How Increased Food and Energy Prices Affect Consumer Welfare

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Washington, DC 20036-5831

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29, 2009

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The Issue:

The dramatic increase of world oil prices and the global food crisis were two prominent news headlines in the first half of 2008. The average price of a barrel of oil produced by the Organization of the Petroleum Exporting Countries doubled from 2001 to 2005, passing $100 for the first time in mid-February 2008. Further, the real price of oil skyrocketed to surpass the old-time high of 1981 during the Iraq-Iran War. It was not until late 2008 that a global economic slump, with a weak demand for oil, caused oil prices to slide from a peak of $147 per barrel in July to about $40 at the end of 2008.

The high oil prices hit hard at every stage of food production, from fertilizers to tractors to transport. In addition, a complex combination of events threw the world food supply and demand out of balance in mid-2008, resulting in the world's worst food crisis since the 1970s. These events included poor harvests, competition with biofuels—diverting corn and other crops for ethanol in the United States and the European Union, surging demand for food in emerging countries, especially China and India, and a blockage in global food trade.

U.S. consumers are not immune to the effects of high global food and energy prices—two basic living expenditures competing for consumers' budgets. High food and energy prices inevitably erode the American household's purchasing power, especially low-income households. In particular, high costs of food and energy may curtail household spending for other essential goods and services, such as health care. Thus, it is important to investigate consumer demand for food and energy and evaluate the consumer welfare effects of increased food and energy prices.

The Methodology:

To analyze the consumer welfare effects of price changes in food and energy, we develop a measure of Hicksian compensating variation as a function of all commodity prices and compensated price elasticities. The unique feature of this approach is that all direct- and cross-commodity effects of a demand system are incorporated into the welfare measurement.

Let an expenditure function be $E(p, u)$, defined as the minimum amount of expenditure necessary to get to a given level of utility u and a vector of prices p. Suppose that at some initial price level p^0 and expenditure level $E(p^0, u^0)$, the consumer achieves utility u^0. The compensating variation (CV) to reflect the change of expenditures necessary to compensate consumers for the effects of price changes moving to price level p^1 is given by

(1) $$CV = E(p^1, u^0) - E(p^0, u^0)$$

A positive CV implies a requirement of more spending to achieve the same utility level as before the price changes, and thus there is a decrease in consumer welfare. By contrast, a negative CV implies a drop in spending, and thus a gain in consumer welfare.

Let $q^h(p^1, u^0)$ be a vector of Hicksian compensated demand at given price vector p^1 and at the same initial utility level u^0. The CV can be expressed as the following inner products of price and quantity vectors:

(2) $$CV = p^1 \bullet q^h(p^1, u^0) - p^0 \bullet q^0$$

By further defining $dp = p^1 - p^0$ as a vector of price changes, and $dq^h = q^h(p^1, u^0) - q^0$ as a vector of compensated quantity changes, the above CV equation is transformed into

(3) $$CV = (p^0 q^0) \bullet (dp/p^0 + dq^h/q^0 + dp/p^0 \bullet dq^h/q^0)$$

We approximate the change in compensated demand, $dq^h = q^h(p^1, u^0) - q^0$, by applying the first-order differential form as

(4) $dq_i^h / q_i = \sum_j e_{ij}^* (dp_j / p_j)$

where $e_{ij}^* = (\partial q_i^h / \partial p_j)(p_j / q_i)$ is a compensated price elasticity, and dq_i^h is a change of Hicksian demand for the *i*th good. Given the initial prices p^0, quantities demanded q^0, various scenarios assigned for the price vectors of p^1, and q^h derived from the estimated demand system, we can measure Hicksian compensating variation.

The Estimated Price and Expenditure Elasticities

To estimate a U.S. complete demand system, we first compile consumption expenditure data covering 1960 to 2006 from *U.S. Personal Consumption Expenditures* by the Bureau of Economic Analysis, U.S. Department of Commerce. This data set consists of about 80 individual expenditure items categorized in three general groups: durable goods, nondurable goods, and services. In the data series, quantities and prices for each expenditure item are presented in the form of indexes with year 2000 as the base year, while the data of expenditures are measured in billion dollars.

Using this set of data, we then estimate a U.S. complete demand system of 11 expenditure categories, with food and energy as separate categories, while the parametric constraints of homogeneity, symmetry, and Engel aggregation are incorporated into the estimation. Table 1 presents the estimated results in food and energy categories, which are our primary concern. In the table, each entry shows the demand elasticities of the categories in the left column with respect to their prices and per capita expenditures at the top of the table.

Among the estimates, we find that the price elasticity of energy, -0.084, is inelastic, suggesting that on average a 10-percent increase in the price of energy would decrease the quantity demanded by 0.84 percent. With a low price sensitivity of demand and little scope to raise supply in the short run, a small increase in the demand for energy or a decrease in the quantity available in the market can lead to a very large increase in the price of energy; this well explains the soaring energy price in response to an increase in the demand for energy.

The own-price elasticities for food consumed both at home and away from home are also inelastic, at -0.5177 and -0.4033, respectively. These estimates suggest that, on average, a 10-percent increase in the price of food consumed at home and away from home would decrease the quantities demanded respectively by 5.18 and 4.03 percent. The demand for food, similar to that for energy, is not sensitive to price changes; it takes a large price increase to bring demand into line with supply, which is quite fixed in the short run. For food consumed away from home, its own-price elasticity is also less elastic.

Table 1 also includes the estimated expenditure elasticities, shown in the last column of the table. These estimates reflect the responsiveness of quantity demanded in each category to a change in per capita total expenditures. The estimated expenditure elasticity for energy is 0.8379, suggesting that a 10-percent increase in per capita expenditures would increase energy demanded by 0.84 percent. The estimated expenditure elasticities for food consumed at home and away from home are 0.6558 and 1.0598, respectively.

