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The Effects of Energy Price Shocks on Household Food Security in Low-Income Households

Charlotte J. Tuttle and Timothy K.M. Beatty

United States Department of Agriculture

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Abstract

Unexpected changes in energy prices, including prices for gasoline and heating fuel (natural gas and electricity), can affect three indicators of food distress, or food access at the household level. This study uses data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration to examine the effects of unexpected changes in energy prices on household food security. Findings reveal that an unexpected rise in the prices of gasoline, natural gas, and electricity increases the probability of food access problems, while an unexpected drop in the price of each energy source decreases the probability. The overall estimates from the analysis are small, but the effects of energy price shocks increase in magnitude for low-income households. This effect suggests that low-income households are more vulnerable to unexpected jumps in energy prices than households with higher incomes.

Keywords

food security, energy price shocks, heat and eat, poverty

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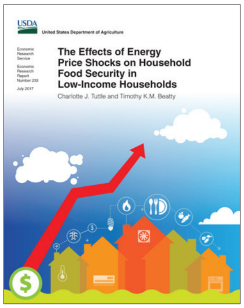

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What is the issue?

Gasoline, natural gas, and electricity prices vary widely over time. Yet, because these goods are necessary and demand for the goods does not respond to change in prices—gasoline for driving to work and natural gas and electricity for heating homes and running kitchen appliances—households may face challenges meeting basic needs when energy prices rise unexpectedly. As income drops, household expenditures also fall. This effect can be particularly detrimental to low-income households, which have few savings and assets and whose budget share allocated toward energy expenditures is already large compared with households with higher incomes. While previous studies have examined the effects of unexpected increases, or positive shocks, in energy prices on household food spending, this is the first study to examine whether such price shocks can result in an increase in three measures of food distress, including food insecurity. Food-insecure households lack access to adequate food for a healthy lifestyle.

What did the study find?

This study estimated the effects of energy price shocks on three measures of food distress: (1) the 30-day measure for *food insecurity*; (2) *food insufficiency,* which indicates a household is unable to access either the quantity or quality of food it believes it needs; and (3) *more money,* where a household indicates it needs more money to buy sufficient food relative to its last food purchase. Researchers examined data on low-income households, low-income households that reside in the 26 States (among the 48 contiguous States) with the coldest average temperatures in December, and the total sample. Findings include the following:

- The effects of energy price shocks increase in magnitude for low-income households, which already allocate a larger share of their budgets to energy expenditures than other households. This suggests that low-income households are more vulnerable to unexpected jumps in energy prices than other households.

- Positive shocks to gasoline prices have a statistically significant effect on the probability of needing more money for food relative to a household's most recent food shopping in the total sample as well as in the low-income sample. Negative gasoline shocks decrease the probability of 30-day food insecurity in the total sample but have no effect on the low-income sample.

- Positive and negative shocks to natural gas prices have a statistically significant effect on each food-distress indicator in the total sample and in the low-income sample. In the low-income sample of households that reside in cold States, only negative natural gas price shocks affect the probability of food stress and needing more money.

- Positive shocks to electricity prices increase the probability of food stress and needing more money in the total sample as well as in the low-income sample. Negative shocks to electricity prices decrease the probability of food insecurity and food stress in the low-income sample of households that reside in cold States.

How was the study conducted?

The study uses data from the Current Population Survey Food Security Supplement (CPS-FSS) for the years 2001-2014 and the U.S. Energy Information Administration (EIA) for the years 2000-2014. The Current Population Survey is a survey representative at the State and national level that is administered monthly by USDA and the U.S. Census Bureau. The CPS-FSS survey collects data on food access, expenditure, shopping, and participation in USDA's Supplemental Nutrition Assistance Program. The analysis merges State-level energy price information from EIA with the CPS data. Energy price shocks are calculated using State-level monthly gasoline, natural gas, and electricity price information provided by the EIA. These shocks represent deviations from respondents' expectations of monthly energy prices. The CPS-FSS is administered in December of each year, when unexpected changes in energy prices that can affect heating and transportation can be most detrimental.

The Effects of Energy Price Shocks on Household Food Security in Low-Income Households

Introduction

Food security can be defined as a household's access to sufficient food to lead a healthy lifestyle. Food insecurity, in turn, suggests a condition in which a household does not have the resources to access enough food to meet its daily needs. In the United States, food insecurity is a growing concern to policymakers, particularly due to the high costs of food and nutrition assistance programs and the growing need for program benefits. From 2000 to 2007, the food-insecurity rate in the United States ranged from 10 to 12 percent (USDA-ERS, 2016). But after the Nation's financial crisis hit in late 2007, U.S. food insecurity jumped to nearly 15 percent and remained at a rate between 14 and 15 percent until 2014 and then declined to 12.7 percent in 2015. Furthermore, food insecurity may have lasting health consequences for members of affected households. Previous studies have found that food-insecure adults are more likely to suffer from diabetes, obesity, and depression (Vozoris and Tarasuk, 2003; Wilde and Peterman, 2006; Seligman et al., 2010).

Children also suffer health-related effects when exposed to food insecurity, including increased risk of hospitalizations, cognitive development delays, and stunting, as well as poor school performance (Cook et al., 2006; Jyoti et al., 2005; Walker et al., 2007). Critically, these health issues may have life-long consequences that follow the individual through adulthood and affect future earnings. The high economic costs incurred from food insecurity are drivers of policy research related to determinants and potentially preventative measures of food insecurity.

Food insecurity primarily results from a loss of resources that prevents a household from purchasing enough food. Thus, any drop in income may increase the likelihood that a household will be food insecure if it cannot smooth consumption over time. While a number of studies have considered factors that contribute to household food insecurity (job status, disability status, education level, etc.) (e.g., Rose, 1999; Furness et al., 2004), other studies have found that unexpected decreases in income may be a more accurate determinant of the condition (Gundersen and Gruber, 2001; Leete and Bania, 2010). When households experience an unexpected decrease in income, they may be unable to service all necessary household expenditures. As a result, tough decisions must be made; some households may overlook certain needs to pay for others. And as households allocate budgeted income toward other household expenses, food spending tends to decline. This effect implies that food insecurity may not be a chronic condition but is instead episodic, occurring only in times of unexpected or severe financial stress.

Household expenses affect the amount of disposable income that is available. Households may not be able to postpone such expenses as rent, heat, gasoline for cars, or appliance repairs until a more financially secure time. A household may be food secure for most of the year, but an unexpected shock to household income may push the household into food insecurity by limiting the amount of disposable income available to purchase necessities such as food. Gundersen and Gruber (2001) find that, for low-income households, income shocks are a greater predictor of food insecurity than income itself. This ERS study extends Gundersen and Gruber's research by looking at specific income shocks, namely unexpected changes in gasoline and energy prices, and their effects on household food access, including food insecurity.

Unexpected changes in energy prices may be particularly detrimental to low-income households. There is considerable empirical evidence to suggest that households adjust the quantity and quality of foods they eat in response to unexpected increases in energy prices (Bhattacharya et al., 2003; Cullen et al., 2005; Beatty et al., 2011). Moreover, gasoline price shocks are found to affect the quality of food purchased, causing households to substitute away from more expensive food to cheaper food to maintain constant gasoline consumption (Gicheva et al., 2010). Because few substitutes exist for energy in the short run, low-income households may find it difficult to adjust energy consumption. As a result, poorer households may have little choice but to hold quantities roughly constant when faced with an unanticipated price change. While this tradeoff between food and energy consumption is well documented, it is not clear whether the energy price shocks that trigger it are large enough to make households exhibit behavior consistent with food insecurity, such as skipping meals, cutting the size of meals, and lacking sufficient money to buy enough food for the household.

