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The Demand for Disaggregated Food-Away-From-Home and Food-at-Home Products in the United States

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Julian M. Alston

Abstract

Food away from home (FAFH) comprises nearly half of all U.S. consumer food expenditures. Hence, policies designed to influence nutritional outcomes would be incomplete if they did not address the role of FAFH. However, because of data limitations, most studies of the response of food demand to policy changes have ignored the role of FAFH, and those studies that have included FAFH have treated it as a single good. We, therefore, estimate demand for 43 disaggregated FAFH and food-at-home (FAH) products, using a 2-stage budgeting framework. We find that the demands for disaggregated FAFH products differ in price responsiveness and tend to be more sensitive to changes in food spending patterns than FAH products. Many foods are found to have statistically significant substitution and complementary relationships within and among food groups. Predicted changes in quantities based on our estimates that include all goods and services and those estimates that include only a subset of foods differ substantially, implying that evaluations of health and nutrition policy based on elasticities of demand for only a subset of goods may be misleading.

Keywords: Food demand, food away from home (FAFH), demand systems, elasticities.

Acknowledgments

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Summary

What Is the Issue?

Food away from home (FAFH, including limited-service and full-service restaurants) constitutes a large and growing portion of the food budget: in 2009, the annual average household expenditure on FAFH was $2,619, or approximately 41 percent of the food budget for an average U.S. household, compared with $1,320, or approximately 29 percent of the food budget in 1984. Because FAFH comprises a sizable share of total food expenditures and nutritional intake for an average American, disregarding the relationships between FAFH and any other subset of foods may produce misleading results for formulating nutrition and health policy. Many studies have excluded or inadequately represented FAFH, such that the estimates only partially capture the effects of policy-induced food price changes on consumer demand and nutrition.

Those analyses that included all goods and services treated FAFH as a composite good, but disaggregated products in FAFH might differ from one another in terms of responsiveness to price- and income-led expenditure changes, nutritional characteristics, or both. Little is known about how demands for different types of FAFH respond to price changes, but a handful of studies have found that demand responds to changes in income differently for full-service food than it does for limited-service food.

What Did the Study Find?

Statistically significant cross-price relationships exist between and within groups of foods. Evidence suggests that demands for FAFH products differ from demands for food-at-home (FAH) products. Further, FAFH products differ among one another in their nutritional characteristics, quality, and responsiveness to changes in prices and expenditure. Specific findings related to cross-price relationships and consumer demand for FAFH include:

- The demands for disaggregated FAFH products tend to be more sensitive to income-induced changes in total expenditures than are FAH products. This finding may explain why the budget share for FAFH products dipped during the recent recession, while the budget shares for many FAH products increased. During December 2007-June 2009, monthly total expenditures fell 0.51 percent for the average American. In addition, the prices of most FAH products, which are mostly gross substitutes for FAFH products, fell relative to the prices of the FAFH products. Hence, income-induced changes in total expenditures and the relative affordability of FAH versus FAFH products caused demand for FAFH to fall.
- The demand for full-service FAFH responds much more readily to price changes than does the demand for limited-service FAFH and other FAFH (including vending machines, mobile food vendors, and school and employee sites).

- Compared with the demands for foods commonly deemed "unhealthy" (e.g., cheese, white bread, cakes and cookies, frozen foods), the demands for many products commonly deemed "healthy" (fruits and vegetables, nonwhite bread, fish, and seafood) tend to be much less responsive to price changes. For example, the demand for nonwhite bread is much less price-elastic than the demand for white bread, and the demand for cookies and cakes is one of the most price-elastic.
- Many of these "healthy" and "unhealthy" foods show statistically significant substitution and complementary relationships within and among food groups—a finding that complicates any analysis trying to predict the effects of policy-induced price changes on food demands and nutritional outcomes.
- Using forecasts of price and total expenditure changes between 2011 and 2012 to predict food consumption changes over the same span, we found that predictions based on estimates of (conditional) demand elasticities that ignore the total effects of substitutions and complementarities differ substantially—sometimes even taking opposite signs—from predictions based on estimates of (unconditional) demand elasticities that include all goods and services. For example, consumption of each disaggregated dairy product was predicted to *increase* approximately 0.5-1 percent in 2012 when using unconditional demand elasticities, but to *decrease* a similar amount according to conditional elasticities. Similar contradictions in forecast changes in consumption between the two sets of demand elasticities are found for pork, poultry, eggs, sugar and sweets, and frozen foods.
- The substantial cross-price relationships between products in different groups suggest that nutrition policy analysis based on demand elasticities for small groups of products is likely to be misleading.

How Was the Study Conducted?

Using the 1998–2010 Consumer Expenditure Survey diary section, we constructed a monthly time series of household expenditures by aggregating detailed weekly expenditure data into 43 products (i.e., 3 FAFH products, 38 FAH products, alcoholic beverages, and a nonfood composite), and then averaged these data over households for a given month. We then matched the average monthly expenditures to monthly consumer price indices.

We estimated demand for the 43 products using 2-stage budgeting, where the representative consumer allocates expenditures for market goods and services to groups of goods in the first stage, and then chooses products within each group of goods in the second stage. First, we estimated demand for eight food groups (cereals and bakery products, dairy, meat and eggs, fruits and vegetables, nonalcoholic beverages, other FAH, and FAFH/alcoholic beverages), and a nonfood composite good. Second, we modeled the second-stage allocation of expenditures on the eight food groups as weakly separable groups—a structure that allowed us to estimate demand for goods in a given group without considering demand for goods in other groups.

Using demand elasticity estimates from the first- and second-stage allocations, we approximated “unconditional” demand elasticities, which consider the total expenditure for all goods and services. We then computed the changes in food quantities implied by forecasted changes in prices and personal consumption expenditures between 2011 and 2012. The computation used the two sets of demand elasticities and compared the simulated changes to show the influence of intergroup substitution on measures of changes in total nutritional intake.

Introduction

Food away from home (FAFH) is a sizable component of total food consumption and the nutritional intake of U.S. adults and children. FAFH also, therefore, constitutes a large and growing portion of the food budget: in 2009, the annual average household expenditure on FAFH was $2,619, or approximately 41 percent of the food budget for an average U.S. household, compared with $1,320, or approximately 29 percent of the food budget in 1984 (U.S. Department of Labor, Bureau of Labor Statistics, 2010a).

Recent findings suggest that FAFH may contribute significantly to obesity and poor dietary quality in the United States. Several studies have found that the nutritional content of FAFH is poor compared with food consumed at home (FAH) (Lin, Guthrie, and Frazao, 1999; Jeffrey et al., 2006; Todd, Mancino, and Lin, 2010). In addition, some types of FAFH (e.g., limited-service FAFH, vending machines, and lunch trucks) may be nutritionally worse than others.[1] Consumer proximity to limited-service restaurants—especially proximity to dense concentrations of limited-service restaurants—has been found to contribute to obesity (Chou, Grossman, and Saffer, 2004; Davis and Carpenter, 2009; Currie et al., 2010). Conversely, Binkley (2008) found that—although food from limited-service restaurants tended to be more energy-dense and nutritionally inferior to food from full-service restaurants—meals from limited-service restaurants tended to be smaller. On the whole, the evidence suggests that consuming FAFH may have dramatic effects on dietary quality and body weight and that different types of FAFH may affect dietary quality and individual body weight differently.

[1] Throughout this study, the different types of FAFH are defined by establishment type. Full-service FAFH are establishments that provide food services to patrons who order and are served while seated (i.e., waiter/waitress service) and pay after eating. Limited-service FAFH are establishments primarily engaged in providing food services (except snack and nonalcoholic beverage bars) where patrons generally order or select items and pay before eating.

Given the potential significance of FAFH for dietary quality and nutrition, policies designed to influence nutritional outcomes should address the role of FAFH. However, because most studies of the response of food demand to policy changes have disregarded the role of FAFH, the estimates from these studies incompletely reflect changes in food consumption and nutrition resulting from the policy changes. Those studies that included FAFH treated it as a single good, but evidence suggests that FAFH products are heterogeneous in their nutritional characteristics and quality and in how they respond to changes in prices and expenditures.

Some studies have analyzed the relationships between the demands for disaggregated FAFH products and total expenditure or income (i.e., Engel curve analysis), but little is known about the effects of either prices or total expenditure on the demand for disaggregated FAFH products. Only a handful of studies have estimated the effect of price and total expenditure on demand for FAFH as a composite group; to our knowledge, estimates of the effects of prices and total expenditure on demand for disaggregated FAFH have not been published before now. In addition, demand studies that included FAFH as a composite also included fairly aggregated groups of FAH products, whereas some economists have argued that more disaggregated products in terms of "healthy" and "unhealthy" foods would be more useful for policy analysis (Andreyeva, Long, and Brownell, 2009).

In this study, we estimate the demand for disaggregated FAFH and FAH products— including 38 FAH products, 3 FAFH products, alcoholic beverages, and nonfood—as elements of an unconditional system of demand equations in a two-stage budgeting process. We find statistically significant cross-price relationships, between and within groups of foods, using the first- and second-stage estimates—a finding that underscores the potential usefulness of considering all foods, not just a subset of foods, in evaluating policies targeting nutrition and health outcomes. Using estimates of demand elasticities from the first and second stages, we approximate unconditional elasticities of demand. In particular, we find that demand for full-service FAFH differs from its first-stage aggregate: FAFH and alcoholic beverages. Also, demands within the group comprising FAFH and alcoholic beverages differ from each other. Likewise, compared with demand for "healthy" foods, demand for foods commonly deemed "unhealthy" respond differently to own-price changes. Using the unconditional and conditional sets of demand elasticities, we compute predicted changes in consumption of foods implied by forecasts of price changes between 2011 in 2012, compare the results, and discuss the policy implications of basing analysis on estimates derived from conditional versus unconditional demand systems.

Previous Research on Modeling Demand for Food Away From Home

In a recent review of the economic literature on the demand for food, Okrent and Alston (2011) found that—in the handful of studies that have estimated the demand for FAFH—FAFH was always treated as a composite food. The earliest studies of food demand that included FAFH as composite good included fairly aggregated foods in other categories as well (Barnes and Gillingham, 1984; Craven and Haidacher, 1987; Nayga and Capps, 1992). Later studies that included disaggregated FAH products and FAFH used fairly restrictive demand systems, which may poorly approximate the actual process that generated the data (Park et al., 1996; Raper et al., 2002).[2]

Piggott (2003); Reed, Levedahl, and Hallahan (2005); and Okrent and Alston (2011) used flexible demand systems with time-series data to estimate demand for FAFH and FAH products in complete demand systems. Piggott (2003) estimated demand for FAH, FAFH, and alcoholic beverages using the nested price independent generalized logarithmic (PIGLOG) demand system and annual data from 1969 to 1999 (i.e., USDA expenditures matched to the Consumer Price Index (CPI)). The nested PIGLOG is very flexible, nesting popular models of demand such as the almost ideal demand system (Deaton and Muellbauer, 1980a) and the indirect translog (Christensen, Jorgenson, and Lau, 1975), as well as globally flexible versions of these models. But again, the estimates of demand elasticities for these three food and beverage groups may be too aggregated to be useful in studies of nutrition policy.

Reed, Levedahl, and Hallahan (2005) presented estimates of demand elasticities for an FAFH composite, six FAH products, and a nonfood composite using the semiflexible almost ideal demand system (Moschini, 1998) and the Consumer Expenditure Survey (CEX) aggregated into a quarterly time series matched to the CPI. However, the demands for all of the goods were found to have quite large income elasticities (all in the elastic range), which violates Engel's law. Okrent and Alston (2011) argued that—because unit roots were detected in the logarithmic transformations of the price indexes and budget shares used in their analysis—a differential-demand systems model would be appropriate for modeling demand using those data. They modeled demand for FAFH, alcoholic beverages, eight FAH products, and a nonfood composite using Barten's synthetic model (Barten, 1993; Brown, Lee, and Seale, 1994), which nests four differential-demand systems (i.e., the Rotterdam, National Bureau of Research (NBR), Central Bureau of Statistics (CBS), and differenced linear almost ideal demand system). All of these studies treat FAFH as a single composite good, although the effects of prices and expenditure may differ among individual FAFH products.

A few studies analyzed the relationship between demand for disaggregated FAFH products and income or total expenditure, assuming that the price of food from limited-service restaurants relative to food from full-service restaurants would be the same across households. Using different data sets, Byrne, Capps, and Saha (1998) and Stewart et al. (2004) found that income, household size, and labor force participation were statistically significant determinants of expenditure on FAFH for various establishment types. However, to our knowledge, no study before this one has evaluated the effects of changes in prices and total expenditure on demands for disaggregated FAFH products.

[2]For the compensated law of demand to hold using the LES, all goods must be normal and substitutes for each other. The linear expenditure system (LES) also implies that Engel curves are linear. Last, the own-price elasticity of demand for each food is approximately proportional to its demand elasticity with respect to total expenditure (Deaton and Muellbauer, 1980b, p. 66).

Data

Like Reed, Levedahl, and Hallahan (2005) and Okrent and Alston (2011), we use the Consumer Expenditure Survey (CEX) paired with CPIs to estimate the demands for disaggregated FAFH and FAH products, alcoholic beverages, and nonfood. The CEX is a nationwide household survey administered every year since 1984 and designed to represent the total U.S. civilian noninstitutionalized population. The CEX consists of two surveys: a diary survey and a quarterly interview survey. The diary survey collects detailed data on expenditures for frequently purchased items, such as food and apparel, while the interview survey obtains detailed data on expenditures for infrequently purchased items, such as property, automobiles, and major appliances, and on recurring expenses, such as rent, utilities, and insurance premiums. The diary survey collects detailed data on FAH and FAFH expenditures for a 2-week period. The interview survey contains data on expenditures on aggregate food categories, such as FAH and FAFH (U.S. Department of Labor, Bureau of Labor Statistics, 2010b).

The CEX diary data are from cross-sections of households and can be aggregated to construct a weekly, monthly, quarterly, or annual time series of average expenditures per consuming unit. Because the CPIs are available monthly and annually, we aggregated the CEX diary data to create a monthly series. When consuming units reported expenditures for a week that straddled 2 months, those expenditures were assigned to the month that included 4 or more of the days in question. Households that did not report purchasing a particular food were assigned a zero. To extrapolate the sample observations to the population, we applied the sample weights calculated by the Bureau of Labor Statistics (BLS). The CEX public microdata are available from 1980 through 2010, but we used a subset of the data since it was only in 1998 that the CEX began publishing detailed data on FAFH (specifically, food from limited-service restaurants, full-service restaurants, vending machines and lunch trucks, employee and school sites, and catered affairs).[3]

[3]Expenditures on food from catered affairs are inconsistent between 1998 and 2009 in that between 2005 and 2009, no expenditures on food from catered affairs were reported. Hence, we exclude catered food from our analysis.

