Impact of commodity price movements on CPI inflation

An analysis of price movements of four commodities—crops, animal slaughter and processing, dairy, and oil and gas—reveals that only oil and gas prices had a considerable impact on CPI inflation; thus, even large increases in the prices of the first three of these commodities do not necessarily contribute substantially to inflation

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A worldwide surge in commodity prices that began in late 2006 and ended in mid-2008 generated interest in studying the effects of commodity price movements on consumer prices. During this period, prices for commodity crops nearly doubled while prices for oil and natural gas more than doubled. In a recent article, Bart Hobijn of the Federal Reserve Bank explored the relationship between commodity price changes (for crops, oil, and natural gas) and changes in inflation as measured by the Bureau of Economic Analysis (BEA).[1] Hobijn analyzed BEA's Personal Consumption Expenditures (PCE) Price Indexes from June 2006 through June 2008, to determine the extent to which commodity price swings affected the price of final consumer goods. Hobijn found that the commodity price increases translated into larger price increases in the United States only for those goods most closely related to the commodities in question. The contribution of the price surges to overall inflation was less pronounced.

Building upon Hobijn's work, this article explores the effects of price changes in four commodity groups (crops, animal slaughter and processing, dairy, and oil and natural gas) on the Bureau of Labor Statistics (BLS, the Bureau) Consumer Price Index (CPI) for various final goods, and on overall CPI consumer inflation, from 2003 through 2008. Although the increases in crop and oil prices, and in natural gas prices, during the years 2006 through 2008 were relatively high, the prices of these commodities exhibited noticeable highs and extreme volatility several years prior to Hobijn's analysis. Numerous factors drove commodity price volatility during this earlier period, the most important of which were fundamental changes to supply and demand, speculative market trading, exchange rate fluctuations, and political conflicts in key producing regions of the globe.

The analysis presented here produces findings similar to Hobijn's. In general, despite large runups in commodity prices, the effects on overall rates of CPI inflation were relatively modest, although certain CPI categories were heavily influenced by the price movements of the commodities examined. In the shorter periods with particularly dramatic price movements, the results were similar: the impact on overall inflation was still relatively modest, whereas the impact of commodity prices was more pronounced on those CPI indexes which were closely related to the commodities. However, unlike Hobijn's piece, this article finds that oil and gas commodity price movements

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had an appreciable impact on overall CPI inflation, as well as on the lower level indexes, both in the longer term and in specific years.

The article is divided into three main sections. The first section outlines the methodology employed to conduct the analysis, describes the modified Leontief model used to calculate the importance of different commodities for the production of final goods, and discusses both the underlying assumptions of the study and some of its inherent limitations. The second section delineates the components of the four commodity aggregates used in the analysis. The last section examines the major price movements of each commodity aggregate and their impact on several measures of CPI inflation.

Methodology

The analysis that follows examines input–output data in combination with commodity price index data to estimate price transmission from commodity prices to various consumer price indexes. Input–output data are used to compute the input shares of commodities for different consumer goods. Input shares indicate the percentage of value of a final good, or a set of final goods, that can be attributed to a specific input commodity or to a set of input commodities. For this study, the input shares of crops, animal slaughter and processing, dairy, and oil and gas are calculated for a number of CPI categories and then used to examine how commodity price changes would affect the prices of consumer goods if the entire commodity price change were passed forward to the consumer good.

To calculate input shares, a Leontief model is utilized. The model is based on the premise that an economy consists of interdependent industries. In order to produce output, these industries consume products produced by other industries, and possibly themselves, as inputs to production. The model shows that total demand for a product i is the sum of all intermediate demand (from other industries) and final demand (personal consumption, investment, government spending, and net exports) for the product. The Leontief model presented here excludes investment, government spending, and net exports, to focus on final demand for consumers. Total demand for product i can be expressed mathematically as

$$r_i = a_{i1}r_1 + a_{i2}r_2 + \ldots + a_{ij}r_j + \ldots + a_{in}r_n + b_i, \quad \text{for } i = 1,2,\ldots,j,\ldots n,$$

where r_i is the total demand for product i, a_{ij} is a technical coefficient expressing the value of i necessary to produce a dollar's worth of product j, b_i is final demand for product i, and n is the total number of industries.

To provide a context for this equation, consider the example of a country with only three industries, one producing commodity i (electricity), another producing commodity j (utility natural gas), and the third producing commodity k (coal). Electricity is consumed both for final demand (as personal consumption) and as intermediate demand in the production of natural gas and coal. Total demand for electricity can then be written as

$$r_e = a_{e,\text{ung}}r_{\text{ung}} + a_{e,c}r_c + b_e,$$

where $a_{e,\text{ung}}$ is a coefficient expressing the value of electricity necessary to produce a dollar's worth of utility natural gas, r_{ung} is total demand for utility natural gas, $a_{e,c}$ is a coefficient expressing the value of electricity necessary to produce a dollar's worth of coal, r_c is total demand for coal, and b_e is final demand for electricity. To complete the model, similar equations could be written to describe total demand for coal and utility natural gas. The complete Leontief model can then be used to determine the share of each commodity input to one another.

In this study, the values for r, a, and b are derived from BEA input–output tables and from input–output tables compiled by former BLS analyst Carl Chentrens.[2] (For a complete and more technical discussion of the methodology, see Appendix A.) The input shares are then used to examine the impact of changes in commodity prices on the CPI. The effect of commodity price movements is calculated by multiplying the input shares of a given commodity by the change in the producer price index for that commodity.

This method of calculating the contribution of commodity price changes to the CPI assumes that such changes are immediately and fully passed through to the consumer. Previous studies have shown, however, that that is not necessarily the case:[3] for some commodities, it can take up to a year for the increases to pass through to consumers. This concern is somewhat mitigated by the fact that average producer prices and consumer prices are compared from one year to the next, as opposed to point-to-point price change comparisons. The former method better captures price levels over the entire year and is less influenced by sharp, short-lived movements. Nonetheless, the assumption of immediate and full passage through to the consumer is one limitation of the study. Also, the input–output tables indicate the composition of final goods in terms of PCE categories. Therefore, in order to examine the CPI categories of interest (such as food and beverages, fuels and utilities, and motor fuel), PCE categories

were mapped to the appropriate CPI categories. The PCE-to-CPI mappings were based on a 2007 jointly published BEA–BLS paper.[4]

Components of commodity aggregates

In examining the effects of price changes for crops, animal slaughter processing, dairy, and oil and gas on the CPI, input shares are calculated with the use of BEA input–output data and price changes of the commodities are measured with producer price indexes (PPIs). Unfortunately, in most cases, currently published PPIs do not correspond exactly to input–output table categories, so aggregate PPIs are created to match commodities in the input–output tables. To achieve this result, standard PPI aggregation methodologies were used to combine detailed PPIs into higher level categories. Exhibit 1 shows the PPIs that were aggregated together to match the BEA input–output codes.

Commodity price movements and the CPI

This section discusses the major factors influencing producer prices for certain commodity aggregates over the period from 2003 through 2008, as well as notable effects of price transmission from each of the four commodity aggregates on consumer prices. Effects from all four commodity aggregates were analyzed for the aforesaid period, as well as for a specific subperiod during which price movements seemed particularly interesting. As mentioned earlier, the focus is on average yearly prices instead of point-to-point price changes, in order to limit the effects of short-term price spikes.

Exhibit 1. Components of commodity aggregates

Input–output commodities	Commodity (C) and industry (I) data[1]
Crops	(C) Fruits and melons, fresh/dry vegetables and nuts (011) (C) Grains (012) (C) Raw cotton (0151) (C) Hay, hayseeds, and oilseeds (018)
Animal slaughter and processing	(C) Meats (0221) (C) Processed poultry (0222)
Dairy	(I) Dairy product manufacturing (3115)
Oil and gas	(C) Natural gas (0531) (C) Crude petroleum (domestic production) (056) (C) Liquefied petroleum gas (0532)

[1] Commodity is PPI commodity; industry is NAICS industry.