Because the demand for energy is inelastic—in other words, households do not tend to change consumption of energy in response to changes in prices—as energy prices increase, households likely reallocate their income from other household expenditures, including food, to energy expenditure in the short run (Bernstein and Griffen, 2006). This demand effect allows households to maintain a constant level of energy consumption. Similarly, an unexpected drop in energy prices could increase disposable income, enabling households to allocate more money to other needs.

Although a drop in disposable income due to higher energy prices suggests that households will decrease food expenditure, a drop in food expenditure is not necessarily equivalent to a drop in the quantity of food consumed. Aguiar and Hurst (2005) consider whether the fall in individual food expenditure that occurs after retirement directly translates to a drop in consumption. Using data from USDA's Continuous Survey of Food Intakes by Individuals (CSFII), Aguiar and Hurst find that at retirement, food expenditure falls by 17 percent, whereas time spent on food preparation and shopping increases by 53 percent. In this case, the drop in expenditure does not necessarily affect the amount, quantity, or quality of food consumed.

This study examines the effects of shocks to gasoline, natural gas, and electricity prices to determine if such shocks are large enough to push households into or lift households out of different levels of food distress. These indicators include whether a household feels it can access enough food and sufficient quality of food, whether a household needs more money to access sufficient food, and whether a household exhibits behavior consistent with USDA's 30-day measure of food insecurity. All three overlapping indicators represent food distress, defined for the purposes of this analysis as an interruption in food access for the household.[1]

[1]Note that food-insecurity measures also address conditions that contribute to food insufficiency and needing more money. These food-distress indicators, therefore, overlap in meaning.

Recent Literature on Heat and Eat

Results of "heat and eat" studies consistently show that households at low levels of income or expenditure are likely to adjust food spending in response to price and weather shocks. Food and fuel expenditures account for a greater share of the total budgets of low-income households than of middle- and high-income households (Ageletos et al., 2014). Furthermore, low-income households have minimal financial buffers to protect against unexpected price increases (Carroll, 2011). This means that they lack savings and assets that would cushion them from the effects of changes in disposable income. Bhattacharya et al. (2003) link the Bureau of Labor Statistics' Consumer Expenditure Survey (CES) and the National Center for Health Statistics' National Health and Nutrition Examination Survey (NHANES) to temperature data compiled by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). Bhattacharya et al. observe that, in response to unexpected cold spells, households at all levels of income increase their fuel expenditure, but only low-income households reduce food expenditure. The magnitude of the reduction in food expenditure is similar to the magnitude of the observed increase in fuel expenditure, which suggests that low-income families may purchase food in lower quantities or at cheaper prices to free up money to pay for heat. Alternatively, the findings could be interpreted to suggest that households increase food expenditure when temperatures are unseasonably warm due to a reduction in heating costs.

Two studies have discussed the relationship between household heating costs and total expenditure. Using the CES data merged with monthly data on energy prices and temperatures, Cullen et al. (2005) focus on the effects of anticipated and unanticipated price and weather changes on household expenditure, including food expenditure. Findings suggest that expected price or weather changes have no effect on household expenditure at all levels of income, implying that most households have the means to smooth consumption when they are aware of an upcoming change in prices or temperatures. Conversely, unexpected price or weather changes greatly affect household expenditure, including food expenditure of low-income households. This suggests that price and weather shocks have more severe consequences when households lack sufficient financial means. Lastly, Beatty et al. (2011), in a United Kingdom study, find results similar to those of other studies: cold weather shocks cause households of all income levels to increase their fuel expenditure but cause only low-income households to adjust their food expenditure.

The literature also examines the effects of gasoline price shocks on household expenditure. Gicheva et al. (2010) find that low-income households decrease food expenditure in response to unexpected increases in gasoline prices. They find that households in these situations tend to substitute away from eating out toward more affordable at-home consumption. Furthermore, households facing sudden spikes in gasoline prices tend to maintain the quantity of food purchased but reallocate food expenditure toward sale items. As in other studies, Gicheva et al. find the response to gasoline price shocks is largest for low-income households. In short, previous studies consistently find that exogenous energy price and weather shocks cause households to restrict spending on other goods, including food.

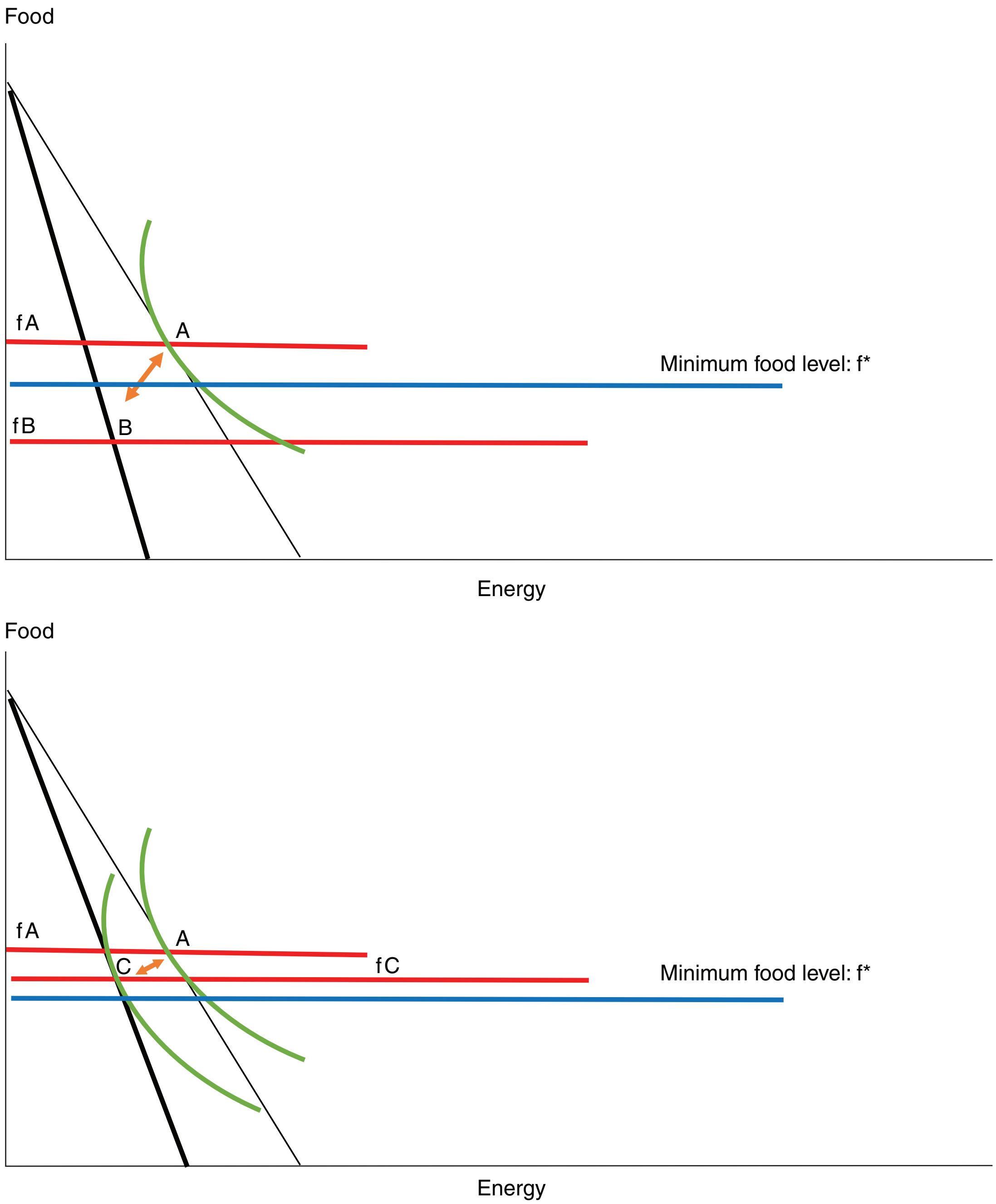
While the heat and eat literature finds that exogenous shocks to energy prices and unexpected cold spells affect food expenditure, it does not establish that the changes in food expenditure caused by the shocks are sufficiently large enough to create or, conversely, relieve hardship. The food-security literature finds that low-income households are unable to smooth large, potentially exogenous shocks, and, as a result, income shocks may increase the probability that a household suffers from food insecurity (Gundersen and Gruber, 2001; Leete and Bania, 2010). Building on both analyses, this ERS study examines whether the small exogenous shocks associated with unanticipated spikes in energy prices are large enough to increase the probability that a household will experience food insecurity or some level of food distress or, in the case of a drop in price, decrease the probability that a household will be food insecure.

