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U.S. DEPARTMENT OF AGRICULTURE

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April 2022

Quantifying Consumer Welfare Impacts of Higher Meat Prices During the COVID-19 Pandemic

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Abstract

While the U.S. food system has been largely able to maintain operations and provide consumers with the variety of foods they desire since the Coronavirus (COVID-19) pandemic began, U.S. households have been facing sharply higher food prices for many staple items, especially meat. In this study, U.S. households' meat purchases at retail stores for at-home consumption during the COVID-19 pandemic are examined and compared with those before the virus outbreak. A demand model is estimated using data collected during 2019 and 2020 on households' purchases of beef, pork, poultry, and other meats (mainly lamb and mutton) at retail stores. Results show that households spent more on meat for at-home consumption during 2020. This increase in expenditures reflects both higher retail food prices—which other research attributes to pandemic-related supply chain problems—and higher quantities purchased that offset reductions in meat consumption at restaurants and other foodservice facilities. Although U.S. households maintained their overall level of meat consumption during 2020, higher prices for meat at retail food stores still reduced their welfare. Those losses were higher during the spring and summer of 2020 and peaked in June 2020, with U.S. households' monthly welfare down by $24.51 per household during that month due to higher prices for meats in general. Higher prices for beef, pork, and poultry accounted for $8.30, $7.07, and $8.18, respectively, of that total. In December 2020, households' monthly welfare loss was $6.19 per household with higher prices for beef, pork, and poultry accounting for $2.44, $1.54, and $1.89, respectively.

Keywords: COVID-19, coronavirus, pandemic, meat demand, scanner data, compensating variation, food system resiliency, U.S. Department of Agriculture, USDA, Economic Research Service, ERS.

Acknowledgments

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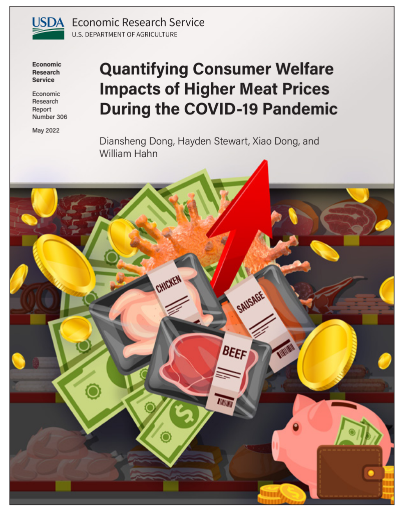


What Is the Issue?

The Coronavirus (COVID-19) pandemic affected all facets of the food system, in particular meat processors. During 2020 some packing plant workers tested positive for COVID-19, which forced the temporary closure of numerous plants and reduced operating capacity at others. U.S. meat production fell. While food supplies remained ample overall, U.S. households faced sharply higher prices for many staple items, including meat. Retail food prices rose about 3.4 percent during 2020, almost twice their usual rate. Meat prices increased at a faster rate, with retail beef and pork prices rising 25 percent and 12 percent, respectively, in June 2020, year-over-year. Prices for retail poultry and other meats (mainly lamb and mutton) also rose more than overall retail food prices, though less than beef and pork prices.

What Did the Study Find?

The COVID-19 pandemic altered food purchasing patterns by restricting restaurant dining, which encouraged U.S. households to eat out less and consume more food at home. During 2020, U.S. households increased their spending on meat for at-home consumption by 14.5 percent. Households bought more beef, pork, poultry, and other meats at grocery and other retail stores despite higher retail prices for each type of meat. Across the four types of meats, ERS researchers found the following statistics:

- The average retail price paid for meat increased 6.9 percent on a dollars-per-pound basis in 2020 over 2019. Beef prices increased the most at 8.9 percent, with pork, poultry, and other meats (mainly lamb and mutton) increasing by 5.7 percent, 4.9 percent, and 5.3 percent, respectively.
- Households increased their average purchases of meat for at-home consumption by 7.2 percent on a quantity basis in 2020 over 2019. In the four meat categories—beef, pork, poultry, and other meats—purchases of

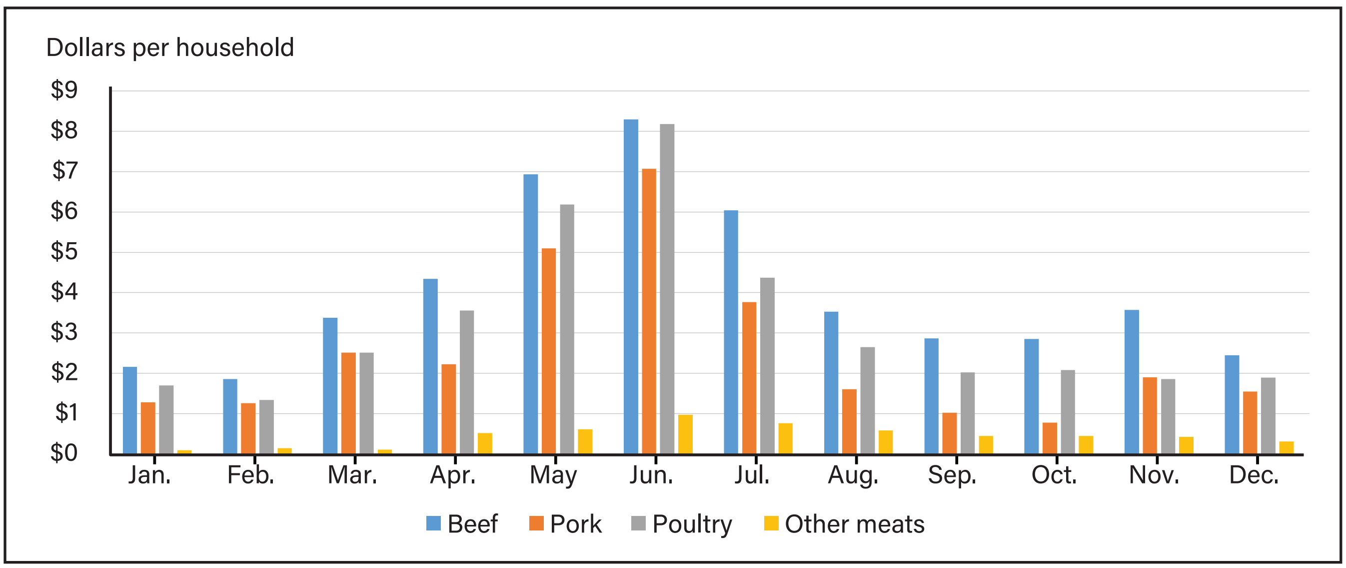
other meats increased the most at 13.5 percent, followed by pork (8 percent), poultry (7 percent), and beef (6.2 percent), which is nearly the reverse pattern of the price increases.

Despite being able to generally maintain their overall level of meat consumption (including consumption of meat both at and away from home), U.S. households' economic well-being fell with higher meat prices at retail stores. Those losses were higher during the spring months when operations at packing plants were most affected by the virus and peaked in June 2020, with U.S. household economic well-being down by $24.51 per household during that month due to higher prices for meats in general. Higher prices for beef, pork, and poultry accounted for $8.30, $7.07, and $8.18, respectively, during that month. In December 2020, U.S. household economic well-being was down $6.19 per household with higher prices for beef, pork, and poultry accounting for $2.44, $1.54, and $1.89, respectively.

How Was the Study Conducted?

The authors undertook a counterfactual analysis in this study. That is, what if retail prices for at-home meats had remained at their 2019 levels throughout 2020? How much better off economically would U.S. households have been? To answer this question and more generally gain a better understanding of U.S. household demand for beef, pork, poultry, and other meats during the pandemic, the authors used scanner data purchased from Information Resources, Inc. (IRI). Prices, expenditures, and purchased quantities in 2020 were compared with those in 2019. An Almost Ideal Demand System (AIDS) model for U.S. households' purchases of each type of meat was then estimated. The results were used to calculate the reduction in welfare that households incurred over each month of the pandemic due to higher meat retail prices compared with the same month of the previous, non-pandemic year.

U.S. households' welfare was lower in 2020 with higher retail prices for beef, pork, poultry, and other meats



Note: Well-being is defined as the "Reduction in U.S. households' well-being estimated by the method of compensating variation."

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

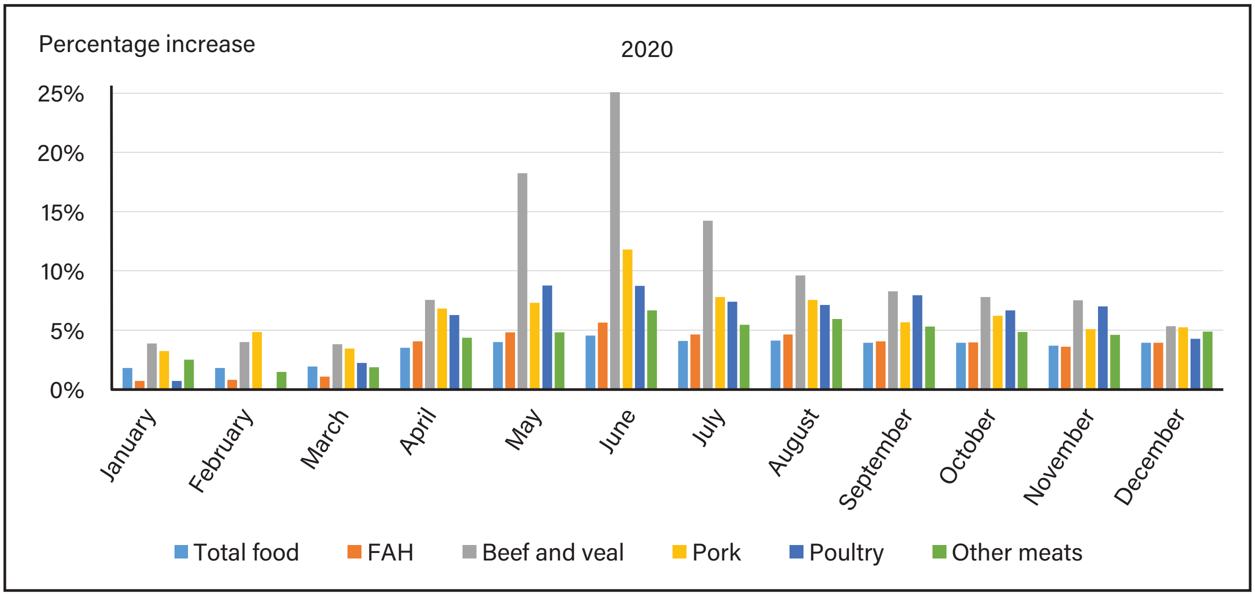
Quantifying Consumer Welfare Impacts of Higher Meat Prices During the COVID-19 Pandemic

Introduction

When COVID-19 began to spread in the United States starting in March 2020, households sharply reduced their consumption of meals and snacks at restaurants and other foodservice facilities. Instead, they consumed more meals at home using foods purchased at supermarkets and other retail food stores (Chenarides et al., 2021; Hobbs, 2021; Balagtas and Cooper, 2021; Cowley, 2020; Zeballos and Dong, 2021). Some consumers, driven by pandemic-induced anxiety, bought more food than they normally consume and stockpiled groceries (Hobbs, 2021). In a survey of consumers in two U.S. cities, Chenarides et al., (2021) reported 47 percent of survey respondents bought more food than usual and 33 percent stockpiled food. However, the overall food supply remained ample. Most respondents in the Chenarides et al., (2021) survey maintained their usual consumption patterns for major food groups. From a health perspective, the most significant changes in dietary intake during COVID-19, as reported by participants, were increases in snacking, which were offset by sharp declines in fast food consumption.

Accommodating the shift in consumer demand from food-away-from-home (FAFH) to food bought for at-home (FAH) consumption while dealing with supply disruptions associated with the pandemic was a challenge for the U.S. food marketing system. U.S. meat production was hit especially hard as many packing plants had to close at least temporarily (Balagtas and Cooper, 2021; Saitone et al., 2021; Hobbs, 2021; Taylor et al., 2020; Cowley, 2020). Households accustomed to finding their preferred food products at retail stores faced occasional out-of-stock situations and higher prices for what they could find (Chenarides et al., 2021; Hobbs, 2021; Balagtas and Cooper, 2021). The ERS Food Price Outlook shows that retail food prices rose about 3.4 percent in 2020, almost twice their usual rate. Prices for some foods, especially meats, rose much more—with retail beef and pork prices rising 25 percent and 12 percent, respectively, in June 2020 (figure 1). Retail poultry and other meat prices also rose more than overall retail food prices, though less than beef and pork.