We constructed the budget shares as expenditure for each food group divided by total expenditures on all goods and services for the first stage, and as expenditure for each disaggregated food product divided by expenditures for its group for the second stage (table 1). On average, for 1998-2010, nonfood constituted the largest share of the budget for all goods and services at 81 percent, followed by FAFH and alcoholic beverages (8 percent), meat and eggs (3 percent), and other FAH (3 percent). Within the FAFH and alcohol category, food from limited-service and full-service restaurants constituted about 41 percent and 37 percent, respectively, although the average monthly share of limited-service FAFH, within FAFH and alcohol, declined over the entire period (a linear trend of -0.09 percent per month), while the share of full-service FAFH increased (a linear trend of 0.14 percent per month). Other FAFH—which includes food from vending machines and mobile vendors, as well as employee and school sites—constitutes about 7 percent of the expenditure on FAFH and alcohol, and this share has declined by 0.24 percent per month, on average. Expenditure on all of the disaggregated FAFH and alcohol products declined relative to expenditure on total goods and services during the most recent recession (December 2007-June 2009). This finding contrasts starkly with the data on most FAH products, for which expenditure

Table 1
Summary statistics and trends for budget shares and prices

	Budget shares (%)				Consumer price indexes (Jan. 1999=100)			
			Avg. monthly growth (%)[b]				Avg. monthly real growth (%)[c]	
	Mean[a]	Std. dev.	Jan. 98 - Dec. 10	Dec. 07 - June 09	Mean[a]	Std. dev.	Jan. 98 - Dec. 10	Dec. 07 - June 09
Cereals/bakery	1.66	0.21	-0.12	0.51	114.71	12.90	0.23	0.02
Flour, flour mixes	4.40	0.77	-0.23	1.56	113.84	15.68	0.27	0.05
Breakfast cereals	19.01	1.51	-0.20	0.43	105.40	4.05	0.07	-0.14
Rice, pasta	10.18	1.24	-0.09	1.30	115.89	18.92	0.30	0.09
Non-white bread	11.26	1.01	0.04	0.20	123.93	20.96	0.35	0.14
White bread	7.69	0.73	-0.23	-0.38	122.75	19.73	0.33	0.12
Biscuits, rolls, muffins	9.15	0.87	-0.02	0.52	120.15	17.28	0.30	0.09
Cakes, cookies	17.91	1.62	-0.17	-0.18	113.74	12.60	0.23	0.02
Other bakery products	20.41	1.86	-0.04	-0.02	114.29	10.91	0.20	-0.01
Dairy	1.21	0.11	-0.01	0.03	110.68	11.02	0.28	0.07
Cheese	31.66	2.20	0.07	0.20	111.71	11.53	0.38	0.16
Frozen dairy desserts	17.35	3.00	-0.17	0.32	107.68	7.55	0.18	-0.04
Milk	36.74	2.32	-0.08	-0.94	110.70	13.04	0.22	0.00
Other dairy	14.25	2.15	0.24	0.21	112.11	11.09	0.21	-0.01
Meat and eggs	2.88	0.38	-0.16	0.41	126.17	16.18	0.21	-0.01
Beef	29.09	2.37	-0.22	0.00	135.30	22.95	0.33	0.12
Pork	20.23	1.53	-0.21	0.44	119.61	9.97	0.21	-0.01
Other red meat	13.03	1.19	-0.09	0.00	116.34	11.56	0.21	0.00
Poultry	18.11	1.62	-0.17	0.21	112.85	10.78	0.14	-0.07
Fish	14.75	1.50	-0.07	0.35	111.67	11.51	0.22	0.01
Eggs	4.80	0.77	0.06	0.07	116.70	22.64	0.21	0.00
Fruits and vegetables	1.69	0.19	0.06	0.40	113.57	13.54	0.26	0.04
Apples	6.99	1.14	0.01	-0.29	131.99	22.25	0.33	0.12
Bananas	6.57	0.86	-0.11	0.52	110.56	10.99	0.17	-0.04
Citrus	7.84	1.27	0.13	0.34	128.36	25.40	0.36	0.15
Other fresh fruit	17.59	4.90	0.21	-0.29	95.53	11.49	0.18	-0.04
Potatoes	6.64	0.78	0.00	0.61	134.29	26.39	0.40	0.19
Lettuce	4.88	0.39	0.07	0.30	122.06	16.24	0.21	0.00
Tomatoes	6.95	0.75	0.05	-0.37	93.78	15.53	0.27	0.06
Other fresh vegetables	19.43	1.28	0.08	0.14	118.92	15.52	0.28	0.06
Proc. fruits, vegetables	23.10	2.93	0.06	0.69	115.85	14.63	0.26	0.05

--continued

Table 1
Summary statistics and trends for budget shares and prices--continued

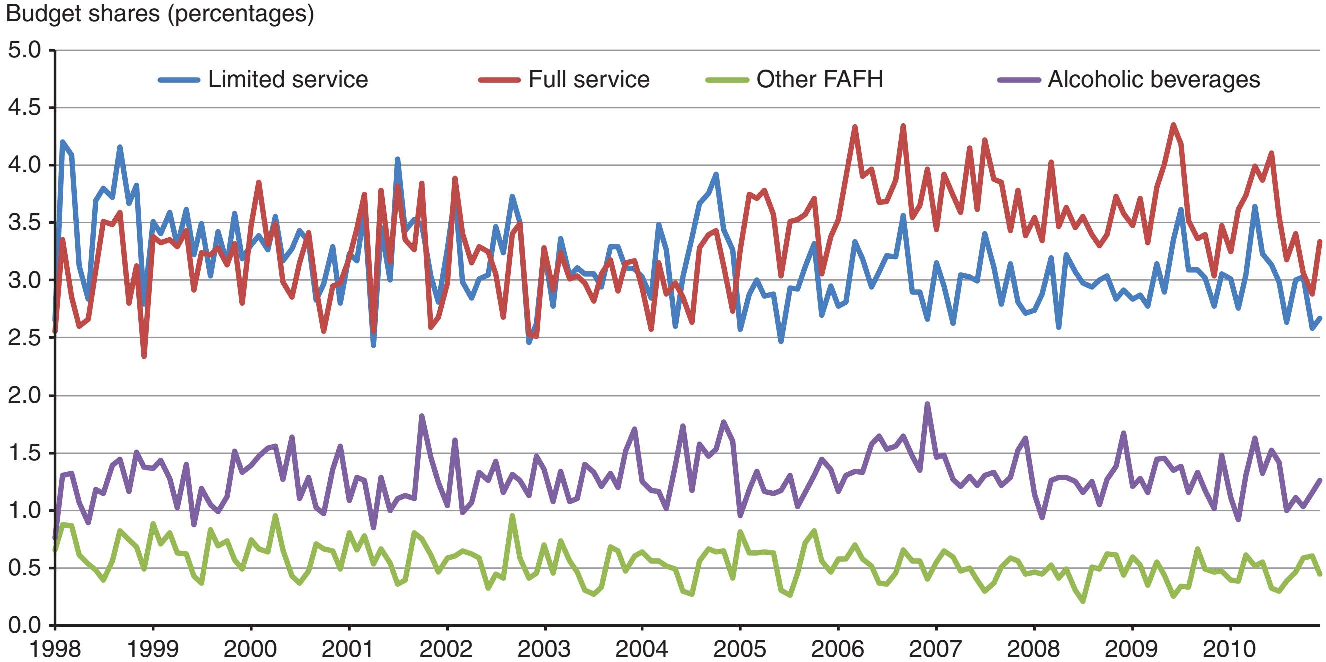
	Budget shares (%)				Consumer price indexes (Jan. 1999=100)			
			Avg. monthly growth (%)[b]				Avg. monthly real growth (%)[c]	
	Mean[a]	Std. dev.	Jan. 98 - Dec. 10	Dec. 07 - June 09	Mean[a]	Std. dev.	Jan. 98 - Dec. 10	Dec. 07 - June 09
Nonalcoholic beverages	0.75	0.09	-0.10	0.53	109.10	7.63	0.14	-0.07
Coffee, tea	17.44	2.42	-0.19	0.18	104.68	10.56	0.19	-0.02
Carbonated beverages	35.07	3.85	-0.88	0.11	113.09	10.40	0.27	0.06
Noncarbonated beverages	45.20	3.66	0.15	-0.63	106.09	5.53	0.11	-0.11
Frozen beverages	2.29	1.10	0.20	0.53	115.02	15.95	0.16	-0.06
Other FAH	2.76	0.34	0.14	0.53	109.81	8.57	0.16	-0.05
Sugar, sweets	18.75	3.28	-0.05	0.44	111.27	10.79	0.20	-0.01
Fats, oils	16.81	1.86	-0.03	0.53	111.73	12.90	0.23	0.02
Soups	5.93	1.16	0.02	0.72	110.46	6.99	0.13	-0.09
Frozen meals	17.15	1.80	0.26	0.23	104.86	4.74	0.09	-0.12
Snacks	3.73	0.39	0.11	0.44	113.16	11.63	0.21	0.00
Condiments, sauces, season.	15.26	1.14	0.15	0.69	108.56	7.76	0.15	-0.07
Miscellaneous FAH	22.37	3.54	0.41	0.16	107.74	5.84	0.11	-0.10
FAFH and alcohol	8.38	0.75	0.00	0.00	116.41	12.92	0.24	0.03
Alcohol	15.55	2.06	0.05	-0.05	110.90	11.44	0.22	0.01
Full service	37.34	2.71	0.14	-0.22	116.29	12.68	0.24	0.02
Limited FAFH	40.61	3.13	-0.09	-0.24	115.55	11.51	0.25	0.04
Other FAFH	6.51	1.67	-0.24	-0.23	109.71	10.29	0.17	-0.05
Nonfood	80.67	1.58	0.00	-0.06	116.43	11.14	0.21	0.00

Sources: U.S. Department of Labor, BLS, Consumer Expenditure Survey (2010a/b).
Notes: Foods in the first stage are highlighted.
FAFH = Food away from home, including limited-service and full-service restaurants.
FAH = Food-at-home.
[a] The mean expenditure shares for the disaggregated products are conditional on the group expenditure.
[b] The average monthly growth rate in the expenditures for the food as a share of total expenditures on goods and services (price) is the coefficient on a linear trend in the ordinary least squares (OLS) regression of the logarithmic transformation of the budget share (price) on the linear trend and a constant.
[c] The real price is the price index for a particular food divided by the consumer price index for all items.

increased as a share of total goods and services during the recession, with the exception of some fruits and vegetables (i.e., bananas, other fresh fruit, and tomatoes), some cereals and bakery products (i.e., white bread, cakes and cookies, and other bakery products), and milk.

The budget shares for all foods exhibit considerable month-to-month variation. Expenditure on limited-service FAFH decreased from about 4 percent to 3 percent of the total budget for all goods and services of an average household between 1998 and 2010 (fig. 1). Conversely, the share of the total expenditures for goods and services spent on full-service FAFH grew

Figure 1
Monthly household budget expenditures for FAFH and alcohol products as a share of total expenditures on goods and services, 1998-2010



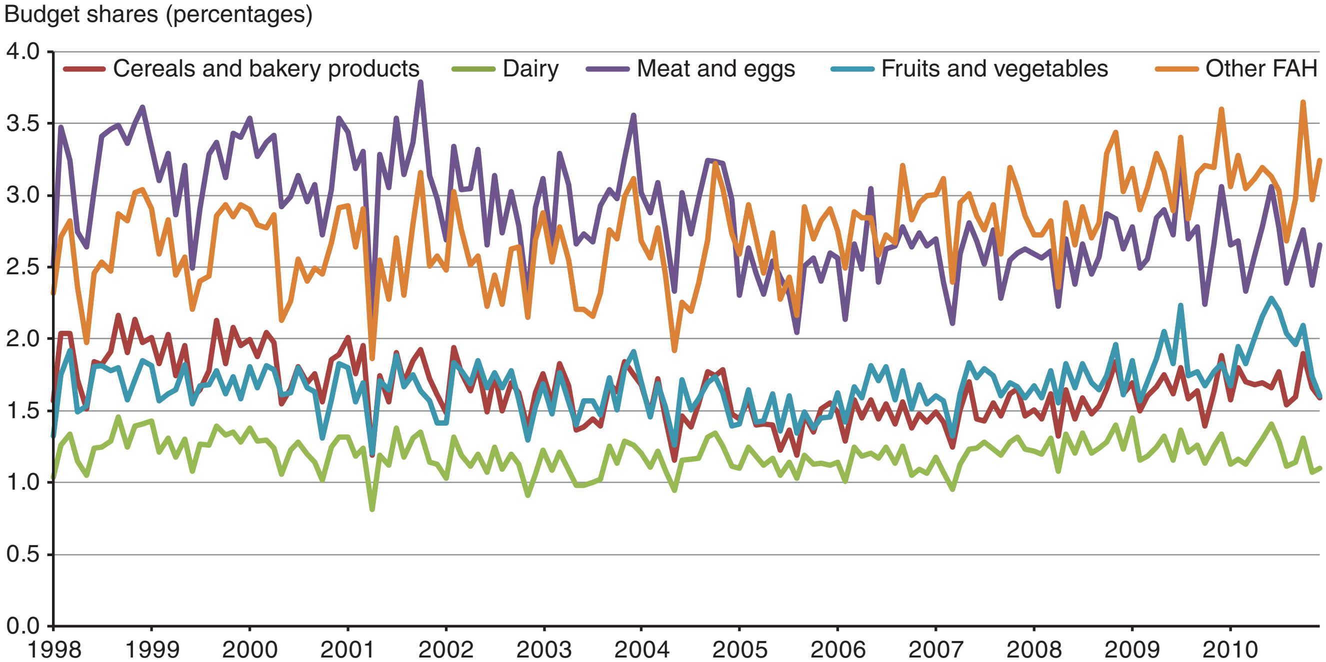
Note: FAFH = Food away from home, including limited-service and full-service restaurants
Source: Authors' calculations using the Consumer Expenditure Survey (Department of Labor, Bureau of Labor Statistics, 2010a) and the Consumer Price Indexes (Department of Labor, Bureau of Labor Statistics, 2010c).

between 1998 and 2007, but fell thereafter. Expenditures on the FAH products with the largest budget shares likewise seemed to reflect the recession's influence, declining as a share of the total budget on goods and services until 2006, and then increasing thereafter (fig. 2). In contrast, the share of total expenditure on other FAH—which consists of sugar and sweets; fats and oils; soups; frozen foods; and condiments, sauces, and gravies—was unaffected by the recession, remaining flat until 2004 and then growing, unabated.

Most of the food groups in our analysis correspond directly to one of the CPIs. However, two of the food groups—other FAFH and FAFH/alcoholic beverages—correspond to more than one CPI (U.S. Department of Labor, Bureau of Labor Statistics, 2010c). We constructed a composite price index for each of these food groups as a harmonic mean of disaggregated price indexes, each weighted by its first- or second-stage expenditure share. All price indexes are scaled to be equal to 100 in January 1999.

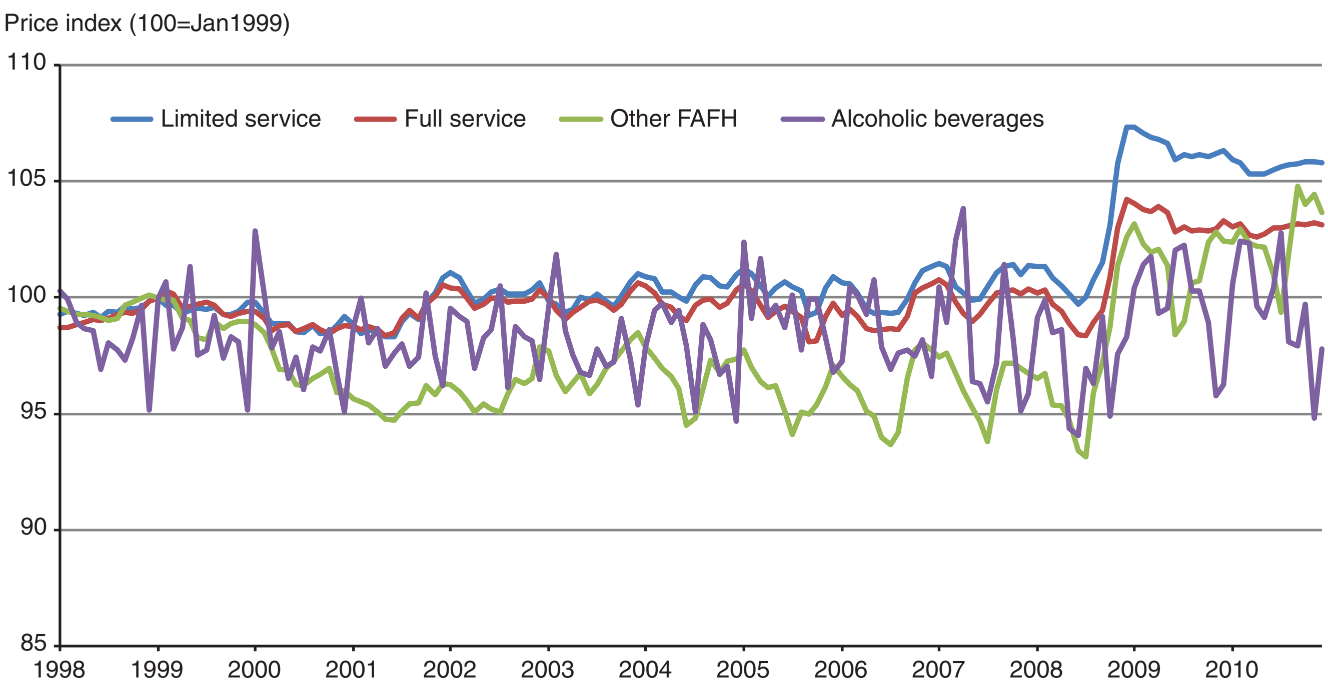
The price indexes for limited-service and full-service FAFH deflated by the CPI for all items seem to track each other, although the commodity price shocks in 2007 and 2008 had a much bigger impact on limited-service FAFH than on full-service FAFH (fig. 3). The growth in both of these real price series is fairly flat until 2008. On the other hand, the real price of other FAFH generally declined until 2008. Of the four products, the real price for alcoholic beverages exhibits the most price variation from month to month, but does not seem to trend up or down over the sample period. Compared to the deflated prices of FAFH, the deflated FAH prices decreased dramatically after the commodity price shocks in 2008 (fig. 4).