A Model of Price Shocks

The model of price shocks proposed in this study shows how the income effect of an energy price shock affects the food-security status of low-income households. This model assumes that low-income households have limited liquid assets and little savings and, therefore, are unable to smooth consumption when energy prices change unexpectedly. In other words, if prices unexpectedly increase, the income effect of the price change is immediate. Previous studies have shown that unexpected jumps in energy prices trigger declines in household food expenditure by low-income households. Lower food expenditure, however, does not necessarily indicate food insecurity. Conversely, when energy prices fall unexpectedly, low-income households may increase their food expenditure.

Figure 1 illustrates how fuel price shocks can affect whether a household is food secure. In both the top and bottom portion of the figure, f* is a critical level of food for the household. A household is food secure if it consumes a level of food higher than f*. A household is food insecure if it consumes a level of food below f*. In the figure, a household may choose between food and energy. In the top portion, if the household starts at point A of food consumption and on the outermost budget constraint, an unexpected increase in energy prices results in the budget constraint pivoting to the left. This is because higher energy prices mean a household must purchase less energy given its budget. The unexpected increase in the energy price was large enough to cause the household to move to point B, a point below f*, the critical level of food consumption. Because point B is below f*, the household has insufficient food. In the second figure, a household experiences an unexpected, yet small, increase in an energy price and decreases food expenditure from point A to point C, once again pivoting the budget constraint to the left. Unlike the top portion, because point C is above f*, the critical level of food, the household remains food secure despite the drop in food consumption after the energy price shock.

Figure 1
Fuel price shocks and food insufficiency



Note: This figure illustrates how the size of an energy price shock can affect the food-security status of a household. In the top figure, the price shock is large enough to cause the household to decrease food expenditure to a level below f*, or the critical level of food expenditure for food security. Therefore, after the price shock, the household's food expenditure is consistent with food insecurity. In the bottom figure, the price shock is smaller. Although the household decreases its food expenditure, it is not to a level below f*, and the household remains food secure.
Source: USDA, Economic Research Service.

Data

This study estimates the effects of energy price shocks on three separate measures of food distress. The analysis uses data from the Current Population Survey Food Security Supplement (CPS-FSS) from the years 2001 to 2014 combined with data on monthly prices for gasoline from the years 2000 to 2010 and for natural gas and electricity from the years 2000 to 2014, where prices from the year 2000 were used to estimate the shocks. The CPS is a monthly survey of roughly 50,000 households from the non-institutionalized civilian population throughout the United States. The three overlapping measures of food distress mentioned earlier are used for dependent variables (see table 1).[2] These variables, while correlated, represent three measures of food distress:

1. Food insecurity: a 30-day measure of food insecurity that shows a household meets conditions indicating behavior consistent with food insecurity. The variable takes on the value of one if the household indicates low food security or very low food security and zero if it indicates food security or marginal food security. Because the CPS-FSS food-security variable changed in 2005, only the years 2005-14 are included in the food-insecurity regression.

2. Food stress: derived from USDA's food-sufficiency question that classifies whether a household indicates its access to the quality or quantity of food is sufficient. The variable takes on the value of one if the household indicates it has enough food but not the kind of food it wants to eat, sometimes not enough to eat, or often not enough to eat. The variable takes on the value of zero if it indicates it has always enough *and* the kind of food it wants to eat.

3. More money: a liquidity variable that captures whether or not the household states it needs more money to purchase enough food, compared with its most recent food spending. The variable takes on the value of one if the household indicates it needs more money to purchase enough food and takes on the value of zero if it indicates it does not need more money to purchase enough food.

It is important to note that survey questions related to these variables are not administered to the entire sample in the CPS-FSS but are only asked when a respondent indicates some level of financial stress or low income (see table 1). Each dependent variable was recoded as a zero-one variable, where one signals food insecurity, food stress, or the need for more money.

State-level price data are drawn from the U.S. Energy Information Administration (EIA). Natural gas and electricity prices cover the years 2000-2014. Gasoline prices cover the years 2000-2010. Gasoline prices are reported as average dollars per gallon of regular gasoline from each State in each month from 2000 to 2010. Natural gas prices are reported as average dollars per 1,000 cubic feet for residential consumers for each State in each month from 2000 to 2014. Finally, electricity prices are reported as average cents per kilowatt hour for each State in each month from 2000 to 2014. In other words, each State-level energy price is averaged within each month of each year from 2000 to 2014 (see box "Energy Choices of Households"). While energy prices may vary within States and energy prices depend on a number of factors, including local infrastructure and energy availability as well as costs of labor, EIA only provides data at a State or regional level for the 15 years covered in this analysis. Therefore, within-State variation cannot be parsed out in this analysis.

[2]The correlation of the dependent variables ranges from 0.3 to 0.4. This is likely because many of the conditions measured in the food-insecurity variable are also addressed in the food stress and more money variables.

Table 1
Dependent variables representing food distress from the Current Population Survey Food Security Supplement (2001-14)

Variable	Variable name	CPS-FSS question	Dummy variable = 1 if household:
HRFS30D1 or HRFS30M1	Food insecure	Based on the number of affirmative responses to 12-item, 30-day food-security questionnaire	Indicates low food security or very low food security
HESS1	Food stress	"Which of these statements best describes the food eaten in your household: enough of the kinds of food we want to eat, enough but not always the kinds of food we want to eat, sometimes not enough to eat, or often not enough to eat?"	Indicates enough but not always the kinds of food we want to eat, sometimes not enough to eat, often not enough to eat
HES8B or HES10	More money	"In order to buy just enough food to meet your needs or the needs of your household, would you need to spend more than you do now, or could you spend less?"	Indicates would need to spend more than you do now

Source: USDA, Economic Research Service. CPS-FSS= Current Population Survey Food Security Supplement.

Box 1

Energy Choices of Households

In 2015, average household expenditure for homes heated with natural gas was $578 in the winter months. Households using heating oil spent $1,392, and homes using electric heat spent $930 (EIA, 2015). Fuel expenditure varies per household depending on household size, equipment, thermostat settings, weather, and energy-efficiency characteristics.

The choice of heating fuel preferred by households varies by region. In the West, Midwest, and Northeast, natural gas is the primary heating source. In the South, electric heating is the primary source. The map on page 9 provides regional preferences (EIA, 2015).

The U.S. Energy Information Administration reports that on average, from 2005 through 2013, 50 percent or more of consumers in the Northeast used natural gas as their primary energy source. The second choice was heating oil at around 25 percent. In the Midwest, over 70 percent of consumers used natural gas and only 15-25 percent of consumers used electricity. In the South, the primary energy source was electricity, with 55-65 percent of consumers using electricity and 30-35 percent using natural gas. Finally, around 60 percent of consumers in the West used natural gas during the period, and between 30 and 25 percent used electricity. The overall trend for the United States during this period was around 50 percent of consumers using natural gas and between 30 and 50 percent using electricity (EIA, 2014A).