Figure 1
Food price inflation during COVID-19: 2020 monthly prices compared with the same month in 2019



FAH = food at home.

Source: USDA, Economic Research Service (ERS) using data from U.S. Bureau of Labor Statistics' Consumer Price Indexes (not seasonally adjusted) and USDA, ERS Food Price Outlook.

The U.S. food system is efficient and productive (Saitone and Sexton, 2017; Brown and Tousey, 2019) as well as resilient (Gagnon and Lopez-Salido, 2020).[1] When challenged in the past, the food system generally continued to provide consumers with their desired variety of foods while still holding down prices and quickly recovering. Gagnon and Lopez-Salido (2020) examined the performance of supermarkets that faced large swings in food demand. Some fluctuations they examined were caused by labor conflicts, such as strikes that sharply reduced demand at a targeted store and caused a surge in demand at another nearby store. Other demand swings they studied were caused by major snowstorms or hurricanes that caused some people to stockpile food and others to take refuge in nearby cities where they increased the demand for food. In all cases, Gagnon and Lopez-Salido (2020) found that such shocks have, at best, a modest effect on the level of retail prices.[2]

The pandemic was in many ways unprecedented for both consumers and suppliers. In this study, authors examined average U.S. household purchases of meat for at-home consumption during the pandemic and the impact of higher retail meat prices on household well-being. Data on average meat purchases by households at the U.S. State level during 2019 and 2020 are used. These data allow for the examination and comparison of average meat demand in 2020 during the pandemic with 2019, before the outbreak of the virus. Demand for beef, pork, poultry, and other meats at the U.S. State level is estimated to better understand household purchase behavior in response to price and income changes during the pandemic. Finally, results are used to conduct a welfare analysis. Specifically, we asked if FAH meat prices had remained at 2019 levels throughout 2020, how much better off would U.S. households have been?

[1] Increased coordination and consolidation among food manufacturers, wholesalers, retailers, and producers along the entire supply chain have been credited for enabling the food system to offer consumers a wide variety of products and services while keeping prices low (Saitone and Sexton, 2017). Food retailers such as large supermarket and supercenter chains, use category management techniques to offer consumers tens of thousands of food products differentiated by package size, flavor, and various methods of production, such as organic versus conventional, among other characteristics. However, this is most cost effective on a large scale, resulting in a few dominant supermarkets in any market area (Ellickson, 2007).

[2] Results are consistent with the equilibrium moving along flat short- to medium-term retail supply curves (or, equivalently, consistent with a high-price elasticity of retail supply).

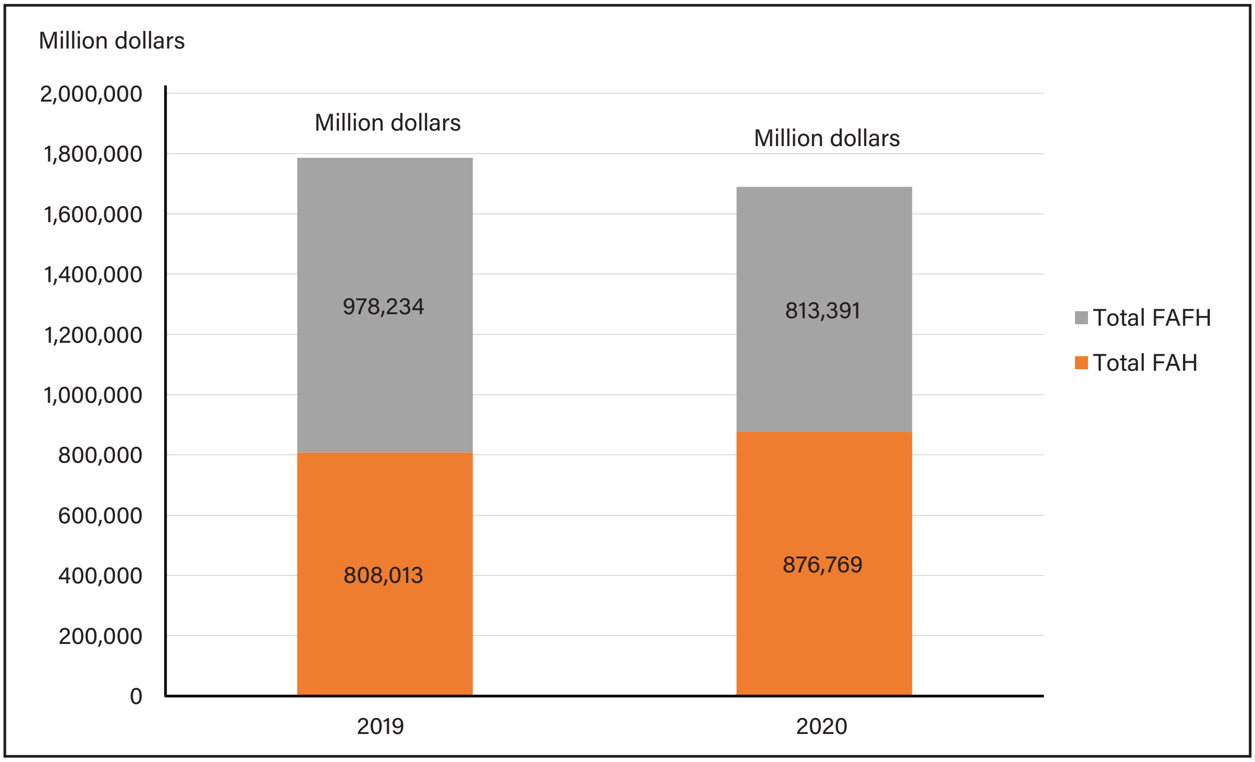
Impact of the COVID-19 Pandemic on U.S. Meat Demand and Supply

This report reviews the effect of COVID-19 on consumers and producers, with an emphasis on U.S. meat demand and supply.

Impact on Household Meat Demand

The COVID-19 pandemic did not prevent U.S. households from buying restaurant meals and snacks, but restrictions on in-person dining limited their options (take-out and delivery options remained generally plentiful). The ERS Food Expenditure Series reported total U.S. food away from home (FAFH) expenditures decreased by $165 billion, while total U.S. food at home (FAH) expenditures rose by $69 billion from 2019 to 2020 (figure 2). Overall, total food expenditures decreased by a net $96 billion, owing partly to price differences between FAH and FAFH that reflect the greater amount of value-added services FAFH meals and snacks embody (e.g., the restaurant prepares the food and provides cleaning up services).

Figure 2
Food expenditures in 2019 and 2020, nominal expenditures



FAFH = food away from home. FAH = food at home.

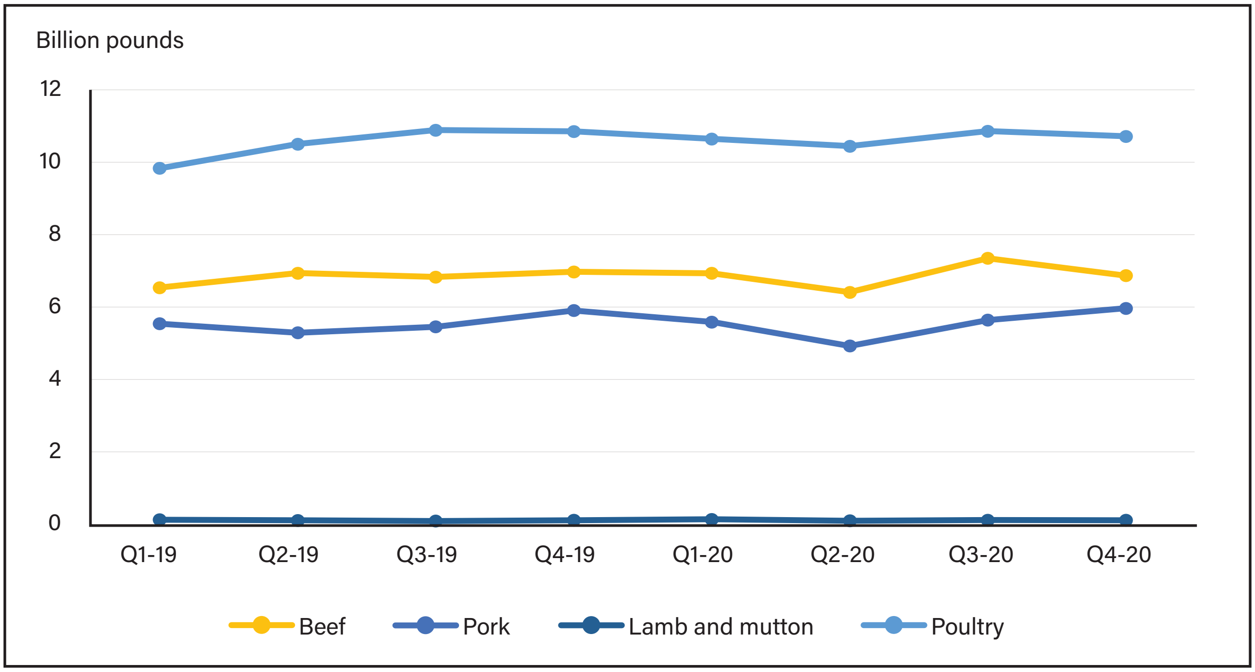
Source: USDA, Economic Research Service Food Expenditure Series (Nominal Expenditures).

While the COVID-19 pandemic prevented consumers from eating out as often as they might otherwise prefer, ERS Food Availability data confirm evidence reported by Chenarides et al., (2021) that U.S. meat consumption was stable overall (figure 3).[3] U.S. households maintained their previous intake levels by substituting FAH

[3] USDA, Economic Research Service creates an annual data series that allows analysts to track long-run consumption trends for more than 200 commodities. Data on the amounts of foods available for human consumption are used to proxy for actual consumption. Total availability trends upward for most meats over time, attributed partly to U.S. population growth.

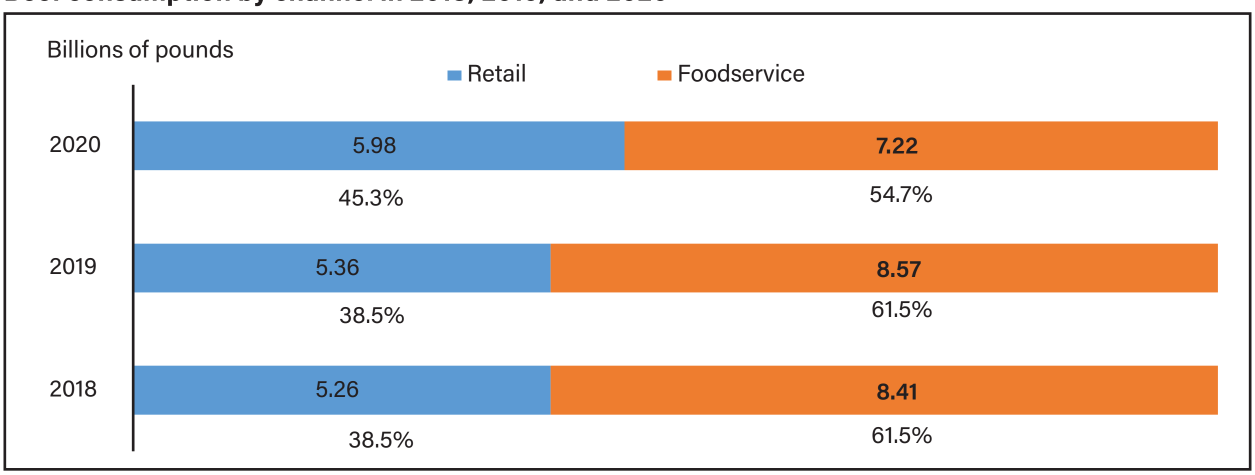
meats for FAFH meats (see the example for beef consumption in figure 4). Past research suggests the U.S. food marketing system might have been able to accommodate this shift in consumer demand from FAFH meats to FAH meats without large changes in retail meat prices (Gagnon and López-Salido, 2020), if suppliers had not also faced other challenges.