Figure 2
Monthly household budget expenditures for selected FAH products as a share of total expenditures on goods and services, 1998-2010



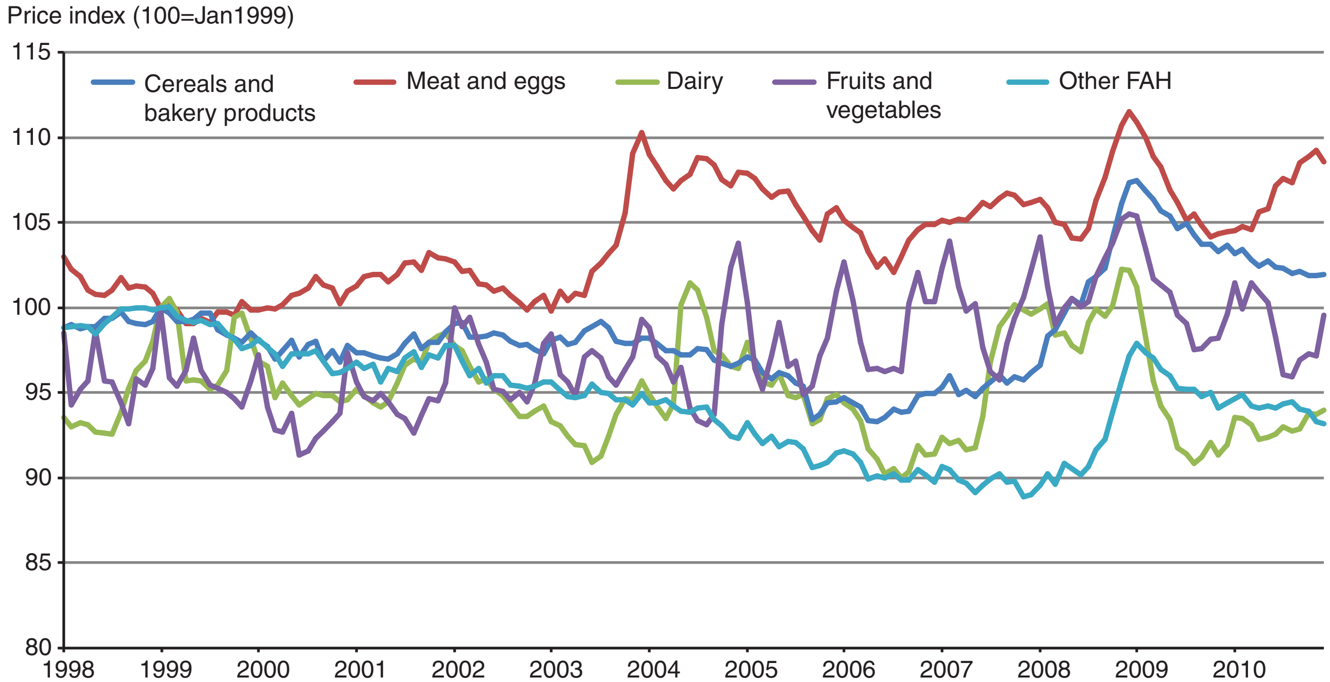
Note: FAH = Food at home
Source: Authors' calculations using the Consumer Expenditure Survey (U.S. Department of Labor, BLS, 2010a) and the Consumer Price Indexes (U.S. Department of Labor, BLS, 2010c).

Figure 3
Real prices for disaggregated FAFH and alcohol products, 1998-2010



Note: FAFH = Food away from home, including limited-service and full-service restaurants
Source: Authors' calculations using the Consumer Expenditure Survey (U.S. Department of Labor, BLS, 2010a) and the Consumer Price Indexes (U.S. Department of Labor, BLS, 2010c).

Figure 4
Real prices for selected FAH products, 1998-2010



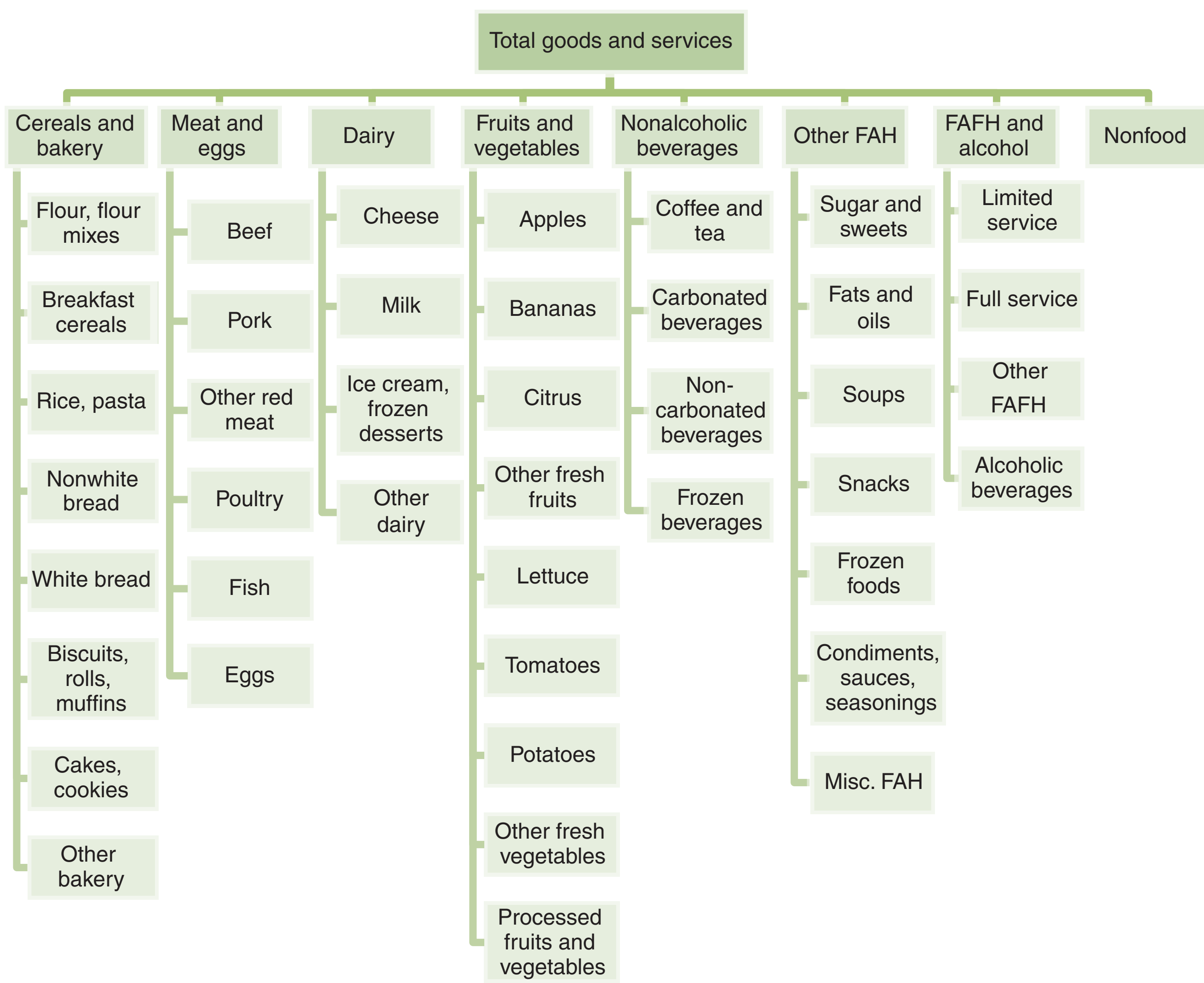
Note: FAH = Food at home
Source: Authors' calculations using the Consumer Expenditure Survey (U.S. Department of Labor, BLS, 2010a) and the Consumer Price Indexes (U.S. Department of Labor, BLS, 2010c).

Estimation Approach

Given that we have a limited number of observations and a large number of parameters to estimate, we assume that a representative household purchases goods in a two-stage budgeting process (Strotz 1957, 1959; Gorman, 1959; Barten, 1977), as follows. First, consumers allocate their budget for all goods and services among composite groups, including six FAH groups, FAFH and alcoholic beverages, and nonfood (fig. 5). Second, assuming that the seven food groups are weakly separable, consumers then choose disaggregated food products within each of the groups, conditional on expenditure for that group. We estimate the first- and second-stage demands for nonfood and disaggregated food products. We then use the first- and second-stage estimates to approximate "unconditional" elasticities of demand for disaggregated food products.[4]

[4]"Unconditional" in this context means conditional on total expenditure on food, alcoholic beverages, and nonfood.

Figure 5
Food products within the two-stage budgeting framework



Notes: FAFH = Food away from home, including limited-service and full-service restaurants
FAH = Food-at-home
Demand for market goods and services assumed to be separable from demand decisions about leisure and savings.

Estimation of First- and Second-Stage Demand

Since unit roots are often detected in time-series data, Gao and Shonkwiler (1993) suggested working with difference models rather than level-data models because the consequences of differencing when it is not needed are much less serious than those of failing to difference when it is appropriate. Hence, we opted to use the Generalized Ordinary Differential Demand System (GODDS) (Barten, 1993; Eales, Durham, and Wessells, 1997) to estimate demands in both the first and second stages.

The GODDS nests several commonly used differential demand systems, including the Rotterdam model (Theil, 1965; Barten, 1966); the Central Bureau of Statistics (CBS) model (Keller and van Driel, 1985); the differenced linear almost ideal demand system (DLAIDS) (Deaton and Muellbauer, 1980a); and the National Bureau of Research (NBR) model (Neves, 1987). The GODDS is

(1) $d\mathbf{w}_n = (c_n + \varphi_1\mathbf{w}_n)d \ln \mathbf{Q} + \sum_{k=1}^{N}[d_{nk} + \varphi_2\mathbf{w}_n(\delta_{nk} - \mathbf{w}_k)]d \ln \mathbf{p}_k$,

where c_n and d_{nk} are expenditure and price coefficients to be estimated, respectively; φ_1 and φ_2 are nesting coefficients; δ_{nk} is the Kronecker delta; $\mathbf{w}_n$ is a $t \times 1$ vector of expenditure shares for good n; $\mathbf{p}_k$ is a $t \times 1$ vector of prices of good k; and $\mathbf{Q}$ is a $t \times 1$ vector of Divisia volume indexes (see appendix for more details on this model). The values of φ_1 and φ_2 that generate the various nested models in GODDS are

(2) $\varphi_1 = -1, \varphi_2 = 1$ Rotterdam model

(3) $\varphi_1 = 0, \varphi_2 = 0$ DLAIDS

(4) $\varphi_1 = 0, \varphi_2 = 1$ CBS model

(5) $\varphi_1 = -1, \varphi_2 = 0$ NBR model.

Restrictions from demand theory can also be imposed a priori or tested,

(6) $\sum_{n=1}^{N} d_{in} = 0,$

(7) $\sum_{n=1}^{N} d_{ni} = 0, \sum_{n=1}^{N} c_n = -\varphi_1,$

(8) $d_{ik} = d_{ki},$

(i.e., homogeneity, adding-up, and symmetry, respectively). The formulas for the price and expenditure elasticities of demand for the GODDS are

(9) $\eta_{ik} = \dfrac{d_{ik} - c_i w_k}{w_i} + (\varphi_2 - 1)\delta_{ik} - (\varphi_1 + \varphi_2)w_k,$

(10) $\eta_{iM} = \dfrac{c_i - \varphi_1 w_i + w_i}{w_i}$.

Approximating Unconditional Elasticities of Demand

Many studies model only the second stage of the two-stage budgeting process, and some have argued that the resulting conditional elasticities of demand are a useful approximation to the unconditional elasticities (Capps and Havlicek, 1984; Heien and Pompelli, 1988; Gao and Spreen, 1994). However, the conditions that allow conditional elasticities of demand to approximate unconditional elasticities do not hold empirically.[5] Hence, we approximate the unconditional elasticities of demand by assuming consumers purchase goods in a two-stage budgeting process, and use the first- and second-stage elasticities of demand to approximate the unconditional elasticities of demand.

Carpentier and Guyomard (2001) approximated unconditional elasticities of demand using an approximation to the Slutsky substitution terms that are assumed to be weakly separable. Denoting the superscript as representing the composite group and the subscript as representing the elementary good, they approximated the unconditional Marshallian expenditure (η_{iM}) and price (η_{ij}) elasticities of demand as

(11) $\eta_{iM} \approx \eta^{I}_{iM}\,\eta^{IM}$,

(12) $\eta_{ij} \approx \delta^{IJ}\eta^{I}_{ij} + w^{J}_{j}\,\eta^{I}_{iM}\,\eta^{J}_{jM}\left(\delta^{IJ}/\eta^{J}_{jM} + \eta^{IJ}\right) + w^{J}_{j}\,w^{J}\,\eta^{IM}\,\eta^{I}_{iM}\left(\eta^{J}_{jM} - 1\right)$,

where

η^{I}_{iM} = expenditure elasticity for good $i \in I$ conditional on expenditure for group *I,*

η^{IM} = expenditure elasticity for composite group *I* with respect to total expenditure, *M,*

η^{I}_{ij} = Marshallian elasticity of demand for good $i \in I$ with respect to price $j \in J$ conditional on $I = J$,

η^{IJ} = Marshallian elasticity of demand for composite group *I* with respect to composite price *J,*

w^{J}_{j} = budget share for good $j \in J$ conditional on *J,*

w^{J} = budget share for composite group *J,*

$$\delta^{IJ} = \begin{cases} 1, \text{ if I = J} \\ 0, \text{ otherwise} \end{cases}.$$

We use the formulas in (11) and (12) and our first- and second-stage estimates of elasticities of demand to approximate unconditional elasticities of demand for disaggregated food products. The approximate unconditional elasticities of demand satisfy the restrictions implied by homogeneity, symmetry, and Cournot and Engel aggregation.

[5] Gao and Spreen (1994) and Heien and Pompelli (1998) argued that conditional elasticities of demand for meat are appropriate when the aggregate price elasticity of demand for meat is close to one in magnitude. However, Okrent and Alston (2011) found that the aggregate own-price elasticity of demand for meat is considerably less than one.

New Estimates of Demand for Disaggregated Food-Away-From-Home and Food-at-Home Products

To estimate the GODDS, we augmented equation (1) in two ways. First, because our data are discrete, we approximated the infinitesimal changes with their discrete counterparts:

(13) $dw_n \approx \Delta w_n = w_{n,t} - w_{n,t-12}, \forall n = 1,...,N,$

(14) $dp_n \approx \Delta \ln p_n = \ln p_{n,t} - \ln p_{n,t-12}, \forall n = 1,...,N,$

(15) $d \ln Q \approx \Delta \ln M - \sum_{n=1}^{N} \Delta \ln p_n$, where = $(w_{n,t} + w_{n,t-12}), \forall n = 1,...,N.$

Seale, Marchant, and Basso (2003) recommended twelfth-differencing rather than first-differencing the data when monthly data are used in estimation. In addition, we detected unit roots at seasonal frequencies for many of the logarithmic transformations of the prices and expenditure shares (see appendix tables A.1. and A.2).[6] Second, we included a constant in each equation that acts as a linear trend term when modeling differenced data. To avoid singularity of the variance-covariance matrix, we left out the nonfood equation for the first-stage estimation, and used Engel and Cournot aggregation conditions (i.e., equation (7)) to recover the parameter estimates of nonfood demand; likewise, we left out equations for other bakery products, other dairy, eggs, processed fruits and vegetables, frozen beverages, and miscellaneous FAH in the estimation of the respective second-stage allocations. The GODDS was estimated for the first- and second-stage allocations using iterated feasible generalized least squares, which yield maximum-likelihood estimates of the demand parameters and imply that the system estimates are invariant to which of the equations is deleted (Kmenta and Gilbert, 1968; Barten, 1969).[7]

We first tested whether the data support restrictions associated with any of the nested models (i.e., equations (2)-(5)) using the likelihood ratio statistic. The restrictions associated with the DLAIDS model cannot be rejected for most of the estimated models of second-stage allocations; the model for fruits and vegetables is an exception (table 2). This model implies that the Engel curves of products within these second-stage allocations are of the form used by Working (1943) and Leser (1963) (i.e., $w_n = \alpha_n + \beta_n \ln M$, where M is total expenditure and w_n is the budget share for product n), and both the Slutsky substitution and marginal budget terms vary over time. All of the nesting restrictions on parameters are rejected in the second-stage model of demand for fruits and vegetables, while none of the nesting parameter restrictions is rejected in the second-stage model of demand for dairy.

In the first-stage allocations, the restrictions associated with the NBR and Rotterdam models cannot be rejected; the NBR and Rotterdam models assume constant marginal budget shares. The model restrictions associated with the CBS model, which has price coefficients similar to the Rotterdam model (i.e., constant Slutsky substitution terms) and an income coefficient similar to the DLAIDS, cannot be rejected for the second-stage models of demand for meat and eggs, dairy, and FAFH/alcohol. Hence, because the restrictions associated with multiple nested models cannot be rejected in

[6]Unlike annual data, monthly data could have a unit root at the zero frequency (i.e., standard longrun unit root where first-differencing would have to be applied to render the series stationary) or at seasonal frequencies corresponding to the number of cycles per year. For example, the data-generating process may cycle every 6 months and be nonstationary, which implies that a unit root occurs at that frequency. The goal of the procedure developed by Hylleberg et al. (1990) is to test hypotheses about a particular unit root without taking a stand on whether other seasonal or zero frequency (longrun) unit roots are present. The estimation equations included a constant, a time trend, and lagged dependent variables, and the set of lags was determined using the Bayesian Information Criterion (BIC) and inspection of the partial autocorrelation for each series.

[7]We checked that our estimates were indeed invariant to the equation omitted by arbitrarily leaving out different equations in the first- and second-stage estimation, re-estimating the parameters and standard errors, and recovering the parameters and standard errors of the excluded equation using adding-up. We found our estimates to be invariant to any choice of equation omitted in estimation.