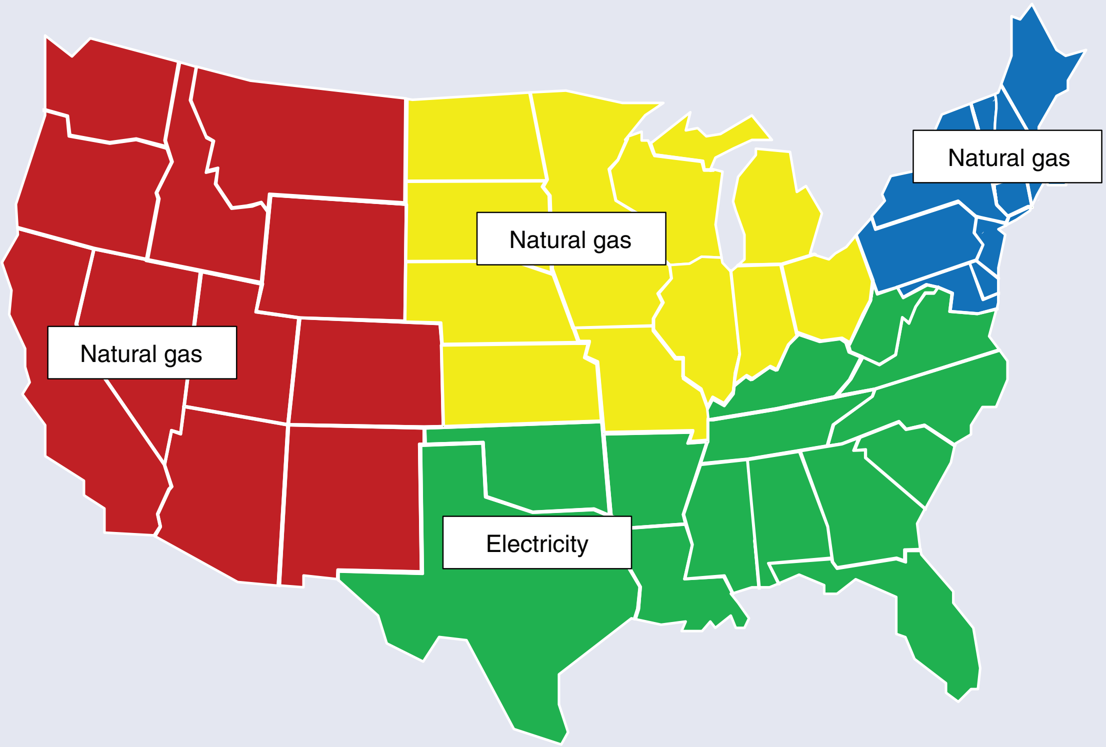
continued—

Box 1

Energy Choices of Households—continued

Box figure 1

Primary heating energy source for West, Midwest, Northeast, and South



Source: USDA, Economic Research Service using data from U.S. Energy Information Administration (2015), "Household Heating Costs Are Expected To Be Lower Than Previous Two Winters."

The share of income that a household spends on energy is often related to socio-economic status, demographic characteristics, and family size. Low-income households spend nearly three times the share of their income on energy than higher income households (7.2 percent versus 2.3 percent). African-American households spend 5.4 percent of their income, and Latino households spend 4.1 percent. Low-income and higher income households typically pay the same amount on energy, but low-income households have significantly lower annual incomes, causing the energy burden to be much higher for them (Drehobl and Ross, 2016).

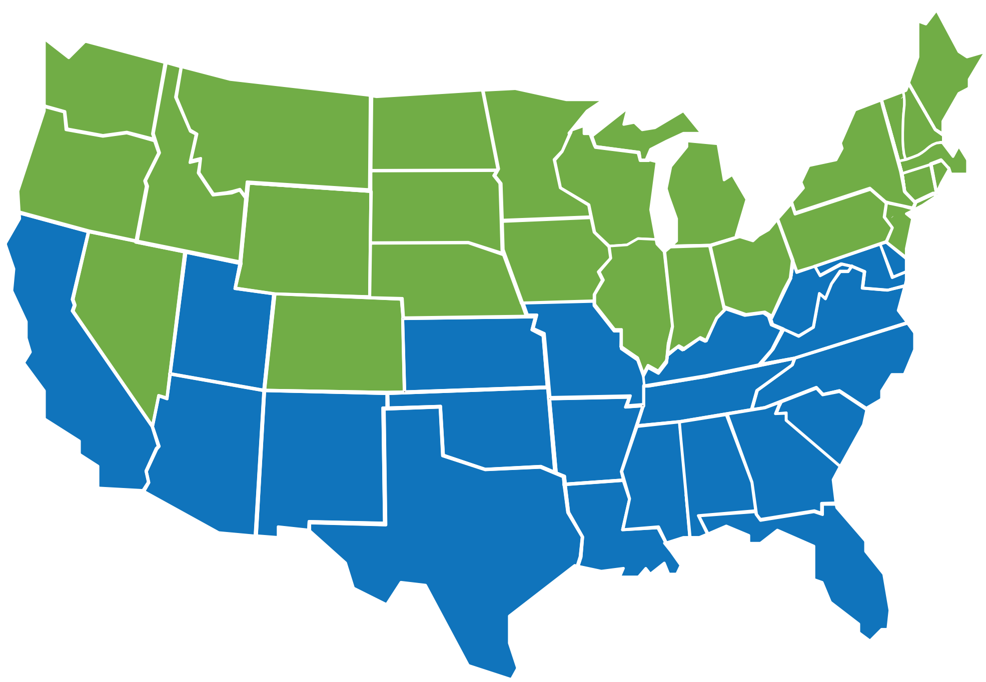
The effects of a price shock will most likely differ among samples and, consequently, have different results. Because of this, we examine three separate samples: (1) the total sample in the merged data; (2) households at or under 185 percent of the Federal poverty line (FPL); and (3) households at or under 185 percent of the FPL that reside in cold States—defined simply as the 26 States (among the 48 contiguous States) with the coldest average temperature in the month of December over 2000-2014 (see fig. 2). Although it is true that within-State average temperature ranges may be large in some States, because our data reflect State-level prices, it was more appropriate to use State-level average temperature for this analysis. Over the time period of the analysis, the average monthly temperature for cold-State households was 46 degrees Fahrenheit, with a minimum of 41 degrees and a maximum of 52 degrees for the month of December. Average monthly temperature for noncold-State households was 59 degrees Fahrenheit, with a minimum of 53 degrees and a maximum of 71 degrees for the month of December. Cold States are associated with larger household budget shares for energy than noncold States, and hence, it is possible that cold temperatures may be accompanied by more price inelasticity in energy. As stated earlier, previous studies find that low-income households tend to have a greater response to price shocks as well as a greater likelihood to adjust food expenditure in response to these shocks (Cullen et al., 2005). Thus, it seems plausible that households in cold States will have the largest response to heating fuel price shocks.

Car ownership and access to public transportation will likely influence the effects of gasoline price shocks on low-income households. Although the CPS-FSS does not contain data on car ownership or access to transportation, previous research indicates that vehicle ownership increases with increasing levels of income. This finding is confirmed in National Housing Travel Survey data from 2009 that show 24 percent of low-income households do not own a vehicle, while 98 percent of higher income households own a vehicle (NHTS, 2014). This may mean that shocks to gasoline prices have a less direct effect on food access for low-income households.

Because the subgroups that comprise the samples overlap, estimating the effects of price shocks on a comparison group can provide further insight into the responses of the samples of interest, namely low-income households and low-income households in cold States. Two further samples are analyzed: (1) households above 185 percent of the FPL for comparison to households below 185 percent of the FPL, and (2) households that reside in noncold States that encompass the Southern and Southwestern United States for comparison with low-income households in cold States. These results are reported alongside their comparison groups.