Crops. As seen in chart 1, from December of 2001 through the end of 2008 the crops PPI (obtained by aggregating current PPIs for fruits and melons; fresh/dry vegetables and nuts; raw cotton; and hay, hayseeds, and oilseeds) was moderately stable in its movement, although volatility increased from June 2006 through December 2008. Historically, crop production has been influenced by a variety of factors, including climate conditions, fluctuations in demand, the distribution of plantings among a variety of crops with different yields, food safety issues, and fertilizer prices. The considerable increase in the crops price measure observed in the 2006-to-mid-2008 timeframe was associated with surging oil prices and U.S. government incentives to increase plantings of corn and soybeans for the production of ethanol.[5]

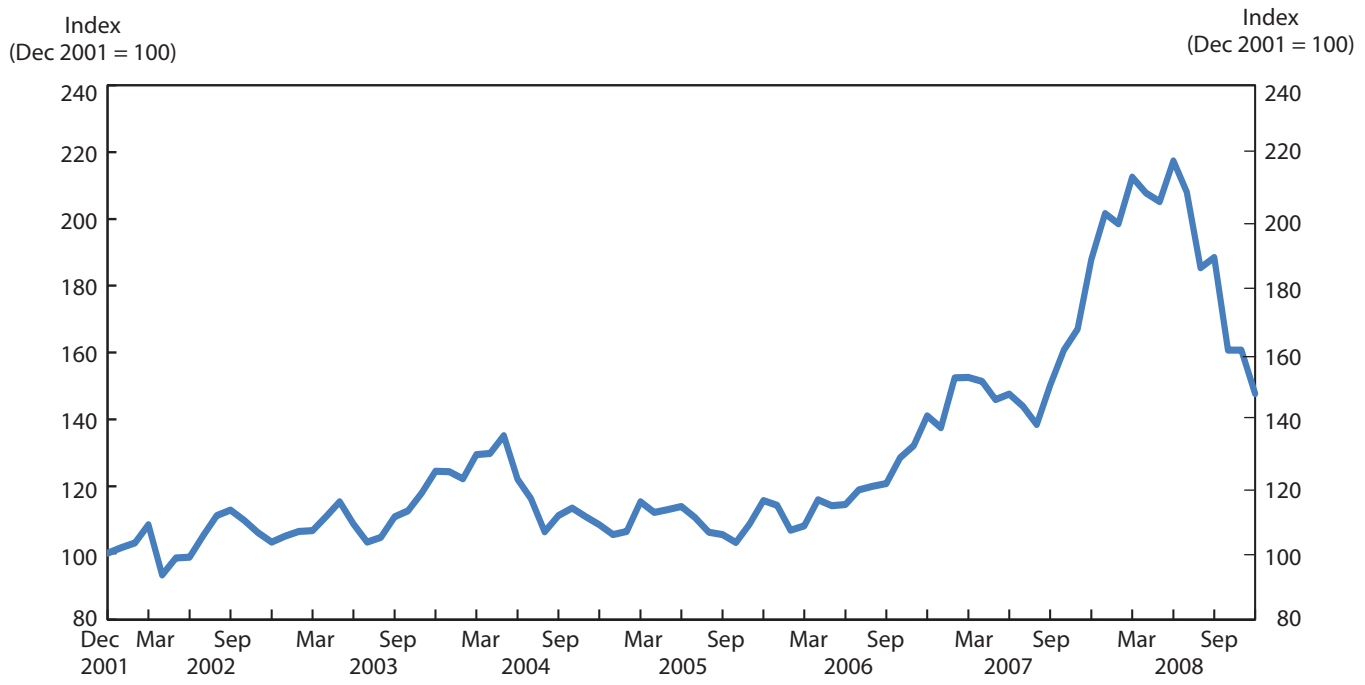
In recent years, a strong expansion of government-based initiatives promoting ethanol production, such as the Renewable Fuel Standard provision in the 2005 U.S. Energy Policy Act, has affected virtually every aspect of the grains and oilseeds industries.[6] Ethanol production increased from 3 billion gallons in 2003 to more than 6 billion gallons in 2007.[7] The Energy Independence and Security Act of 2007,[8] with its goal of producing 15 billion gallons of cornstarch-based ethanol by 2022, triggered more crop shifts to corn and soybean, in turn lowering supplies of other grains and oilseeds.

During the period from 2006 to mid-2008, climate conditions also were a key factor in the increase in crop prices. World wheat prices were driven upward in 2007 as drought conditions in the United States lowered domestic output. In addition, global wheat supplies were limited by drought in Australia, another major wheat exporter. In early 2008, soybean prices increased substantially because of a shortened soybean season, excessive rainfall and flooding, and reduced yields.[9]

The market volatility stemming from higher ethanol demand and from weather factors appeared to spur increased levels of speculation in food commodity markets.[10] Speculation initially pushed prices higher, but when oil prices tumbled in mid-2008 because of a weakening economy and declines in demand, prices for other commodities (including crops) fell similarly.

In analyzing the effect of commodity price movements on CPI inflation, several different measures were examined. The first column of table 1 shows, for 2007–2008 and 2003–2008, the percentage of the total value of the goods and services covered by each index that can be traced back to

Chart 1. Producer Price Index for crops



crops. The second column indicates the movement of each CPI over the specified periods and was taken directly from CPI tables produced by the Bureau. The third column shows what the movement for the different CPIs would have been had crop prices remained constant. Values in this column were obtained by multiplying the input share of crops by the change in crop producer prices (which represents the contribution of crop price movements to inflation) and then subtracting the result from the corresponding number in the same row in the second column. The numbers are obtained under the assumption that all else remains unchanged. The last column indicates the percentage-point contribution of crop price increases to CPI inflation. Values in this column were calculated by taking the difference of the corresponding values in the same row in the second and third columns and then dividing by the corresponding values in the same row in the second column.[11] (A detailed analysis for each year is available from the authors.)

Although crop prices exhibited major movements in recent years, their impact on consumer prices was limited (as can be seen in table 1): even though crop prices increased by 83.18 percent (a 10.62-percent annual compounded rate of change) from 2003 to 2008, the change in the CPI for all items was less than 20 percent over the same timeframe. Under the methodology and assumptions of this article, had crop prices remained constant and were all else held equal, the all-items CPI movement would have increased at a slightly lower rate of 18.94 percent. Rising crop prices therefore accounted for less than 4 percent of the increase in the all-items CPI from 2003 to 2008. The reason the impact of crop prices on the all-items CPI was minimal was that the input share of crops averaged just 1.05 percent. In the subperiod from 2007 to 2008, the impact was stronger because the crop price changes were greater (59.83 percent, a 26.42-percent annual compounded rate of change) and the input share of crops in the all-items CPI was higher, though still relatively modest (1.15 percent). During this subperiod, the increase in the all-items CPI was 6.80 percent; it would have been 6.19 percent had crop prices remained constant. From 2007 to 2008, almost 9 percent of the increase in the all-items CPI can be attributed to the increase in crop prices, whereas crop price increases accounted for less than 4 percent of the increase in the overall 2003–2008 period.

