman et al. (2022) observed that wide spreads between Chinese and international meat prices could be narrowed by reducing barriers to trade.

Growth in Chinese meat consumption could be slower than indicated if China's income growth slows more than expected. Concerns about health impacts from meat consumption and aging of the population could also slow the growth in meat consumption. Rising prices and scarcity of raw materials for conventional meat production in China might stimulate development of viable plant-based or artificial meat products (Ortega et al., 2022).

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Appendix 1: China's Meat Reserve

China maintains national, provincial, and local meat reserves in case of disaster, public health emergency, animal disease outbreak, and for market stabilization. Reserves consist of live swine and frozen pork (beef and mutton are held in certain regions). In 2007, China's Ministry of Commerce released a list of more than 200 farms and meat companies that held swine or frozen pork in reserve. Facilities and storage costs are financed by the Chinese Government. The former Economic and Trade Commission managed reserves until the Huashang Reserve Management Center (华商储备商品管理中心) was established by China's State Council in 1998.

Pork is reportedly held up to 4 months and beef and mutton 8 months (Yicai, 2019). No data are revealed on the size of the reserve. In 2011, China's State Council issued a document ordering large- and medium-sized cities to maintain a 10-day supply of pork in reserves and a 7-day supply for other cities. No pork is held in reserve for rural markets.

Reserves are also stocked with imported pork. The Chinese *Economic Observer* (2009) revealed that large volumes of pork were imported during 2008 and 2009 to stock reserves. Announcements of auctions to release pork reserves during 2020–21 stated that the reserves were composed entirely of imported pork.

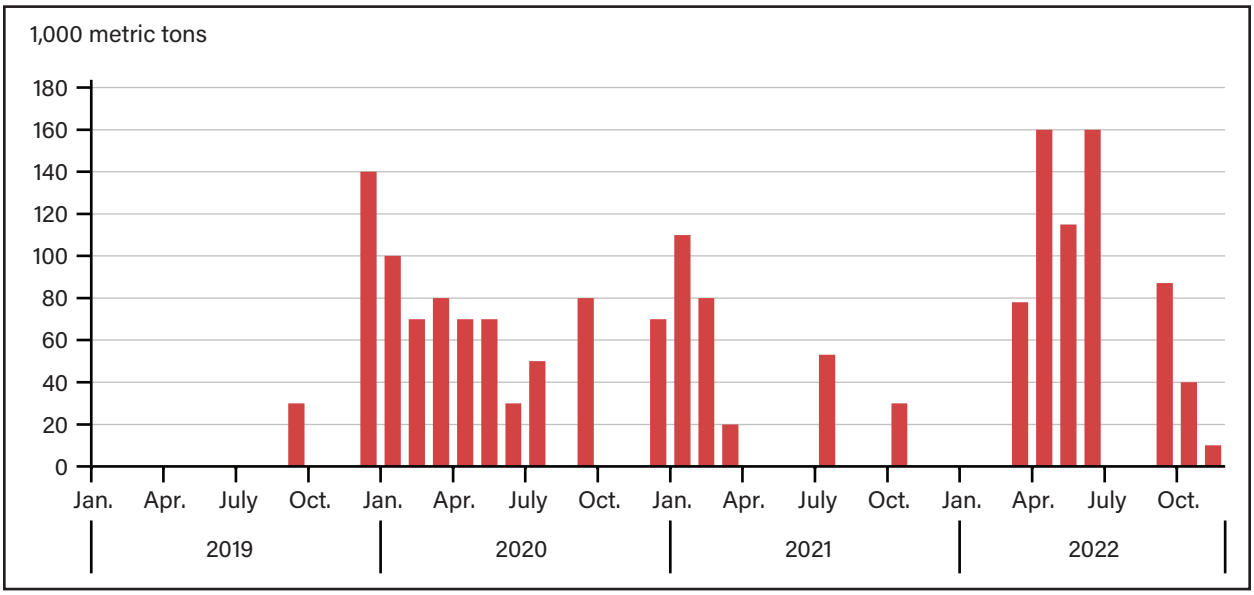
Yicai (2019) cited instances of reserve releases during and after floods, an earthquake, a foot and mouth disease outbreak, and a reserve of 40,000 metric tons during a swine disease epidemic in 2007. The reserve was incorporated into a 2009 hog "price alert" policy, established to stabilize the market by purchasing and releasing pork reserves, triggered mainly by the ratio of hog price to corn price. A similar mechanism was revived in 2021.

Purchases of pork for reserves are made when pork prices are falling and the ratio of pork to corn price is low, such as in 2013, early 2019, and 2021–22. Yicai (2022b) said 290,000 metric tons of pork purchased in 2010 were the largest purchase of reserve pork to intervene in the market. Pork reserves are sold to bolster supplies when the ratio of pork price to corn price is high.