The Consumer Welfare Effects of Increased Prices

Based on the estimated demand elasticities, we further apply the Slutsky equation to calculate compensated demand elasticities for use in measuring the Hicksian compensating variation under various scenarios of price changes. Since food and energy prices have become increasingly intertwined, we estimate the loss of consumer welfare caused by the simultaneous increase of their prices.

In table 2, we present a total of 36 scenarios for combined changes in the prices of food consumed at home and energy, ranging from 0 to 25 percent at 5-percent intervals. For example, a 10-percent increase in the prices of both food and energy would increase per capita total compensated expenditures or incur a consumer welfare loss of $405. Similarly, a 20-percent increase in the prices of both food and energy would increase per capita total compensated expenditures by $795. In the case of increases in energy price by 10 percent and food price by 5 percent, the table shows that per capita total compensated expenditures would increase by $284.

The surging and volatile food and energy prices would take away the purchasing power of consumers and hit hardest on the poor, who can afford it least. Thus, it is important to estimate how much of a welfare loss low-income households suffer when the cost of food and energy goes up. We first assume that our estimated demand system is applicable to different income groups for providing an approximate estimation. We then look at Bureau of Labor Statistics data for average household incomes in 2004-2006. In the lowest 20-percent income quintile, households with 1.7 family members, the average income before taxes is $5,662 per person. In the second lowest 20-percent income quintile, households with 2.2 family members, the average income before taxes is $14,764 per person.

Based on the loss of consumer welfare under various scenarios of price changes in food and energy, we calculate the “burden indexes” (defined here as the ratios of consumer welfare loss to income per person) of the two lowest 20-percent income quintile households, and the results are shown in the lower part of table 2. In the lowest 20-percent income quintile, for example, the diagonal entries show that the burden indexes would increase from 3.61 percent to 17.4 percent because of increases in both the food and energy prices from 5 to 25 percent. In the second lowest 20 percent income quintile, however, the same increases of both food and energy prices would increase the burden indexes from 1.38 percent to 6.67 percent, substantially smaller than those of the lowest income quintile households.

Conclusion

In this study, we find that the demands for both food and for energy are relatively inelastic to price changes in the short run, and that it would take a large increase in their prices to offset even a small increase in the demands for food and for energy or a small decrease in their available quantities in the market. These estimated results well explain the recent soaring prices in food and energy.

We also develop the Hicksian compensating variation as a function of all commodity prices and compensated price elasticities to quantify the changes in consumer welfare caused by price variations in food and energy. The unique feature of this approach is that all direct- and cross-commodity effects of a demand system are incorporated into the welfare measurement. The calculated welfare effects indicate that an increase of food and energy prices would substantially increase compensated expenditures or incur a consumer welfare loss, a heavy burden for low-income households.

Table 1--Demand elasticities related to food and energy, 1960-2006

Quantity	Price			Expenditure
	Food at home	Food away from home	Energy	
		-- Percent --		
Food at home	**-0.5177**	-0.0175	0.0605	0.6558
	(0.1007)	(0.0682)	(0.0301)	(0.1304)
Food away from home	-0.0624	**-0.4033**	0.1403	1.0598
	(0.1125)	(0.2232)	(0.0450)	(0.1565)
Energy	0.0922	0.1649	**-0.0840**	0.8379
	(0.0551)	(0.0492)	(0.0316)	(0.1313)
Expenditure share	0.0841	0.0518	0.0261	

Note: For each pair of estimates, the upper figure is the estimated elasticity, and the lower figure in parenthesis is the estimated standard error.

Table 2--Consumer welfare effects of increased the prices of food and energy

		Increased the price of energy by					
		0%	5%	10%	15%	20%	25%
Compensating variation (CV)					-- Dollars --		
	0%	**0**	79.19	158.03	236.52	314.66	392.44
Increased	5%	123.80	**204.19**	284.24	363.93	443.26	522.25
the price of	10%	241.98	323.58	**404.82**	485.71	566.25	464.44
food by	15%	354.55	437.35	519.80	**601.89**	683.63	765.01
	20%	461.51	545.51	629.15	712.44	**795.38**	877.97
	25%	562.85	648.05	732.89	817.39	901.53	**985.32**
Burden index for the lowest 20% income quintile households					-- Percent --		
	0%	**0.00**	1.40	2.79	4.18	5.56	6.93
Increased	5%	2.19	**3.61**	5.02	6.43	7.83	9.22
the price of	10%	4.27	5.71	**7.15**	8.58	10.00	8.20
	20%	8.15	9.63	11.11	12.58	**14.05**	15.51
	25%	9.94	11.45	12.94	14.44	15.92	**17.40**
Burden index for the second lowest 20% income quintile househ					-- Percent --		
	0%	**0.00**	0.54	1.07	1.60	2.13	2.66
Increased	5%	0.84	**1.38**	1.93	2.46	3.00	3.54
the price of	10%	1.64	2.19	**2.74**	3.29	3.84	3.15
food by	15%	2.40	2.96	3.52	**4.08**	4.63	5.18
	20%	3.13	3.69	4.26	4.83	**5.39**	5.95
	25%	3.81	4.39	4.96	5.54	6.11	**6.67**

Notes: The consumer welfare effects are calculated based on a Hicksian compensating variation equation.
Per capita incomes for the lowest and the second lowest quintiles are $5,662 and $14,764, respectively.
The burden index is calculated as the ratio of consumer welfare loss to income per person.