As one would expect, the impact of the increases in commodity crop prices on the core CPI, defined as the CPI

Table 1. Impact of price changes in crops on selected CPI categories

CPI	Average crop input shares		CPI price change		CPI price change had crop prices remained constant		Impact of crop price changes on CPI	
	2007–2008	2003–2008	2007–2008	2003–2008	2007–2008	2003–2008	2007–2008	2003–2008
All Items	1.15	1.05	6.80	19.70	6.19	18.94	8.90	3.83
All Items less food and energy	.35	.34	4.68	13.19	4.49	12.96	4.00	1.79
Housing	.58	.58	6.45	19.98	6.14	19.58	4.78	1.97
Shelter	.12	.10	6.26	18.54	6.20	18.47	1.00	.41
Fuels and utilities	.10	.09	13.00	53.25	12.95	53.19	.39	.12
Food and beverages	6.14	5.60	9.49	21.19	6.22	17.11	34.42	19.26
Apparel	.43	.40	–.46	–4.12	–.69	–4.41	...	...
Transportation	.16	.14	8.13	27.93	8.05	27.83	1.02	.37
Motor vehicles	.19	.16	–2.41	–5.96	–2.51	–6.08	...	...
Motor fuel	.13	.12	26.53	139.82	26.46	139.73	.26	.06
Recreation	.40	.38	2.09	6.61	1.88	6.35	10.13	4.02
Crops PPI price change	59.83	83.18	...	...	...	...	...	...
Annual compounded rate of change	26.42	10.62	...	...	...	...	...	...

NOTE: Last column uses calculated values; percent changes in previous columns are rounded to two decimal places.

for all items less food and energy, was much smaller because input shares were lower, averaging just 0.34 percent from 2003 to 2008 and 0.35 percent from 2007 to 2008. In the years 2003–2008, the impact of crop prices on core inflation was quite low, 13.19 percent, and it would have been only slightly lower, 12.96 percent, without the contribution from rising crop prices. Even when crop prices soared in 2007–2008, the core CPI was only slightly higher than it would have been if crop prices had remained constant (4.68 percent as opposed to 4.49 percent).

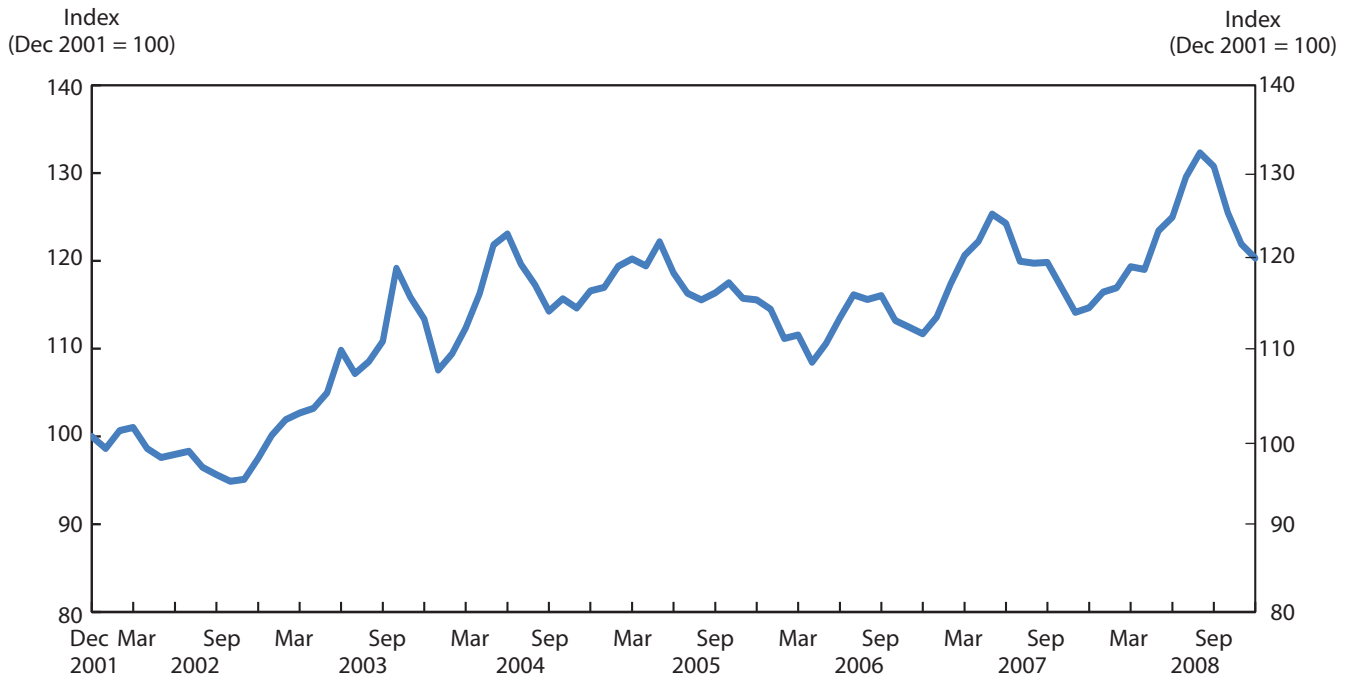
Although broad measures of price change were minimally affected by crop price movements, the runup in crop prices substantially affected the CPI for food and beverages, as the input share of crops in food and beverages, averaging 5.60 percent from 2003 to 2008, was much higher than both the share in the core CPI and the share in the all-items CPI. During this period, the CPI for food and beverages was 21.19 percent; it would have been just 17.11 percent had crop prices remained constant. Higher crop prices therefore accounted for nearly 20 percent of the total increase in the food and beverages index from 2003 to 2008. In the 2007–2008 subperiod, the impact was even stronger: the CPI for food and beverages was 9.49 percent, whereas it would have been only 6.22 percent had crop prices remained constant. The impact of rising crop prices thus accounted for nearly 35 percent of the increase in the food and beverages component of the CPI from 2007 to 2008.

Animal slaughter and processing. As seen in chart 2, from December 2001 to December 2008 the PPI for animal slaughter and processing fluctuated, although the price trend was increasing over the period. U.S. livestock and poultry production is based predominantly on a system of grain-fed animals. Even though increased feed (grain) prices contributed to the volatility in the PPI for animal slaughter and processing from 2006 to 2008,[12] yearly average prices did not change substantially. The major upward shift in prices occurred in 2003 and 2004.

A decline in beef production, increases in demand, and the discovery of the disease bovine spongiform encephalitis (BSE), the market reaction to which limited supply in the United States, all contributed to higher beef and cattle prices through much of 2003. The higher beef and cattle prices then spurred demand for other meat items, such as pork and poultry.[13] Although animal slaughter and processing prices dropped precipitously in late 2003 with the discovery of BSE in the United States, by mid-2004 prices had mostly recovered. A deadly bout of avian flu in Asia also contributed to the increase in animal slaughter and processing prices.

Despite strong increases in animal slaughter and proc-

Chart 2. Producer Price Index for animal slaughter and processing



essing prices in 2003–2004 and continued volatility in prices through 2008, their impact on consumer prices was limited. As shown in table 2, animal slaughter and processing price movements did not have a large impact on broad measures of CPI price change. In 2003–2008, the input share of animal slaughter and processing in the all-items CPI, while higher than the 1.05 percent for crops, was still fairly low, averaging 1.33 percent. The increase in animal slaughter and processing prices (26.26 percent, a 5.03-percent annual compounded rate of change) was also much lower than the increase in crop prices. Consequently, animal slaughter and processing prices had a minimal impact on the all-items index. Had animal slaughter and processing prices remained constant, the change in the all-items index would have been 19.37 percent, compared with the actual change of 19.70 percent. Rising animal slaughter and processing prices therefore accounted for only 1.68 percent of the change in the all-items CPI from 2003 to 2008. The impact was stronger in 2003–2004 because animal slaughter and processing price changes were greater (18.42 percent, an 8.82-percent annual compounded rate of change) and the input share of animal slaughter and processing in the all-items index was higher, but still relatively modest (1.36 percent). During the 2-year span, the all-items CPI rose 5.02 percent, whereas it would have risen 4.78 percent had animal slaughter and processing prices remained constant. Therefore, the increase in commodity prices accounted for 4.78 percent of the change in the all-items CPI.