The first large, concentrated releases of pork reserves started in 2019 and continued into 2020 after an African swine fever epizootic reduced pork supplies (appendix figure 1). Reserve releases were reduced in 2021, as pork output increased and prices declined sharply. Reserve releases resumed during 2022 to address a new round of pork price increases. Annual totals of monthly releases indicate that 170,000 metric tons of pork were released in 2019, 620,000 tons in 2020, 293,000 tons in 2021, and 650,100 tons in 2022. The largest releases were about 1.5 percent of national pork consumption in 2020 and 1.2 percent of consumption in 2022. Three releases of beef and mutton reserves of about 100 tons each were made during 2022 in western regions Xinjiang and Tibet, and a purchase of 300 tons was made in Tibet during October 2022.

Appendix figure 1

China's monthly sales of pork reserves, 2019–22



Source: USDA, Economic Research Service, compiled from announcements posted on the Huashang Reserve Management Center web site.

Appendix 2: A Review of China's Meat Statistics

China's livestock production and consumption data have been based on a combination of administrative reports, surveys, and censuses over the years. Sample surveys and decennial agricultural censuses were incorporated into the estimation methods beginning in the 1990s. China's National Bureau of Statistics (NBS) is the official source of China's statistics. The National Animal Husbandry Station of China's Ministry of Agriculture and Rural Affairs (MARA) has a parallel livestock statistical reporting system. The MARA data are used in internal reports, and some data are published in an annual yearbook and on public web sites. A separate NBS household survey of household income and expenditures directly measures purchases of meat and other food items.

National Bureau of Statistics Official Livestock Production Data

NBS reactivated its rural survey teams to measure agricultural output in 1978 (NBS had been suspended during political turbulence that began in the mid-1960s), but surveys focused on the measurement of grain and field crops. An administrative reporting system was the main mode of counting animals until livestock surveys were launched in 1999. MARA continues an administrative reporting system that compiles data reported by village officials responsible for veterinary affairs or bookkeeping. These reports are filed with town officials, compiled, and passed up to prefecture, provincial, and national authorities.

Zhong (1997) called attention to the apparent inflation of Chinese meat production statistics during the 1990s. At the time, local officials had incentives to exaggerate animal numbers to show growth in production. The incentives included meeting requirements of specific campaigns, such as the "market basket system" to boost supplies of meat and other "nonstaple" foods and a "straw for beef" program to expand cattle production by feeding animals stalks, straw, and other crop residues. Zhong and other authors observed a divergence between the per capita production of meat products and direct measures of consumption reported by the NBS household survey.

Zhong suspected that the inflation of livestock production data was a primary cause of the divergence in the two data series. China's first agricultural census of animal inventories and hog slaughter in 1996—the first national direct enumeration of livestock—confirmed that livestock and meat output data was inflated. A National Bureau of Statistics analysis of the census data estimated that per capita meat output was 36.6 kilograms, nearly 20 percent less than the 43.8-kilogram amount published in annual statistical yearbooks (National Agricultural Census Office, 2000). The difficulty of counting widely dispersed animals was highlighted by the census's finding that 135 million rural households raised hogs, 28.5 million raised sheep, 10.6 million households raised cattle, and nearly all the producers raised 10 or fewer head.

Following the census, NBS revised downward its estimates of livestock numbers and meat output. USDA, ERS compared 1996 data published in NBS's Rural Statistical Yearbooks for 1997 and 1998 to evaluate the revisions. The comparison shows that Chinese aggregate meat output was revised downward by 22.5 percent. Beef output was revised downward by 28.1 percent, mutton by 24.6 percent, and pork by 21.8 percent. NBS did not publish poultry meat production estimates in the 2 years following the first census.[22]

[22] NBS omitted estimates of poultry meat output from the 1998 and 1999 editions of *Rural Statistical Yearbook*.

Appendix table 1
Revisions of China's meat output data following three agricultural censuses, 1996–2016

	Year	Meat	Pork	Beef	Mutton	Poultry
			Percent			
First census	1996	-22.5	-21.8	-28.1	-24.6	NA
Second census	2006	-12.0	-10.5	-23.1	-22.5	-9.5
Third census	2016	1.1	2.4	-13.9	0.2	6.0

NA=not available.

Note: Revisions are calculated by USDA, ERS by comparing data released before and after agricultural censuses.

Source: USDA, Economic Research Service calculations using meat production data published in China's National Bureau of Statistics, *Rural Statistical Yearbook*.

In 2000, NBS began reporting livestock production data based on a dual statistical system. A survey monitored animal inventories and slaughter for a sample of rural households, while other livestock-producing units (presumably including state farms, collectives, cooperatives, companies, and institutional farms) had to file regular reports of livestock data with statistical departments. NBS expanded the sample data to make national and provincial estimates based on the results of the 1996 census.

A second agricultural census was conducted for 2006, but the report included only one table showing swine, cattle, sheep, and poultry inventories. Meat output data reported in the 2008 *Rural Statistical Yearbook* included a footnote explaining that livestock data for 2000–2006 included in the yearbook had been revised based on results of the agricultural census. Comparison with data in the 2007 yearbook indicated that meat output for the census year 2006 was revised down 12 percent. The pork revision was smaller (-10.5 percent) than the 1996 revision, but beef (-23.1 percent) and mutton (-22.5 percent) were similar in magnitude to revisions following the first census. Poultry meat output was revised downward by 9.5 percent.[23]

NBS revised meat data again following a third agricultural census conducted for 2016. Only a brief communique was issued about the census results. The 2018 *Rural Statistical Yearbook* included a footnote explaining that livestock data for 2007–17 had been revised based on census results (the description of livestock data in the appendix did not mention the census). A comparison of data in 2017 and 2018 yearbooks showed a much smaller 1.1-percent upward revision in meat production. Poultry, pork, and mutton data were revised upward, but beef output was revised downward by 12.9 percent. Historical revisions of beef output erased growth that had previously been reported in yearbooks for 2008–16.