Figure 2

Cold States (shown in green) had the coldest average temperatures in December from 2000 to 2014



Note: Cold States, represented in green, are 26 States with the coldest average temperatures in December over the years 2000 through 2014.
Source: USDA, Economic Research Service using temperature data from U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

Table 2 shows the summary statistics for the sample, including the overall rate of the three food-distress indicators as well as the general demographic characteristics in the sample. Note that the low-income subgroup has higher rates of each food-distress indicator, nearly double that of the total sample. At the same time, the low-income subgroup that resides in cold States has slightly lower rates of each food-distress variable than the overall low-income sample. Furthermore, households in the low-income subgroup are more likely to be headed by a female, less likely to be headed by an individual who is married or employed and, finally, tend to have more children under age 18 in the household.

Table 2

Summary statistics of the three samples analyzed from the Current Population Survey Food Security Supplement, 2001-14

	Total sample		Low-income households		Low-income households in cold States	
	Mean	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev**
Food insecure	0.051	0.218	0.093	0.319	0.089	0.316
Food stress	0.231	0.421	0.407	0.495	0.387	0.487
More money	0.127	0.332	0.243	0.430	0.225	0.418
Food expenditure ($)	129.45	94.49	100.74	79.64	99.77	80.26
Family income bracket average ($)	35,000-39,999		12,5000-14,999		12,5000-14,999	
SNAP participation	7.96	27.06	21.66	41.19	22.28	41.67
Age (years)	49	16	49	19	50	19
White	0.859	0.348	0.801	0.399	0.862	0.344
Black	0.091	0.288	0.141	0.348	0.079	0.271
Female	0.483	0.499	0.575	0.494	0.572	0.494
Married	0.535	0.498	0.373	0.483	0.356	0.479
Employed	0.645	0.478	0.463	0.498	0.468	0.499
WIC participation	0.029	0.168	0.081	0.273	0.076	0.265
Number in household	1.815	0.591	1.825	0.69	1.787	0.689
Number of children	0.58	1	0.727	1.169	0.712	1.17
Observations	551,310		179,002		82,558	

Note: Each summary statistic for each subgroup is significantly different from the same statistics for the other subgroups at a 1-percent level with the exception of the age variable, which does not differ significantly over each subgroup. SNAP=Supplemental Nutrition Assistance Program. WIC=Special Supplemental Nutrition Program for Women, Infants, and Children.

Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement, 2001-14.

Empirical Approach

For the empirical strategy, we use three separate binary dependent variables that indicate the varying degrees of food distress. This sample uses household and energy price data from the continental 48 States over 14 years, including data on monthly energy price shocks. Because the CPS-FSS is only administered in December of each year where respondents are asked about food access and food-related behavior that reflects the past 12 months and 30 days, only energy price shock data for December is used; this yields 672 independent observations on energy price shocks. December energy shocks are based on previous months' temperatures as well as previous Decembers' temperatures.[3]

Previous studies find that households show a greater response to unanticipated price changes than to anticipated changes. Therefore, price shocks for each energy type are defined as a large deviation from prices that households expect to see. To simulate gasoline, natural gas, and electricity shocks, we construct the following model using energy price data drawn from the EIA over the years 2000-2014:

$$Price_{st} = Trend_t \beta_1 + Trend_t^2 \beta_2 + e_{st} \qquad (1)$$

where $Price_{st}$ is State-level monthly energy prices, and $Trend_t$ is the difference between the current year and 2000. Deviations from fitted values (i.e., the residuals, e_{st}) are the price shocks used in the main empirical model (3). These residuals capture deviations from the expected fuel price based on the information set available to the household at every point in time. For this analysis, each price shock represents one standard deviation above or below the expected price of the household.

After the price shocks are estimated, the EIA data containing the shocks are merged with the CPS-FSS using State and month variables. Therefore, each respondent in the household is assigned the price shocks that align with his or her State of residence and the year he or she participated in the survey. Because the analysis only considers the food-distress indicators that are reported in December, only December price shocks are included in the data after the merge.

A positive shock (price increase) will constrain the household's budget by decreasing available income. A negative shock, on the other hand, will increase the household's available income, freeing up cash for household expenses. Because the two effects are not symmetric, positive and negative shocks are included separately. Table 3 provides average prices in December for gasoline, natural gas, and electricity as well as the number of States that experience a positive and/or negative price shock one standard deviation from the expected price from each energy source during each year.

During 2000-2014, average prices among States remain fairly constant for natural gas and electricity, while the range over States is large (fig. 3). For example, in 2008, natural gas prices ranged from around \$6 in North Dakota to above \$14 in Florida, implying that State-level characteristics may affect heating fuel prices. Meanwhile, gasoline prices were volatile, although the range is relatively small, indicating that gasoline prices vary relatively little among States. For cold States, energy prices over the period did not vary much (see fig. 4) and followed trends similar to those across all States.

[3]The timing of the survey varies over the years. In 2015, the survey was administered December 13-22, which means the 30-day period was from mid-November through mid-December. This may mean the 30-day food-security variable may also reflect behavior associated with unexpected changes in energy prices in the month of November as well as December. This is a limitation to this study as only the December energy price shock is included in the analysis.

For this analysis, the empirical model is

$$Prob(FI_{ist}) = Shock_{st}(Positive)\beta_1 + Shock_{st}(Negative)\beta_2 + X_i\beta_3 + u_s + v_t + e_{st} \qquad (2)$$

where FI_{ist} is the outcome variable food insecure, food stress, or needing more money, $Shock_{st}$ represents positive and negative price shocks, and X_i includes household demographic variables, which include household number, gender, race, income dummies, and participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP). In the CPS-FSS, income is reported as a categorical variable; therefore, 16 dummy variables are included in the regression to capture category membership. Previous studies find that energy expenditure differs among demographics. Because of this, including these indicators is critical for this analysis (Drehobl and Ross, 2016). State- and year-fixed effects are also included, where u_s represents State-fixed effects and v_t represents year-fixed effects. A fixed-effects logit is used to estimate the probability of each food-distress indicator. Marginal effects are then computed from the estimates in the initial regression.[4] The marginal effects are reported in the Results section of this report.

Table 3

Average gasoline, natural gas, and electricity prices and price shocks in December, by year