As regards the core CPI, the impact of increases in animal slaughter and processing prices was much smaller. In 2003–2008, the change in the core index was 13.19 percent, and it would have been only marginally lower, 13.12 percent, without the contribution from rising animal slaughter and processing prices. Even in the 2003–2004 subperiod, when prices rose more substantially, the core index was only slightly higher than it would have been had animal slaughter and processing prices remained constant (3.25 percent compared with 3.20 percent).

Although animal slaughter and processing price movements affected broad CPI measures only minimally, they had a substantial impact on the CPI for food and beverages because of their high input share (more than 8 percent for both 2003–2008 and the 2003–2004 subperiod). From 2003 to 2008, the food and beverages index increased 21.19 percent; without the contribution from higher animal slaughter and processing prices, it would have increased only 19.19 percent. Higher animal slaughter and

Table 2. Impact of price changes in animal slaughter and processing on selected CPI categories

CPI	Average animal slaughter and processing input shares		CPI price change		CPI price change had animal slaughter and processing prices remained constant		Impact of animal slaughter and processing price changes on CPI	
	2003–2004	2003–2008	2003–2004	2003–2008	2003–2004	2003–2008	2003–2004	2003–2008
All items	1.36	1.33	5.02	19.70	4.78	19.37	4.78	1.68
All items less food and energy	.29	.28	3.25	13.19	3.20	13.12	1.58	.54
Housing	.07	.07	5.15	19.98	5.13	19.96	.25	.09
Shelter	.04	.04	5.17	18.54	5.16	18.53	.15	.06
Fuels and utilities	.05	.05	12.76	53.25	12.76	53.24	.07	.02
Food and beverages	8.20	8.03	5.59	21.19	4.14	19.19	25.96	9.43
Apparel	.60	.58	–2.89	–4.12	–2.99	–4.27	...	...
Transportation	.16	.16	6.70	27.93	6.67	27.89	.43	.14
Motor vehicles	.24	.26	–5.06	–5.96	–5.10	–6.02	...	...
Motor fuel	.10	.08	37.54	139.82	37.52	139.80	.05	.02
Recreation	.20	.19	2.26	6.61	2.23	6.56	1.52	.72
Animal slaughter and processing PPI price change	18.42	26.26	...	...	...	...	...	...
Annual compounded rate of change	8.82	5.03	...	...	...	...	...	...

NOTE: Last column uses calculated values; percent changes in previous columns are rounded to two decimal places.

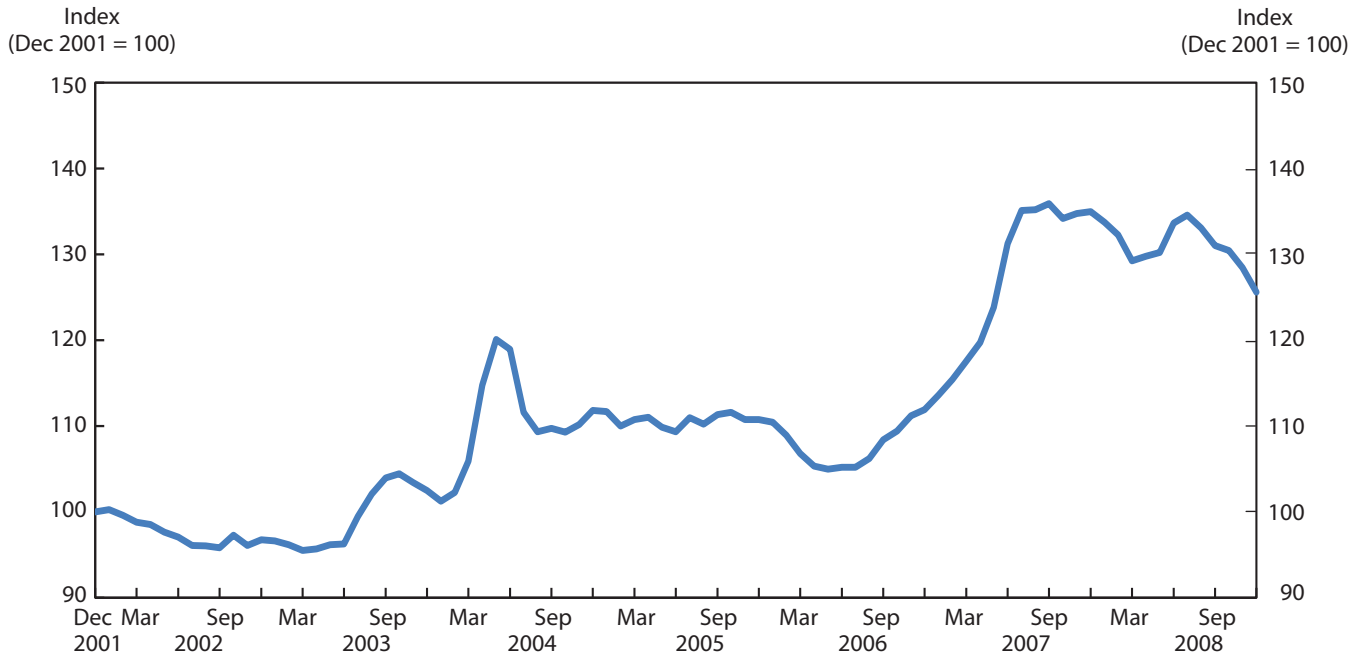
processing prices therefore accounted for 9.43 percent of the total change in the food and beverages index in that period. In 2003–2004, the impact was even stronger: the food and beverages index increased 5.59 percent, whereas the change would have been only 4.14 percent had animal slaughter and processing prices remained constant. In sum, animal slaughter and processing prices accounted for more than one-quarter of the food and beverages price change during the subperiod.

Dairy. The dairy PPI was derived from the industry-based PPI for dairy product manufacturing.[14] As seen in chart 3, dairy prices have historically been less volatile because of government price support programs and a market loss payment system. In recent years, however, a number of factors and events led to price uncertainty and volatility in the dairy product-manufacturing industry: total milk production, which is influenced by both the number of milk cows and the amount of milk per cow; commercial stocks; international trade; and changes to the regulation of dairy products.

From 2000 to 2006, dairy prices were relatively stable, although the industry did see a sharp spike in 2004 due to a rapid decline in milk cow numbers following a ban on imported animals from Canada after the discovery of BSE earlier in the year. Dairy prices began to increase steadily from mid-2006 through mid-2007 and remained high through mid-2008. The upward price shift was driven by strong demand and tight global supplies. Low stocks in the European Union, lower milk production because of droughts in Australia, New Zealand, and the United States, and strong demand (particularly from China) all contributed to the price increases.[15]

As with crops and animal slaughter and processing, rising dairy prices did not strongly influence the all-items or core CPI. Table 3 shows that the impact of dairy price movements on inflation was smaller than that attributable to those two commodities, primarily because of their higher input share. In 2003–2008, the input share of dairy in the all-items CPI averaged 0.65 percent while dairy prices rose 34.20 percent (a 5.03-percent annual compounded rate of change). Had dairy prices been flat over the period, the increase in the all-items CPI would have been 19.49 percent, compared with the actual value of 19.70 percent. Therefore, rising dairy prices accounted for a little more than 1 percent of the change in the all-items index during 2003–2008. In 2007, when dairy prices rose at their highest rate, their impact on the all-items CPI was still minimal: despite a 19.11-percent rise in dairy prices, the change in the all-items index was only about 0.1 percentage point higher than it would have been had dairy prices remained constant (2.73 percent as opposed to 2.85 percent).

Chart 3. Producer Price Index for dairy



The impact of the increases in commodity dairy prices on the core CPI was nearly nonexistent as the input share of dairy in the core CPI was just 0.14, on average, both in 2003–2008 and in 2007. From 2003 to 2008, the increase in the core index was 13.19 percent, and it would have been only marginally lower, 13.15 percent, without the contribution from rising dairy prices. In 2007, despite the 19.11-percent increase in dairy prices, the core CPI was still only marginally higher than it would have been had dairy prices remained constant (2.33 percent compared with 2.30 percent).