China's agricultural censuses are also subject to many of the same problems. News reports (and at least one article issued by NBS) revealed that some officials had filled in census forms in their offices using data from previous censuses, other records, or their own estimates. An article by NBS cited examples of fraud detected in the third agricultural census that included evidence of altered or fabricated data, failure of enumerators to personally interview farmers, report forms filled in with administrative data, and inconsistencies between report forms and data transmitted to NBS.

A circular issued by the Livestock and Veterinary Bureau of China's Ministry of Agriculture and Rural Affairs (2020) instructed local officials to improve livestock data collection and reporting acknowledged "prominent problems." These included lack of attention to the task in many localities, lack of budgetary support, incomplete records on farms, late or inaccurate reporting of data, and unclear responsibilities for livestock reporting at the county level. A county statistical bureau in Guangdong Province reported that statisticians lacked

[23] Explanatory text in appendices of NBS yearbooks from 2000 to 2017 described the "successful" completion of the 2006 census, but continued to state that livestock data estimates were based on the 1996 census.

knowledge of the industry due to rapid personnel turnover; statisticians were not permitted to enter swine or poultry farms to verify data due to biosecurity measures; and statisticians did not interface or exchange data with related departments (Wei, 2021). A county bureau in Gansu Province complained that veterinary personnel who were given responsibility for livestock statistical work were under-qualified and neglected statistical data due to animal disease epidemics (Yao, 2021). The Gansu article said that increased attention to counting animals to support poverty alleviation programs led to a neglect of counting other farms, including those farms raising domesticated wildlife. The Gansu article noted that statisticians struggled to count the growing volume of livestock transported from other counties and provinces. Statisticians collected data by telephone from far-flung farmers, some of whom intentionally concealed livestock from statisticians.

Ministry of Agriculture and Rural Affairs Livestock Reporting

The MARA livestock reporting is based on monitoring of 4,000 fixed observation points that include a sample of large-scale pig farms, villages, and rural households. These data do not directly measure meat consumption and this survey is independent of the NBS survey used to develop national meat production estimates. Authors discuss this data collection system to gain perspective on official meat production data that comprise the main component of meat disappearance.

A *Southern Rural Journal* (2016) interview with a MARA official explained that the livestock reporting system had consisted of crude annual reports filed once per year by veterinary technicians and village accountants until 2008. That year, a fluctuation in swine numbers due to a disease outbreak prompted China's State Council to fund monthly livestock reporting and standardize the reports. The official noted that the MARA system duplicates NBS surveys to some degree but only NBS can report national data. The main function of these data is to provide monthly percentage changes in swine and sow inventories that are reported on a MARA web site (statistics on levels of swine inventories occasionally appear in news articles or presentations made by officials but are not published). According to the Southern Rural News (2016) interview, the MARA reporting system bypasses prefecture and county officials to prevent tampering with the data. The system incorporates direct reporting by large-scale farms to a central data cloud platform.

Documents and news releases about an initiative to improve the MARA system during 2019–20 revealed the difficulties of counting livestock. These problems may also affect the quality of surveys conducted by the National Bureau of Statistics.

A group of officials at a Shanxi Province livestock and veterinary extension center observed that village-level reporters often do not clearly understand technical livestock concepts in the forms the reporters are asked to complete, and personnel often neglect to file reports because they receive no compensation (Li et al., 2019). The authors observed that many farmers kept rudimentary records that did not conform to the items requested on statistical report forms; surveyors were often prohibited from entering farms to verify data due to biosecurity measures; computer equipment in villages was often poor; and data were vulnerable to loss or errors because the data was stored on multiple machines or media.

Similarly, a September 2020 document issued by the MARA Livestock and Veterinary Bureau called for rectifying persistent problems in livestock monitoring work. According to the document, some localities had lapses in reporting, errors, and unverified data due to personnel turnover and a low priority on livestock reporting. Moreover, poor management and conflict with other departments could result in the omission of records, multiple sets of data, and numbers that are confused or inaccurate. The document ordered local personnel to verify the accuracy of data, carry out spot checks of large-scale farms, and establish a record system for small farms by the end of 2020.

Household Income and Expenditure Surveys

The household income and expenditure survey (described in the appendix of Gale and Huang (2006)) reports average per capita purchases of meats, consumer expenditure, and personal income based on accounts kept by a national sample of households that recorded income and expenditures throughout the year. This survey has been conducted annually since the early 1980s.