Table 2
Likelihood ratio statistics for nested models

Model	Expenditure group	*Likelihood ratio statistic*	
Rotterdam (φ_1 = -1, φ_2 = 1)	Total goods and services	3.37	[0.19]
	Cereals and bakery	19.65	[0.00]
	Meat and eggs	6.57	[0.04]
	Dairy	3.86	[0.14]
	Fruits and vegetables	56.69	[0.00]
	Nonalcoholic beverages	13.38	[0.00]
	Other FAH	17.24	[0.00]
	FAFH and alcohol	12.56	[0.00]
DLAIDS (Differenced linear almost ideal demand system) ($\varphi_1 = \varphi_2 = 0$)	Total goods and services	15.16	[0.00]
	Cereals and bakery	5.74	[0.06]
	Meat and eggs	0.47	[0.79]
	Dairy	0.83	[0.66]
	Fruits and vegetables	11.55	[0.00]
	Nonalcoholic beverages	3.92	[0.14]
	Other FAH	4.10	[0.13]
	FAFH and alcohol	5.62	[0.06]
CBS (Central Bureau of Statistics) (φ_1 = 0, φ_2 = 1)	Total goods and services	17.59	[0.00]
	Cereals and bakery	7.14	[0.03]
	Meat and eggs	2.66	[0.26]
	Dairy	2.62	[0.27]
	Fruits and vegetables	14.65	[0.00]
	Nonalcoholic beverages	6.56	[0.04]
	Other FAH	6.17	[0.05]
	FAFH and alcohol	3.81	[0.15]
NBR (National Bureau of Research) (φ_1 = -1, φ_2 = 0)	Total goods and services	0.50	[0.78]
	Cereals and bakery	18.25	[0.00]
	Meat and eggs	5.33	[0.07]
	Dairy	1.79	[0.41]
	Fruits and vegetables	52.70	[0.00]
	Nonalcoholic beverages	11.26	[0.00]
	Other FAH	15.30	[0.00]
	FAFH and alcohol	14.10	[0.00]

Source: Authors' calculations.

Notes: The bracketed terms are p-values for the null hypothesis that the nesting restrictions are supported by the data.

FAFH = Food away from home, including limited-service and full-service restaurants.

FAH = Food-at-home..

some cases (as with the estimates of first-stage allocations and second-stage models of demand for dairy and meat/eggs), but are completely rejected in others (as with second-stage model of demand for fruits and vegetables), we present elasticities of demand for the GODDS model for all of the first- and second-stage allocations, including those cases where a more restrictive model could have been used. It has been argued that the GODDS and its reparameterization, Barten's synthetic model, are not merely artificial composites of known differential demand systems, but can be viewed as demand systems in their own right (Eales, Durham, and Wessells, 1997; Matsuda, 2005).

We then tested whether the data supported the restrictions of homogeneity (equation 6) and symmetry (equation 8) from demand theory for the first- and second-stage estimates based on the GODDS (table 3). For the first-stage estimates, homogeneity and symmetry were rejected. Many of the second-stage estimates supported symmetry, except fruits and vegetables and other FAH. Homogeneity is supported only in the nonalcoholic beverage and FAFH/alcoholic beverages second stages.[8] Since we find some support for both symmetry and homogeneity restrictions, we model the first and second stages using the GODDS and with these restrictions.

Last, we tested for first-order autocorrelation in the first- and second-stage estimates (with homogeneity and symmetry restrictions) using the Rao-Breusch-Godfrey test for first-order autocorrelation for the system of equations (Edgarton and Shukur, 1999).[9] We detected first-order autocorrelation in the second-stage estimates for nonalcoholic beverages only. Following Berndt and Savin (1975), we constrained the first-order autocorrelation coefficient to be the same across all equations to preserve adding-up.

[8]Deaton and Muellbauer (1980a) found that homogeneity is frequently rejected.

[9]Because Edgarton and Shukur (1999) found that the power and size of the Rao-Breusch-Godfrey test deteriorates as the number of equations increases, we also tested for autocorrelation in each equation using the Breusch-Godfrey test and did not find overwhelming evidence of autocorrelation in the first or second stages (see table 4 and appendix tables A.3-A.9).

Table 3
Goodness of fit, tests of autocorrelation, and restrictions from demand theory for all first- and second-stage estimates based on GODDS (Generalized Ordinary Differential Demand System)

Conditional on expenditure for	System R^2	Rao-Breusch-Godfrey statistic	Likelihood ratio statistics for restrictions from demand theory					
			Symmetry		Homogeneity		Symmetry and homogeneity	
Total goods and services	0.15	0.64	49.22	[0.00]	22.44	[0.00]	61.28	[0.00]
Cereals and bakery	0.07	0.65	23.78	[0.31]	23.64	[0.00]	45.16	[0.02]
Meat and eggs	0.18	0.30	23.28	[0.05]	18.06	[0.00]	39.78	[0.00]
Dairy	0.20	1.47	4.96	[0.17]	11.92	[0.00]	13.24	[0.05]
Fruits and vegetables	0.08	0.93	60.32	[0.00]	17.02	[0.03]	77.84	[0.00]
Nonalcoholic beverages	0.09	2.19	5.04	[0.17]	0.20	[0.98]	10.50	[0.11]
Other food at home	0.07	0.57	53.00	[0.00]	21.26	[0.00]	74.66	[0.00]
Food away from home/alcohol	0.09	1.85	3.26	[0.35]	4.14	[0.25]	6.28	[0.39]

Source: Authors' calculations.
Notes: The bracketed terms are p-values for the likelihood ratio tests of the null hypothesis that the restrictions from demand theory are supported by the data. The Rao-Breusch-Godfrey statistic is approximately distributed F(p,q), of which the 5% critical value is (i) 1.39 for the first-stage model, with p = 49 and q = 609, and, in the second-stage allocations (ii) 1.39 for cereals and bakery, with p = 49 and q = 609; (iii) 1.46 for meat and eggs, with p = 25 and q = 466; (iv) 1.88 for dairy, with p = 9 and q = 290; (v) 1.31 for fruits and vegetables, p = 64 and q = 676; (vi) 1.88 for nonalcoholic beverages, with p = 9 and q = 319; (vii) 1.67 for other FAH, with p = 16 and q = 536; and (viii) 1.88 for FAFH and alcoholic beverages, with p = 9 and q = 288.

We then re-estimated the nonalcoholic beverages' second stage with a correction for first-order autocorrelation, using iterated feasible generalized nonlinear least squares.[10]

First-Stage Estimates of Demand Elasticities for Composite Goods

The GODDS model seems to fit the monthly data well. The single-equation R^2 statistics ranged between 0.58 for FAFH and alcohol and 0.77 for cereals and bakery products (table 4). The system R^2 based on Bewley, Young, and Colman (1987) is 0.17, indicating that about 17 percent of the variation in the dependent variables in the first stage can be explained by the price terms in the GODDS model.[11] The constant is significant in the equations for cereal and bakery products, meat and eggs, and fruits and vegetables; in particular, the estimated constants indicate trends of increasing consumption for cereals and bakery products and meat and eggs, and decreasing consumption for fruits and vegetables.

All of the own-price elasticities for the first-stage allocations are negative, which is consistent with demand theory. Most of the own-price elasticities of demand are significant at 10 percent except for dairy, for which the estimate

[10]We estimated ρ to be 0.22 for nonalcoholic beverages.

[11]Bewley, Young, and Colman (1987) developed a measure of goodness-of-fit for a system of equations model as

$$\text{system } R^2 = 1 - \frac{1}{1 + LR/(T(n\text{-}1))},$$

where *LR* is twice the difference between the log likelihood of the model in (1) and the log likelihood of the model with the dependent variable regressed on a constant only. We use a variant of this measure used by Lee, Brown, and Seale (1994) and Brown, Lee, and Seale (1994) where *LR* is twice the difference between the log likelihood of the model in (1) and the log likelihood of the model with the dependent variable regressed on the aggregate income term, d *ln* Q. As Lee, Brown, and Seale (1994) and Brown, Lee, and Seale (1994) showed, this measure is invariant to the equation left out in estimation.

Table 4
First-stage uncompensated elasticities of demand from the GODDS model

	With respect to price of							
Elasticity of demand for	Cereals and bakery	Meat and eggs	Dairy	Fruits and vegetables	Non-alcoholic drinks	Other FAH	FAFH and alcohol	Nonfood
Cereals and bakery	-0.58	0.05	0.36	-0.31	-0.09	0.25	0.16	0.16
	(0.25)	(0.12)	(0.08)	(0.13)	(0.15)	(0.29)	(0.34)	(0.29)
Meat and eggs	0.03	-0.31	0.02	0.11	0.08	0.26	0.17	-0.40
	(0.07)	(0.17)	(0.05)	(0.09)	(0.04)	(0.11)	(0.32)	(0.40)
Dairy	0.49	0.06	-0.05	-0.03	-0.16	-0.44	0.23	-0.21
	(0.10)	(0.12)	(0.09)	(0.11)	(0.07)	(0.16)	(0.30)	(0.29)
Fruits and vegetables	-0.30	0.18	-0.02	-0.79	0.02	0.58	0.24	0.04
	(0.13)	(0.15)	(0.08)	(0.19)	(0.09)	(0.20)	(0.39)	(0.36)
Nonalcoholic beverages	-0.21	0.31	-0.25	0.05	-0.65	0.65	-0.05	0.13
	(0.32)	(0.16)	(0.12)	(0.20)	(0.39)	(0.46)	(0.51)	(0.38)
Other FAH	0.15	0.27	-0.19	0.36	0.18	-0.98	0.45	-0.32
	(0.18)	(0.11)	(0.07)	(0.12)	(0.12)	(0.30)	(0.34)	(0.28)
FAFH and alcohol	0.03	0.05	0.03	0.05	-0.01	0.14	-0.71	0.20
	(0.07)	(0.11)	(0.04)	(0.08)	(0.05)	(0.11)	(0.38)	(0.37)
Nonfood	-0.02	-0.05	-0.02	-0.02	-0.01	-0.04	-0.06	-1.00
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.04)	(0.06)

--continued

Table 4
First-stage uncompensated elasticities of demand from the GODDS model--continued

Elasticity of demand for	With respect to total expenditure	R^2	Breusch-Godfrey statistic	Constant
Cereals and bakery	0.01 (0.05)	0.77	1.66	0.0002 (0.0001)
Meat and eggs	0.04 (0.07)	0.59	4.90	0.0005 (0.0002)
Dairy	0.11 (0.05)	0.74	2.20	0.0001 (0.0001)
Fruits and vegetables	0.04 (0.06)	0.66	5.87	-0.0002 (0.0001)
Nonalcoholic beverages	0.02 (0.05)	0.70	0.18	0.0000 (0.0001)
Other FAH	0.09 (0.04)	0.76	0.08	-0.0003 (0.0002)
FAFH and alcohol	0.21 (0.06)	0.58	3.63	0.0003
Nonfood	1.21 (0.01)	na	na	na

Source: Authors' calculations using feasible generalized least squares GLS (Stata version 11) with homogeneity and symmetry constraints imposed.

Notes: Estimates of elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 and the Breusch-Godfrey statistic are for the individual equations and Breusch-Godfrey statistic is distributed $\chi^2(1)$, for which the 10% critical value is 2.71.

FAFH = Food away from home, including limited-service and full-service restaurants; FAH = Food at home; GODDS = Generalized Ordinary Differential Demand System.

is very small, indicating a very inelastic demand. Demand for nonfood is found to be the most responsive to changes in own price (own-price elasticity of -1.00), followed by other FAH (own-price elasticity of -0.98). The own-price elasticity of demand for FAFH and alcohol is -0.71, which compares well with the estimate by Reed, Levedahl, and Hallahan (2005), but is considerably less than in other studies. Okrent and Alston (2011) found that across eight studies the average of the estimates of own-price elasticity of demand for FAFH was -1.02 (table 5). In fact, all of this study's own-price elasticities are less than the average across studies reported in Okrent and Alston (2011). Our first-stage own-price elasticities are mostly consistent with those of Reed, Levedahl, and Hallahan (2005); Huang and Lin (2000); and Park et al. (1996).

Of the 56 cross-price elasticities of demand, 20 are statistically significant at the 10-percent level of significance. Many of the FAH products (i.e., cereals and bakery products, dairy, and other FAH) are gross substitutes for FAFH and alcohol, although these relationships are not found to be statistically significant. Other FAH is a statistically significant gross substitute for both meat/eggs and fruits/vegetables, but a gross complement for dairy. And dairy

Table 5
Comparison of first-stage elasticities of demand from this study with previous studies

	This study		Reed, Levedahl, Hallahan (2005)		Huang and Lin (2000)[b]		Park et al. (1996)[c]		Okrent and Alston (2011), table 5	
	Own-price	Expen-diture	Own-price	Income	Own-price	Expen-diture	Own-price	Expen-diture	Number of studies repre-sented	Average own-price across studies
Cereals and bakery	-0.58	0.01	-0.61	1.31	-0.45	0.63	-0.14	0.43	3	-0.86
Meat and eggs	-0.31	0.04	-0.61	1.81	-0.41	0.78	-0.45	0.64	8	-0.52
Dairy	-0.05	0.11	-0.86	2.25	-0.79	0.67	-0.36	0.57	8	-0.85
Fruits and vegetables	-0.79	0.04	-0.98	1.60	-0.72	1.07	-0.49	0.65	4	-0.91
Nonalcoholic beverages	-0.65	0.02	-0.74[a]	1.04a	-1.01	1.04	na	na	na	na
Other FAH	-0.98	0.09			-0.40	0.82	-0.58	0.59	11	-0.80
FAFH and alcohol	-0.71	0.21	-0.69	1.38	na	na	-0.96	1.42	8	-1.02
Nonfood	-1.00	1.21	-0.86	0.92	na	na	na	na	2	-0.93

Source: Estimates for this study based on the GODDS and average monthly household expenditures based on the Consumer Expenditure Survey (U.S. Department of Labor, BLS, 2010a) and the Consumer Price Indexes (U.S. Department of Labor, BLS, 2010c).

[a] Nonalcoholic beverages included in other FAH category.

[b] The own-price and expenditure elasticities in this table are simple averages for disaggregated elasticities presented in Huang and Lin (2000) within the groups comprising cereals and bakery, meat and eggs, dairy, and fruits and vegetables.

[c] Estimates for nonpoverty status households only (table 8). The own-price and expenditure elasticities in this table are simple averages for disaggregated elasticities presented in Park et al. (1996) within the groups comprising cereals and bakery, meat and eggs, dairy, and fruits/vegetables. The other FAH category only includes fats and oils.

FAFH = Food away from home, including limited-service and full-service restaurants; FAH = Food-at-home; GODDS = Generalized Ordinary Differential Demand System.

is also found to be a statistically significant gross complement for nonalcoholic beverages.

Not unexpectedly, demand for nonfood is the most responsive to total expenditure (elasticity of 1.21), followed by demand for FAFH and alcohol (0.21). Demands for FAFH and alcohol are twice as responsive to changes in total expenditure as the most expenditure-elastic FAH products, namely dairy (0.11) and other FAH (0.09). Compared with the total-expenditure elasticities from the studies listed in table 5, the ones here are quite small, mainly because the nonfood budget share is 80 percent.

Conditional Elasticities of Demand for Disaggregated Food Products

We estimated demand for disaggregated food products, assuming the products belonged to the following weakly separable groups: cereals and bakery products, meat and eggs, dairy products, fruits and vegetables, nonalcoholic beverages, other FAH, and FAFH/alcohol. Hence, the elasticities of demand for the disaggregated FAH products are conditional on total expenditure for the respective group. First-order autocorrelation is not detected in most of the second-stage estimates, with the exception of nonalcoholic beverages, based on the Rao-Breusch-Godfrey test. The system R^2 for the second-stage allocations ranges between 0.07 for other FAH and cereals/bakery products and 0.20 for dairy. For brevity, we report the elasticities of demand, single-equation R^2, first-order autocorrelation coefficient, Breusch-Godfrey LM statistic, and the trend term in each equation for the second-stage allocations in appendix tables A.3-A.9.

Unconditional Elasticities of Demand for Disaggregated Food Products

Using equations (11) and (12) and the estimated elasticities of demand from the models of the first- and second-stage allocations, we approximated the elasticities of demand for disaggregated FAH and FAFH products conditional on total expenditure for all goods and services. Table 6 shows the own-price and expenditure elasticities of demand for disaggregated food products compared with Huang (1993) and Bergtold, Akobundo, and Peterson (2004).[12] Appendix table A.10. contains the 43 × 43 matrix of all elasticities. The standard errors were bootstrapped using the parametric residual method suggested by Green, Hahn, and Rocke (1987).

Cereals and Bakery Products. The demands for flour and prepared flour mixes; rice and pasta; and biscuits, rolls, and muffins are almost perfectly inelastic; the point estimates are close to zero and not statistically significantly different from zero (table 6). These findings approximate those of Huang (1993). By comparison, Bergtold, Akobundu, and Peterson (2004) found the own-price elasticity of demand to be closer to -1.0 for rice, pasta, and flour, but only the own-price elasticity of demand for pasta was statistically significant. The demands for breakfast cereals and cakes/cookies are price-elastic (i.e., elasticities of -1.05 and -1.20, respectively). The demand for nonwhite bread is less responsive to changes in price than the demand for white bread (elasticities of -0.59 and -1.54, respectively). Most of the cross-price elasticities of demand for foods within the cereals and bakery products group are statistically insignificant, although white bread and nonwhite bread are statistically significant gross substitutes, and flour/prepared flour mixes is a gross substitute for rice and pasta and a gross complement to nonwhite bread. Compared with the disaggregated demands of the other groups, the demands for all of the cereals and bakery products are relatively expenditure-inelastic, with elasticities ranging between 0.00 and 0.01. Bergtold, Akobundu, and Peterson (2004) and Huang (1993) also found the demands for disaggregated cereals and bakery products to be expenditure-inelastic and even inferior (i.e., expenditure elasticity is less than zero), compared to disaggregated products within other food groups.