Increases in dairy prices did substantially affect the CPI for food and beverages through the higher input share of dairy (3.90 percent from 2003 to 2008, 3.83 percent in 2007) in food and beverages, although the impact was largest in 2007. In 2003–2008, the change in the CPI for food and beverages was 21.19 percent, whereas it would have been 19.95 percent, a relatively modest impact, had dairy prices remained constant. In 2007, however, the food and beverages index rose 3.91 percent; had dairy prices remained constant that year, the index would have risen only 3.20 percent. Rising dairy prices therefore accounted for nearly 18 percent of food and beverages inflation in 2007.

Oil and gas. The oil and gas PPI was calculated by aggregating indexes for natural gas, crude petroleum (domestic production), and liquefied petroleum gas. As seen in chart 4, crude oil and natural gas prices have historically been quite volatile. The depletion of finite resources, changes in exchange rates, policies of the Organization of the Petroleum Exporting Countries (OPEC), political and environmental shocks, commodity speculation, and changes in demand have all influenced oil and gas price movements in the past. Between 2001 and 2008, a number of these factors contributed to large price spikes in 2003, 2005, and 2008.

The increase in natural gas and oil prices in 2003 was due largely to a Venezuelan oil strike in late 2002 that reduced crude oil production and led to an increase in the world price of the commodity. According to the U.S. Department of Energy, the United States received more than half of Venezuela's crude exports at the time and replacing the lost volumes proved difficult.[16] High prices at the end of 2005 were due to shocks to oil and natural gas infrastructure caused by Hurricanes Katrina and Rita hitting the Gulf of Mexico.[17] All oil and natural gas production in the Gulf was shut in, import terminals were closed, and several pipelines and refineries were inoperable.[18]

Table 3. Impact of price changes in dairy on selected CPI categories

CPI index	Average dairy input shares		CPI price change		CPI price change had dairy prices remained constant		Impact of dairy price changes on CPI	
	2007	2003–2008	2007	2003–2008	2007	2003–2008	2007	2003–2008
All items	.64	.65	2.85	19.70	2.73	19.49	4.11	1.05
All Items less food and energy	.14	.14	2.33	13.19	2.30	13.15	1.08	.34
Housing	.04	.04	3.16	19.98	3.15	19.96	.23	.07
Shelter	.02	.02	3.65	18.54	3.65	18.54	.12	.04
Fuels and utilities	.03	.03	3.04	53.25	3.04	53.24	.18	.02
Food and beverages	3.83	3.90	3.91	21.19	3.20	19.95	17.99	5.86
Apparel	.11	.12	–.38	–4.12	–.40	–4.16	...	...
Transportation	.06	.06	2.12	27.93	2.11	27.91	.51	.07
Motor vehicles	.07	.07	–1.35	–5.96	–1.36	–5.99	...	...
Motor fuel	.04	.05	8.16	139.82	8.16	139.81	.09	.01
Recreation	.09	.09	.46	6.61	.44	6.58	3.44	.43
Dairy PPI price change	19.11	34.20	...	...	...	...	...	...
Annual compounded rate of change	19.11	5.03	...	...	...	...	...	...

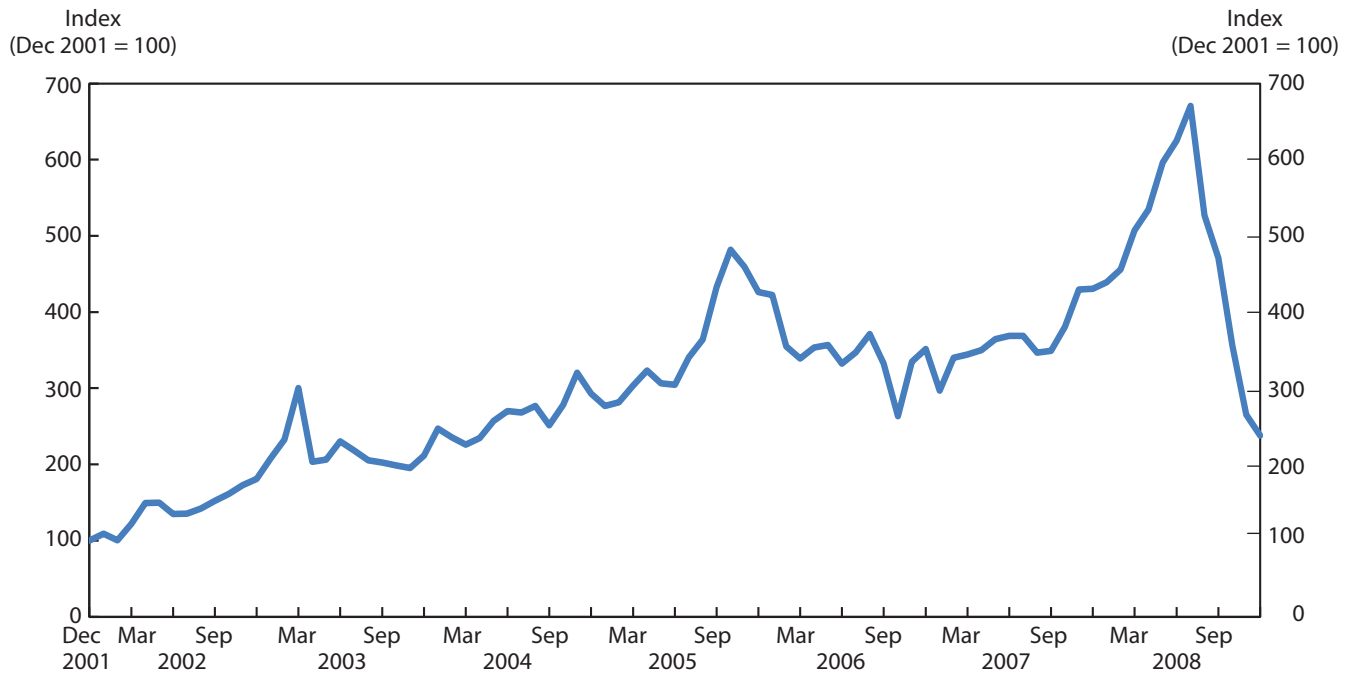
NOTE: Last column uses calculated values; percent changes in previous columns are rounded to two decimal places.

The increase in crude oil and natural gas prices that culminated in record-high prices in mid-2008 was driven by strong demand from Europe, Latin America, the Middle East, and Asia, as well as the declining value of the dollar. After peaking in midyear, prices decreased rapidly through the rest of the calendar year. Between lessening demand for crude oil and weakened economies in the United States and Europe, the global market for crude oil declined. Concerns about slowing global demand affected futures traders and OPEC alike, depressing prices further.

In contrast to crops, animal slaughter, and dairy, rising oil and gas prices had a large impact on overall consumer price inflation. Movements in oil and gas prices had a pronounced effect on the percent change in the all-items CPI through both the magnitude of the increases in oil and gas commodity prices and the substantially higher input share of oil and gas in the all-items index. As table 4 shows, from 2003 through 2008 oil and gas prices increased 232.25 percent (a 22.16-percent annual rate) and the average input share was 3.88 percent. Over that period, the percent change in the all-items CPI was 19.70 percent; had oil and gas prices remained unchanged, it would have been 14.55 percent. Rising oil and gas prices therefore accounted for more than 25 percent of the percent change in the all-items CPI from 2003 to 2008. In 2008,[19] the impact was even more pronounced because of the large price increase (30.09 percent) and the high input share (4.78 percent). In that year, the percent change in the CPI for all items was 3.84 percent, whereas it would have been 2.40 percent had oil and gas prices remained constant. Higher oil and gas prices therefore accounted for 37.48 percent of the percent change in the all-items CPI in 2008. Rising oil and gas prices accounted for a substantial amount of the inflation both over the entire period from 2003 to 2008 and in 2008. However, the overall rate of inflation was still quite modest relative to the magnitude of the price increases in oil and gas, demonstrating that even large movements in oil and gas prices do not necessarily lead to extremely high inflation.