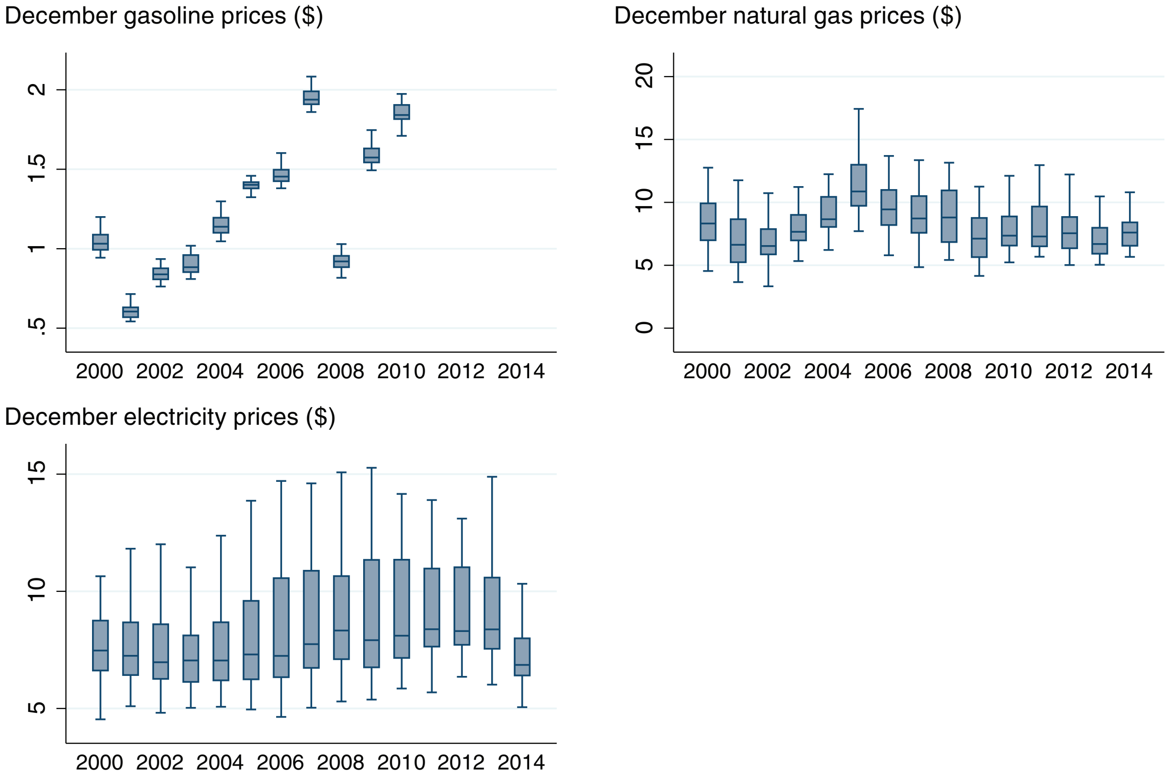
	Average gasoline price ($)	States with positive shock one standard deviation above average price (+)	States with positive shock one standard deviation below average price (-)	Average natural gas price ($)	States with positive shock one standard deviation above average price (+)	States with positive shock one standard deviation below average price (-)	Average electricity price ($)	States with positive shock one standard deviation above average price (+)	States with positive shock one standard deviation below average price (-)
2000	1.04	2	0	5.00	5	9	7.86	1	3
2001	0.61	0	2	6.12	6	12	7.38	10	14
2002	0.74	0	4	5.95	2	16	7.17	10	14
2003	0.9	3	0	6.95	6	2	7.17	8	19
2004	1.15	12	0	7.84	10	0	7.22	6	16
2005	1.40	10	0	9.77	41	0	7.71	13	13
2006	1.47	2	1	8.07	19	0	8.00	13	11
2007	1.95	48	0	7.51	12	4	8.23	15	8
2008	0.92	0	48	7.45	14	8	8.51	15	12
2009	1.59	4	0	6.00	4	37	8.46	12	17
2010	1.85	18	0	7.50	1	32	8.47	11	3
2011				8.12	2	17	9.14	8	2
2012				7.80	2	16	9.09	8	0
2013				7.35	1	16	9.19	8	1
2014				7.89	5	1	7.53	4	13

Note: Gasoline prices are missing from 2011 to 2014 because the data were unavailable at the time of this analysis.
Source: USDA, Economic Research Service using energy price information from the U.S. Energy Information Administration, 2000-2014.

[4]Marginal effects are calculated with STATA 11 using the margins command for each price shock variable.

Figure 3

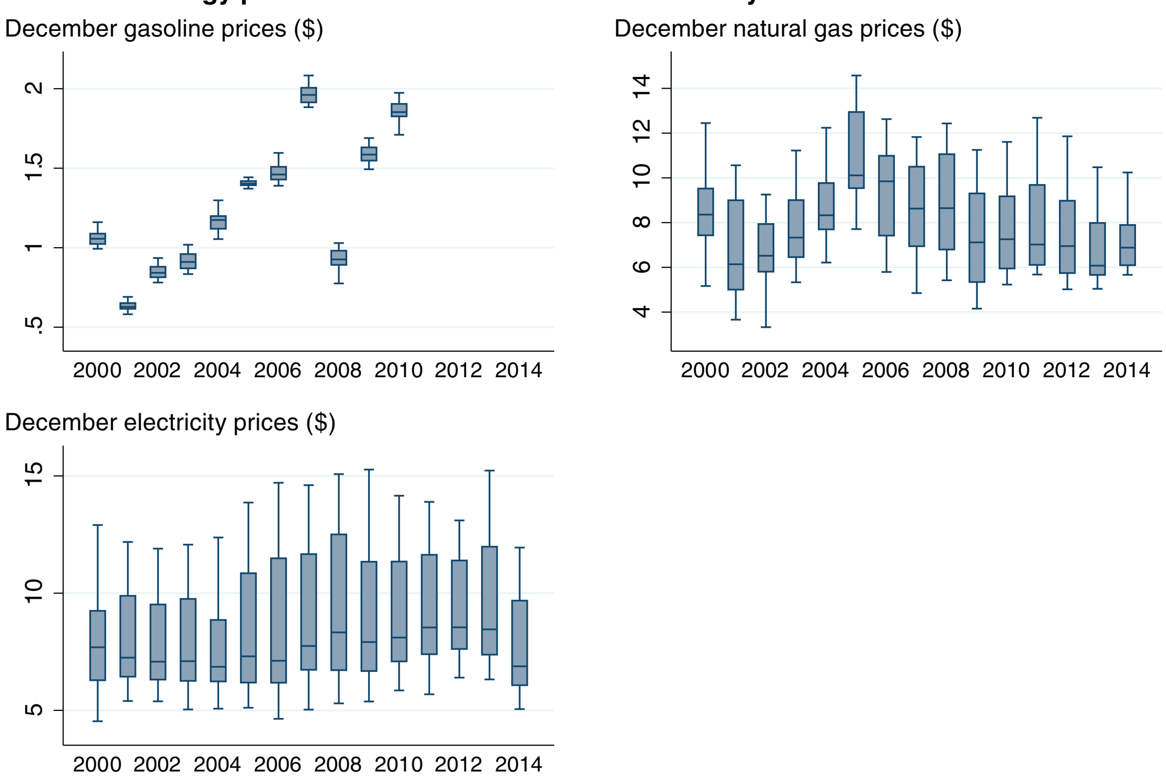
State-level energy prices in the month of December



Note: Excludes outside values. Each bar in each graph represents State-level prices for each year.
Each bar contains a median line for each year as well as outliers of each price.
Source: USDA, Economic Research Service using price data from the U.S. Energy Information Administration.

Figure 4

State-level energy prices in the month of December for only cold States



Note: Excludes outside values. Each bar in each graph represents State-level prices for each year.
Each bar contains a median line for each year as well as outliers of each price.
Source: USDA, Economic Research Service using price data from the U.S. Energy Information Administration.

To confirm that correlation does not affect the results, we provide a correlation matrix in table 4. Although the correlation matrix indicates limited correlation among prices and price shocks, we run each energy shock separately to ease interpretation. In fact, when each energy price shock is included in a single regression, the results are identical to the separate regressions.

All price shock regressions include shocks that occur in December and are analyzed for the total sample and low-income sample. For the low-income sample that resides in cold States, only electricity and natural gas price shock regressions are used. Gasoline price shocks will likely not affect the probability of any food-distress indicator differently in cold and noncold States. Although natural gas and electricity provide more than household heating (such as cooking fuel), a primary use of these fuels is to heat a house, something that occurs more in winter months such as December. Gasoline from the pump, however, is not used for heating homes; therefore, it is not used to analyze different responses in cold States.

Table 4

Correlation matrix of price shocks over the years 2000-2014

	Negative gasoline shock	Positive gasoline shock	Negative natural gas shock	Positive natural gas shock	Negative electricity shock	Positive electricity shock
Negative gasoline shock	1					
Positive gasoline shock	-0.0767	1				
Negative natural gas shock	0.1101	-0.0447	1			
Positive natural gas shock	-0.0547	-0.0629	-0.1919	1		
Negative electricity shock	0.0241	-0.0506	0.0742	-0.0403	1	
Positive electricity shock	0.1129	0.0508	-0.1317	0.1174	-0.165	1

Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Results

Because energy demand is inelastic, it is likely that the probability that a household experiences some level of food distress will increase in response to positive energy price shocks and decrease in response to negative energy price shocks. Theoretically, the effect will be largest for low-income families because they lack the savings, assets, and income to protect themselves from price shocks.