Figure 3
U.S. meat consumption in billions of pounds per quarter, 2019 and 2020



Source: USDA, Economic Research Service Livestock and Meat Domestic Data, All Supply and Disappearance (in carcass weight).

Figure 4
Beef consumption by channel in 2018, 2019, and 2020



Source: *Beef. It's What's For Dinner*, March 26, 2021. Courtesy of BeefItsWhatsForDinner.com.

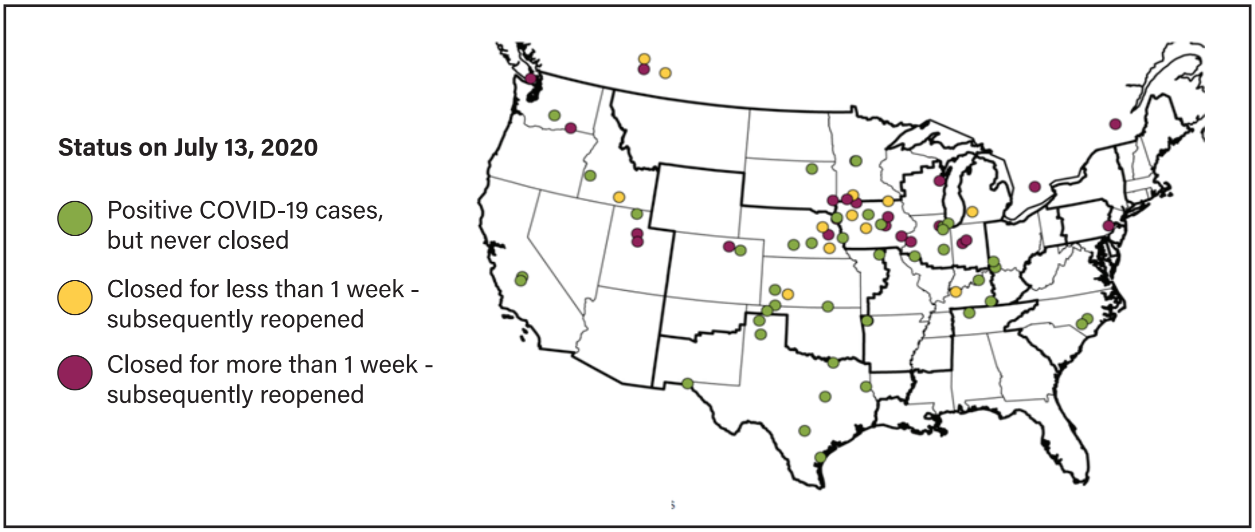
Impact on Meat Supply

Livestock production is among the sectors of the U.S. food economy that substantially changed in structure over the years, with minimum negative impact to consumers (Martinez et al., 2021; McDonald et al., 2018; McDonald and McBride, 2009). By spreading fixed costs for equipment and other production factors such as labor, over a greater amount of output, beef packers kept their average costs down. Martinez et al., (2021) and Cowley (2020) reported that packing plants are geographically concentrated. While farmers and ranchers are located across the Nation, they supply beef cattle to a relatively concentrated feedlot industry located primarily in the center of the country. These operators, in turn, supply nearby packing houses that are often owned by large firms.

When COVID-19 spread and shelter-in-place orders were issued in March 2020, U.S. residents largely stayed at home. Exempt from these orders were agricultural workers and food manufacturers, which included meat processors who continued working through the pandemic to meet consumer needs as much as their unique situations allowed. Luckstead et al., (2021) reported that managers sought to mitigate the risk to their workers by implementing social distancing policies and other measures. Some workers still fell ill with COVID-19 and many packing plants were forced to temporarily scale back or even suspend operations (Balagtas and Cooper, 2021; Taylor et al., 2020). Meat-packing plants are crowded places to work (Aday and Aday, 2020), and the cold and humid environment within them may facilitate spread of the virus. Saitone et al., (2021) showed that COVID-19 infections were greatest in counties with meat-packing plants.

Figure 5

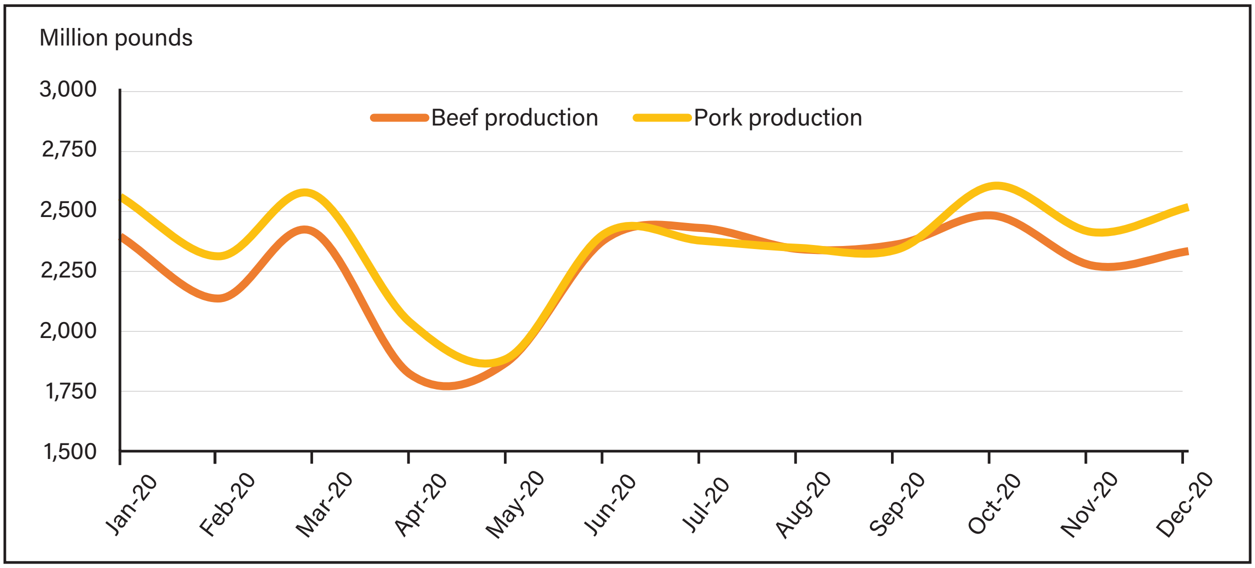
U.S. meat-packing plant locations affected by COVID-19



Source: Cowley, C. 2020. "COVID-19 Disruptions in the U.S. Meat Supply Chain," Federal Reserve Bank of Kansas City.

Between April 2020 and June 2020, more than 80 beef and pork packing plants confirmed cases of COVID-19 (Cowley, 2020). On average, about 10 percent of employees tested positive for the virus. At some plants, COVID-19 affected as many as 30 percent to 70 percent of the workforce. By July 2020, almost half of plants with outbreaks closed for at least a brief period (figure 5).

Figure 6
U.S. beef and pork production, January 2020 to December 2020



Source: USDA, Economic Research Service Livestock and Meat domestic data.

Because of temporary shutdowns at beef and pork packing plants, U.S. production was substantially lower during the first 3 months of the COVID-19 pandemic (Balagtas and Cooper, 2021; Martinez et al., 2021; Lusk et al., 2021; USDA, Agricultural Marketing Service, 2020; American Farm Bureau Federation, 2020; Cowley, 2020). In March 2020, U.S. pork production totaled 2.6 billion pounds and beef production totaled 2.4 billion pounds. By contrast, in April and May 2020, the output of both types of meat fell and remained at or below 2 billion pounds per month. The Federal Government took steps to prevent a significant meat shortage that included deeming meat processors as critical infrastructure and ordering them to remain open (USDA, 2020). As a result of these efforts and others by plant managers to implement COVID-19 protocols, production returned to normal for beef and pork by June 2020 (figure 6).

Measuring Household Meat Demand and Welfare Loss During the COVID-19 Pandemic

Given the supply problems and higher retail meat prices caused by the COVID-19 pandemic, U.S. households adjusted their FAH meat purchases. One way to measure this adjustment is to compare U.S. households' FAH meat purchases in 2020 with those in 2019 before the pandemic using scanner data from Information Resources, Inc. (IRI). ERS has used these real-time, weekly data to produce reports for stakeholders with information and insights throughout the pandemic (USDA, ERS, 2021). The data are collected from households and retail stores. Together, these two datasets include the information needed to derive estimates of product prices, as well as State average households' meat expenditures during each month of 2019 and 2020. The data include months during which supply disruptions were most problematic and months during which meat production recovered (figure 6).[4]

IRI Real-Time Data

The household-based data acquired by ERS, similar to IRI Consumer Network data derived from National Consumer Panel (NCP), include measures of U.S. household meat purchases.[5] Participating households used in-home scanning devices to record their food-at-home (FAH) purchases. However, unlike NCP data focused on individual households, these data are geographically representative estimates at the U.S. State level obtained using proprietary sample weights. The dataset contains: (1) number of buying households for a particular product in a particular State; (2) percentage of buying households for a particular product in a particular State; (3) projected number of buying households for a particular product in a particular State; (4) average spending per household among buying households for a particular product in a particular State; (5) projected total number of buying trips for a particular product in a particular State; and (6) average spending per trip among buying households for a particular product in a particular State. Since the data are aggregated to the State level, they do not include information on the characteristics of purchasing households.

The store-based data acquired by ERS contain sales information provided by a panel of retailers, including supermarkets, supercenters, warehouse club stores, and convenience stores, among other formats.[6] However, unlike IRI's InfoScan data focused on individual stores, these data are geographically representative estimates of U.S. store sales at the U.S. State, metropolitan area, and national levels. This includes information on panelists' sales measured both in dollars and in physical terms (i.e., total quantities sold in pounds).

For the main empirical analysis, IRI data on households' average purchases of beef, pork, poultry, and other meats[7] for each State during each month of 2019 and 2020 were combined with measures of average retail prices derived from IRI's store-based data. While the raw data notably contain information on households' purchases of specific cuts of meats such as beef steaks and beef roasts, any changes in the specific cuts that households consumed were not included in this report. Changes in specific meat cuts were likely caused by stockouts that forced some consumers to choose a cut of meat other than their favorite or to which cuts of meat households prefer when eating at home versus away from home. A focus was placed on how households

[4] Since the real-time Information Resources, Inc. (IRI) data report the week-ending dates instead of a specific month for a monthly entry, the dates are transformed to an associate month using the information in the appendix table.

[5] Muth et al., (2016) provide an overview of the Consumer Network data that ERS buys from Information Resources, Inc. (IRI) on a recurring basis.

[6] Muth et al., (2016) also provide an overview of the retail store data that ERS buys from Information Resources, Inc. (IRI) on a recurring basis.

[7] Other meats consist of lamb, mutton, rabbit, venison, etc. The meat products include all formats (fresh, frozen, etc.) purchased from all retail channels (supermarket, mass merchandiser, convenience store, etc.) used for at-home consumption.

maintained their overall consumption of beef, pork, poultry, and other meats defined at the commodity level.[8] This is the level at which dietary recommendations for meats are generally stated.[9]

Measures of average retail prices for all four types of meat were derived from IRI store-based data for each State and each month of 2019 and 2020. The weighted total value of store sales in a given State and month (measured in dollars) was divided by the corresponding value of those same sales measured in pounds (i.e., the average price charged by all stores in a State on a dollars-per-pound basis was calculated).[10] The resulting ratios, known as unit values, are widely used in demand analyses, including the estimation of demand systems using a time series of observations on retail food sales.[11] In one study, Heng et al., (2018) used unit values derived from retail-level scanner data to estimate a demand system for 15 different beverages. Weekly sales data from April 2013 to April 2015 were used. Schulz et al., (2012) used unit values also derived from retail-level scanner data to estimate two separate demand systems for ground beef. One that aggregated over products based on brand type (i.e., unbranded, store brand, local/regional brand, and national brand) and another that aggregated over products based on lean percentage (e.g., 70–77 percent lean, 78–84 percent lean, etc.). The report used weekly sales data from January 1, 2004, through March 31, 2009.