Price movements in oil and gas also affected core inflation substantially. The input share of oil and gas in the core CPI, though smaller than that for the all-items CPI, averaged 2.54 percent from 2003 to 2008 and 3.05 percent in 2008. Core inflation was 13.19 percent over the 2003–2008 period and would have been 9.77 percent without the contribution from higher oil and gas prices. As with the all-items CPI, higher oil and gas prices therefore accounted for 25.93 percent of core inflation during the period. In 2008, core inflation was 2.30 percent, and it would have been only 1.38 percent had oil and gas prices not increased. In that year, higher oil and gas prices therefore accounted for 39.92 percent of core inflation, similar

Chart 4. Producer Price Index for oil and gas



to the impact that increasing gas and oil prices had on the percent change in the all-items CPI. The high percentage of both the all-items CPI and core inflation accounted for by oil and gas prices indicates the importance of oil and gas prices to a broad range of goods and services.

Many different CPI categories were affected considerably by rising oil and gas prices, but the three categories affected most from 2003 through 2008 were transportation, motor fuels, and fuels and utilities. In analyzing the impact of higher oil and gas prices on these indexes, the fact that oil and natural gas are combined in the input–output tables and treated as one industry or commodity becomes a limitation. Crude oil and natural gas prices do not always move in a similar fashion, and some final-demand categories are more sensitive to one than the other. Most notably, large increases in crude oil prices lead to substantial increases in the CPI for transportation and motor fuels whereas natural gas price movements are the more dominant factor in fuels and utilities. Despite this limitation, useful information can still be gleaned from examining the impact of combined oil and gas prices on these subindexes.

Motor fuel and transportation. The input share of oil and gas in motor fuel averaged 43.64 percent from 2003 to 2008. During this period, the percent change in the CPI for motor fuel was 139.82, whereas it would have been only 69.02 percent without the contribution from higher oil and gas prices. Oil and gas price movements therefore accounted for more than half (50.63 percent) of the increase in the CPI for motor fuel during the 2003–2008 timeframe.[20] In 2008, the impact was even stronger: the increase in the CPI for motor fuel was 16.97 percent, whereas it would have been just 2.44 percent had oil and gas prices remained constant. Higher oil and gas prices therefore accounted for a large part of the increase in motor fuel prices in 2008.

Motor fuel is a subcategory of the broader CPI transportation index. As can be seen in table 4, almost 67 percent of the inflation in transportation from 2003 to 2008 was caused by rising oil and gas prices. Nearly all (93.69 percent) of the 5.88-percent inflation in transportation in 2008 can be attributed to increasing oil and gas prices. Although the oil and gas input share of transportation is less than that of motor fuel, crude oil prices were still the main driver for CPI transportation inflation.

Fuels and utilities. The input share of oil and gas in fuels

Table 4. Impact of price changes in oil and gas on selected CPI categories

CPI	Average oil and gas input shares		CPI price change		CPI price change had oil and gas prices remained constant		Impact of oil and gas price changes on CPI	
	2008	2003–2008	2008	2003–2008	2008	2003–2008	2008	2003–2008
All items	4.78	3.88	3.84	19.70	2.40	14.55	37.48	26.12
All items less food and energy	3.05	2.54	2.30	13.19	1.38	9.77	39.92	25.93
Housing	5.19	4.49	3.19	19.98	1.62	13.87	49.06	30.56
Shelter	1.07	.86	2.52	18.54	2.20	17.40	12.76	6.16
Fuels and utilities	26.02	24.06	9.66	53.25	1.83	17.14	81.03	67.81
Food and beverages	2.24	1.82	5.37	21.19	4.70	18.74	12.56	11.55
Apparel	1.91	1.57	–.08	-4.12	–.65	–6.25	...	...
Transportation	18.32	13.87	5.88	27.93	.37	9.28	93.69	66.76
Motor vehicles	1.92	1.58	–1.07	–5.96	–1.65	–8.11	...	...
Motor fuel	48.29	43.64	16.97	139.82	2.44	69.02	85.61	50.63
Recreation	2.75	2.28	1.62	6.61	.80	3.56	50.97	46.15
Oil and gas PPI price change	30.09	232.25	...	...	...	...	...	...
Annual compounded rate of change	30.09	22.16	...	...	...	...	...	...

NOTE: Last column uses calculated values; percent changes in previous columns are rounded to two decimal places.

and utilities averaged 24.06 percent from 2003 to 2008. During this period, the percent change in the CPI for fuels and utilities was 53.25 percent, whereas it would have been only 17.14 percent without the contribution from higher oil and gas prices. Oil and gas price increases therefore accounted for more than two-thirds (67.81 percent) of the increase in fuels and utilities prices over the 2003–2008 period. In 2008, the impact was stronger: the CPI for fuels and utilities was 9.66 percent; it would have been just 1.83 percent had oil and gas prices remained constant. Higher oil and gas prices therefore accounted for 81.03 percent of the increase in prices for fuels and utilities in 2008.

THE ANALYSIS PRESENTED IN THIS ARTICLE has revealed results similar to those of Hobijn. The effect of commodity price increases was more pronounced for specific CPI categories than it was for broader CPI measures. Higher oil and gas prices substantially affected motor fuels, transportation, and fuels and utilities price changes, and increasing crop, animal slaughter and processing, and dairy prices contributed to higher prices for food and beverages. From 2003 to 2008, price increases in crops, animal slaughter and processing, and dairy accounted for slightly more than one-third[21] of the increase in the food and beverages CPI; in subperiods when price movements in these commodities were especially strong, the impact was even more pronounced. Crops, animal slaughter and processing, and dairy together accounted for about 7 percent of the all-items CPI price change and less than 3 percent of the core CPI price change during the 2003–2008 period. Furthermore, even the largest price movements for these commodities in a given year contributed only minimally to all-items and core inflation. From 2003 to 2008, higher oil and gas prices accounted for approximately two-thirds of the increase in transportation prices, about one-half of the increase in motor fuel prices, and roughly two-thirds of the increase in fuels and utilities prices. In 2008, the substantially higher oil and gas prices accounted for a majority of the price increase in all three indexes.

However, unlike Hobijn's account, the analysis presented here finds that oil and gas commodity price movements had a substantial impact on the all-items CPI, as well as on lower level indexes both in the longer term and in specific years. Rising oil and gas prices contributed substantially to both all-items and core CPI price changes from 2003 through 2008, accounting for approximately 26 percent of both indexes combined. During years of large price increases in oil and gas, higher prices accounted for an even greater share of the all-items and core CPIs; in 2008, higher prices accounted for nearly 40 percent of each. Whereas almost all subindexes were substantially affected

by oil and gas prices, the most heavily affected were transportation, motor fuels, and fuels and utilities.

Several factors could have contributed to the difference between Hobijn's findings and those of this analysis with regard to the impact of oil and gas commodity prices on all-items CPI inflation. Whereas Hobijn used the 2006 BEA input–output tables to compute input shares, this study has used the updated 2008 BEA input–output tables. In addition, the aggregated PPI index for oil and gas used here includes commodity data for liquefied petroleum, a PPI category that did not appear in Hobijn's oil and gas index. Lastly, the analysis presented here has used CPI data in order to analyze the effect of commodity price movements on consumer inflation, while Hobijn used PCE data to calculate this pass-through.