Tables 5 through 7 show the results of the separate regressions for the total sample. An unexpected jump in gasoline prices only significantly affects needing more money to buy food (table 5). Recall the price shock variable equals one if the change in the energy price shock is one standard deviation or more from the mean. The results indicate that an unexpected increase of that magnitude raises the probability of needing more money by 3.1 percentage points, from 12.6 percent to 15.7 percent. Negative gasoline price shocks have no significant effect on the probability of any food-distress indicator in the total sample.

A positive natural gas price shock one standard deviation from the expected mean increases the probability of food insecurity by 0.8 percentage points, from 5.4 percent to 6.2 percent (table 6). The same shock increases the probability of food stress by 1.2 percentage points, from 23.1 percent to 24.3 percent, and needing more money by 1.0 percentage point, from 12.6 percent to 13.6 percent. Meanwhile, a negative shock to natural gas prices decreases the probability of each food-distress indicator: 0.3 percentage points for food insecurity, 1.2 percentage points for food stress, and 1.0 percentage points for needing more money.

Lastly, a positive shock to electricity prices results in a significant increase in the probability of food stress and needing more money indicators, but the magnitudes of each marginal effect are small (table 7). The probability increases for food stress by 0.5 percentage points, from 23.1 percent to 23.6 percent; and for needing more money by 1.3 percentage points, from 12.6 percent to 13.9 percent. The average negative shock to electricity prices decreases the probability of food stress by 0.9 percentage points.

Next, responses to energy price shocks in the low-income sample are analyzed. Households in the sample report income below 185 percent of the FPL. To provide further insight on their responses, we analyze a comparison group of households that report income above 185 percent of the FPL. While these households are relatively wealthier than the low-income sample, many households above the FPL still face financial struggles. In fact, as of 2014, a family of four with an income of 200 percent of the FPL has a monthly income of just under $4,000, or around $48,000 per year. We expect that the responses in the low-income sample will be larger than those in the higher income sample, given that low-income households tend to allocate a greater proportion of their income toward energy.

Positive shocks to gasoline prices significantly increase the probability of needing more money in the low-income sample but have no significant effect in the higher income sample (table 8). A positive gasoline shock results in a 7.3-percentage-point increase in needing more money, from 24.3 percent to 31.6 percent. Negative gasoline price shocks have no significant effect on the probability of any indicator in either the low-income sample or the higher income sample.

Table 5

Total sample: gasoline prices

Variables	Food insecure mean (0.051)	Food stress mean (0.231)	More money mean (0.126)
Gasoline shocks (+)	-0.015 -0.014	0.019 -0.018	0.031** -0.014
Gasoline shocks (-)	-0.003 -0.005	-0.009 -0.009	0.003 -0.006
Observations	411,280	477,507	475,727
Pseudo R-squared	0.1503	0.1193	0.119

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects.
Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Table 6

Total sample: natural gas prices

Variables	Food insecure mean (0.051)	Food stress mean (0.231)	More money mean (0.126)
Natural gas shocks (+)	0.006*** -0.002	0.012*** -0.003	0.010*** -0.002
Natural gas shocks (-)	-0.005*** -0.001	-0.012*** -0.002	-0.010*** -0.001
Observations	411,280	477,507	475,727
Pseudo R-squared	0.1508	0.1175	0.1185

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects.
Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Table 7

Total sample: electricity prices

Variables	Food insecure mean (0.051)	Food stress mean (0.231)	More money mean (0.126)
Electricity shocks (+)	0.002* -0.001	0.005*** -0.002	0.013*** -0.002
Electricity shocks (-)	-0.003** -0.001	-0.009*** -0.002	0 -0.003
Observations	411,280	477,507	475,727
Pseudo R-squared	0.1507	0.1186	0.1186

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects.
Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Table 8
Low-income versus non-low-income sample: gasoline prices

	Low-income households (Income <185% FPL)			Non-low-income households (Income >185% FPL)		
Variables	Food insecure mean (0.093)	Food stress mean (0.407)	More money mean (0.243)	Food insecure mean (0.015)	Food stress mean (0.145)	More money mean (0.068)
Gasoline shocks (+)	-0.008	0.046	0.073**	-0.019	-0.01	-0.002
	-0.033	-0.055	-0.0032	-0.011		
Gasoline shocks (-)	-0.009	-0.005	0.007	0	-0.013	-0.003
	-0.014	-0.078	-0.015	0		
Observations	137,754	159,944	159,199	248,810	292,847	291,879
Pseudo R-squared	0.0483	0.0351	0.0419	0.1092	0.0699	0.0684

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects.
Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Positive shocks to natural gas prices cause significant increases in the probability of each food-distress indicator in the low-income sample but only one significant response in the higher income sample (table 9). For low-income households, a positive shock increases the likelihood of food insecurity by 2.3 percentage points, food stress by 2.2 percentage points, and needing more money by 1.4 percentage points. The same shock to natural gas prices causes a much smaller response in higher income households: a 0.6-percentage-point increase in the probability of food stress. Negative shocks to natural gas prices significantly affect the probability of each food-distress indicator in the low-income sample as well as in the higher income sample. However, for each indicator, the low-income coefficient is more than double the magnitude of the higher income coefficient. In low-income households, a negative shock to natural gas prices decreases the likelihood of food insecurity by 0.6 percentage points, food stress by 1.7 percentage points, and needing more money by 1.3 percentage points. Meanwhile, in higher income households, the same shock decreases the probability of food stress by 0.8 percentage points and needing more money by 0.4 percentage points.

Electricity price shocks also have statistically significant effects on both subgroups (table 10). A positive shock increases the likelihood of needing more money by 1.9 percentage points. The same shock increases the probability of food stress in higher income households by 0.6 percentage points and needing more money by 0.7 percentage points, nearly half the magnitude of the low-income sample. Negative shocks to electricity prices also have statistically significant effects on the probability of each indicator in the low-income sample; these shocks decrease the probability of food insecurity by 0.7 percentage points, food stress by 1.3 percentage points, and needing more money by 0.8 percentage points. This price shock also has a statistically significant effect in the higher income subgroup but only decreases the probability of food stress by 0.6 percent.

Table 9

Low-income versus non-low-income sample: natural gas prices

Variables	Low-income households (Income <185% FPL)			Non-low-income households (Income >185% FPL)		
	Food insecure mean (0.093)	Food stress mean (0.407)	More money mean (0.243)	Food insecure mean (0.015)	Food stress mean (0.145)	More Money mean (0.068)
Natural gas	0.017***	0.022***	0.014***	0	0.006*	0.001
shocks (+)	-0.005	-0.006	-0.005	-0.001	-0.003	-0.015
Natural gas	-0.011***	-0.017***	-0.013***	-0.001*	-0.008***	-0.004*
shocks (-)	-0.003	-0.004	-0.004	-0.001	-0.003	-0.002
Observations	137,754	159,944	159,199	248,810	292,847	291,879
Pseudo R-squared	0.0485	0.0353	0.042	0.1092	0.0699	0.0684

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects.
Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Table 10

Low-income versus non-low-income sample: electricity prices

Variables	Low-income households (income <185% FPL)			Non-low-income households (income >185% FPL)		
	Food insecure mean (0.093)	Food stress mean (0.407)	More money mean (0.243)	Food insecure mean (0.015)	Food stress mean (0.145)	More money mean (0.068)
Electricity	0.009***	0.001	0.019***	-0.001	0.006**	0.007**
shocks (+)	-0.003	-0.006	-0.007	-0.001	-0.003	-0.003
Electricity	-0.008***	-0.013***	-0.008***	0	-0.006**	0.004
shocks (-)	-0.003	-0.004	-0.004	-0.001	-0.004	-0.002
Observations	137,754	159,944	159,199	248,810	292,847	291,879
Pseudo R-squared	0.0343	0.0438	0.0468	0.1092	0.0699	0.0686

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects.
Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Lastly, we compared the effects of shocks to heating fuel, natural gas, and electricity prices for low-income households that reside in the coldest 26 States versus those for low-income households that reside in the Southern United States (tables 11 and 12). For both subgroups, positive shocks to natural gas prices do not significantly affect the probability of any food-distress indicator. However, negative shocks to natural gas prices do significantly affect the probability of food stress and needing more money: a 2.6-percentage-point drop for food stress and a 1.8-percentage-point drop for needing more money.