The final dataset includes information on household-average expenditures for beef, pork, poultry, and other meats for 48 continental States and the District of Columbia during 24 months from January 2019 through December 2020. The total number of observations is 49 x 24 = 1,176. Since the number of households that reported meat expenditures was insufficient in some States to make a statistically valid projection in all months, excluded from the model estimation were those observations without information on any meat purchases. In total, 142 observations were dropped, including 24 each in the District of Columbia, North Dakota, South Dakota, and Wyoming; 23 in Vermont; 19 in Montana; 3 in Rhode Island; and 1 in Delaware.[12] A total of 1,034 observations remained. Among the 1,034 meat purchase observations, beef is the most purchased product (1,020 observations), followed by poultry (1,014), pork (899), and other meats (342). Table 1 shows a summary of households' average monthly meat expenditures, purchase quantities, and prices for total meat and each of the four meat types. Table 2 and figure 7 show total meat prices, expenditures, and quantities during each month of 2020 as a percentage of the same value during the same month of 2019. Table 2 and figures 8 through 11 show the same information for each type of meat.

[8] For an analysis of U.S. household demand for specific meat cuts, see Schulz et al., (2012) and Nayga et al., (1994).

[9] Dietary recommendations for all protein foods, including meats and poultry, are stated in ounce equivalents, and different cuts of meat count equally toward meeting recommendations (USDA and U.S. Department of Health and Human Services, 2020).

[10] Since not all States are included in the store data for all months, we used the average monthly prices for all the included States to approximate prices for missing States.

[11] Another approach for estimating this type of demand system uses the Consumer Prices Index (CPI) published by the U.S. Bureau of Labor Statistics (BLS) (Okrent and Alston, 2012).

[12] Observations without purchase information are excluded from the household-based data. However, those observations without information to derive prices in the store-based data are kept. Fourteen States and districts (Connecticut, Delaware, District of Columbia, Idaho, Iowa, Kansas, Minnesota, Mississippi, Montana, Nebraska, New Jersey, New Mexico, North Dakota, South Dakota, and Wyoming) are in the store-based data without information to derive prices. The average price for States included in the store-based data is used for prices in States for which that information is not available, but purchase information from the household-based data is available.

Table 1

Household meat expenditures, prices, and quantities in 2019 and 2020

Month	Expenditure (dollars)					Price (dollars per pound)					Quantity (pounds)				
	Total	Beef	Pork	Poultry	Other meats	Total	Beef	Pork	Poultry	Other meats	Total	Beef	Pork	Poultry	Other meats
Jan.-19	157.62	77.63	33.21	41.93	4.85	3.37	5.09	2.62	2.37	2.84	47.33	15.24	12.69	17.68	1.71
		(0.49)	(0.21)	(0.27)	(0.03)										
Feb.-19	151.60	74.92	30.88	41.28	4.53	3.41	5.20	2.63	2.40	3.14	44.80	14.41	11.73	17.21	1.44
		(0.49)	(0.20)	(0.27)	(0.03)										
Mar.-19	149.66	80.05	28.55	35.98	5.07	3.48	4.99	2.59	2.40	3.59	43.45	16.04	11.02	14.98	1.41
		(0.53)	(0.19)	(0.24)	(0.03)										
Apr.-19	154.30	67.26	40.40	41.43	5.23	3.26	5.43	2.63	2.39	2.03	47.63	12.38	15.34	17.34	2.57
		(0.44)	0.26	(0.27)	(0.03)										
May-19	143.90	71.03	29.15	39.10	4.60	3.48	5.44	2.65	2.38	3.41	41.82	13.05	11.02	16.41	1.35
		(0.49)	0.20	(0.27)	(0.03)										
Jun.-19	144.65	72.97	31.17	36.19	4.31	3.57	5.53	2.71	2.39	3.79	40.99	13.20	11.50	15.15	1.14
		(0.50)	0.22	(0.25)	(0.03)										
Jul.-19	137.05	65.50	29.14	38.85	3.58	3.47	5.42	2.66	2.36	3.85	40.45	12.08	10.96	16.48	0.93
		(0.48)	0.21	(0.28)	(0.03)										
Aug.-19	135.29	65.39	26.40	40.25	3.26	3.50	5.44	2.68	2.40	3.79	39.50	12.02	9.84	16.79	0.86
		(0.48)	0.20	(0.30)	(0.02)										
Sep.-19	138.34	72.56	28.29	34.05	3.44	3.54	5.29	2.64	2.38	3.78	39.64	13.71	10.72	14.30	0.91
		(0.52)	0.20	(0.25)	(0.02)										
Oct.-19	143.84	73.46	29.14	37.95	3.29	3.48	5.27	2.67	2.36	3.67	41.81	13.94	10.91	16.06	0.90
		(0.51)	0.20	(0.26)	(0.02)										
Nov.-19	144.14	71.34	27.70	41.18	3.91	2.91	5.19	2.66	1.61	2.82	51.11	13.75	10.43	25.55	1.38
		(0.49)	0.19	(0.29)	(0.03)										
Dec.-19	161.46	66.35	36.44	53.96	4.71	2.98	5.53	2.66	1.89	2.24	56.33	11.99	13.69	28.54	2.11
		(0.41)	0.23	(0.33)	(0.03)										
2019 average	**146.82**	**71.67**	**30.81**	**40.13**	**4.22**	**3.37**	**5.32**	**2.65**	**2.28**	**3.25**	**44.02**	**13.47**	**11.62**	**17.62**	**1.30**
		(0.49)	**0.21**	**(0.27)**	**(0.03)**										
Jan.-20	151.70	72.00	31.66	44.05	3.99	3.42	5.34	2.70	2.42	2.87	44.77	13.49	11.73	18.17	1.39
		(0.47)	(0.21)	(0.29)	(0.03)										
Feb.-20	148.14	71.22	30.43	42.54	3.93	3.49	5.39	2.72	2.45	3.15	42.98	13.21	11.17	17.35	1.24
		(0.48)	(0.21)	(0.29)	(0.03)										
Mar.-20	182.30	92.10	36.73	47.38	6.11	3.58	5.31	2.79	2.47	3.61	51.35	17.35	13.15	19.16	1.69
		(0.51)	(0.20)	(0.26)	(0.03)										
Apr.-20	182.96	84.97	45.65	46.25	6.09	3.56	5.83	2.86	2.49	2.32	51.72	14.58	15.95	18.56	2.63
		(0.46)	(0.25)	(0.25)	(0.03)										
May-20	184.76	94.54	40.09	44.95	5.15	3.95	6.39	3.00	2.54	3.64	47.29	14.79	13.36	17.71	1.42
		(0.51)	(0.22)	(0.24)	(0.03)										
Jun.-20	174.19	88.79	36.18	43.48	5.75	4.16	6.98	3.11	2.59	3.93	42.63	12.72	11.64	16.82	1.46
		(0.51)	(0.21)	(0.25)	(0.03)										
Jul.-20	171.12	90.25	36.02	39.55	5.30	3.95	6.14	2.86	2.56	4.10	44.01	14.70	12.59	15.43	1.29
		(0.53)	(0.21)	(0.23)	(0.03)										
Aug.-20	162.27	84.25	32.19	40.86	4.97	3.76	5.83	2.73	2.51	4.10	43.68	14.44	11.77	16.25	1.21
		(0.52)	(0.20)	(0.25)	(0.03)										
Sep.-20	160.22	80.89	31.68	42.60	5.05	3.64	5.57	2.70	2.47	4.09	44.70	14.51	11.74	17.22	1.23
		(0.50)	(0.20)	(0.27)	(0.03)										
Oct.-20	156.87	76.36	30.29	46.06	4.16	3.57	5.54	2.72	2.45	4.06	44.78	13.79	11.14	18.82	1.02
		(0.49)	(0.19)	(0.29)	(0.03)										
Nov.-20	160.70	82.20	31.55	42.30	4.68	3.12	5.47	2.71	1.73	2.87	52.76	15.03	11.62	24.48	1.63
		(0.51)	(0.20)	(0.26)	(0.03)										
Dec.-20	182.93	76.79	40.94	59.65	5.54	3.06	5.76	2.71	1.99	2.29	60.83	13.34	15.09	29.97	2.43
		(0.42)	(0.22)	(0.33)	(0.03)										
2020 average	**168.18**	82.91	35.17	45.06	5.04	**3.61**	**5.80**	**2.80**	**2.39**	**3.42**	**47.18**	**14.31**	**12.55**	**18.85**	**1.47**
		(0.49)	**(0.21)**	**(0.27)**	**(0.03)**										
% change over 2019	**14.5%**	**15.7%**	**14.2%**	**12.3%**	**19.5%**	**6.9%**	**8.9%**	**5.7%**	**4.9%**	**5.3%**	**6.9%**	**8.9%**	**5.7%**	**4.9%**	**5.3%**
		(1.0%)	**(-0.3%)**	**(-2.0%)**	**(4.3%)**										

Notes: Expenditure shares are in parentheses. Other meats consist of lamb, mutton, rabbit, venison, etc.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Table 2

Percentage changes in meat expenditures, prices, and quantities sold between 2019 and 2020

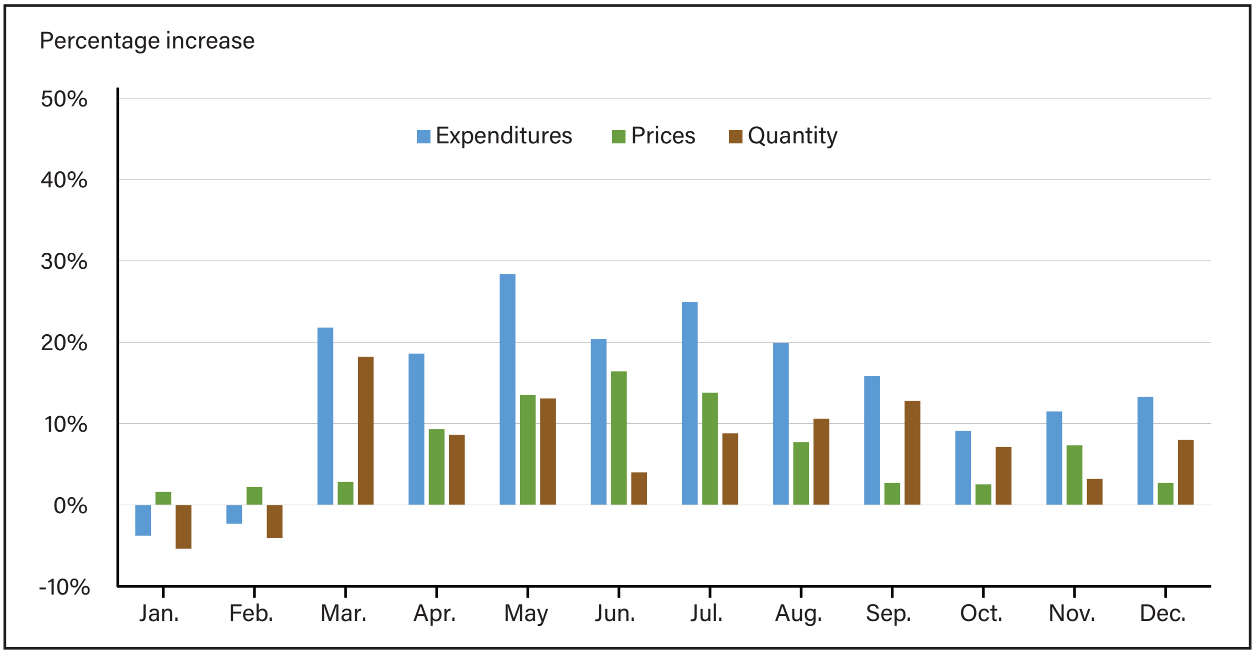
Month	Expenditure					Price					Quantity				
	Total	Beef	Pork	Poultry	Other meats	Total	Beef	Pork	Poul-try	Other meats	Total	Beef	Pork	Poul-try	Other meats
January	−3.8%	−7.3%	−4.7%	5.1%	−17.8%	1.6%	4.8%	3.2%	2.3%	1.4%	-5.4%	-11.5%	-7.6%	2.7%	−18.9%
Feb.	−2.3%	−4.9%	−1.5%	3.1%	−13.4%	2.2%	3.7%	3.5%	2.2%	0.3%	-4.1%	-8.3%	-4.8%	0.8%	−13.7%
March	21.8%	15.0%	28.6%	31.7%	20.4%	2.8%	6.4%	7.8%	3.0%	0.3%	18.2%	8.2%	19.3%	27.9%	20.0%
April	18.6%	26.3%	13.0%	11.6%	16.5%	9.3%	7.2%	8.7%	4.3%	13.9%	8.6%	17.8%	3.9%	7.0%	2.3%
May	28.4%	33.1%	37.5%	15.0%	12.0%	13.5%	17.4%	13.4%	6.5%	6.8%	13.1%	13.4%	21.3%	8.0%	4.9%
June	20.4%	21.7%	16.1%	20.1%	33.4%	16.4%	26.3%	14.6%	8.2%	3.9%	4.0%	−3.7%	1.2%	11.0%	28.4%
July	24.9%	37.8%	23.6%	1.8%	48.3%	13.8%	13.3%	7.6%	8.7%	6.6%	8.8%	21.6%	14.9%	-6.4%	39%
August	19.9%	28.8%	22.0%	1.5%	52.3%	7.7%	7.2%	1.9%	4.9%	8.1%	10.6%	20.2%	19.7%	-3.2%	40.9%
Sept.	15.8%	11.5%	12.0%	25.1%	46.5%	2.7%	5.4%	2.2%	3.9%	8.3%	12.8%	5.8%	9.5%	20.4%	35.3%
October	9.1%	4.0%	3.9%	21.4%	26.2%	2.5%	5.1%	1.8%	3.6%	10.5%	7.1%	−1.1%	2.1%	17.2%	14.2%
Nov.	11.5%	15.2%	13.9%	2.7%	19.7%	7.3%	5.4%	2.2%	7.2%	1.7%	3.2%	9.3%	11.4%	−4.2%	17.7%
Dec.	13.3%	15.7%	12.3%	10.5%	17.6%	2.7%	4.0%	1.9%	5.3%	2.1%	8.0%	11.3%	10.2%	5.0%	15.2%
Average	14.5%	15.7%	14.2%	12.3%	19.5%	6.9%	8.9%	5.7%	4.9%	5.3%	7.2%	6.2%	8.0%	7.0%	13.5%