In sum, crops, animal slaughter and processing, and dairy price movements had a limited impact on CPI inflation while the impact of oil and gas commodity price movements was much larger. From 2003 through 2008, crop prices rose by 83 percent, animal slaughter prices grew by 26 percent, dairy prices increased by 34 percent, and oil and gas prices shot up by 230 percent. Despite all this growth, CPI inflation was just 19.7 percent over the same period. Thus, although crop, animal slaughter and processing, dairy, and oil and gas commodity prices are important contributors to consumer price inflation, even large increases in the prices of these commodities do not necessarily lead to excessively high rates of inflation. □

Notes

[1] Bart Hobijn, "Commodity Price Movements and PCE Inflation," *Current Issues in Economics and Finance* (New York, Federal Reserve Bank of New York, November 2008).

[2] Carl Chentrens, "Employment Outlook: 2008–2018—Layout and Description for 202-Order Input–Output Tables: 1993 through 2008, Historical and Projected 2018" (U.S. Bureau of Labor Statistics, 2009). This table is no longer available; however, for more recent tables, see Directorate for Science, Technology and Industry of the Organisation for Economic Co-operation and Development, "Input–Output Tables" (Paris, OECD, Mar. 25, 2012), **http://www.oecd.org/document/3/0,3746,en_2649_34445_38071427_1_1_1_1,00.html**.

[3] See, for example, Stephen P. A. Brown and Mine K. Yücel, "Gasoline and Crude Oil Prices: Why the Asymmetry?" *Economic and Financial Review* (Dallas, Federal Reserve Bank of Dallas, third quarter, 2000).

[4] Clinton P. McCully, Brian C. Moyer, and Kenneth J. Stewart, "A Reconciliation between the Consumer Price Index and the Personal Consumption Expenditures Price Index" (U.S. Bureau of Economic Analysis and U.S. Bureau of Labor Statistics, September 2007), **http://www.bea.gov/papers/pdf/cpi_pce.pdf**.

[5] See Joshua A. Byrge and Kevin L. Kliesen, "Ethanol: Economic Gain or Drain?" *The Regional Economist* (St. Louis, Federal Reserve Bank of St. Louis, July 2008), **http://www.stlouisfed.org/publications/re/articles/?id=33**.

[6] For information on the Energy Policy Act, see "Energy Policy Act of 2005" (Public Law 109-58, U.S. Department of the Interior, Aug. 8, 2005), **http://www.doi.gov/pam/EnergyPolicyAct2005.pdf**.

[7] To produce 6 billion gallons of ethanol would require approximately 2.2 billion bushels of corn. (See "Ethanol Reshapes the Corn Market," *Amber Waves: The Economics of Food, Farming, Natural resources, and Rural America* (U.S. Department of Agriculture, April 2006), **http://www.ers.usda.gov/amberwaves/april06/features/ethanol.htm**.)

[8] The act is featured on the website of the U.S. Senate Committee on Energy & Natural Resources, **www.energy.senate.gov/public**.

[9] Monthly reports on various aspects of agriculture appear on the website of the Economic Research Service of the U.S. Department of Agriculture, **www.ers.usda.gov**. For information on crops, see *Economics, Statistics, and Market Information System* (U.S. Department of Agriculture, no date), **http://usda.mannlib.cornell.edu/MannUsda/viewTaxonomy.do?taxonomyID=25**.

[10] *Ibid.*

[11] Let CPI(i, j) = annual average CPI value for category j in year i, PPI(i, j) = annual average PPI value for category j in year i, and share(i, j) = input share for year i for category j. Then the formulas for columns 2, 3, and 4 are as follows:

Column 2: $\prod_{i=1}^{N}\left(\frac{\text{CPI}(i,j)}{\text{CPI}(i\ -\ 1,j)}\right)\ -\ 1]\times 100$

Column 3: [Column 2]×[100% – [Column 4]]

Column 4: $\left[\prod_{i=1}^{N}\left[\text{share}(i,j)\times\left(\frac{\text{PPI}(i,j)}{\text{PPI}(i-1,j)}-1\right)+1\right]-1\right]\times 100/[\text{Column 2}]$

[12] Increased production costs (due to higher feed prices) led farmers to increase slaughter rates, putting downward pressure on prices in the short term with the increased supply to market. The upward and downward price movements from 2006 to 2008 reflected which of these two factors (higher feed prices or increased slaughter rates) was dominant in the short term.

[13] Monthly reports on various aspects of agriculture appear on the website of the Economic Research Service of the U.S. Department of Agriculture, **www.ers.usda.gov**. For information on animal slaughter and processing, see *Economics, Statistics, and Market Information System* (U.S. Department of Agriculture, no date), **http://usda.mannlib.cornell.edu/MannUsda/viewTaxonomy.do?taxonomyID=25**.

[14] This industry encompasses the manufacture of dairy products, from raw milk and processed milk to dairy substitutes. The products range from fluid milks, yogurt, butter, cheese, and ice cream to dry or condensed milk and whey products.

[15] Monthly reports on various aspects of agriculture appear on the website of the Economic Research Service of the U.S. Department of Agriculture, **www.ers.usda.gov**. For information on dairy, see *Economics, Statistics, and Market Information System* (U.S. Department of Agriculture, no date), **http://usda.mannlib.cornell.edu/MannUsda/viewTaxonomy.do?taxonomyID=25**.

[16] For information on the Venezuelan oil strike, see Joanne Shore and

John Hackworth, "Impacts of the Venezuelan Crude Oil Production Loss" (U.S. Energy Information Administration, Mar. 15, 2007), **http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2003/venezuelan/vzimpacts.htm**.

[17] For information on hurricanes that struck in 2005, see "Hurricane Impacts on the U.S. Oil and Natural Gas Markets," *EIA Report on Hurricane Impacts on U.S. Energy* (U.S. Energy Information Administration, Dec. 27, 2005), **http://tonto.eia.doe.gov/oog/special/eia1_katrina.html**; "Hurricane Katrina's Impact on the U.S. Oil and Natural Gas Markets," *EIA Report on Hurricane Katrina's Impact on U.S. Energy* (U.S. Energy Information Administration, Sept. 7, 2005), **http://www.eia.gov/oog/special/eia1_katrina_090705.html**; "Hurricane Katrina's Impact on the U.S. Oil and Natural Gas Markets," *Daily Report on Hurricane Katrina's Impact on U.S. Energy* (U.S. Energy Information Administration, Sept. 15, 2005), **http://www.eia.gov/oog/special/eia1_katrina_091505.html**; "Hurricane Impacts on the U.S. Oil and Natural Gas Markets," *Daily Report on Hurricane Impacts on U.S. Energy* (U.S. Energy Information Administration, Sept. 26, 2005), **http://www.eia.gov/oog/special/eia1_katrina_092605.html**; and "Hurricane Impacts on the U.S. Oil and Natural Gas Markets," *Daily Report on Hurricane Impacts on U.S. Energy* (U.S. Energy Information Administration, Oct. 11, 2005), **http://www.eia.gov/oog/special/eia1_katrina_101105.html**.

[18] For safety reasons, oil and gas companies will "shut in" production from offshore platforms that are expected to be in the path of a hurricane. The platforms are abandoned until the storm passes.

[19] As discussed earlier, there were three major movements in oil and natural gas producer prices from 2001 to 2008: in 2003, 2005, and 2008. In all 3 years, oil and gas prices were up by more than 30 percent. The year 2008 is chosen as the subperiod of interest because the input share was the highest in that year, causing the price movement in 2008 to have the largest impact.

[20] Major inputs into fuel prices are oil and gas extraction, petroleum and coal products manufacturing, and wholesale and retail margins. A plausible explanation for the fact that oil prices account for only about 50 percent of fuel price increases is that refining (petroleum and coal products manufacturing) costs went up. Also, in more recent years transportation costs have been affected by volatility in ethanol prices.

[21] The contribution of one-third was arrived at by adding the various impacts of the commodity price changes on the CPI (i.e., 19.26 for crops, 9.43 for animal slaughter and processing, and 5.86 for dairy, totaling 34.55 percent).