Meat and Eggs. Pork and "other red meat" (that is, other than beef and pork) are price-elastic (own-price elasticities of -1.26 and -1.05), while the other products in the meat and eggs group—beef, poultry, fish/seafood, and eggs—are price inelastic, with eggs being the most price inelastic (own-price elasticity of -0.24). The rankings of meat products in terms of their price responsiveness are roughly consistent with results from Huang (1993), although some of our estimates are statistically significantly smaller, at the 10-percent level of significance (e.g., pork, other red meat, fish/seafood, and eggs). Also, similar to Huang's findings (1993), beef and pork are statistically significant gross substitutes for each another. Demands for meat products are slightly more responsive to changes in total expenditure than

[12]Huang (1993) and Bergtold et al. (2004) are the only recent studies to our knowledge that included a number of disaggregated FAH products in their estimation of unconditional demand systems, such that their results can be compared with ours. Huang (1993) directly estimated demand for 39 foods and a nonfood composite using quantity indexes constructed from per capita disappearance data (ERS) and consumer price indexes. The per capita disappearance data, however, are not direct estimates of retail purchases because they are measured as total commodity supply less quantities used for farm inputs, exports, ending stocks, and industrial uses. Hence, the per capita disappearance data measure food use at a very basic level, do not distinguish between FAFH and FAH, and do not measure use of highly processed foods such as bakery products and frozen dinners in the finished product form (although the ingredients in those products are included as components of less highly processed foods such as sugar, flour, vegetables for processing, and fresh meat). Bergtold et al. (2004) used price and quantity scanner data (e.g., IRI Infoscan) and the flexible and separable translog multistage demand system (Moschini 2001) to estimate demand for 49 processed foods and an "all-other-goods" composite. One limitation of their dataset is that it did not include information on several key food categories, including fresh meats, fruits and vegetables, and FAFH, and such products were lumped into the "all-other-goods" composite in their model.

Table 6
Comparison of unconditional elasticities of demand from this study with previous studies

	This study		Bergtold, Akobundu, and Peterson (2004)[a,b]		Huang (1993)[b]	
	Own-price	Expenditure	Own-price	Income	Own-price	Expenditure
Cereals and bakery						
Flour and flour mixes	0.07	0.01	-0.86	0.06	-0.08	0.13
Breakfast cereals	-1.05*	0.00	na	na	na	0
Rice and pasta	-0.07	0.01	-0.87	-0.06	0.07	0.15
Nonwhite bread	-0.59*	0.00	-0.80	-0.21	na	na
White bread	-1.54	0.01			na	na
Biscuits, rolls, muffins	-0.21	0.00	-1.03	-0.55	na	na
Cakes and cookies	-1.20*	0.01	na	na	na	na
Other bakery products	-0.55	0.00	na	na	na	na
Meat and eggs						
Beef	-0.70*	0.05	na	na	-0.62	0.39
Pork	-1.26*	0.04	na	na	-0.73	0.66
Other red meat	-1.05*	0.02	na	na	-1.87	-0.57
Poultry	-0.81*	0.03	na	na	-0.45	-0.02
Fish	-0.84*	0.03	na	na	-0.13	0.41
Eggs	-0.24*	0.03	na	na	-0.11	0.29
Dairy						
Cheese	-0.70*	0.13*	-1.18	-0.03	-0.25	0.42
Ice cream	-0.23	0.13*	-0.88	0.05	-0.08	0.00
Milk	-0.10	0.09*	-0.80	-0.20	-0.04	0.12
Other dairy	-1.04*	0.09*	-1.03	0.31	-0.28	0.52
Fruits and vegetables						
Apples	-0.58*	0.03	na	na	-0.19	-0.36
Bananas	-1.01*	0.05	na	na	-0.50	0.00
Citrus	-1.10*	0.06	na	na	-0.65	-0.33
Other fresh fruit	-0.90*	0.04	na	na	-0.80	0.34
Potatoes	-0.42*	0.03	na	na	-0.10	0.11
Lettuce	-0.84*	0.04	na	na	-0.09	0.37
Tomatoes	-0.58*	0.06	na	na	-0.62	0.92
Other fresh vegetables	-0.94*	0.04	na	na	-0.26	0.69
Proc. fruits and vegetables	-0.77*	0.03	-1.20	-0.29	-0.40	0.56

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Table 6
Comparison of unconditional elasticities of demand from this study with previous studies (continued)

	This Study		Bergtold, Akobundu, and Peterson (2004)[a,b]		Huang (1993)[b]	
	Own-price	Expenditure	Own-price	Income	Own-price	Expenditure
Nonalcoholic beverages						
Coffee and tea	-0.12	0.02	-0.45	-0.27	-0.18	0.82
Carbonated drinks	-0.30	0.01	-1.15	-0.03	na	na
Nonfrozen noncarb. drinks	-0.44	0.02	-0.65	-0.12	-0.56	0.37
Frozen noncarb. drinks	-0.61	0.01	-0.70	-0.14	na	na
Other food at home						
Sugar and sweets	-0.56	0.13*	-0.66	-0.16	-0.04	0.21
Fats and oils	-0.21	0.08*	-0.62	-0.51	-0.13	0.23
Soups	0.19*	0.07*	-1.51	0.59	na	na
Frozen foods	-1.05	0.09*	-1.08	-0.27	na	na
Snacks	-1.14*	0.08*	-1.17	-0.10	na	na
Condiments, sauces, seas.	-1.92*	0.07*	-1.00	-0.01	na	na
Misc. FAH	-1.48*	0.11*	-1.17	0.01	na	na
Food away from home/alcohol						
Alcohol	-1.15*	0.32*	na	na	na	na
Limited-service	-0.13	0.18*	na	na	na	na
Full-service	-1.96*	0.20*	na	na	na	na
Other FAFH	-0.43*	0.21*	na	na	na	na
Nonfood	-1.00*	1.21*	-1.00	0.99	-0.98	1.17

* designates statistical significance at the 10-percent level for estimates in this study only.

[a] Bergtold et al. (2004) presented own-price and expenditure elasticities of demand for four quarters. We averaged the elasticity estimates over the quarters.

[b] Some of the products in Bergtold et al. (2004) and Huang (1993) did not correspond directly to the products in this study. Hence, we calculated the average own-price and expenditure elasticities of demand for multiple products that corresponded to a product in this study.

Source: Estimates from this study based on first-stage elasticities of demand (table 4), second-stage elasticities of demand (appendix tables A.4-A.9) and formulas derived by Carpentier and Guyomard (2001) in equations (12) and (13).

FAFH = Food away from home, including limited-service and full-service restaurants; FAH = Food-at-home.

are demands for cereals and bakery products, with expenditure elasticities ranging between 0.02 for other red meat and 0.05 for beef. But this effect is still small and insignificant compared to the other products in the system.

Dairy. The own-price elasticities of demand for cheese and other dairy are statistically different from zero at the 10-percent level of significance (-0.70 and -1.04, respectively) and much more price-elastic than the demands for fluid milk and ice cream/frozen desserts (-0.10 and -0.23, respectively), which are not found to be statistically significant. Huang (1993) found demand for similar dairy products to be mostly price-inelastic, whereas Bergtold, Akobundu, and Peterson (2004) found demand for comparable items to be much more elastic. Our results fall between the two studies' findings. Cheese is found to be a statistically significant gross substitute for other dairy, which includes yogurt and sour cream. Compared with the disaggregated demands in the cereals/bakery, meat/eggs, fruits/vegetables, and nonalcoholic beverages groups, demands for disaggregated dairy products are almost twice as responsive to changes in total expenditure, with expenditure elasticities ranging between 0.09 for milk and other dairy and 0.13 for cheese and ice cream. Again, these estimated elasticities of demand with respect to total expenditure fall generally in between the estimates of Bergtold, Akobundu, and Peterson (2004) and Huang (1993). Bergtold, Akobundu, and Peterson found cheese and milk to be inferior products (a good that decreases in demand when income increases) and the elasticity of demand for ice cream and cheese with respect to total expenditure to be close to zero.

Fruits and Vegetables. In this group, all of the own-price elasticities are statistically significant, with demand for citrus being the most elastic (own-price elasticity of -1.10) and demand for potatoes being the least elastic (own-price elasticity of -0.42). Within the fruits and vegetables group, few of the cross-price relationships are statistically significant with the exception of processed fruits and vegetables, which is a gross complement to fresh tomatoes. The elasticities of demand for the disaggregated fruits and vegetables with respect to total expenditure are small, ranging between 0.03 and 0.06. Compared with Huang (1993), the present study finds the demands for disaggregated fruits and vegetables to be generally more price-elastic and more expenditure-inelastic.

Nonalcoholic Beverages. Within this group, none of the elasticities of demand with respect to price or expenditure elasticities is significant. The elasticities of demand with respect to total expenditure are close to zero, and the own-price elasticities of demand are small compared with most other food products, with the demand for coffee and tea being the least price responsive at -0.12. Huang (1993) found the own-price elasticity of demand for coffee and tea to be -0.18, while Bergtold, Akobundu, and Peterson (2004) found the own-price elasticity for coffee to be -0.45. However, Bergtold, Akobundu, and Peterson (2004) found the demand for carbonated beverages (averaged across diet and regular cola estimates) to be much more price elastic (-1.15) than our estimate for carbonated beverages (-0.30).

Other FAH. Most of the demands for products within the other FAH group are price-elastic, with seasonings, condiments, and sauces being the most price elastic (-1.92), followed by miscellaneous FAH (-1.48), snacks (-1.14), and frozen meals (-1.05). This finding is consistent with Bergtold, Akobundu and Peterson (2004), who found sauces and marinades, mayonnaise, relishes, and dressings to be generally price elastic. We find the demands for sugars/sweets and fats/oils to be price-inelastic, but both relationships are statistically insignificant. Compared with the other food product categories, the "other FAH" products are the most responsive to changes in their own price with the exception of FAFH and alcohol.

FAFH and Alcohol. The demands for limited-service FAFH and other FAFH (vending machines, mobile food vendors, and school/employee sites) are the most inelastic in the group (-0.13 and -0.43, respectively). The own-price elasticity of demand for full-service FAFH is -1.96, and is statistically different from the own-price elasticity of demand for limited-service FAFH at the 10-percent level of significance. Full- and limited-service FAFH are found to be gross substitutes, although this relationship is not statistically significant. Demand for alcohol is also price-elastic (-1.15). All of the FAFH products and alcohol are more than twice as responsive to changes in total expenditure compared to the FAH products. Alcohol is the most price-responsive (0.32), followed by other FAFH (0.21), full-service FAFH (0.20), and limited-service FAFH (0.18).

Potential Policy Implications

Because disaggregated FAFH and FAH products may differ in responsiveness to prices and total expenditure, as well as in nutritional content, we estimate elasticities using a more disaggregated approach than previously done in the literature. Our results show that the demand for full-service FAFH is much more responsive than the demand for limited-service FAFH to changes in price, and the demands for all FAFH products are at least twice as elastic with respect to changes in total expenditure than their FAH counterparts. The finding that FAFH products are much more responsive to changes in total expenditure—and that these FAFH products are generally gross substitutes for many FAH products—can explain why the budget share for these products dipped during the 2007-09 recession, while the budget shares for many FAH products increased. In particular, during the period of December 2007-June 2009, monthly total consumer expenditures fell by about 0.5 percent on average, while the prices of most FAH products, which are mostly gross substitutes for FAFH products, fell relative to the prices of the FAFH products. Hence, income-induced changes in total expenditures and movements in prices of FAH products relative to prices of FAFH products caused demand for FAFH to fall during the most recent recession.

The demands for disaggregated FAH products, which include some foods that are considered to be "healthy" and others considered too be "unhealthy," also varied in their responsiveness to changes in prices and total expenditure. "Healthy" foods—such as nonwhite bread, most fruits and vegetables, and fish/seafood—are generally less responsive to changes in their own prices than their "unhealthy" counterparts. For example, for cereals and bakery products, we found that the unconditional demand for white bread was much more price elastic than the unconditional demand for nonwhite bread, and the demand for cookies and cakes was one of the most price elastic within the group. Likewise, the unconditional demands for snacks, condiments/sauces/seasonings, and frozen foods were very price elastic compared with the demands for other FAH products.

However, own-price effects are only one part of an analysis of the effects of policy-induced price changes on consumption. The cross-price relationships between "unhealthy" and "healthy" foods are complex; in analyzing the effect of a change in the price of a "healthy" or "unhealthy" food on the nutritional outcome of an individual, one must consider the cross-price, as well as the own-price, effects.

To further demonstrate the importance of these cross-price relationships and intergroup substitution on the quantities of food consumed, we forecast the changes in consumption for several foods between 2011 and 2012—given forecast changes in prices and total expenditures—and compare the predictions based on alternative elasticity measures. We use the "unconditional" demand elasticities reported in appendix table A.10 to obtain forecasts that consider intergroup as well as intragroup substitution; and we use the "conditional" demand elasticities reported in appendix tables A.3-A.9 (i.e., conditional on group expenditure) to obtain forecasts that consider only intragroup substitution.

The forecast changes in prices of food from 2011 to 2012 are taken from the CPI forecasts by the U.S. Department of Agriculture, ERS (2011), and the forecast changes in prices for nonfood and total expenditures are taken from the Federal Reserve Bank of Philadelphia's Fourth Quarter 2011 Survey of Professional Forecasters (2011) (table 7).[13] According to the ERS price forecasts, the prices of beef, fish/seafood, fats/oils, and cereals/bakery products will increase the most (between 4 and 4.5 percent) from 2011 to 2012, whereas the prices for fresh vegetables, eggs, and nonalcoholic beverages will increase the least, between 1.5 and 2 percent. The price of nonfood products, as proxied by core inflation for 2012, is predicted to increase by 1.8 percent, while total personal consumption expenditures are predicted to increase 1.7 percent.

[13]The survey reports the mean annualized predictions by professional forecasters of changes in headline (all items) and core (all items excluding food and energy) inflation and personal consumption expenditures (PCE). We used predicted core inflation and headline PCE to proxy for 2012 predicted proportional changes in nonfood price and total expenditures, respectively.

Using these predicted changes in prices and total expenditure, we forecast changes in food quantities using both unconditional and conditional elasticities. Both sets of forecasts indicate decreases in the quantities of disaggregated cereals and bakery products consumed, but the magnitudes differ substantially; the forecasts based on the conditional elasticities of demand are three to four times larger in absolute terms than the forecasts based on the unconditional elasticities of demand. Even though the conditional own-price elasticities of demand were not statistically different from the unconditional own-price elasticities of demand at the 10-percent level of significance, the conditional forecasts disregarded statistically significant intergroup substitution and complementary relationships found in the first stage (i.e., dairy, fruits/vegetables, and nonfood). The conditional forecasts followed the same pattern for the disaggregated FAFH products.

The predicted percentage changes in dairy consumption based on the elasticities of demand conditional on dairy expenditure take opposite signs compared with the predicted percentage changes based on the unconditional elasticities of demand: consumption of each of the disaggregated dairy products is predicted to *increase* between 0.61 percent and 0.9 percent in 2012 based on the unconditional demand elasticities, but predicted to *decrease* between 0.63 percent and 0.97 percent based on the conditional demand elasticities. Similar contradictions between the two sets of elasticities are found for other food products as well (e.g., pork, poultry, eggs, sugar and sweets, frozen foods). Again, dairy—like cereals and bakery products—has several statistically significant cross-price relationships between groups of foods at the first stage that results in complementary and substitution relationships among the disaggregated products in these groups, causing contradictions in our forecast changes in quantities consumed depending on which set of elasticities is used.

The substantial cross-price relationships between products in different groups lead to two important and related implications. First, the predicted changes in quantities of foods consumed based on the conditional demand elasticities pertaining to a weakly separable group are different in magnitude, and sometimes in direction of change, than predicted changes in quantities based on unconditional elasticities of demand. Second, policy analysis based on conditional demand elasticities for a small group of products is likely to be misleading.