Note: Other meats consist of lamb, mutton, rabbit, venison, etc.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Figure 7

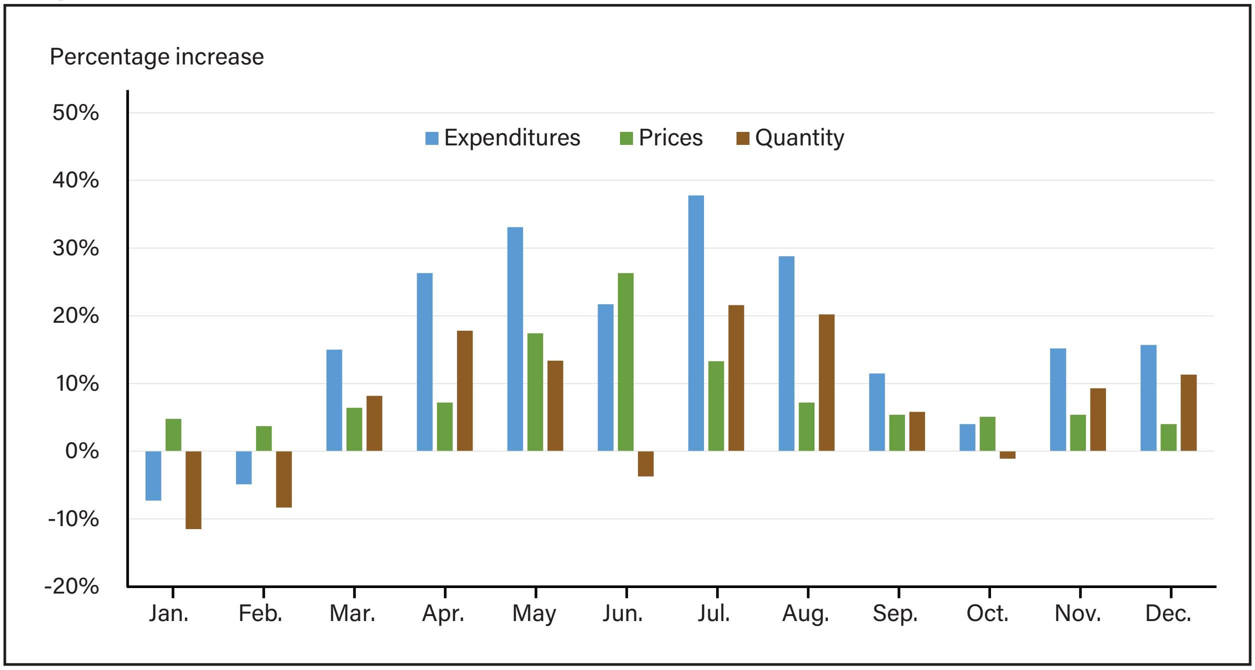
Percent change in total meat expenditures, prices, and quantities at retail establishments, 2019 compared with 2020



Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Figure 8

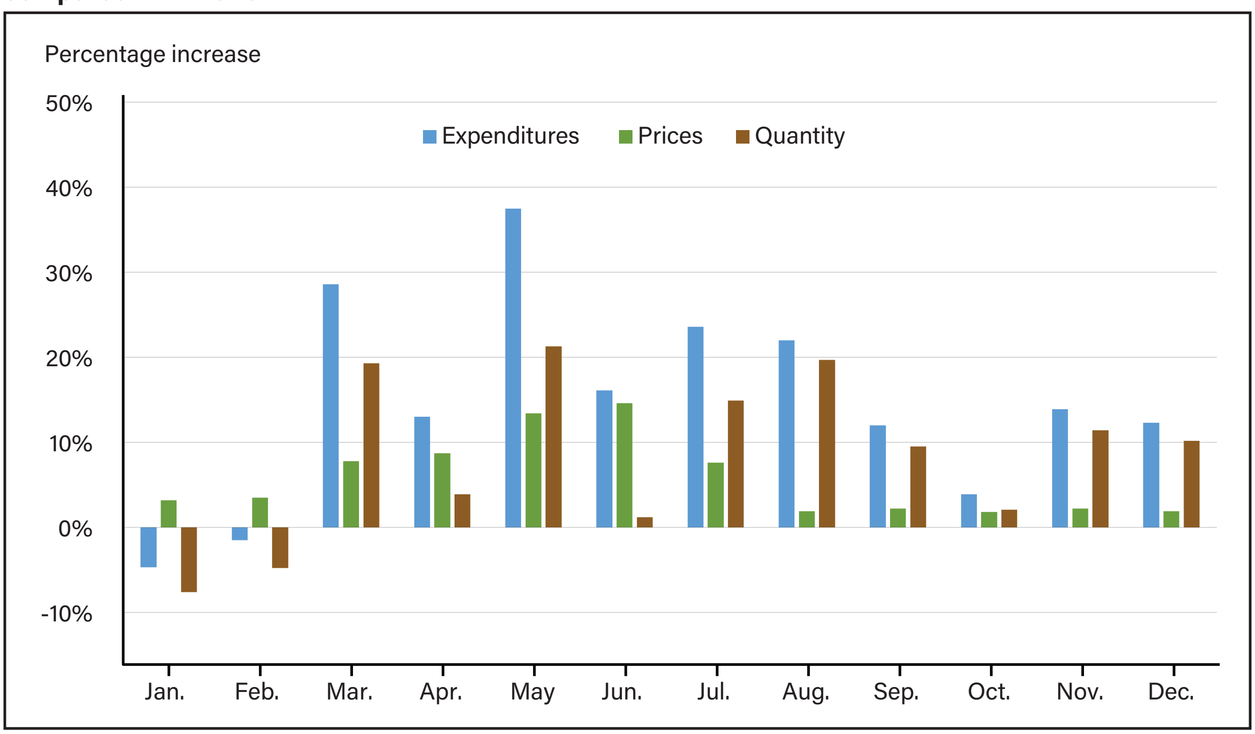
Percent change in beef expenditures, prices, and quantities at retail establishments, 2019 compared with 2020



Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Figure 9

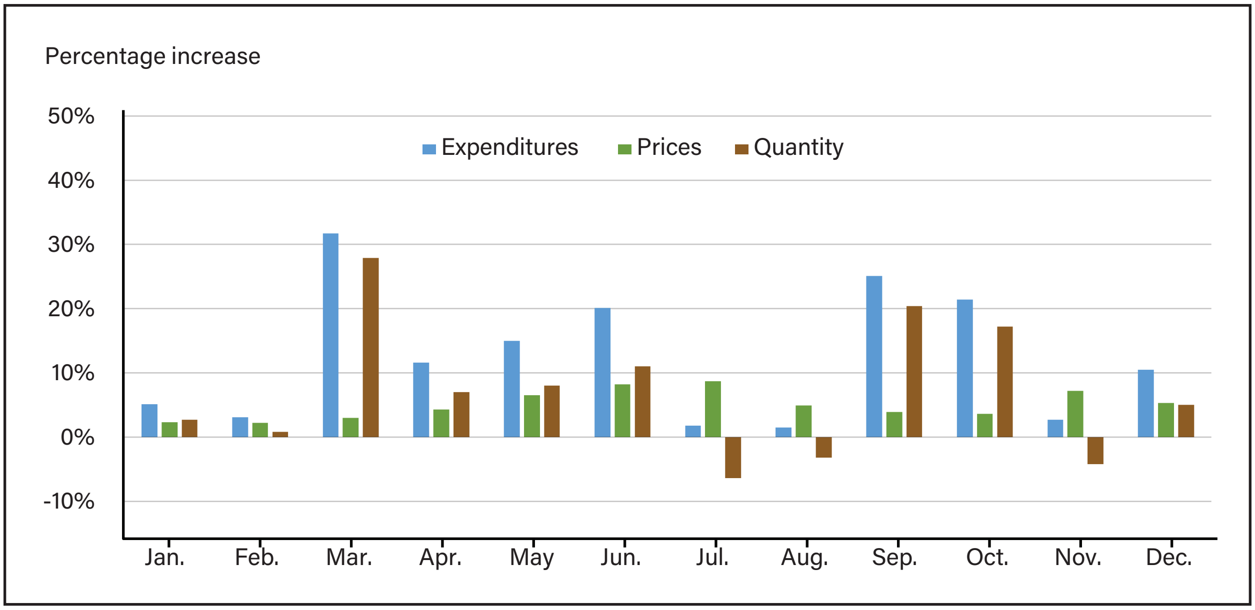
Percent change in pork expenditures, prices, and quantities at retail establishments, 2019 compared with 2020



Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Figure 10

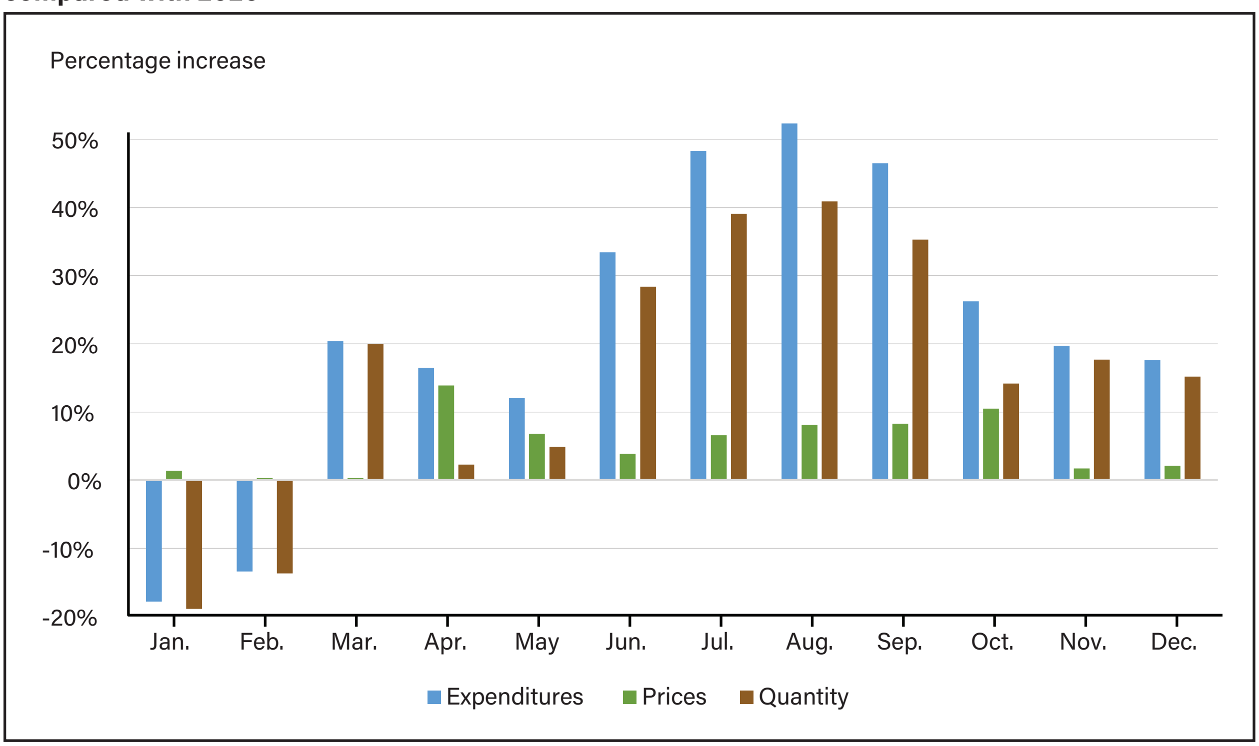
Percent change in poultry expenditures, prices, and quantities at retail establishments, 2019 compared with 2020



Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Figure 11

Percent change in other meats expenditures, prices, and quantities at retail establishments, 2019 compared with 2020



Note: Other meats consist of lamb, mutton, rabbit, venison, etc.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Meat products became more expensive at U.S. retail food stores in 2020 as many workers at packing houses became ill with COVID-19 and output fell (table 2, figures 7-11). The data show retail prices for beef, pork, and poultry started to increase in March 2020 and reached an apex in June, during the height of COVID-19 transmission at meat processing plants (Cowley et al., 2020; Taylor et al., 2020). Prices for beef and pork rose the most. Beef and pork prices began to fall after June 2020 but remained higher than before the pandemic. Over the course of 2020, average prices for all meats increased by 6.9 percent compared with 2019 (table 2). Within categories, beef increased the most at 8.9 percent, with pork, poultry, and other meats increasing by 5.7 percent, 4.9 percent, and 5.3 percent, respectively (table 2).

U.S. households greatly increased their expenditures for FAH meats to offset reductions in FAFH meat consumption (figures 2 to 4; and figure 7) and to pay for higher retail meat prices (table 2, figure 7). In May to August 2020, meat expenditures were at least 20 percent higher than during 2019. Overall, consumers increased their expenditures on all meat by 14.5 percent from 2019 to 2020. Higher levels of spending allowed U.S. households to buy more of all types of meats at retail stores during the COVID-19 pandemic (table 2, figures 7–11). Average quantity sold for all meats increased by 7.2 percent for 2020 compared with 2019. Within meat categories, other meats (mainly lamb and mutton) increased the most at 13.5 percent, followed by pork (8 percent), poultry (7 percent), and beef (6.2 percent), which is nearly the reverse pattern of the price increases.

Meat Demand Model

While a descriptive analysis of the raw data with summary statistics can yield important insights, a formal analysis of the data is necessary to properly measure the relationship between retail food prices, households' expenditures, and quantities purchased, as well as the effect that higher retail food prices had on U.S. household welfare. Past research suggests that the U.S. food marketing system might have been able to accommodate households' substitution of FAH meats for FAFH meats (Gagnon and Lopez-Salido, 2020) except that many packing plants were forced to scale back operations during the spring and summer of 2020. Both issues are supply-side challenges. A counterfactual analysis was conducted to estimate the impact on U.S. household welfare by asking if retail meat prices were at their 2019 levels throughout 2020, how much better off would households have been?

Using the data with 1,034 State-level observations on monthly U.S. household-average FAH meat demand over 2019 and 2020, we estimated a demand model for beef, pork, poultry, and other meats. The price variables are unit values calculated from IRI store-based data. Our measure of the welfare effect of a price change is the compensating variation: the amount of income that a household must receive to make it indifferent between an old set of prices and a new set of prices.

Purchases of away-from-home meats were excluded from the welfare analysis. The authors focused on household welfare loss due to higher FAH meat prices only. Restaurant meals containing meats are likely a substitute for similar home-cooked meals. Generally, omitting a substitute product can bias estimates of the loss upward in welfare that occurs when prices for an item increase. Intuitively, this is because consumers are denied the option to choose that substitute product instead of the included product whose price has increased. However, during the COVID-19 pandemic, meat price increases may not have been isolated to meats sold for at-home consumption. Meats sold at restaurants may have become more expensive as well.[13] Moreover, while take-out and delivery options remained generally plentiful, we believe FAFH as a whole was a less viable substitute for FAH for many households. Thus, if we were including FAFH meat consumption in the analysis, the welfare loss would have likely been higher.

[13] ERS Food Price Outlook reported that FAFH prices increased 3.1 percent in 2019 and 3.4 percent in 2020.

Following classic economic theory and previous analyses of U.S. food (particularly meat) demand by Edgton (1997), Okrent and Alston (2012), Eales and Unnevehr (1988), Lakkakula et al., (2016), Nayga and Capps (1994), and Sellen and Goddard (1997), we assume that for modeling purposes, all households budget separably, in stages. That is, households first allocate their income across housing, transportation, FAFH, and different food groups for FAH, such as meats, grains, and vegetables, among other needs and wants. They then divide any money allocated to a food group for FAH in the first stage to specific types of products in a second stage. In the case of meats for FAH, it can be theorized that total FAH meat expenditures are divided among beef, pork, poultry, and other meats in the model's second stage.

Empirical analyses of meat demand typically focus on only one stage of a household's budgeting process. In this study, we followed that same general approach. We focused on the second stage and did not attempt to estimate a complete first stage system; rather, we simplified the first stage to a single equation that explains a household's total FAH meat spending during 2019 and 2020. In keeping with economic theory, a measure of households' income is included in this equation. Because the IRI-collected data that ERS purchased are aggregated to the State level, household-level average meat expenditures in a particular State are assumed to be a function of that State's median household income. The data for this variable were obtained from the American Community Survey (ACS).[14] We hypothesized the COVID-19 pandemic may have caused U.S. households to temporarily allocate more money to FAH, including more meats than they would normally purchase given their income level. Stay-at-home orders issued by governments to limit spread of the virus kept consumers away from restaurants which, in turn, increased consumer demand for foods for at-home consumption. Anxiety further drove some households to stockpile food, buying more than they usually do or need. Following Dhar et al., (2003), we defined FAH meat expenditure in log form as:

(1) $$lnX = \delta' Y + \eta$$

where X is average household-level FAH meat expenditures and Y is a 3 x 1 vector of explanatory variables. Aside from our intercept term, Y includes the income variable and, to capture the influence of the pandemic, a dummy variable that takes the value of 1 for and after March 2020 when the pandemic widely began in the United States, and 0 before March 2020. δ is a vector of parameters [3 x 1], and η is an error term.

To model the second stage of the multistage budgeting process and explain how households spread their meat expenditures over beef, pork, poultry, and other meats, we estimated a demand model based on the Almost Ideal Demand System (AIDS) first introduced by Deaton and Muellbauer (1980). This model is consistent with economic theory because it satisfies all axioms of consumer choice and well accommodates aggregation over consumers. A basic system of 4 AIDS expenditure share equations is:

(2) $$W = \alpha + \gamma ln\, P + \beta(ln\, X - lna(P)) + \varepsilon$$

where W is a 4 x 1 vector of expenditure shares, $ln\ P$ is a 4 x 1 vector of log product prices, ln X is log meat expenditures, and $lna(P) = \alpha_0 + \alpha' \, lnP + \frac{1}{2}(lnP)' \, \gamma(lnP)$. The model also contains a number of parameters to be estimated: α_0 [1 x 1], [15] α [4 x 1], β [4 x 1], and γ [4 x 4]. This model assumed demand is linear in the logarithm of total expenditure. A quadratic AIDS model could be used to allow for a nonlinear relationship; however, as Banks et al., (1997) mentioned, food demand is usually linear in the logarithm of total expenditure.

[14] This dataset is collected by the U.S. Department of Commerce, Bureau of the Census.

[15] We normalized α_0 to 0 in our model estimation.

To ensure the model conforms with economic theory, the following restrictions are placed on the parameters: $I\alpha$=1,$I\gamma$=0,$I\beta$=0, where I is a 4x1 vector of 1's.[16] Finally, ε is a 4x1 vector of error terms where $\varepsilon \sim N(0,\Sigma)$[17] and $I\varepsilon$ =0 and $I\Sigma$ =0.[18]

We allowed for the likelihood that households' meat choices depended on their demographic characteristics in addition to prices and expenditures. It is possible to incorporate such variables into the above basic AIDS by transforming the intercept in equation (2), α, as:[19]

(3) $$\alpha = \vartheta_0 + \vartheta_1 Z$$

where Z is [k x 4] vector of demographics and k is the number of such variables. Inserting equation (3) into equation (2) completes the specification of our demand model for the second stage of a household's budgeting process:

(4) $$W^* = \vartheta_0 + \vartheta_1 Z + \gamma lnP + \beta(\ln X - lna(P)) + \varepsilon$$

Following previous studies, we include in Z the percentage of a State's population age 5 or younger to examine if households with pre-kindergarten age children have different grocery shopping behaviors. We also include measures of racial and ethnic diversity to capture different preferences for meat products, and the percent of the population with a college degree as reported in the ACS to see if education was associated with differences in household meat consumption, possibly due to gained nutrition knowledge. The monthly unemployment rate at the State level—published by the Bureau of Labor Statistics—was added in the analysis to capture income effects. Region and season were also included in the analysis to capture regional and seasonal specific effects, along with the dummy variable to capture pandemic months. ϑ_0 [4 x 1] and ϑ_1 [4 x k] are parameter vectors. ϑ_0 and ϑ_1 have the following restrictions: $I\vartheta_0$=1 and $I\vartheta_1$=0.

The household meat demand model can be estimated using maximum likelihood techniques and the procedure in Wales and Woodland (1983) and Dong et al., (2004) to account for data censoring.[20] This procedure is unique among methods that account for data censoring because budget constraints are imposed in both the observed expenditure shares and the latent expenditure shares. Equations (1) and (4) are jointly determined. In addition to being efficient, this approach also helped to ensure parameter estimates were consistent as total meat expenditure X in (4) may be endogenous (LaFrance, 1993).[21] Marshallian price elasticities, total FAH meat expenditure elasticities, and demographics elasticities can all be obtained using the estimate of equation (4) (Dong et al., 2004). The demographics included in Z and Y, as well as their summary statistics, are provided in table 3.

[16] These restrictions ensure adding up, homogeneity, and symmetry.

[17] The error term follows a joint normal distribution with a mean vector of 0 and a variance covariance matrix Σ.

[18] We imposed adding up. See footnote 16 for additional information.

[19] This way of accounting for household demographic effects is called demographic translating, which allows demographics to change the level of demand but not to alter the slope. Note this makes demographic heterogeneity enter the demand system linearly via the intercept in equation (2) but also non-linearly through households' expenditures via the price index *lna*(P) (Pollak and Wales, 1981; Lecocq and Robin, 2015).

[20] In Information Resources, Inc. (IRI) data, since not all States consist of sufficient number of households that reported meat expenditures to make a statistically valid projection in all months, the data are censored. Moreover, households in some States report no expenditures on some meat products. These observations are also censored.