According to documentation in the 2012 edition of the China National Bureau of Statistics *China Yearbook of Household Survey*, parallel rural and urban surveys collected income and expenditures from 74,000 rural households and 66,000 urban households. In 2013, the household survey was reorganized as a national survey. The 2016 edition of the yearbook said the household survey was conducted for a sample of 160,000 households in urban and rural communities based on the households' place of residence. The sample had previously been chosen on the basis of the locality where they are officially registered as residents (the hukou), thus potentially excluding migrants who did not actually live where they were registered. The 2012 yearbook stated that one-third of the urban household sample was rotated each year and the entire rural sample was changed every 5 years. The yearbook documentation states that the standard error for income estimates was less than 1 percent.

According to documentation in the 2013 edition of the *China Yearbook of Household Survey* (applying to data collected in 2012), urban "meat" included purchases of fresh, live, and processed products; and various domestic livestock, poultry, and wild meat. Fresh and frozen pork, beef, and mutton included internal organs, heads, feet, skin, bones, and blood, but not processed products. Poultry included all domestic and wild poultry. The rural survey said it reported live, fresh, and chilled/frozen meat based on the estimated equivalent weight as fresh meat, as well as canned meat and cured pork. Rural poultry was based on weight after removal of feathers and internal organs. No details on meat items were provided in more recent editions of the yearbook.

Beginning in 2013, the household survey counted income of rural migrants living in cities as urban income. The documentation did not address expenditures and purchases, but USDA, ERS authors presume that purchases of meat were also counted based on where the household resides. The pre-2013 sampling method may have understated rural per capita consumption by counting migrants as members of rural households even though the migrants were working or at school elsewhere most of the year and therefore did not consume food at their registered place of residence.

Discontinuities in the meat consumption were reported separately for rural and urban households. In 2013—the year when the survey was reorganized—rural pork consumption jumped by 6 kilograms and rural poultry consumption jumped by 1.5 kilograms. The discontinuities were not evident in the weighted averages of rural and urban consumption analyzed in this report.

Sample households kept accounts of food expenditures at stores, markets, cafeterias, and restaurants throughout the year. Expenditures on away-from-home food and beverage service were reported in statistical tables, but the amounts of food consumed away from home were not counted. The amount of meat in processed ready-to-eat meals is also difficult to count. With rising food consumption away from home and in processed forms, it seems likely that these consumption statistics understated the growth in meat consumption.

Some analysts have questioned whether the burden of keeping diaries throughout the year may prompt higher-income and busier households to decline participation. While respondents receive a small subsidy it may not offset the burden of recording purchases throughout the year. Annual consumption quantities are likely to be understated if some respondents failed to record or transmit data during part of the year.

Appendix 3: Meat Demand Estimates

Authors conducted a stationarity test of meat demand to check if statistical properties of mean demand data changed over time. Augmented Dickey-Fuller (ADF) tests fail to reject the null hypothesis that each meat demand, measured by both disappearance and household purchase, has a unit root at all common significance levels. Therefore, authors took first differences of the variables to transform them to be stationary and estimated the following differenced linear consumption models: as described in the text.

$$\Delta Q_i = a_i I_{AI} + \sum_{j=1}^{3} b_{ij} \Delta p_j + d_i \Delta Y + e_i, i =$$ pork, poultry, beef/mutton as described in the text.

There is a concern that prices may be endogenous in demand estimation as demand may affect prices during the price formation procedure. Without addressing the endogeneity issue, the estimates may be biased. To test and control for the potential price endogeneity, researchers utilized a generalized method of moments (GMM) with instrumental variables. The two main components of production costs were used as instrumental variables for meat prices. These variables included cost categories "material and services" (mainly consisting of feed cost) and labor cost for producing each kilogram of carcass weight of each type of meat. Production cost data were obtained from the Chinese National Development and Reform Commission's annual production cost survey for hogs, chickens, beef cattle, and sheep. Costs per head were divided by reported average weight of the animal to obtain cost per kilogram.

Hansen's J statistic suggested that the instruments were uncorrelated with the error term and thus valid. The null hypothesis that prices are exogenous cannot be rejected at all common significance levels by the C (difference-in-Sargan) statistic. One reason for the exogeneity of prices is that consumers generally take prices as predetermined when they make purchase decisions. A constant was not included in the models since the model without a constant has lower AIC and BIC than the one with a constant.

The model was estimated using seemingly unrelated regression with robust standard errors. The regression estimates from annual data for 1999–2021 household purchase data and disappearance data are shown in appendix table 2. The parameter estimates of meat prices and income were used to calculate price and income elasticities, which are shown in table 3. The estimation from the differenced linear demand models shows that avian influenza reduced poultry consumption significantly.