Table 7
Forecast changes in food consumption, 2011 to 2012, based on forecast changes in prices and expenditure, using alternative sets of elasticities of demand

	Forecast changes in prices and total expenditure	Predicted changes in food quantities based on		Predicted changes in expenditures based on	
		Unconditional elasticities[a]	Conditional elasticities[b]	Unconditional elasticities[a]	Conditional elasticities[b]
	Annual percentage change				
Flour and prep. mixes	4.0	-1.25	-4.23	2.75	-0.23
Breakfast cereals	4.0	-0.48	-1.56	3.52	2.44
Rice and pasta	4.0	-1.01	-3.69	2.99	0.31
Nonwhite bread	4.0	-0.44	-1.62	3.56	2.38
White bread	4.0	-0.78	-2.63	3.22	1.37
Biscuits, rolls, muffins	4.0	-0.39	-1.81	3.61	2.19
Cakes and cookies	4.0	-0.84	-2.67	3.16	1.33
Other bakery	4.0	-0.55	-1.92	3.45	2.09
Beef	4.5	-0.39	-3.39	4.11	1.11
Pork	3.5	0.58	-1.75	4.08	1.75
Other red meat	3.0	1.35	0.07	4.35	3.07
Poultry	3.5	0.28	-1.31	3.78	2.19
Fish	4.5	-1.08	-3.11	3.43	1.39
Eggs	1.5	0.75	-0.77	2.25	0.73
Cheese	2.5	0.90	-0.97	3.40	1.53
Ice cream and frozen desserts	2.5	0.87	-0.92	3.37	1.58
Milk	2.5	0.61	-0.63	3.11	1.87
Other dairy	2.5	0.69	-0.71	3.19	1.80
Apples	3.5	-0.70	-1.55	2.81	1.95
Bananas	3.5	-0.62	-2.11	2.88	1.39
Citrus	3.5	-0.91	-2.64	2.59	0.86
Other fruits	3.5	-0.16	-1.45	3.35	2.05
Potatoes	1.5	0.90	0.09	2.40	1.59
Lettuce	1.5	1.02	-0.38	2.52	1.12
Tomatoes	1.5	0.22	-1.55	1.72	-0.05
Other veg.	1.5	1.66	0.27	3.16	1.77
Processed fruits/vegetables	3.5	-0.32	-1.15	3.18	2.35
Coffee and tea	2.0	0.78	-0.16	2.78	1.84
Carbonated drinks	2.0	0.66	-0.31	2.66	1.69

--continued

Table 7

Forecast changes in food consumption, 2011 to 2012, based on forecast changes in prices and expenditure, using alternative sets of elasticities of demand (continued)

	Forecast changes in prices and total expenditure	Predicted changes in food quantities based on		Predicted changes in expenditures based on	
		Unconditional elasticities[a]	Conditional elasticities[b]	Unconditional elasticities[a]	Conditional elasticities[b]
	Annual percentage change				
Nonfrozen noncarbonated drinks	2.0	1.06	-0.35	3.06	1.65
Frozen noncarbonated drinks	2.0	0.44	-0.22	2.44	1.78
Sugar and sweets	2.5	0.56	-2.06	3.06	0.44
Fats and oils	4.0	-0.07	-1.62	3.93	2.38
Soups	3.5	1.86	1.00	5.36	4.50
Frozen foods	3.5	0.63	-1.15	4.14	2.35
Snacks	3.5	-0.08	-1.59	3.42	1.91
Condiments, sauces, seasonings	3.5	-0.80	-2.20	2.70	1.30
Misc. food at home	3.5	-0.13	-2.28	3.37	1.22
Alcohol	3.0	-0.61	-1.93	2.39	1.07
Limited	3.0	-0.42	-1.09	2.58	1.91
Full	3.0	-0.49	-1.22	2.51	1.78
Other food away from home	3.0	-0.51	-1.30	2.49	1.70
Nonfood	1.8	-0.35	na	1.45	na

Notes: Forecast changes in food prices from 2011 to 2012 are based on forecast changes in Consumer Price Index for foods (U.S. Department of Agriculture, ERS, 2011); forecast changes in the nonfood price and total expenditure are based on the mean of reported predictions for 2012 by a sample of professional forecasters for core inflation and headline personal consumption expenditures (Federal Reserve Board of Philadelphia, 2011).

[a] The predictions based on the unconditional elasticities of demand use elasticities of demand reported in appendix table A.10.

[b] The predictions based on conditional elasticities of demand use elasticities reported in appendix tables A.3-A.9

Conclusion

Many studies have evaluated the effect of policy-induced price changes on food consumption and nutritional outcomes. Several studies have based their analysis on demand elasticities for only a subset of foods (i.e., conditional on expenditure for a particular group of foods), which ignores important cross-price relationships of foods not included in a given analysis. In particular, because FAFH comprises a significant share of total food expenditures and nutritional intake for an average American, disregarding the potential cross-price relationship between FAFH and another relevant subset of foods may lead to misleading results regarding nutrition and health policy.

This study is the first to present disaggregated estimates of demand elasticities for different types of FAFH within a complete demand system for food, alcohol, and nonfood. We find that the demand for full-service FAFH is much more price-elastic than the demand for food from limited-service restaurants. All of the disaggregated products within FAFH are much more responsive to changes in total expenditure than all of the FAH products. Hence, our findings suggest that decreases in total expenditure during the most recent recession had a much greater impact on demands for most FAFH products than for FAH products.

We also present disaggregated elasticities of demand for FAH products. The demands for products within any group can vary considerably in terms of responsiveness to price changes, aggregating groups in policy simulations masks important dissimilarities within food groups in terms of nutrient characteristics and responses to prices and total expenditure. In particular, the demands for products commonly deemed to be “healthy” (fruits and vegetables, nonwhite bread, fish and seafood) tend to be much less responsive to own-price changes compared with those commonly deemed to be “unhealthy” (e.g., white bread, cakes and cookies, frozen foods, snacks). Many of these “healthy” and “unhealthy” foods are found to have statistically significant substitution and complementary relationships within and among food groups, which complicates analysis that tries to predict the effects of policy-induced changes in prices and income on demands for foods and the nutritional outcomes of consumers. Consequently, forecasts of the changes of quantities of food based on estimates of conditional demand elasticities that ignore the total effects of intergroup substitution and complementarities differ substantially in magnitude and sometimes even direction from forecasts based on estimates of unconditional demand elasticities that include all goods and services.

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Appendix Tables

Appendix table A.1
Test for seasonal unit roots in monthly logarithmic transformation of price series

		Seasonal frequency (Tests of coefficients in HEGY test regression)						
		0	π	$\pi/2$	$2\pi/3$	$\pi/3$	$5\pi/6$	$\pi/6$
	Lag	$\pi_1=0$	$\pi_2=0$	$\pi_3=\pi_4=0$	$\pi_5=\pi_6=0$	$\pi_7=\pi_8=0$	$\pi_9=\pi_{10}=0$	$\pi_{11}=\pi_{12}=0$
Cereals and bakery	4	0.02	-2.65	8.53	7.95	9.47	5.04	10.01
Flour and flour mixes	0	-2.29	-2.97	11.00	13.36	14.47	11.56	15.34
Breakfast cereals	2	-1.16	-3.35	11.48	16.92	10.30	8.45	12.44
Rice and pasta	2	0.09	-3.26	8.25	10.55	10.03	7.58	15.71
Nonwhite bread	9	-2.47	-3.71	8.56	9.97	24.58	8.24	10.15
White bread	1	-3.21	-2.40	7.74	9.15	9.35	9.74	12.75
Biscuits, rolls, muffins	1	-2.25	-2.83	8.02	6.41	8.44	10.72	12.01
Cakes and cookies	9	-0.27	-2.05	9.22	10.54	6.09	4.00	11.29
Other bakery products	9	-4.22	-4.53	3.00	11.86	12.48	2.36	7.37
Meat and eggs	0	-2.90	-4.01	9.89	10.24	14.04	11.71	15.58
Beef	0	-1.78	-3.03	11.84	15.86	10.64	11.51	13.57
Pork	13	0.25	-4.73	2.18	1.88	16.39	17.95	7.60
Other red meat	1	-0.39	-4.03	12.40	9.15	11.68	13.17	6.24
Poultry	0	-3.74	-3.58	13.31	12.36	15.08	11.02	11.42
Fish	2	-3.80	-2.69	11.57	10.39	6.20	11.34	12.46
Eggs	3	-0.95	-3.25	9.53	6.41	7.47	5.75	9.09
Dairy	2	-3.45	-3.58	11.15	11.96	11.09	11.44	10.94
Cheese	4	-2.01	-2.41	13.71	8.40	6.43	11.22	4.91
Ice cream	6	-1.41	-2.84	3.67	8.82	8.10	10.20	10.00
Milk	0	-2.96	-3.81	11.39	17.07	14.23	13.66	16.79
Other dairy	2	-2.83	-2.62	13.24	17.77	15.54	9.62	13.85
Fruits and vegetables	6	-0.44	-4.51	4.99	5.88	2.25	9.35	4.42
Apples	4	-3.09	-3.21	14.39	9.51	9.72	9.33	11.70
Bananas	11	-1.01	-1.73	9.09	7.85	4.83	9.42	9.56
Citrus	9	-3.43	-1.14	7.35	6.85	2.53	13.18	9.54
Other fresh fruit	11	1.79	-4.73	13.94	13.13	7.55	6.99	6.13
Potatoes	2	-2.92	-2.22	12.67	13.27	11.36	7.68	9.86
Lettuce	16	-3.04	-2.62	18.27	4.74	5.88	27.88	11.35
Tomatoes	3	-2.28	-4.13	8.17	7.95	8.25	7.49	6.78
Other fresh vegetables	1	-0.93	-3.73	10.63	11.30	8.56	8.46	8.16
Proc. fruits & vegetables	1	-2.67	-2.40	6.40	8.07	11.16	12.39	13.92
Nonalcoholic beverages	2	-2.24	-2.64	8.23	10.71	9.65	9.96	12.60
Frozen noncarb. drinks	14	-1.14	-1.58	12.34	7.57	0.54	2.18	2.50
Nonfro noncarb. drinks	4	-4.27	-3.94	20.96	25.76	24.76	26.48	16.64

--continued

Appendix table A.1

Test for seasonal unit roots in monthly logarithmic transformation of price series (continued)

		Seasonal frequency (Tests of coefficients in HEGY test regression)						
	Lag	0 $\pi_1=0$	π $\pi_2=0$	$\pi/2$ $\pi_3=\pi_4=0$	$2\pi/3$ $\pi_5=\pi_6=0$	$\pi/3$ $\pi_7=\pi_8=0$	$5\pi/6$ $\pi_9=\pi_{10}=0$	$\pi/6$ $\pi_{11}=\pi_{12}=0$
Carbonated drinks	5	-2.97	-3.69	9.69	16.58	11.72	15.90	20.27
Coffee and tea	9	-3.20	-4.46	8.45	14.32	10.49	2.61	8.73
Sugar and sweets	6	-3.01	-4.33	4.70	3.10	6.18	16.72	4.44
Fats and oils	10	-0.18	-2.82	13.96	7.25	9.36	7.68	4.58
Miscellaneous foods	4	1.72	-3.52	7.66	13.71	8.45	8.99	9.21
Soups	4	-3.44	-3.81	13.07	12.57	17.02	9.07	12.30
Frozen foods	7	-2.53	-3.18	9.42	9.01	8.34	12.96	13.74
Snacks	3	0.03	-2.95	22.36	12.73	11.22	10.66	7.80
Cond., sauces, seas.	2	-2.17	-4.23	4.30	6.54	4.63	13.02	3.59
Other miscellaneous	5	-3.20	-3.09	13.26	8.87	12.24	17.81	7.91
Other FAFH	4	-3.83	-4.53	14.75	17.73	19.15	18.28	26.08
Limited-service FAFH	5	-1.62	-3.44	7.23	7.50	10.40	5.77	8.67
Full-service FAFH	6	-3.50	-3.29	12.70	13.89	8.21	16.55	7.78
Alcoholic beverages	25	-1.04	-4.83	6.44	2.82	1.16	4.38	0.92
Nonfood	4	-2.13	-3.28	10.61	9.89	11.83	11.44	6.13

Note: The HEGY test regressions included a trend, constant, and lagged dependent variables. Beaulieu and Miron (1993) derived the critical values from the distributions of the HEGY test statistics for monthly data. The critical values for the test regression with a trend and a constant and 240 observations for a 10-percent level of significance are:

-2.99 for the test of the null hypothesis $\pi_1 = 0$ versus the alternative $\pi_1 < 0$ (test of long-run unit root), -2.47 for the test of the null hypothesis $\pi_2 = 0$ versus the alternative $\pi_2 < 0$ (test of unit root corresponding to a biannual cycle), and 5.25 for the joint test of the null hypothesis $\pi_n = \pi_{n-1} = 0$, n = 2, 6, 8, 10, 12 (test of unit root corresponding to seasonal frequencies $\pi/2$, $2\pi/3$, $\pi/3$, $5\pi/6$ and $\pi/6$).

FAFH = Food away from home.

Source: Authors' calculation of HEGY test for monthly data using logarithmic transformation of consumer price indexes (U.S. Department of Labor, BLS, Consumer Expenditure Survey (2010a); U.S. Department of Labor, BLS, Consumer Price Index Database (2010c)).

Appendix table A.2
Test for seasonal unit roots in monthly expenditure share series

		Seasonal frequency (Tests of coefficients in HEGY test regression)						
		0	π	$\pi/2$	$2\pi/3$	$\pi/3$	$5\pi/6$	$\pi/6$
	Lag	$\pi_1=0$	$\pi_2=0$	$\pi_3=\pi_4=0$	$\pi_5=\pi_6=0$	$\pi_7=\pi_8=0$	$\pi_9=\pi_{10}=0$	$\pi_{11}=\pi_{12}=0$
Cereals and bakery	6	-1.18	-1.69	12.24	6.72	3.73	12.05	8.98
Flour and flour mixes	3	0.93	-0.46	1.73	0.51	1.73	0.77	3.06
Breakfast cereals	7	-1.28	-3.01	0.89	4.37	1.58	4.47	1.20
Rice and pasta	8	-3.09	-3.61	1.21	9.57	2.30	9.15	2.06
Nonwhite bread	15	-0.10	-0.56	0.90	1.46	15.48	2.44	1.88
White bread	1	-0.38	-1.89	8.31	4.81	8.43	11.01	5.11
Biscuits, rolls, muffins	3	-1.49	-1.58	13.80	3.34	5.82	2.57	3.68
Cakes and cookies	6	-3.99	-4.54	14.01	5.09	1.49	10.63	2.65
Other bakery products	17	-2.39	-2.38	0.41	1.69	0.06	0.78	0.28
Meat and eggs	3	-2.90	-4.08	14.16	12.22	9.98	8.24	10.49
Beef	8	-1.86	-1.57	1.57	4.72	4.50	7.03	2.11
Pork	3	-2.32	-1.92	1.85	1.38	5.49	3.55	0.85
Other red meat	3	-1.61	-2.42	9.23	16.00	3.01	13.89	2.05
Poultry	11	-0.53	0.15	0.20	0.98	0.18	0.26	0.05
Fish	4	-2.64	-3.05	11.29	4.07	4.92	6.18	3.17
Eggs	2	-0.77	-3.08	7.97	10.58	10.26	9.18	2.82
Dairy	3	-1.98	-2.58	4.65	7.84	7.88	5.58	2.67
Cheese	9	-4.81	-1.34	2.33	5.59	3.61	1.50	0.02
Ice cream	7	-2.98	-2.70	6.71	7.67	4.10	17.46	0.35
Milk	13	-4.37	-3.31	8.01	1.41	2.83	11.63	0.91
Other dairy	2	-4.11	-4.39	10.89	7.16	6.56	10.28	8.06
Fruits and vegetables	1	-0.45	-2.01	14.98	8.27	4.12	19.85	5.78
Apples	11	-4.02	-1.56	1.90	4.21	0.58	8.55	0.51
Bananas	2	1.83	-1.29	2.28	5.03	2.26	3.02	0.78
Citrus	4	2.42	-1.37	3.57	0.42	1.53	2.88	2.97
Other fresh fruit	4	1.15	-2.33	1.43	1.78	0.67	6.82	0.86
Potatoes	0	-1.81	-3.65	10.34	10.50	5.02	9.07	2.36
Lettuce	9	-1.51	-0.96	1.36	7.56	0.82	6.24	3.52
Tomatoes	2	-2.41	-3.64	3.57	4.71	4.84	3.14	4.08
Other fresh vegetables	4	-1.31	-3.12	5.96	6.27	4.60	3.18	2.67
Proc. fruits & vegetables	9	0.09	-0.49	8.39	1.09	0.50	2.88	0.37
Nonalcoholic beverages	1	-2.53	-2.75	12.28	11.49	3.96	8.52	7.36
Frozen noncarb. drinks	5	-0.40	-3.49	8.56	1.86	9.00	8.01	13.40
Nonfro. noncarb. drinks	7	0.53	-3.39	5.19	4.14	1.86	4.08	0.13
Carbonated drinks	4	-2.77	-2.92	10.96	2.36	5.74	5.09	9.65
Coffee and tea	4	0.19	-1.62	6.93	2.72	1.99	6.94	1.07
Sugar and sweets	3	-1.98	-2.78	3.32	5.38	2.52	1.40	1.10
Fats and oils	3	1.06	-2.42	3.47	3.25	3.06	4.77	3.56

--continued

Appendix table A.2

Test for seasonal unit roots in monthly expenditure share series (continued)

		Seasonal frequency (Tests of coefficients in HEGY test regression)						
	Lag	0 $\pi_1=0$	π $\pi_2=0$	$\pi/2$ $\pi_3=\pi_4=0$	$2\pi/3$ $\pi_5=\pi_6=0$	$\pi/3$ $\pi_7=\pi_8=0$	$5\pi/6$ $\pi_9=\pi_{10}=0$	$\pi/6$ $\pi_{11}=\pi_{12}=0$
Miscellaneous foods	4	1.73	-1.85	2.42	1.72	1.74	1.79	0.57
Soups	2	-0.67	-1.09	2.59	2.57	0.84	1.82	1.12
Frozen foods	3	0.85	-1.45	2.29	3.56	4.60	4.02	2.49
Snacks	1	-0.55	-2.44	8.03	9.12	9.89	9.95	6.60
Condiments, sauces, seasonings	2	-2.03	-1.77	2.48	2.81	1.58	2.91	2.47
Other miscellaneous	6	-2.33	-1.57	3.55	2.01	2.51	9.52	0.59
Other FAFH	1	-1.94	-4.40	9.06	11.84	3.05	14.89	2.63
Limited-service FAFH	8	-1.44	-2.91	3.55	0.90	5.50	10.53	1.52
Full-service FAFH	5	-3.60	-1.11	9.09	7.23	10.53	13.76	1.15
Alcoholic beverages	11	-3.44	-1.21	1.55	5.82	0.43	2.14	0.32
Nonfood	2	-3.46	-3.92	10.41	9.55	4.48	12.57	4.06

Note: See notes to table A.1.