[21] Unit values can also be endogenous when used to account for prices. In our study, a test similar to the Durbin-Wu-Hausman test (Durbin, 1973; Wu, 1973; Hausman, 1978) was performed to test for this type of endogeneity. Specifically, we first regressed the 4 meat unit values on Z, the vector of demographics in equation (4), and other exogenous variables. We then used the predicted unit values from this regression to re-estimate (4). A likelihood ratio (LR) test showed the two models are not significantly different from each other with the LR test statistic as 3.02 and the p-value as 0.082. In other words, we could not reject the hypotheses of unit value exogeneity at the 5-percent level.

Table 3
Demographic variables in expenditure share and total expenditure

Variable name	Description	Mean	Standard deviation
	Expenditure shares (Z)		
Intercept	Intercept	1	0.00
Kids 1 to 5	Percentage of people aged 1 to 5	5.89	0.56
Black	Percentage of African American	12.1	9.46
Asian	Percentage of Asian	3.84	2.82
Hispanic	Percentage of Hispanic	13.1	10.8
College	Percentage of college education or above	31.9	5.53
Unemployment	Percentage of unemployment	5.54	3.41
Summer	=1 if summer	0.12	0.33
Fall	=1 if fall	0.25	0.43
Winter	=1 if winter	0.17	0.37
West	=1 if West	0.21	0.41
Midwest	=1 Midwest	0.23	0.42
South	=1 if South	0.37	0.48
COVID-19 time	=1 if in pandemic	0.42	0.49
	Total expenditure (Y)		
Intercept	Intercept	$1.00	$0.00
Median income	State medium household income ($)	$62,805	$10,634
COVID-19 time	=1 if in pandemic	$0.42	$0.49

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Compensating Variation

Economists commonly estimate demand systems to gain important insights on consumer behavior and well-being. These estimations can shed light on how consumers might adjust their purchases with changes in prices, expenditures, or even their own demographic characteristics such as income or household composition. Elasticities calculated with respect to prices, expenditures, and demographics measure the percentage change in quantities purchased with changes in these variables. It is also possible to estimate how much a change in prices can affect a consumer's well-being (utility). A utility function measures the well-being that a consumer experiences based on the amounts of products consumed. An indirect utility function measures the optimized consumer utility based on their utility-maximizing selection of products, which is in turn based on products' prices and expenditures. For instance, higher prices imply a lower level of utility given any constant level of expenditures since prices determine the amounts of products that can be purchased and consumed with a fixed amount of money.

We estimated an AIDS model in part to understand how higher meat prices during the COVID-19 pandemic affected U.S. household welfare. Following Banks (1997), the indirect utility function associated with the model is:

(5) $$u(X,P) = \frac{\ln X - \ln a(P)}{\exp\left(\beta' (\ln P)\right)} .$$

The variables and parameters are defined above. After estimating all the parameters in the model, we calculated a consumer's level of utility given an initial level of expenditure, X_0, and an initial set of prices, P_0, as: $u(X_0, P_0) = \frac{\ln X_0 - \ln a(P_0)}{\exp\left(\beta' (\ln P_0)\right)}$. Suppose that prices were to increase from P_0 to P_1. Utility should decrease as the consumer could no longer afford as many goods as previously. To keep the consumer's level of utility unchanged, additional income would be required. The compensating variation (*CV*) is the amount of additional income needed, and it can also be estimated using the results of the AIDS model. Let X_1 be the level of expenditures a consumer would need to attain the same level of utility as was attainable with X_0 and P_0 given the new price level, P_1. The *CV* can then be calculated as $X_1 - X_0$ where the value of X_1 can be determined from the function: $\frac{\ln X_1 - \ln a(P_1)}{\exp(\beta' (\ln P_1))} = \frac{\ln X_0 - \ln a(P_0)}{\exp(\beta' (\ln P_0))}$. See Attanasio et al., (2013).

Equivalently, we can also rewrite (5) with *X* as a function of u and *P* (i.e., $X(u,P)$). This function is known as the expenditure or cost function and, as above, $CV = X_1 - X_0 = X(u,P_1) - X(u,P_0)$ is the amount of income a consumer would need to keep utility constant after an increase in P from P_0 to P_1 (Hahn and Davis, 2014; Huang and Huang, 2012). Following Huang and Huang (2012), we derived the *CV* from the expenditure function approach as below:

$$(6) \qquad CV = (P_1 Q_0)[\psi ((dP/P_0)] + (P_0 Q_0)(dP/P_0)$$

where ψ is a [4 x 4] matrix of Hicksian price elasticities which can be calculated from the Marshallian price elasticities obtained from the estimate of equation (4) using the Slutsky equation, P_0 is a 4 x 1 vector of original prices, P_1 is a 4 x 1 vector of prices after the change, $dP=P_1-P_0$, and Q_0 is a 4 x 1 vector of original quantities purchased. In practice, equation (6) is easier to use after we have the compensated (Hicksian) price elasticities.[22]

[22] To calculate CV using (6), the indirect utility function or the expenditure function is not needed if we already have Hicksian price elasticities from, for example, a previously published study.

Results

Numerous studies estimated price and expenditure elasticities for different types of meats (Gallet, 2010; Lusk and Tonsor, 2016; Eales and Unnevehr, 1988; Nayga and Capps, 1994), and results are relatively stable over time. However, the COVID-19 pandemic was unprecedented. We observed increases in quantities demanded of FAH and product prices (tables 1 and 2). To allow for the possibility that consumer behavior might be different during the pandemic, we used real-time scanner data collected by IRI and purchased by ERS to estimate a system of average household expenditure share equations for 4 meat products for 48 continental States and the District of Columbia during 24 months from January 2019 through December 2020. Total meat expenditures defined as a function of State-level household median income was jointly estimated with the four individual meat product expenditure share equations to obtain consistent and efficient parameter estimates. Our estimation procedure further accounted for data censoring.

Results for our model's first stage total meat expenditure equation confirmed that increases in households' meat expenditures in 2020 were likely due to circumstances surrounding the pandemic, such as heightened demand for food at home (FAH) in lieu of food away from home (FAFH), higher retail meat prices, and panic (anxiety)-induced buying (table 4). The dummy variable is statistically significant. This binary indicator equals 1 for the months in which the virus was widespread and 0 for all other months. Results show that households' average total meat expenditures were 12 percent higher during pandemic months, all other factors being constant. This percentage is large enough to explain most of the overall 14.5-percent difference in spending on meat between 2019 and 2020 (table 2). The income variable is also significant. All other factors being equal, a 10-percent increase in State-level, median income is associated with a 7.6-percent increase in households' average total meat expenditures. U.S. household median income notably increased by 2.8 percent from 2019 to 2020,[23] which would explain another 2.1 percent of the 14.5-percent increase in total meat expenditures, according to the model results.

Table 4
Elasticities of total meat expenditure

Variable	Elasticity	T-ratio
Intercept	0.20	2.33
Median income	0.76	8.88
COVID-19 time	0.12	4.10

Note: All elasticities are statistically significant at the 5-percent level or above.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

By increasing their FAH meat expenditures in 2020, U.S. households were able to increase their overall retail meat purchases from about 44 pounds per household in 2019 to about 47 pounds per household in 2020 (table 1). Expenditure elasticities of demand for each type of meat estimated from the results on the second-stage, 4-individual product demand system are all positive (fifth column of table 5). Because these expenditure elasticities of demand are all positive, this confirms U.S. household demand for each of them rose in response to the 14.5-percent increase in meat expenditures shown in table 2. Demand for other meats (mainly lamb and mutton) is notably most responsive to changes in expenditures—followed by pork, poultry, and beef, respectively.

[23] The income variable from the American Community Survey (ACS) does not include the stimulus payments.

Table 5
Marshallian price and expenditure elasticities

Demand of	With price of				Total expenditure
	Beef	Pork	Poultry	Other meats	
Beef	**–0.89**	0.05	**0.20**	0.05	**0.59**
Pork	–0.30	**–0.92**	–0.09	**–0.27**	**1.58**
Poultry	0.13	0.01	**–1.26**	0.07	**1.06**
Other meats	**–0.39**	**–0.86**	–0.16	**–0.65**	**2.05**

Notes: Other meats consist of lamb, mutton, rabbit, venison, etc. Bold numbers represent "significant" at 5 percent or above. For example, a 1-percent increase in poultry price would cause a 0.20-percent increase in beef quantity purchases statistically significant from 0 at the 5-percent level, while a 1-percent increase in beef price would cause poultry quantity purchases, but not statistically significant from 0 at the 5-percent level.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Results for the 4-individual meat product demand system also reveal that, except for the 14.5-percent increase in meat expenditures, consumers would have decreased their purchases of all types of meats due to higher prices in 2020 (tables 5 and 6). These results include the uncompensated (Marshallian) price elasticities shown in the first four columns of table 5.[24] All own-price effects are negative.[25] A 10-percent increase in the price of beef, for example, would reduce households' average purchases by 8.9 percent, holding income, meat expenditures, and other product prices constant. Households would buy less beef because an own-price increase would (1) make this type of meat relatively more costly than other meat types (price effect), and (2) reduce the purchasing power of households' meat budgets (income effect). The compensated (Hicksian) price elasticities shown in table 6 net out the second of these two effects and isolate the pure price effect.

Table 6
Hicksian price elasticities

Demand of	With price of			
	Beef	Pork	Poultry	Other meats
Beef	**–0.61**	**0.18**	**0.35**	**0.08**
Pork	**0.44**	**–0.58**	**0.33**	**-0.18**
Poultry	**0.62**	**0.24**	**–0.99**	**0.12**
Other meats	**0.58**	**–0.42**	**0.38**	**–0.54**

Notes: Other meats consist of lamb, mutton, rabbit, venison, etc. All the elasticities are statistically significant at the 5-percent level or above.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Price elasticities of demand reported in the literature are fairly stable for different types of meats over time (Gallet, 2010; Lusk and Tonsor, 2016; Eales and Unnevehr, 1988; Nayga and Capps, 1994). However, because the COVID-19 pandemic was unprecedented in many ways, we estimated our demand system to allow for the possibility that consumer behavior might be different during the pandemic. It was not. In a review of existing studies, Gallet (2010) reported that the Marshallian own-price elasticity of demand ranges

[24] The elasticities reported here are conditional elasticities (conditional on total meat expenditure). Unconditional elasticities can be obtained using the total meat expenditure elasticity with respect to the income from equation (1) and reported in table 4. The compensating variation (CV) calculation is based on the conditional elasticities.

[25] All own-price elasticities are shown along the diagonal of the table.

from –0.746 to –0.955 for beef, from –0.944 to –1.107 for pork, from –0.841 to –1.216 for poultry, and from –0.778 to –0.989 for all meats. Except other meats, our elasticities are all within Gallet's ranges (table 5), which is consistent with evidence that U.S. household eating patterns did not much change between 2019 and 2020 (Chenarides et al., 2021).

Our estimated Marshallian cross-price elasticities also revealed that households have only a limited willingness to grossly substitute one type of meat for another when prices for the first type increase without compensating income. The cross-price effects in table 5 are measures of this willingness.[26] Positive values indicated that two types of meats are price substitutes for each other. However, many of our estimates were negative or statistically insignificant (bold numbers represent significant at 5 percent or above). For example, a 10-percent increase in poultry's price would increase beef purchases by 2 percent, whereas a 10-percent increase in beef's price would cause a positive, but statistically insignificant, increase in poultry purchases. However, when we compensated income (hold utility constant), additional willingness to substitute is revealed. This willingness is shown in our estimated Hicksian elasticities (table 6). For example, holding utility constant, quantity demanded for poultry would increase by 6.2 percent in response to a 10-percent increase in beef prices. Differences in willingness to substitute between meat products as suggested by Marshallian versus Hicksian elasticities suggest that income effects associated with meat price changes dominate any pure price effects. As noted, Hicksian price elasticities measure only pure price effects (net out income effects).