Appendix table 2
Meat consumption regression estimates

	Disappearance of:			Household purchases of:		
	Pork	Beef/mutton	Poultry	Pork	Beef/mutton	Poultry
I_{AI}			-0.703*** (0.174)			-0.825*** (0.150)
Δ (pork price)	-0.325** (.155)	0.009 (.008)	.113*** (.027)	-.364*** (.083)	0.011 (.011)	.109*** (.022)
Δ (beef/mutton price)	.232 (.151)	-0.001 (.012)	.011 (.039)	0.103* (.056)	-0.061*** (.012)	3.50e-4 (.045)
Δ (poultry price)	-0.696 (.719)	0.019 (.058)	-0.110 (.188)	0.199 (.394)	0.048 (.052)	-0.045 (.119)
Δ (income)	1.88e-4 (4.77e-4)	2.28e-4*** (0.37e-4)	4.59e-4*** (1.62e-4)	4.84e-4* (2.58e-4)	2.17e-4*** (0.48e-4)	4.54e-4*** (1.06e-4)
Observations	22	22	22	22	22	22
R-Squared	0.45	0.59	0.56	0.73	0.64	0.54

Note: Standard errors are in parentheses. IAI was retained in the models based on AIC and BIC (Akaike's Information Criteria and Bayesian Information Criteria). "e-4" represents "x 10-4." Models were estimated by seemingly unrelated regression with robust standard errors. ***, **, and * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Both data are for 1999–2021.

Source: USDA, Economic Research Service, based on data from China's National Bureau of Statistics.

A second set of estimates was made based on Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980). ADF tests failed to reject the null hypothesis that each meat expenditure share had a unit root at all common significance levels, with both disappearance data and household purchase data. USDA, ERS researchers, therefore, adopted the first-differenced AIDS model (Deaton and Muellbauer, 1980; Eales and Unnevehr, 1993; Ortega et al., 2009). Dependent variables in the equations are meat budget shares, $\Delta w_i = \Delta \frac{p_i Q_i}{E}$, where Δ represents the difference operation, p_i and Q_i are price and quantity of meat in category i (i=pork, poultry, and beef/mutton) and E is meat expenditure. Note that $\Sigma_i p_i Q_i = E$ and $\sum_i w_i = 1$. The expenditure share generated from first-differenced AIDS is expressed as

$$\Delta w_i = c_i + b_i I_{AI} + \sum_{j=1}^{3} \beta_{ij} \Delta ln p_j + \gamma_i \Delta \ln\left(\frac{E}{P}\right)$$

where c_i, b_i, β_{ij}, and γ_i are parameters to be estimated; p_J is the price of meat category j with j ranging from 1 to 3 representing pork, poultry, and beef/mutton, respectively; ln(P) is a Stone's price index defined by $\ln(P) = \sum_{i=1}^{3} w_i ln p_i$ and $\Delta \ln(P) = \sum_{i=1}^{3} w_i \Delta ln p_i$. The dummy variable IAI is included to capture the impacts of avian influenza on meat consumption. The constant c_i is included to capture the trend effect in the differenced budget share equation, based on the AIC and BIC tests as the model with the constant c_i has lower AIC and BIC than does the model without the constant. The expenditure elasticity, which measures the percentage change in meat demand caused by 1 percent change in meat expenditure, is calculated as $\eta_i = \frac{\gamma_i}{w_i} + 1$. The uncompensated price elasticity is calculated as $\varepsilon_{ij}^{u} = -\delta_{ij} + \frac{\beta_{ij}}{w_i} - \frac{\gamma_i w_j}{w_i}$ and compensated price elasticity $\varepsilon_{ij}^{c} = -\delta_{ij} + \frac{\beta_{ij}}{w_i} + w_j$ where δ_{ij} is the Kronecker delta ($\delta_{ij} = 1$ if i=j and $\delta_{ij} = 0$ if $i \neq j$). All elasticities are calculated at mean.

Estimates of the first-differenced AIDS system of equations were made with restrictions on the parameters of "adding up" ($\sum_i c_i = 0, \sum_i b_i = 0, \sum_i \gamma_i = 0, \sum_i \beta_{ij} = 0$), "homogeneity" ($\sum_j \beta_{ij} = 0$, and "symmetry" ($\beta_{ij} = \beta_{ji}, \forall i \neq j$). Prices and the expenditure are normalized by dividing by their sample mean before the logarithmic transformation. To avoid simultaneity problem, one-period lagged w_i is used in Stone's price index (Eales and Unnevehr, 1993).

Several studies (e.g., LaFrance, 1993; Eales and Unnevehr, 1993; Dhar et al., 2003) pointed out that price and expenditure may be endogenous in the estimation of a food demand system. To test for the presence of endogeneity in price and expenditure, USDA, ERS researchers utilized a Durbin, Wu, and Hausman (DWH) test for the consistency of parameter estimates (LaFrance, 1993). Researchers applied two sets of parameter estimates from the demand system that control for the endogeneity and that do not control to the DWH test. To control for the endogeneity of price and expenditure, price is specified as a function of supply shifters and expenditure as a function of income (Dhar et al., 2003). The reduced-form price equations are specified as $\Delta lnp_j = k_0 + k_1 \Delta lnF_j + k_2 \Delta lnL_j$, where F_j is the material and service cost mainly consisting of feed cost and L_j is the labor cost for producing one unit of carcass weight of the jth meat; and k_0, k_1 and k_2 are parameters to be estimated. The explicit specification captures the supply side of the price formation mechanism (Dhar et al., 2003). The expenditure equation is formulated as $\Delta lnE = g_0 + g_1 \Delta lnY$, where Y is real household income and g_0 and g_1 are parameters to be estimated. Given four hypothesis that are H0: prices and income are exogenous; H1: prices are endogenous and income is exogenous; H2: prices are exogenous and income is endogenous; and H3: prices and income are endogenous, researchers conducted three DWH tests, namely, H0 vs. H1, H0 vs. H2, and H0 vs. H3. Following Dhar et al. (2003), the test statistic is computed as $D_h = (B_{H_0} - B_{H_h})(\Sigma_{H_0} - \Sigma_{H_h})^{-1}(B_{H_0} - B_{H_h})'$, where B_{H_0} represents parameter estimates and Σ_{H_0} the corresponding parameter covariance matrices, respectively, under H0; and B_{H_h} and Σ_{H_h} represent those from the model that controls for the endogeneity of price and/or expenditure under H_h with h=1, 2, and 3. The model under H0 is estimated by using iterative seemingly unrelated regression (SUR) and models under H_h are estimated by using a full information maximum likelihood (FIML) estimation procedure. D_h is asymptotically distributed as $X^2(k)$, where k is the number of potentially endogenous variables. The test suggests that prices are endogenous in estimation with both disappearance and household purchase data sets. One possible reason for price endogeneity is that prices and budget shares are affected by common factors unobserved by the econometrician. The test values of D_h are available from USDA, ERS researchers upon request.