Source: Authors' calculation of HEGY test for monthly data using aggregated average monthly household expenditures (U.S. Department of Labor, BLS, Consumer Expenditure Survey (2010a); U.S. Department of Labor, BLS, Consumer Price Index Database (2010c)).

Appendix table A.3

Second-stage estimated elasticities of demand for cereals and bakery products based on the GODDS model, 1998-2010

Demand for	With respect to price of								With respect to cereals and bakery expenditure	R^2	Breusch-Godfrey statistic	Constant
	Flour and prepared flour mixes	Break-fast cereals	Rice and pasta	Non-white bread	White bread	Biscuits, rolls, and muf-fins	Cakes and cookies	Other bakery				
Flour and prepared mixes	0.07	1.20	0.93	-1.96	-0.37	-0.39	-0.98	-0.33	1.82	0.21	1.27	--0.0022
	(0.60)	(0.62)	(0.52)	(0.45)	(0.49)	(0.60)	(0.95)	(0.70)	(0.21)			(0.0008)
Breakfast cereals	0.33	-1.13	-0.09	-0.10	-0.06	0.09	0.50	-0.22	0.68	0.11	0.29	0.0039
	(0.14)	(0.31)	(0.18)	(0.15)	(0.16)	(0.20)	(0.37)	(0.25)	(0.09)			(0.0016)
Rice and pasta	0.41	-0.34	-0.08	-0.10	-0.36	0.20	-0.43	-0.91	1.62	0.21	9.13	-0.0012
	(0.22)	(0.34)	(0.34)	(0.21)	(0.23)	(0.28)	(0.47)	(0.35)	(0.15)			(0.0013)
Non-white bread	-0.71	-0.17	-0.00	-0.64	0.56	-0.09	0.30	0.04	0.72	0.17	0.73	0.0000
	(0.18)	(0.25)	(0.19)	(0.28)	(0.24)	(0.27)	(0.40)	(0.29)	(0.08)			(0.0008)
White bread	-0.18	-0.23	-0.42	0.77	-1.57	-0.09	0.56	0.01	1.16	0.03	13.89	0.0006
	(0.28)	(0.41)	(0.30)	(0.36)	(0.50)	(0.45)	(0.62)	(0.45)	(0.13)			(0.0009)
Biscuits, rolls, and muffins	-0.14	0.16	0.31	-0.11	-0.05	-0.25	-1.00	0.30	0.77	0.05	0.01	-0.0002
	(0.29)	(0.41)	(0.31)	(0.33)	(0.37)	(0.62)	(0.64)	(0.47)	(0.12)			(0.0011)
Cakes and cook-ies	-0.21	0.44	-0.20	0.14	0.24	-0.55	-1.27	0.24	1.18	0.07	2.80	-0.0005
	(0.23)	(0.40)	(0.27)	(0.25)	(0.27)	(0.33)	(0.74)	(0.43)	(0.12)			(0.0020)
Other bakery	-0.03	-0.24	-0.38	0.01	0.03	0.13	0.27	-0.63	0.85	na	na	na
	(0.15)	(0.23)	(0.17)	(0.16)	(0.17)	(0.21)	(0.38)	(0.35)	(0.08)			

Notes: Estimated elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 and the Breusch-Godfrey statistic are for the individual equations and Breusch-Godfrey statistic is distributed $\chi^2(1)$, for which the 10% critical value is 2.71.
Source: Authors' calculations using iterated feasible generalized least squares (GLS, Stata version 11) with homogeneity and symmetry constraints imposed.
GODDS = Generalized Ordinary Differential Demand System.

Appendix table A.4
Second-stage estimated elasticities of demand for meat based on the GODDS model, 1998-2010

Demand for	With respect to price of						With respect to meat expenditure	R^2	Breusch-Godfrey statistic	Constant
	Beef	Pork	Other meat	Poultry	Fish	Eggs				
Beef	-0.93	0.15	-0.10	-0.17	-0.23	-0.05	1.34	0.18	3.54	0.0009
	(0.19)	(0.14)	(0.12)	(0.11)	(0.13)	(0.03)	(0.07)			(0.0022)
Pork	0.30	-1.40	0.09	0.13	-0.16	-0.03	1.08	0.05	4.61	0.0018
	(0.20)	(0.23)	(0.17)	(0.15)	(0.17)	(0.04)	(0.07)			(0.0016)
Other red meat	-0.02	0.23	-1.12	-0.13	0.50	-0.10	0.63	0.13	0.28	-0.0012
	(0.26)	(0.26)	(0.41)	(0.27)	(0.29)	(0.06)	(0.09)			(0.0013)
Poultry	-0.11	0.21	-0.11	-0.92	0.15	0.01	0.77	0.10	2.51	0.0013
	(0.19)	(0.17)	(0.20)	(0.24)	(0.18)	(0.04)	(0.06)			(0.0013)
Fish	-0.34	-0.19	0.40	0.16	-0.94	-0.02	0.93	0.04	1.34	-0.0019
	(0.25)	(0.23)	(0.26)	(0.22)	(0.31)	(0.05)	(0.10)			(0.0017)
Eggs	-0.14	-0.07	-0.27	0.05	-0.02	-0.26	0.72	na	na	na
	(0.19)	(0.17)	(0.16)	(0.15)	(0.16)	(0.06)	(0.08)			

Notes: Estimated elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 and the Breusch-Godfrey statistic are for the individual equations and Breusch-Godfrey statistic is distributed $\chi^2(1)$, for which the 10% critical value is 2.71.
Source: Authors' calculations using iterated feasible generalized least squares (GLS, Stata version 11) with homogeneity and symmetry constraints imposed.

Appendix table A.5
Second-stage estimated elasticities of demand for dairy based on the GODDS model, 1998-2010

Demand for	With respect to price of				With respect to dairy expenditure	R^2	Breusch-Godfrey statistic	Constant
	Cheese	Ice cream and frozen desserts	Milk	Other dairy				
Cheese	-1.02	-0.14	-0.31	0.26	1.21	0.08	1.73	-0.0017
	(0.21)	(0.12)	(0.10)	(0.17)	(0.08)			(0.0017)
Ice cream and related products	-0.25	-0.43	-0.53	0.04	1.18	0.23	0.00	0.0027
	(0.22)	(0.23)	(0.14)	(0.27)	(0.13)			(0.0014)
Milk	-0.14	-0.18	-0.32	-0.15	0.79	0.38	8.79	0.0028
	(0.09)	(0.06)	(0.08)	(0.08)	(0.07)			(0.0016)
Other dairy	0.69	0.10	-0.40	-1.25	0.85	na	na	na
	(0.37)	(0.32)	(0.21)	(0.52)	(0.17)			

Notes: Estimated elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 and the Breusch-Godfrey statistic are for the individual equations and Breusch-Godfrey statistic is distributed $\chi^2(1)$, for which the 10% critical value is 2.71.
Source: Authors' calculations using iterated feasible generalized least squares (GLS, Stata version 11) with homogeneity and symmetry constraints imposed.

Appendix table A.6

Second-stage estimated elasticities of demand for fruits and vegetables based on the GODDS model, 1998-2010

Demand for	With respect to price of									With respect to fruit/veg. expenditure	R^2	Breusch-Godfrey statistic	Constant
	Apples	Ba-nanas	Citrus	Other fruits	Pota-toes	Let-tuce	Toma-toes	Other veg.	Processed fruits/ vegetables				
Apples	-0.60	-0.03	0.02	-0.11	-0.11	0.03	-0.05	0.21	-0.13	0.77	0.06	0.01	0.0008
	(0.14)	(0.11)	(0.08)	(0.15)	(0.10)	(0.06)	(0.07)	(0.16)	(0.20)	(0.12)			(0.0007)
Bananas	-0.07	-1.01	-0.11	0.06	0.01	-0.14	-0.05	0.12	-0.05	1.24	0.05	3.04	0.0004
	(0.11)	(0.19)	(0.08)	(0.15)	(0.11)	(0.06)	(0.07)	(0.17)	(0.25)	(0.11)			(0.0006)
Citrus	-0.03	-0.10	-1.09	-0.15	-0.10	0.00	0.10	0.05	-0.09	1.41	0.17	0.98	-0.0008
	(0.07)	(0.07)	(0.09)	(0.13)	(0.07)	(0.04)	(0.06)	(0.12)	(0.15)	(0.12)			(0.0007)
Other fruits	-0.06	0.04	-0.04	-0.93	0.03	-0.05	-0.09	-0.11	0.17	1.03	0.00	34.64	-0.0006
	(0.06)	(0.06)	(0.06)	(0.14)	(0.06)	(0.04)	(0.05)	(0.10)	(0.13)	(0.10)			(0.0014)
Potatoes	-0.11	0.04	-0.07	0.14	-0.45	-0.02	0.10	-0.35	-0.03	0.75	0.17	1.38	0.0007
	(0.11)	(0.11)	(0.08)	(0.15)	(0.14)	(0.06)	(0.07)	(0.16)	(0.21)	(0.12)			(0.0007)
Lettuce	0.02	-0.17	0.03	-0.16	-0.04	-0.85	0.05	0.12	-0.01	1.01	0.05	1.41	-0.0001
	(0.08)	(0.08)	(0.07)	(0.13)	(0.08)	(0.07)	(0.06)	(0.13)	(0.16)	(0.10)			(0.0004)
Tomatoes	-0.10	-0.06	0.11	-0.29	0.05	0.01	-0.57	0.00	-0.58	1.43	0.28	1.34	0.0002
	(0.07)	(0.07)	(0.06)	(0.12)	(0.07)	(0.04)	(0.08)	(0.12)	(0.15)	(0.12)			(0.0007)
Other vegetables	0.06	0.05	0.05	-0.09	-0.14	0.03	0.03	-0.98	-0.03	1.01	0.02	6.88	0.0010
	(0.06)	(0.06)	(0.05)	(0.09)	(0.05)	(0.03)	(0.04)	(0.12)	(0.12)	(0.08)			(0.0012)
Processed fruits/ vegetables	-0.04	0.02	0.02	0.18	-0.01	0.01	-0.13	0.03	-0.84	0.77	na	na	na
	(0.06)	(0.07)	(0.05)	(0.09)	(0.06)	(0.03)	(0.04)	(0.09)	(0.16)	(0.09)			

Notes: Estimated elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 and the Breusch-Godfrey statistic are for the individual equations and Breusch-Godfrey statistic is distributed $\chi^2(1)$, for which the 10% critical value is 2.71.

Source: Authors' calculations using iterated feasible generalized least squares (GLS, Stata version 11) with homogeneity and symmetry constraints imposed.

Appendix table A.7

Second-stage estimated elasticities of demand for nonalcoholic beverages based on the GODDS (Generalized Ordinary Differential Demand System) model, 1998-2010

Demand for	With respect to price of: Coffee and tea	Carbonated beverages	Nonfrozen noncarbonated juices and drinks	Frozen noncarbonated juices and drinks	With respect to nonalcoholic beverage expenditure	R^2	Constant
Coffee and tea	-0.17	-0.07	-0.31	-0.01	0.56	0.25	-0.0042
	(0.26)	(0.31)	(0.30)	(0.08)	(0.14)		(0.0017)
Carbonated beverages	-0.12	-0.58	-0.37	0.01	1.06	0.01	0.0074
	(0.15)	(0.34)	(0.30)	(0.07)	(0.09)		(0.0024)
Nonfrozen noncarbonated juices and drinks	-0.22	-0.31	-0.61	0.01	1.13	0.18	-0.0048
	(0.11)	(0.23)	(0.27)	(0.07)	(0.07)		(0.0024)
Frozen noncarbonated juices and drinks	-0.14	0.25	0.38	-1.37	0.88	na	na
	(0.59)	(1.11)	(1.36)	(0.91)	(0.33)		

Notes: Estimated elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 values are for the individual equations.
Source: Authors' calculations using iterated feasible generalized least squares (GLS, Stata version 11) with homogeneity and symmetry constraints imposed and with correction for first-order autocorrelation.

Appendix table A.8

Second-stage estimated elasticities of demand for other FAH based on the GODDS model, 1998-2010

Demand for	With respect to price of: Sugar and sweets	Fats and oils	Soups	Frozen foods	Snacks	Condiments, sauces, seasonings	Miscel-laneous	With respect to other FAH expenditure	R^2	Breusch-Godfrey statistic	Constant
Sugar and sweets	-0.47	-0.06	-0.70	-0.75	0.02	0.63	-0.06	1.39	0.08	0.41	0.0086
	(0.73)	(0.23)	(0.23)	(0.46)	(0.14)	(0.35)	(0.56)	(0.18)			(0.0028)
Fats and oils	0.04	-0.24	-0.19	-0.24	0.02	0.06	-0.27	0.83	0.19	2.06	0.0037
	(0.25)	(0.16)	(0.10)	(0.22)	(0.06)	(0.14)	(0.25)	(0.10)			(0.0013)
Soups	-2.05	-0.48	0.18	0.96	0.05	0.30	0.59	0.45	0.04	0.01	-0.0018
	(0.72)	(0.28)	(0.56)	(0.68)	(0.27)	(0.58)	(0.67)	(0.18)			(0.0009)
Frozen foods	-0.74	-0.26	0.30	-1.06	-0.23	0.07	0.95	0.96	0.05	0.75	-0.0038
	(0.50)	(0.22)	(0.24)	(0.62)	(0.14)	(0.35)	(0.47)	(0.14)			(0.0021)
Snacks	0.22	0.11	0.07	-1.01	-1.15	1.06	-0.10	0.81	0.04	1.31	0.0000
	(0.70)	(0.27)	(0.42)	(0.65)	(0.47)	(0.60)	(0.60)	(0.16)			(0.0005)
Condiments, sauces, seasonings	0.89	0.08	0.10	0.12	0.26	-1.95	-0.25	0.75	0.12	0.80	0.0008
	(0.42)	(0.16)	(0.22)	(0.39)	(0.15)	(0.44)	(0.37)	(0.10)			(0.0013)
Miscellaneous	-0.01	-0.27	0.11	0.69	-0.03	-0.24	-1.44	1.18	na	na	na
	(0.46)	(0.18)	(0.18)	(0.36)	(0.10)	(0.25)	(0.55)	(0.14)			

Notes: Estimated elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 and the Breusch-Godfrey statistic are for the individual equations and Breusch-Godfrey statistic is distributed $\chi^2(1)$, for which the 10% critical value is 2.71.
Source: Authors' calculations using iterated feasible GLS (Stata version 11) with homogeneity and symmetry constraints imposed.

Appendix table A.9

Second-stage estimated elasticities of demand for FAFH (food away from home) and alcohol based on the GODDS model, 1998-2010

Demand for	With respect to price of				With respect to FAFH and alcohol expenditure	R^2	Breusch-Godfrey statistic	Constant
	Alcohol	Limited-service	Full-service	Other FAFH				
Alcohol	-1.13	-2.39	2.17	-0.16	1.53	0.10	6.24	-0.0021
	(0.63)	(0.66)	(0.74)	(0.12)	(0.16)			(0.0020)
Limited-service	-0.89	-0.26	0.31	-0.00	0.84	0.15	4.25	0.0057
	(0.27)	(0.94)	(0.95)	(0.06)	(0.07)			(0.0024)
Full-service	0.92	0.24	-2.08	-0.02	0.94	0.08	21.87	-0.0054
	(0.29)	(0.88)	(0.96)	(0.06)	(0.08)			(0.0027)
Other FAFH	-0.31	-0.06	-0.17	-0.45	0.98	na	na	na
	(0.37)	(0.32)	(0.21)	(0.52)	(0.17)			

Notes: Estimated elasticities of demand were computed at the mean of the data. Standard errors were bootstrapped using the residual method. Total expenditure includes expenditures on durable and nondurable goods and services. The R^2 and the Breusch-Godfrey statistic are for the individual equations and Breusch-Godfrey statistic is distributed $\chi^2(1)$, for which the 10% critical value is 2.71.

Source: Authors' calculations using iterated feasible GLS (Stata version 11) with homogeneity and symmetry constraints imposed.

FAFH = Food away from home, including limited-service and full-service restaurants; FAH = Food at home; GODDS = Generalized Ordinary Differential Demand System.