Despite being able to generally maintain their overall level of meat consumption, U.S. households still incurred a welfare loss due to higher meat prices at retail stores. Our estimates of compensating variation (CV) for each type of meat and total meat calculated using equation (6) are provided in table 7 and illustrated in figures 12a and 12b. The estimated CVs are positive and statistically significant for every month for all types except other meats, indicating that residents in each State experienced a welfare loss as a result of the price rise caused by the pandemic. Estimated welfare reductions are also highest during the spring months when operations at packinghouses were most affected by the virus. In June 2020, U.S. households' average monthly welfare loss is estimated at $24.51 due to higher prices for meats in general (table 7, figure 12a). Higher prices for beef, pork, and poultry accounted for $8.30, $7.07, and $8.18, respectively, of that total (table 7, figure 12b). The total welfare loss per U.S. household from March to December 2020 due to higher retail meat prices was $112.15.

[26] All cross-price elasticities are reported in the off-diagonal elements of tables.

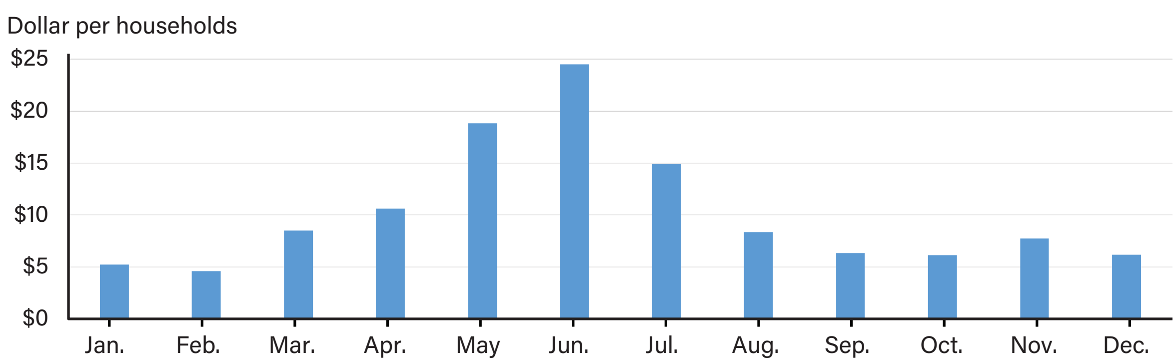
Table 7
Compensating variations (CV)

Month	CV (dollars)									
	Total meat	T-ratio	Beef	T-ratio	Pork	T-ratio	Poultry	T-ratio	Other meat	T-ratio
January	**5.23**	8.09	**2.16**	5.44	**1.28**	3.14	**1.70**	8.16	0.09	0.38
February	**4.59**	8.56	**1.86**	5.98	**1.26**	3.63	**1.33**	7.55	0.14	0.67
March	**8.50**	7.61	**3.38**	5.44	**2.51**	3.25	**2.51**	7.44	0.10	0.25
April	**10.63**	6.13	**4.34**	4.01	**2.22**	2.16	**3.56**	4.84	0.51	1.01
May	**18.82**	7.30	**6.94**	4.53	**5.09**	3.11	**6.19**	7.79	0.61	0.57
June	**24.51**	7.08	**8.30**	3.82	**7.07**	3.29	**8.18**	8.10	0.97	0.77
July	**14.93**	8.29	**6.04**	5.49	**3.76**	3.58	**4.37**	6.48	0.76	1.08
August	**8.35**	7.22	**3.53**	4.62	**1.61**	2.88	**2.64**	5.38	0.58	1.25
September	**6.34**	6.85	**2.86**	4.52	**1.02**	2.50	**2.02**	4.53	0.44	1.48
October	**6.14**	5.85	**2.85**	3.73	**0.77**	1.98	**2.08**	3.86	0.44	1.53
November	**7.74**	9.23	**3.57**	7.31	**1.90**	4.14	**1.86**	5.02	0.42	1.20
December	**6.19**	8.96	**2.44**	7.30	**1.54**	3.87	**1.89**	5.30	0.31	1.08
Average	**10.16**		**4.02**		**2.50**		**3.19**		**0.45**	

Note: Other meats consist of lamb, mutton, rabbit, venison, etc. Bold numbers represent "significant" at 5 percent or above.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Figure 12a
Welfare loss per U.S. household due to overall higher meat prices, 2020

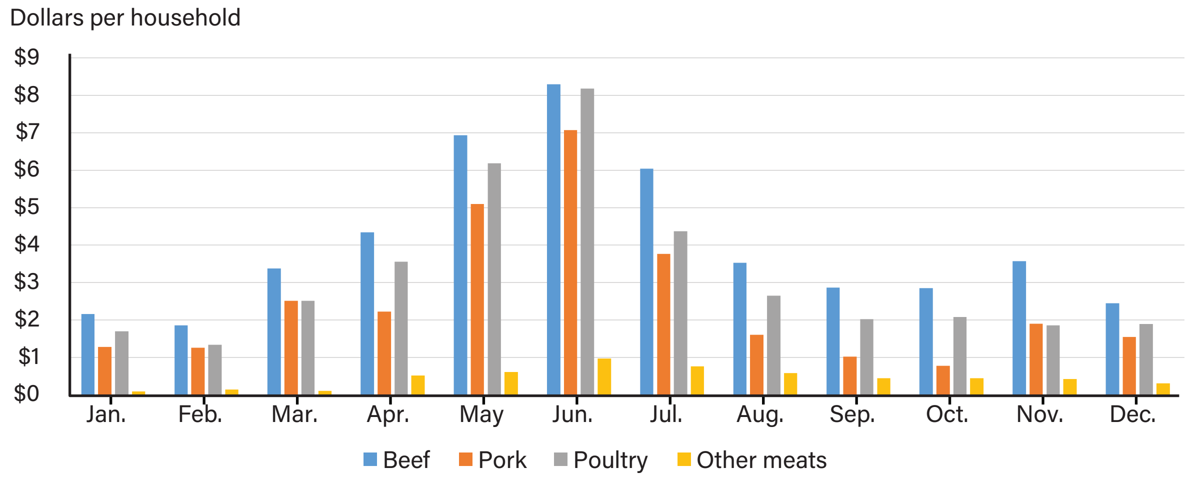


Note: Well-being is defined as the "reduction in U.S. households' well-being estimated by the method of compensating variation."

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Figure 12b

Welfare loss per U.S. households due to higher beef, pork, poultry, and other meats by category, 2020



Note: Well-being is defined as the "Reduction in U.S. households' well-being estimated by the method of compensating variation."

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.

Finally, in table 8, we report our estimated expenditure share elasticities with respect to our demographic variables. Among other things found, a 1 percentage-point increase in the share of households holding a college degree would decrease the beef share by 0.16 percent and increase the poultry share by 0.26 percent. This is important since households with a greater demand for beef have likely experienced relatively greater welfare reduction during the pandemic as that product's price has risen the most.

Table 8

Demographic elasticities of expenditure shares

Variables	Product			
	Beef	Pork	Poultry	Other meats
Child 1 to 5*	**0.40**	–0.19	–0.13	**–2.19**
Black*	–0.02	–0.01	0.04	0.05
Asian*	**–0.05**	0.01	**0.06**	**0.13**
Hispanic*	0.02	**–0.19**	**0.07**	**0.25**
College*	**–0.16**	0.11	**0.26**	–0.27
Unemployment*	–0.02	0.05	–0.01	**0.07**
Summer	0.00	0.01	–0.01	0.00
Fall	0.01	0.00	–0.01	–0.01
Winter	–0.01	–0.01	**0.02**	–0.01
West	0.01	**0.07**	**–0.04**	**–0.13**
Midwest	**–0.02**	**0.09**	**–0.04**	0.00
South	**–0.04**	**0.13**	–0.01	**–0.09**
COVID-19 time	**–0.04**	**0.06**	0.01	**0.078**

Notes: Bold numbers represent significant at 5 percent or above. Numbers for the variables in % (marked as *) are the percentage change in the shares when the variables increase by 1 percent in their percentage rates. Numbers for the dummy variables are the percentage change in the shares when the variables changed from 1 to 0. The season base is spring, and the region base is Northeast.

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data, and 2019 American Community Survey collected by the U.S. Department of Commerce, Bureau of the Census.

Conclusion

The COVID-19 pandemic changed U.S. households' food consumption patterns and tested the resiliency and flexibility of the U.S. food system. During this difficult time, consumers were largely able to maintain their usual dietary patterns with respect to the amounts of different types of foods they consumed, including meats, even though meat suppliers were among the hardest hit segments of the food marketing system. This report examines and compares U.S. household demand for meats for at-home consumption during and before the pandemic. We also asked if retail meat prices remained at their 2019 levels throughout 2020, how much better off would they have been? This question and our results reflect the welfare losses of U.S. households due to the higher meat and poultry prices experienced in 2020.

An analysis of weekly scanner data collected by Information Resources, Inc. (IRI) over 2019 and 2020 reveals U.S. households increased their spending in 2020 on meats for at-home consumption by 14.5 percent compared with 2019. This made it possible to offset reductions in meat consumption away from home by purchasing more beef, pork, poultry, and other meats for at-home consumption despite facing higher retail prices for each type of meat. Some households even bought more food than they normally consume. Across the four types of meats, households increased their average quantities of other meats (mainly lamb and mutton) purchased for at-home consumption by 13.5 percent in 2020 over 2019, followed by pork (8 percent), poultry (7 percent), and beef (6.2 percent), which is nearly the reverse pattern of the price increases.

Despite being able to generally maintain their overall level of meat consumption, U.S. households experienced a lower level of welfare than they would have in an alternate scenario in which U.S. meat retail prices remained at their 2019 levels throughout 2020. Welfare losses incurred by U.S. households were higher during the spring and summer of 2020 when operations at packinghouses were most affected by the virus and peaked in June 2020, with estimated U.S. households' monthly average welfare loss reaching $24.51 due to higher prices for meats in general. Higher prices for beef, pork, and poultry accounted for $8.30, $7.07, and $8.18, respectively, of that total. In December 2020, households' monthly average welfare loss was $6.19 with higher prices for beef, pork, and poultry accounting for $2.44, $1.54, and $1.89, respectively.

Our demand model and welfare analysis focus on U.S. household demand for meats for at-home consumption. We did not explicitly incorporate meats for away-from-home consumption in either our demand model or welfare calculations. Restaurant meals containing meats are likely a substitute for similar home-cooked meals and, in general, omitting a substitute product from one's welfare analysis can bias upward any estimate of the reduction in consumer welfare that occurs because it denies consumers the opportunity to purchase that outside good. However, during the COVID-19 pandemic, meat price increases were not likely isolated to meats sold for at-home consumption. Meats sold at restaurants likely were more expensive as well. Given shutdown orders and consumers' fear of the virus, we believe FAFH was a much less viable substitute for FAH for many households. Thus, if we included FAFH meat consumption in our analysis, the welfare loss would likely be higher.

Future extensions of this research might incorporate plant-based meat alternatives for beef, pork, and poultry. Interest in these products is growing, and recent studies compare consumer preferences for them versus beef (Van Loo et al., 2020).

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Appendix

Appendix table 1
Months and the associated dates

Date starts	Date ends	Month
12/31/2018	1/27/2019	January
1/28/2019	2/24/2019	February
2/25/2019	3/31/2019	March
4/1/2019	4/28/2019	April
4/29/2019	5/26/2019	May
5/27/2019	6/30/2019	June
7/1/2019	7/28/2019	July
7/29/2019	8/25/2019	August
8/26/2019	9/29/2019	September
9/30/2019	10/27/2019	October
10/28/2019	11/24/2019	November
11/25/2019	12/29/2019	December
12/30/2019	1/26/2020	January
1/27/2020	2/23/2020	February
2/24/2020	3/29/2020	March
3/30/2020	4/26/2020	April
4/27/2020	5/31/2020	May
6/1/2020	6/28/2020	June
6/20/2020	7/26/2020	July
7/27/2020	8/30/2020	August
8/31/2020	9/27/2020	September
9/28/2020	10/25/2020	October
10/26/2020	11/29/2020	November
11/30/2020	12/27/2020	December

Source: USDA, Economic Research Service calculations using Information Resources, Inc. (IRI) household and retail scanner data.