The estimates from the first-differenced AIDS model (using disappearance data with a full information maximum likelihood (FIML) method and with endogeneity taken into account) are reported in appendix table 3. Statistically significant constant terms in each equation indicate persistent trends in budget shares for each of the meat categories. The negative constant in the pork equation suggests a declining pork budget share, while the positive constant terms for poultry and beef and mutton indicate a rising trend in budget shares for those meats. These trends are consistent with those shown in figure 13. These trends are statistically significant when expenditure and price variables are included in the model, suggesting that long-term shifts in budget shares occur independent of changes in expenditure growth and changes in relatively prices of meats.

I_{AI} coefficients indicate the occurrence of avian influenza reduced the budget share for poultry and induced more consumption of beef/mutton, but there was no significant impact on pork. Similar results are obtained by using household purchase data, except that more budget shares switch to pork consumption with occurrences of avian influenza and there is no trend in poultry budget share. Estimates for meat price and expenditure elasticities are discussed in the main text.

Appendix table 3

Parameter estimation of first-differenced AIDS Model (disappearance data)

	Pork	Poultry	Beef/mutton
Constant	-0.012*** (0.003)	0.005*** (0.002)	0.007*** (0.002)
I_{AI}	0.004 (0.006)	-0.011** (0.005)	0.007** (0.004)
Δ ln (expenditure/P)	0.397*** (0.056)	-0.142*** (0.040)	-0.255*** (0.033)
Δ ln (pork price)	0.207*** (0.012)	-0.056*** (0.009)	-0.150*** (0.007)
Δ (poultry price)		0.071*** (0.009)	-0.014 (0.011)
Δ ln (beef-mutton price)			0.164*** (0.011)
Observations	22	22	22
R-Squared	0.92	0.78	0.94

Note: Standard errors are in parenthesis. ***, **, and * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. AIDS=Almost Ideal Demand System.

Source: Estimated by USDA, Economic Research Service, with data from China's National Bureau of Statistics, Administration of Customs, National Development and Reform Commission, Ministry of Agriculture and Rural Affairs.

Appendix table 4

Parameter estimation of first-differenced AIDS Model (household purchase data)

Parameters	Pork equation	Poultry equation	Beef/mutton equation
Constant	-0.009** (0.004)	0.003 (0.004)	0.006*** (0.002)
I_{AI}	0.031*** (0.011)	-0.026** (0.011)	-0.005 0.004
Δ ln (expenditure/P)	0.052 (0.070)	0.006 (0.070)	-0.057*** (0.022)
Δ ln (pork price)	0.116*** (0.026)	-0.016 (0.032)	-0.085*** (0.008)
Δ (poultry price)		-0.016 (0.032)	0.046*** (0.016)
Δ ln (beef-mutton price)			0.040*** (0.016)
Observations	22	22	22
R-Squared	0.68	0.31	0.82

Note: Standard errors are in parenthesis. ***, **, and * indicate statistical significance at 1 percent, 5 percent, and 10 percent, respectively. AIDS = Almost Ideal Demand System.

Source: Estimated by USDA, Economic Research Service, with data from China's National Bureau of Statistics, National Development and Reform Commission, Ministry of Agriculture and Rural Affairs.