APPENDIX A: Detailed methodology

To determine the impact of commodity price movements on the price of final consumer goods, the input share for each commodity needs to be calculated. The input share quantifies the importance of the different commodities for the production of the final goods. To calculate input shares for the commodities of interest in this article, this appendix follows a method described by Hobijn.[1] The method utilizes a modified Leontief model, expressed in linear form as $\mathbf{r} = \mathbf{A}\mathbf{r} + \mathbf{b}$.

Solved for **r**, the equation can be written as $\mathbf{r} = (1 - \mathbf{A})^{-1}\mathbf{b}$. In matrix form, this equation can also be expressed as $\mathbf{r} = (\mathbf{I}_n - \mathbf{A})^{-1}\mathbf{b}$, in which **r** represents the input share, vector **b** represents the proportions of each commodity in final-demand categories, $\mathbf{I}_n$ is the 202 × 202 identity matrix, and **A** is a commodity–commodity direct requirements (CCDR) matrix, a 202 × 202 matrix whose (*i*,*j*)th element is the amount, in dollars, of commodity *i* directly required to produce $1 of commodity *j* for final use.[2] The matrix that results from taking the inverse of the difference of the identity matrix and the CCDR matrix $[(\mathbf{I}_n - \mathbf{A})^{-1}]$ is an important component of the methodology used here and is known as the commodity–commodity total requirements (CCTR) matrix, a 202 × 202 matrix whose (*i*,*j*)th element is the production required, both directly and indirectly, of commodity *i* per dollar of delivery to final use of commodity *j*. Once the CCTR matrix and the proportions of final demand for each commodity are calculated, the input shares **r** of the commodities in the final-demand category may be found by taking the cross product of the two: $\mathbf{r} = \mathbf{CCTR} \times \mathbf{b}$.

Note that several steps were required to calculate the CCTR matrix. The process begins with the make and use tables compiled by Carl Chentrens for the Bureau of Labor Statistics.[3] The make table is a 202 × 202 matrix whose (*i*,*j*)th element is the value of commodity *i*'s output by industry *j* in a given year, and the use table is a 202 × 202 matrix whose (*i*,*j*)th element is the value of commodity *i* used in industry *j* (e.g., the value of crops used in animal production).

The make and use tables are then used to calculate the CCDR matrix.[4] One adjustment was made to this matrix (similar to Hobijn's method): the columns for the commodities of interest (crops, animal slaughter and processing, dairy, and oil and gas) were zeroed out. This adjustment must occur because the prices for these commodities are gross output prices and already reflect the inputs used in their production. However, as Hobijn explains, because of the adjustment, the input shares of the four commodities examined do not include the input share of each in the production of the other.[5] Once this adjusted CCDR is created, it is subtracted from a 202 × 202 identity matrix and the inverse of the resulting matrix is taken, yielding the CCTR matrix.

After the CCTR matrix is obtained, the values for vector **b**, are calculated. These values represent the share of each commodity in the final-demand categories of interest. Calculating the values of **b** starts with the final-demand table from the input–output tables. The final-demand table is a 202 × 203 matrix whose (*i*,*j*)th element is the value of commodity *i* used to meet the final consumer demand for category *j* (e.g., the value of printing and related support activities in the category of magazines, newspapers, and sheet music). Two steps are necessary to turn the final-demand tables into the required vectors. First, the amounts listed in the final-demand table need to be converted from purchaser's values to producer's values to make them comparable to the amounts shown in the make and use tables. The purchaser's value is equal to the producer's value plus wholesale and retail trade margins and costs relating to the transportation of the good (by rail, air, water, truck, or pipeline) to the point of purchase. The final-demand table includes columns indicating the amount of the purchaser's value that is due to margin and transportation costs. These given margin and transportation amounts are redistributed back into the commodities to convert the values to producer's prices. Once the values in the final-demand table are adjusted from purchaser's to producer's values, each value in the table is divided by the sum of the entries in its column. Because the final-demand tables detail the amount of each commodity used to meet final consumer demand for a category, dividing by the column totals in this manner gives the proportion of final demand accounted for by each commodity.

At first glance, it may seem that these columns represent the final input shares in which we are interested. However, the final-demand table indicates only how much of each commodity *that is available for final use* is needed to produce each item. The table does not take into account how much of each different commodity is required to make available a dollar's worth of a commodity for final use. The CCTR matrix is needed because it quantifies the interindustry linkages of the different commodities. Multiplying the columns representing the share of each com-

modity in the final-demand categories of interest by the CCTR yields the final input shares for each commodity in the production of the final goods that take into account all inputs of the commodities along the way.

Notes to APPENDIX A

[1] Bart Hobijn, "Commodity Price Movements and PCE inflation," *Current Issues in Economics and Finance* (New York, Federal Reserve Bank of New York, November 2008).

[2] For a detailed discussion of the derivation of the CCDR matrix, see Karen J. Horowitz and Mark A. Planting, "Concepts and Methods of the U.S. Input–Output Accounts" (U.S. Bureau of Economic Analysis, September 2006 and updated April 2009), **http://www.bea.gov/papers/pdf/IOmanual_092906.pdf**, especially chapter 12.

[3] Carl Chentrens, Employment Outlook: 2008–2018—Layout and Description for 202-Order Input–Output Tables: 1993 through 2008, Historical and Projected 2018" (U.S. Bureau of Labor Statistics, 2009). This table is no longer available; however, for more recent tables, see Directorate for Science, Technology and Industry of the Organisation for Economic Co-operation and Development, "Input–Output Tables" Paris, OECD, Mar. 25, 2012), **http://www.oecd.org/document/3/0,3746,en_2649_34445_38071427_1_1_1_1,00.html**.

[4] Horowitz and Planting, "U.S. Input–Output Accounts."

[5] Hobijn, "Commodity Price Movements."

APPENDIX B: Glossary

Commodity–commodity direct requirements (CCDR) matrix A 202 × 202 matrix whose (i,j)th element is the amount, in dollars, of commodity i directly required to produce $1 of commodity j for final use.

Commodity–commodity total requirements (CCTR) matrix A 202 × 202 matrix whose (i,j)th element is the production required, both directly and indirectly, of commodity i per dollar of delivery to final use of commodity j. Equal to the inverse of the difference of the identity matrix and the CCDR: $\mathbf{CCTR} = (\mathbf{I}_n - \mathbf{CCDR})^{-1}$.

Final-demand table A 202 × 203 matrix whose (i,j)th element is the value of commodity i used to meet the final consumer demand for category j.

Input–output tables A means of presenting a detailed analysis of the process of production and the use of goods (products) and services and the income generated in that process. The tables are either (a) make and use tables or (b) symmetric input–output tables.[1] The tables compiled by Chentrens and used in this article are make and use tables.

Input share A measure of the importance of a commodity for the production of final goods.

Leontief model A standard model, given by $\mathbf{x} = (\mathbf{I}_n - \mathbf{A})^{-1}\mathbf{y}$, that relates final demand $\mathbf{y}$ to total output $\mathbf{x}$ through the interindustry linkages represented by the total requirements matrix $(\mathbf{I}_n - \mathbf{A})^{-1}$. Widely used in economic impact analysis to model the changes in total output that are needed to satisfy a change in final demand.

Make table A 202 × 202 matrix whose (i,j)th element is the value of commodity j's output by industry i in a given year.

Producer's value The value that a producer receives for a good. (e.g., the amount a farmer receives for his or her crops).

Purchaser's value The sum of producer's value and wholesale and retail trade margins and costs relating to the transportation of the good (by rail, air, water, truck, or pipeline) to the point of purchase.

Use table A 202 × 202 matrix whose (i,j)th element is the value of commodity i used in industry j (e.g., the value of crops used in animal production).