A positive shock to electricity prices increases the likelihood of needing more money by 2.4 percentage points, from 22.5 percent to 24.9 percent (table 12). Negative shocks to electricity prices decrease the probability of food insecurity by 1.6 percentage points and the probability of food stress by 1.9 percentage points. Once again, in the warmer State sample, no significant effects were found.

Table 11

Low-income households in cold States versus low-income households in warm States sample: natural gas prices

	Low-income households in cold States (income <185% FPL)			Low-income households in warm States (income >185% FPL)		
Variables	Food insecure mean (0.089)	Food stress mean (0.387)	More money mean (0.225)	Food insecure mean (0.094)	Food stress mean (0.429)	More money mean -0.259
Natural gas	0.008	0.007	0.005	-0.003	0.023	0.007
shocks (+)	-0.007	-0.009	-0.007	-0.011	-0.022	-0.017
Natural gas	-0.009*	-0.026***	-0.018***	-0.008	-0.01	-0.001
shocks (-)	-0.004	-0.006	-0.005	-0.006	-0.01	-0.017
Observations	63,142	73,722	73,347	57,890	54,890	54,615
Pseudo R-squared	0.0485	0.0379	0.045	0.0531	0.0318	0.0349

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects. Cold States represent the 26 States with the coldest average December temperatures over the years 2000 through 2014.
Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Table 12

Low-income households in cold States versus low-income households in warm States sample: electricity prices

	Low-income households in cold States (income <185% FPL)			Low-income households in warm States (income >185% FPL)		
Variables	Food insecure mean (0.089)	Food stress mean (0.387)	More money mean (0.225)	Food insecure mean (0.094)	Food stress mean (0.429)	More money mean -0.259
Electricity shocks (+)	0.010**	0.007	0.024***	0.008	-0.001	0.005
	-0.005	-0.013	-0.006	-0.007	-0.008	-0.007
Electricity shocks (-)	-0.008*	-0.019***	-0.004	-0.004	0.021	0
	-0.004	-0.007	-0.006	-0.006	-0.011	-0.007
Observations	63,142	73,722	73,347	46,769	54,890	54,615
Pseudo R-squared	0.0486	0.0379	0.045	0.0531	0.0381	0.0349

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Variables included in the regressions are race dummies, marital status, age, employed, female, number in household, number of children, State, and year fixed effects. Cold States represent the 26 States with the coldest average December temperatures over the years 2000 through 2014.

Source: USDA, Economic Research Service using data from the Current Population Survey Food Security Supplement and the U.S. Energy Information Administration.

Discussion

Energy price shocks occurred throughout the period 2000-2014. For this analysis, positive and negative price shocks that are one standard deviation from the expected price are considered. Both positive and negative energy price shocks affect the probability of each measure of food distress, although the significant results are quite small, suggesting that price shocks have only small effects on household food security and other food-access measures. Nevertheless, low-income households demonstrate larger responses to price shocks than higher income households, which suggests that an unexpected increase in utility costs may present particular challenges for households with tight budgets. Although findings reveal significant responses to price shocks, the responses are small, indicating that the probabilities of food insecurity and the other indicators do not increase substantially, at least following shocks related to gasoline and heating fuel prices. This may stem from two factors:

1. Shocks to natural gas and electricity prices are not salient to consumers. In other words, an unexpected change in energy prices may not present itself to the consumer immediately (bill schedules may differ in the timeline of costs they reflect). Households may not experience the consequences of unexpectedly high utility costs until after they occur, a time period not captured by the data. Additionally, a recent study finds that households may be more responsive to average or expected prices than to unexpected prices (Ito, 2014). However, the same study may not account for low-income households whose budgets are stretched.

2. Previous research finds that a drop in food expenditure does not necessarily translate to lower food consumption (Aguiar and Hurst, 2005; Gicheva et al., 2010). In fact, Gicheva et al. (2010) observe that households may instead alter their typical mix of food purchases by buying less expensive or sale items. These observations may inform the results of the current analysis. This may be reflected in the results in the low-income subgroup, where each positive shock increased the probability of food stress by 2 to 5 percentage points. This variable captures the household's assessment of the quality of food it can access. These results suggest that low-income households may have to limit the quality of food they access to service their energy bills.

Policy Implications

When energy prices rise unexpectedly, low-income households may face difficult budget decisions. For example, if home heating costs suddenly rise, a low-income household may attempt to cover the cost increase by shifting money from other household expenditures, including those allotted to food. Previous studies find that household food expenditure decisions are particularly sensitive to changes in household energy expenditure. This ERS study goes a step further by examining the effects of energy prices on household food security. Findings suggest that energy price shocks have small but statistically significant effects on food security and other measures of food distress. This may indicate that households are already prepared to cope when disposable income is unexpectedly affected by a price shock, perhaps by smoothing income, altering consumption patterns, or participating in welfare assistance programs.

The study finds that more vulnerable households—those with low incomes—are more responsive to energy price shocks than higher income households. For example, positive shocks to gas prices affect the probability of needing more money in the low-income sample analyzed but have no effect in the higher income sample. While the results are relatively small, they imply that households that face greater financial constraints may face greater hardship when disposable income drops unexpectedly. This implies that households are reallocating money between energy and food expenditure and may be unable to smooth consumption to not disrupt either expenditure.

The significant responses to price shocks are small, ranging from around 1.0 percentage points to 7.3 percentage points, a clear outlier. The small response may suggest that current social welfare programs designed to help households cushion themselves from income shocks are effective in the case of shocks to energy prices. USDA's Supplemental Nutrition Assistance Program (SNAP) and the U.S. Department of Health and Human Services' Low Income Home Energy Assistance Program (LIHEAP) are two such Federal programs designed to mitigate the consequences of financial difficulties for low-income households. SNAP is a Federal entitlement program, which means households that qualify for the program are able to participate and access financial help. LIHEAP is a block grant program. Each State is allocated a certain level of funding each year to provide to low-income households to assist them with energy bills for heating and cooling, with the funds often paid directly to households' utility companies. Once the block of funding for a State is depleted each year, no other households can access the funds, even if they qualify. While this may suggest that LIHEAP is limited in its ability to reach the total number of people who qualify for, and need, the financial assistance provided by the program, the results provided earlier indicate that household responses to energy price shocks are small.

The Agricultural Act of 2014 redefined the provision that relates LIHEAP participation to SNAP benefit level. Originally, 16 States provided nominal LIHEAP benefits, as low as $1, that trigger the maximum Standard Utility Allowance (SUA) deduction under SNAP, which, in turn, increases the amount of SNAP benefits that a household could receive. The 2014 legislation requires States to issue LIHEAP benefits greater than $20 annually to trigger the maximum SUA deduction, which means households that receive lower amounts of heating assistance will not automatically receive a bump in their SNAP benefits. Though accommodating energy costs is not a primary purpose of SNAP and a number of States have bypassed the new provision by increasing their LIHEAP benefits to a minimum of $20 annually, the results of this research may inform any future considerations of changes in heat and eat policies and their effects on food consumption.

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