Appendix 4: Data Tables

Appendix table 5

China's per capita disappearance of pork, poultry, beef and mutton, 2000–21

	Per capita output			Per capita net imports			Per capita disappearance		
	Pork	Poultry	Beef/ mutton	Pork	Poultry	Beef/ mutton	Pork	Poultry	Beef/ mutton
Year	Kilograms								
2000	31.3	9.4	4.0	0.1	0.4	0.0	31.4	9.7	4.1
2001	31.7	9.5	4.0	0.0	0.2	0.0	31.7	9.7	4.0
2002	32.1	9.7	4.1	0.0	0.2	0.0	32.1	9.9	4.1
2003	32.8	10.2	4.2	0.0	0.3	0.0	32.7	10.4	4.2
2004	33.4	10.4	4.3	-0.2	0.1	0.0	33.2	10.4	4.3
2005	34.8	11.2	4.3	-0.2	0.2	0.0	34.7	11.4	4.3
2006	35.4	10.4	4.4	-0.2	0.3	0.0	35.2	10.7	4.4
2007	32.6	11.0	4.7	0.0	0.5	0.0	32.6	11.4	4.7
2008	35.3	11.5	4.7	0.2	0.5	0.0	35.5	12.0	4.7
2009	37.0	12.0	4.7	0.0	0.4	0.0	37.0	12.4	4.7
2010	38.3	12.4	4.7	0.1	0.3	0.0	38.4	12.6	4.7
2011	38.0	12.7	4.5	0.3	0.2	0.1	38.3	12.8	4.6
2012	40.0	13.4	4.5	0.3	0.2	0.1	40.4	13.7	4.6
2013	41.1	13.2	4.5	0.4	0.3	0.4	41.5	13.4	4.9
2014	42.3	12.7	4.5	0.3	0.2	0.4	42.6	12.9	4.9
2015	40.8	13.2	4.5	0.5	0.1	0.5	41.3	13.3	5.0
2016	39.0	14.4	4.4	1.1	0.3	0.6	40.1	14.6	5.0
2017	38.9	14.2	4.5	0.8	0.2	0.7	39.8	14.3	5.2
2018	38.4	13.8	4.6	0.8	0.2	1.0	39.3	14.0	5.5
2019	30.2	15.9	4.7	1.4	0.4	1.5	31.6	16.3	6.2
2020	29.1	16.7	4.8	3.0	1.0	1.8	32.2	17.7	6.5
2021	37.5	16.8	4.9	2.5	0.9	1.9	40.0	17.7	6.9

Note: Meat output data are from China's National Bureau of Statistics; Net imports = imports - exports; Disappearance = output + net imports. Per capita values are calculated using population data.

Source: USDA, Economic Research Service based on data from China National bureau of Statistics.

Appendix table 6

China's per capita household meat purchases, 2000–21

	Pork	Poultry	Beef/mutton
Year	Kilograms		
2000	14.5	3.8	1.9
2001	14.3	3.8	1.9
2002	16.3	5.4	1.9
2003	16.5	5.6	2.1
2004	15.9	5.3	2.3
2005	17.6	5.9	2.4
2006	17.5	5.7	2.5
2007	15.6	6.5	2.6
2008	15.8	6.1	2.3
2009	17.1	7.3	2.5
2010	17.6	7.2	2.6
2011	17.6	7.6	3.0
2012	18.0	7.8	2.9
2013	19.8	7.2	2.5
2014	20.0	8.0	2.5
2015	20.1	8.4	2.8
2016	19.6	9.1	3.3
2017	20.1	8.9	3.2
2018	22.8	9.0	3.3
2019	20.3	10.8	3.4
2020	18.2	12.7	3.5
2021	25.2	12.3	3.9

Note: Data for 2000–11 are weighted averages of rural and urban data.

Source: USDA, Economic Research Service, based on China's National Bureau of Statistics.

Appendix table 7

Average meat prices in China, 2000–21

	Pork	Chicken	Beef	Mutton	Beef-mutton average	All meat weighted average
Year	Yuan per kilogram					
2000	14.01	9.71	14.02	17.03	15.04	13.28
2001	14.14	10.07	17.18	15.57	16.61	13.64
2002	13.67	10.14	18.00	16.29	17.40	13.44
2003	13.69	10.35	19.28	17.26	18.54	13.65
2004	16.73	11.29	19.30	18.24	18.91	15.91
2005	17.01	11.70	19.39	19.71	19.51	16.22
2006	15.68	11.00	19.56	19.52	19.55	15.28
2007	22.35	13.45	23.06	23.44	23.20	20.57
2008	27.57	15.01	32.72	30.99	32.06	25.52
2009	19.43	15.46	34.38	33.64	34.10	20.56
2010	20.36	16.32	35.05	37.69	36.08	21.57
2011	27.96	18.53	39.01	46.15	41.81	27.68
2012	26.14	18.94	50.59	55.16	52.39	27.78
2013	25.96	18.57	63.04	63.03	63.04	28.88
2014	24.39	19.38	66.64	65.92	66.35	28.46
2015	26.55	19.94	67.23	62.71	65.35	29.95
2016	30.78	20.29	67.03	59.42	63.78	32.49
2017	27.45	20.05	67.39	60.03	64.26	30.50
2018	24.11	20.72	68.54	64.89	66.99	29.00
2019	35.36	23.71	76.57	74.68	75.77	38.05
2020	53.97	23.64	87.41	83.02	85.55	49.41
2021	35.28	23.24	89.90	86.79	88.58	39.32

Note: Data are not adjusted for inflation; 1991–2021 data are annual averages from monthly data.

Source: USDA, Economic Research Service, based on Chinese National Development and Reform Commission retail food prices, 2000–2008; China's National Bureau of Statistics average food prices, 2009–17; Ministry of Agriculture and Rural Affairs wholesale market prices plus estimated retail margin, 2018–21.

Appendix table 8

China's income, inflation, and population data, 2000–21

	Per capita disposable income	Annual income growth	Change in consumer price index	Change in real per capita income	Population	Population growth	
Year	Yuan	Percent	Percent	Percent	Million	Million	Percent
2000	3,721	6.8	0.4	6.4	1,267	9.6	0.76
2001	4,070	9.4	0.7	8.7	1,276	8.8	0.70
2002	4,532	11.4	-0.8	12.2	1,285	8.3	0.65
2003	5,007	10.5	1.2	9.3	1,292	7.7	0.60
2004	5,661	13.1	3.9	9.2	1,300	7.6	0.59
2005	6,385	12.8	1.8	11.0	1,308	7.7	0.59
2006	7,229	13.2	1.5	11.7	1,314	6.9	0.53
2007	8,584	18.7	4.8	13.9	1,321	6.8	0.52
2008	9,957	16.0	5.9	10.1	1,328	6.7	0.51
2009	10,977	10.2	-0.7	10.9	1,335	6.5	0.49
2010	12,520	14.1	3.3	10.8	1,341	6.4	0.48
2011	14,551	16.2	5.4	10.8	1,349	8.3	0.62
2012	16,510	13.5	2.6	10.9	1,359	10.1	0.75
2013	18,311	10.9	2.6	8.3	1,367	8.0	0.59
2014	20,167	10.1	2.0	8.1	1,376	9.2	0.67
2015	21,966	8.9	1.4	7.5	1,383	6.8	0.49
2016	23,821	8.4	2.0	6.4	1,392	9.1	0.65
2017	25,974	9.0	1.6	7.4	1,400	7.8	0.56
2018	28,228	8.7	2.1	6.6	1,405	5.3	0.38
2019	30,733	8.9	2.9	6.0	1,410	4.7	0.33
2020	32,189	4.7	2.5	2.2	1,412	2.0	0.14
2021	35,128	9.1	0.9	8.2	1,413	0.5	0.03

Source: USDA, Economic Research Service, based on China's National Bureau of Statistics "Chashu" database.

Appendix table 9

Correlation between Chinese household purchases and disappearance of meat

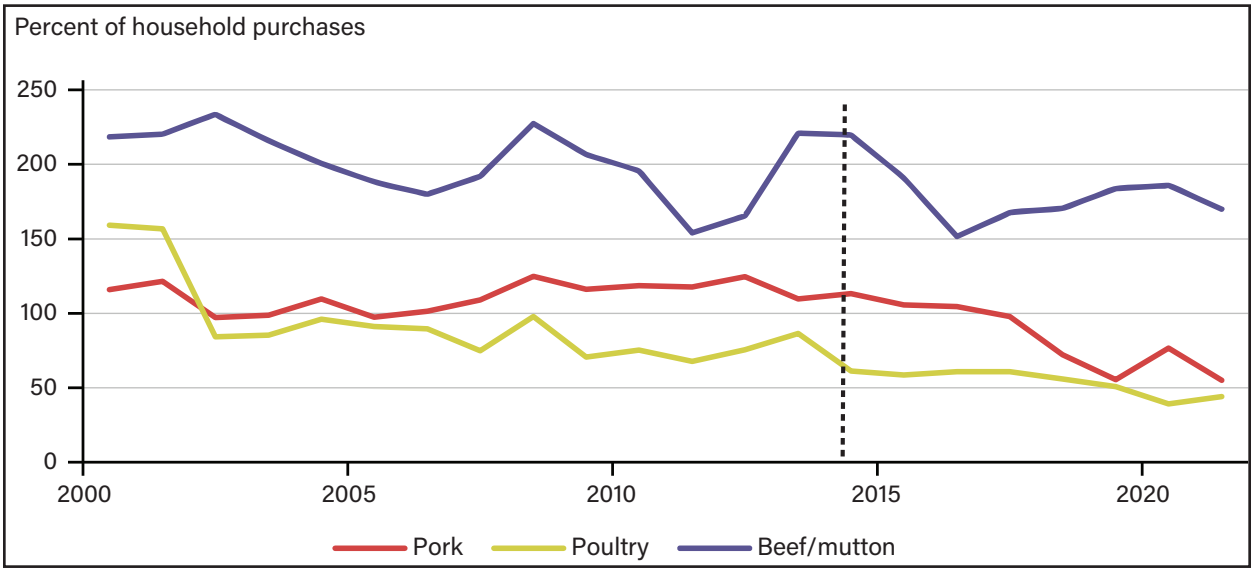
Type of meat	1999–2021	1999–2013	2014–21
	Correlation coefficient		
Pork	.705	.866	.290
Poultry	.984	.940	.987
Beef and mutton	.948	.866	.881

Note: Table shows correlations between year-to-year changes in per capita disappearance and household purchases for each meat and time period.

Source: USDA, Economic Research Service, analysis of data from appendix tables 5 and 6.

Appendix figure 2

Differences between Chinese per capita disappearance and household purchases of meat (2000–21)



Note: This chart shows (disappearance - household purchases)/(household purchases) x 100 calculated from data in appendix tables 5 and 6.

Source: USDA, Economic Research Service, based on data from China National Bureau of Statistics.