Appendix table A.10`
Estimated unconditional elasticities of demand

Demand for	With respect to price of							
	Flour, prep. mixes	Breakfast cereals	Rice and pasta	Nonwhite bread	White bread	Biscuits, rolls, muff.	Cakes and cookies	Other bakery products
Flour, prep. mixes	0.07	1.41	0.94	-1.84	-0.32	-0.30	-0.88	-0.14
	(0.71)	(0.67)	(0.56)	(0.51)	(0.58)	(0.68)	(1.09)	(0.74)
Breakfast cereals	0.32	-1.05	-0.08	-0.05	-0.04	0.12	0.54	-0.15
	(0.15)	(0.33)	(0.19)	(0.17)	(0.18)	(0.21)	(0.40)	(0.25)
Rice and pasta	0.41	-0.15	-0.07	0.00	-0.31	0.28	-0.34	-0.75
	(0.24)	(0.36)	(0.38)	(0.22)	(0.27)	(0.30)	(0.53)	(0.36)
Nonwhite bread	-0.72	-0.09	0.00	-0.59	0.58	-0.05	0.34	0.11
	(0.20)	(0.28)	(0.20)	(0.30)	(0.28)	(0.31)	(0.45)	(0.31)
White bread	-0.18	-0.10	-0.42	0.84	-1.54	-0.04	0.63	0.13
	(0.33)	(0.44)	(0.35)	(0.41)	(0.58)	(0.54)	(0.69)	(0.47)
Biscuits, rolls, muff.	-0.14	0.25	0.31	-0.06	-0.03	-0.21	-0.95	0.38
	(0.33)	(0.44)	(0.34)	(0.38)	(0.45)	(0.71)	(0.72)	(0.47)
Cakes and cookies	-0.22	0.57	-0.19	0.21	0.27	-0.49	-1.20	0.36
	(0.27)	(0.43)	(0.30)	(0.28)	(0.30)	(0.37)	(0.81)	(0.42)
Other bakery	-0.03	-0.14	-0.37	0.06	0.05	0.17	0.31	-0.55
	(0.16)	(0.23)	(0.18)	(0.17)	(0.18)	(0.21)	(0.37)	(0.34)
Beef	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Pork	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Other red meat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)
Fish	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of Beef	Pork	Other red meat	Poultry	Fish	Eggs	Cheese	Ice cream and frozen desserts	Milk
Flour, prep. mixes	0.04	0.02	0.01	0.01	0.01	0.00	0.24	0.13	0.19
	(0.09)	(0.05)	(0.02)	(0.03)	(0.03)	(0.01)	(0.07)	(0.04)	(0.06)
Breakfast cereals	0.01	0.01	0.00	0.01	0.00	0.00	0.09	0.05	0.07
	(0.03)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.03)	(0.01)	(0.02)
Rice and pasta	0.03	0.02	0.01	0.01	0.01	0.00	0.22	0.12	0.17
	(0.08)	(0.04)	(0.02)	(0.03)	(0.03)	(0.01)	(0.06)	(0.03)	(0.05)
Nonwhite bread	0.01	0.01	0.00	0.01	0.01	0.00	0.10	0.05	0.08
	(0.04)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.03)	(0.01)	(0.02)
White bread	0.02	0.01	0.01	0.01	0.01	0.00	0.15	0.08	0.12
	(0.06)	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.05)	(0.03)	(0.03)
Biscuits, rolls, muff.	0.02	0.01	0.00	0.01	0.01	0.00	0.10	0.06	0.08
	(0.04)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.03)	(0.02)	(0.02)
Cakes and cookies	0.02	0.01	0.01	0.01	0.01	0.00	0.16	0.08	0.12
	(0.06)	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.05)	(0.03)	(0.04)
Other bakery	0.02	0.01	0.00	0.01	0.01	0.00	0.11	0.06	0.09
	(0.04)	(0.02)	(0.01)	(0.02)	(0.02)	(0.00)	(0.03)	(0.02)	(0.02)
Beef	-0.70	0.33	0.04	0.01	-0.09	0.00	0.01	0.01	0.01
	(0.20)	(0.15)	(0.11)	(0.12)	(0.12)	(0.03)	(0.03)	(0.01)	(0.02)
Pork	0.48	-1.26	0.20	0.28	-0.05	0.01	0.01	0.01	0.01
	(0.21)	(0.26)	(0.18)	(0.18)	(0.17)	(0.04)	(0.02)	(0.01)	(0.02)
Other red meat	0.09	0.32	-1.05	-0.04	0.56	-0.07	0.01	0.00	0.00
	(0.26)	(0.28)	(0.42)	(0.30)	(0.29)	(0.07)	(0.01)	(0.01)	(0.01)
Poultry	0.02	0.31	-0.03	-0.81	0.23	0.04	0.01	0.00	0.01
	(0.19)	(0.20)	(0.22)	(0.28)	(0.19)	(0.04)	(0.02)	(0.01)	(0.01)
Fish	-0.18	-0.06	0.50	0.28	-0.84	0.02	0.01	0.00	0.01
	(0.24)	(0.24)	(0.25)	(0.23)	(0.30)	(0.06)	(0.02)	(0.01)	(0.01)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of								
	Other dairy	Apples	Bananas	Citrus	Other fresh fruits	Potatoes	Lettuce	Tomatoes	Other fresh vegetable
Flour, prep. mixes	0.08	-0.03	-0.05	-0.06	-0.10	-0.03	-0.03	-0.06	-0.11
	(0.03)	(0.01)	(0.02)	(0.03)	(0.05)	(0.01)	(0.01)	(0.03)	(0.05)
Breakfast cereals	0.03	-0.01	-0.02	-0.02	-0.04	-0.01	-0.01	-0.02	-0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Rice and pasta	0.07	-0.03	-0.04	-0.06	-0.09	-0.03	-0.02	-0.05	-0.10
	(0.02)	(0.01)	(0.02)	(0.03)	(0.04)	(0.01)	(0.01)	(0.02)	(0.05)
Nonwhite bread	0.03	-0.01	-0.02	-0.02	-0.04	-0.01	-0.01	-0.02	-0.04
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
White bread	0.05	-0.02	-0.03	-0.04	-0.06	-0.02	-0.02	-0.04	-0.07
	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)	(0.03)
Biscuits, rolls, muff.	0.04	-0.01	-0.02	-0.03	-0.04	-0.01	-0.01	-0.02	-0.05
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Cakes and cookies	0.05	-0.02	-0.03	-0.04	-0.07	-0.02	-0.02	-0.04	-0.07
	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)	(0.03)
Other bakery	0.04	-0.01	-0.02	-0.03	-0.05	-0.01	-0.01	-0.03	-0.05
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Beef	0.00	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.03
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)
Pork	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Other red meat	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Poultry	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.01	0.02
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Fish	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.02
	(0.01)	(0.00)	(0.01)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of								
	Processed fruits and vegetables	Coffee and tea	Carbonated beverages	Non-carbonated beverages	Frozen beverages	Sugar and sweets	Fats and oils	Soups	Snacks
Flour, prep. mixes	-0.10	-0.02	-0.06	-0.09	0.00	0.12	0.06	0.01	0.01
	(0.05)	(0.03)	(0.12)	(0.17)	(0.01)	(0.16)	(0.09)	(0.02)	(0.02)
Breakfast cereals	-0.04	-0.01	-0.02	-0.03	0.00	0.04	0.02	0.00	0.01
	(0.02)	(0.01)	(0.04)	(0.06)	(0.00)	(0.06)	(0.03)	(0.01)	(0.01)
Rice and pasta	-0.09	-0.02	-0.06	-0.08	0.00	0.10	0.06	0.01	0.01
	(0.04)	(0.03)	(0.11)	(0.15)	(0.01)	(0.15)	(0.08)	(0.02)	(0.02)
Nonwhite bread	-0.04	-0.01	-0.03	-0.03	0.00	0.05	0.02	0.00	0.01
	(0.02)	(0.01)	(0.05)	(0.07)	(0.00)	(0.06)	(0.03)	(0.01)	(0.01)
White bread	-0.06	-0.01	-0.04	-0.06	0.00	0.07	0.04	0.01	0.01
	(0.03)	(0.02)	(0.08)	(0.11)	(0.00)	(0.10)	(0.06)	(0.01)	(0.01)
Biscuits, rolls, muff.	-0.04	-0.01	-0.03	-0.04	0.00	0.05	0.03	0.01	0.01
	(0.02)	(0.01)	(0.05)	(0.07)	(0.00)	(0.07)	(0.04)	(0.01)	(0.01)
Cakes and cookies	-0.07	-0.01	-0.04	-0.06	0.00	0.08	0.04	0.01	0.01
	(0.03)	(0.02)	(0.08)	(0.11)	(0.00)	(0.11)	(0.06)	(0.01)	(0.01)
Other bakery	-0.05	-0.01	-0.03	-0.04	0.00	0.05	0.03	0.01	0.01
	(0.02)	(0.01)	(0.06)	(0.08)	(0.00)	(0.08)	(0.04)	(0.01)	(0.01)
Beef	0.03	0.01	0.04	0.05	0.00	0.09	0.05	0.01	0.01
	(0.02)	(0.01)	(0.02)	(0.03)	(0.00)	(0.04)	(0.02)	(0.01)	(0.01)
Pork	0.02	0.01	0.03	0.04	0.00	0.07	0.04	0.01	0.01
	(0.02)	(0.00)	(0.02)	(0.03)	(0.00)	(0.03)	(0.02)	(0.00)	(0.00)
Other red meat	0.01	0.00	0.02	0.03	0.00	0.04	0.02	0.00	0.00
	(0.01)	(0.00)	(0.01)	(0.02)	(0.00)	(0.02)	(0.01)	(0.00)	(0.00)
Poultry	0.01	0.01	0.02	0.03	0.00	0.05	0.03	0.01	0.01
	(0.01)	(0.00)	(0.01)	(0.02)	(0.00)	(0.03)	(0.01)	(0.00)	(0.00)
Fish	0.02	0.01	0.03	0.04	0.00	0.06	0.03	0.01	0.01
	(0.02)	(0.00)	(0.02)	(0.02)	(0.00)	(0.03)	(0.02)	(0.00)	(0.00)

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of: Condiments, sauces, season.	Miscella-neous FAH	Alcoholic beverages	Limited-service FAFH	Full-service FAFH	Other FAFH	Nonfood	With respect to expenditure
Flour, prep. mixes	0.05	0.12	0.07	0.09	0.11	0.02	0.30	0.01
	(0.07)	(0.16)	(0.17)	(0.22)	(0.27)	(0.05)	(0.61)	(0.08)
Breakfast cereals	0.02	0.04	0.03	0.03	0.04	0.01	0.11	0.00
	(0.03)	(0.06)	(0.06)	(0.08)	(0.10)	(0.02)	(0.23)	(0.03)
Rice and pasta	0.05	0.11	0.06	0.08	0.10	0.02	0.26	0.01
	(0.06)	(0.14)	(0.15)	(0.20)	(0.24)	(0.04)	(0.54)	(0.08)
Nonwhite bread	0.02	0.05	0.03	0.04	0.04	0.01	0.12	0.00
	(0.03)	(0.06)	(0.07)	(0.09)	(0.11)	(0.02)	(0.24)	(0.03)
White bread	0.03	0.08	0.04	0.06	0.07	0.01	0.19	0.01
	(0.05)	(0.10)	(0.11)	(0.14)	(0.17)	(0.03)	(0.39)	(0.05)
Biscuits, rolls, muff.	0.02	0.05	0.03	0.04	0.05	0.01	0.13	0.00
	(0.03)	(0.07)	(0.07)	(0.10)	(0.12)	(0.02)	(0.26)	(0.04)
Cakes and cookies	0.03	0.08	0.04	0.06	0.07	0.01	0.19	0.01
	(0.05)	(0.11)	(0.11)	(0.14)	(0.18)	(0.03)	(0.39)	(0.05)
Other bakery	0.02	0.06	0.03	0.04	0.05	0.01	0.14	0.00
	(0.03)	(0.08)	(0.08)	(0.10)	(0.13)	(0.02)	(0.28)	(0.04)
Beef	0.04	0.09	0.06	0.07	0.09	0.01	-0.54	0.05
	(0.02)	(0.04)	(0.11)	(0.14)	(0.18)	(0.03)	(0.60)	(0.09)
Pork	0.03	0.07	0.04	0.06	0.07	0.01	-0.43	0.04
	(0.02)	(0.03)	(0.09)	(0.11)	(0.14)	(0.02)	(0.48)	(0.07)
Other red meat	0.02	0.04	0.03	0.03	0.04	0.01	-0.25	0.02
	(0.01)	(0.02)	(0.05)	(0.07)	(0.08)	(0.01)	(0.29)	(0.04)
Poultry	0.02	0.05	0.03	0.04	0.05	0.01	-0.31	0.03
	(0.01)	(0.02)	(0.06)	(0.08)	(0.10)	(0.02)	(0.35)	(0.05)
Fish	0.03	0.06	0.04	0.05	0.06	0.01	-0.37	0.03
	(0.01)	(0.03)	(0.08)	(0.10)	(0.12)	(0.02)	(0.42)	(0.06)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand

Demand for	With respect to price of Flour, prep. mixes	Breakfast cereals	Rice and pasta	Non-white bread	White bread	Biscuits, rolls, muff.	Cakes and cookies	Other bakery products	Beef
Eggs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.20)
Cheese	0.05	0.07	0.09	0.05	0.05	0.04	0.12	0.10	0.03
	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.04)	(0.03)	(0.06)
Ice cream and froz. dessert	0.05	0.07	0.09	0.05	0.05	0.04	0.12	0.10	0.03
	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.04)	(0.03)	(0.06)
Milk	0.03	0.05	0.06	0.03	0.04	0.03	0.08	0.07	0.02
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.04)
Other dairy	0.04	0.06	0.07	0.04	0.04	0.03	0.09	0.08	0.02
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.04)
Apples	-0.02	-0.03	-0.04	-0.02	-0.02	-0.02	-0.05	-0.04	0.06
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.05)
Bananas	-0.03	-0.05	-0.06	-0.03	-0.03	-0.03	-0.08	-0.07	0.09
	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.04)	(0.03)	(0.08)
Citrus	-0.03	-0.06	-0.07	-0.03	-0.04	-0.03	-0.09	-0.07	0.10
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.09)
Other fresh fruits	-0.03	-0.04	-0.05	-0.03	-0.03	-0.02	-0.07	-0.05	0.07
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.07)
Potatoes	-0.02	-0.03	-0.04	-0.02	-0.02	-0.02	-0.05	-0.04	0.05
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.05)
Lettuce	-0.02	-0.04	-0.05	-0.02	-0.03	-0.02	-0.06	-0.05	0.07
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.06)
Tomatoes	-0.03	-0.06	-0.07	-0.04	-0.04	-0.03	-0.09	-0.08	0.10
	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.09)
Other fresh vegetables	-0.02	-0.04	-0.05	-0.02	-0.03	-0.02	-0.07	-0.05	0.07
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.06)

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of: Pork	Other red meat	Poultry	Fish	Eggs	Cheese	Ice cream and frozen desserts	Milk	Other dairy	Apples
Eggs	0.03 (0.19)	-0.20 (0.18)	0.15 (0.17)	0.06 (0.17)	-0.24 (0.06)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
Cheese	0.01 (0.03)	0.01 (0.01)	0.01 (0.02)	0.01 (0.02)	0.00 (0.01)	-0.70 (0.24)	0.07 (0.13)	0.15 (0.13)	0.42 (0.19)	0.00 (0.01)
Ice cream and froz. dessert	0.01 (0.03)	0.01 (0.01)	0.01 (0.02)	0.01 (0.02)	0.00 (0.01)	0.13 (0.24)	-0.23 (0.22)	-0.08 (0.16)	0.12 (0.25)	0.00 (0.01)
Milk	0.01 (0.02)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.13 (0.11)	-0.04 (0.07)	-0.10 (0.09)	-0.03 (0.09)	0.00 (0.01)
Other dairy	0.01 (0.02)	0.00 (0.01)	0.01 (0.02)	0.01 (0.02)	0.00 (0.00)	0.93 (0.42)	0.14 (0.29)	-0.08 (0.23)	-1.04 (0.53)	0.00 (0.01)
Apples	0.03 (0.03)	0.01 (0.01)	0.02 (0.02)	0.02 (0.02)	0.00 (0.00)	-0.01 (0.03)	0.00 (0.01)	0.00 (0.02)	0.00 (0.01)	-0.58 (0.16)
Bananas	0.05 (0.04)	0.02 (0.02)	0.03 (0.03)	0.03 (0.03)	0.01 (0.01)	-0.01 (0.04)	0.00 (0.02)	-0.01 (0.03)	0.00 (0.01)	-0.03 (0.12)
Citrus	0.06 (0.05)	0.02 (0.02)	0.04 (0.03)	0.04 (0.03)	0.01 (0.01)	-0.01 (0.05)	-0.01 (0.03)	-0.01 (0.04)	0.00 (0.02)	0.01 (0.09)
Other fresh fruits	0.04 (0.04)	0.02 (0.01)	0.03 (0.02)	0.03 (0.02)	0.01 (0.01)	-0.01 (0.04)	0.00 (0.02)	-0.01 (0.03)	0.00 (0.01)	-0.03 (0.07)
Potatoes	0.03 (0.03)	0.01 (0.01)	0.02 (0.02)	0.02 (0.02)	0.00 (0.00)	-0.01 (0.03)	0.00 (0.01)	0.00 (0.02)	0.00 (0.01)	-0.09 (0.11)
Lettuce	0.04 (0.04)	0.02 (0.01)	0.03 (0.02)	0.03 (0.02)	0.01 (0.01)	-0.01 (0.03)	0.00 (0.02)	-0.01 (0.03)	0.00 (0.01)	0.05 (0.09)
Tomatoes	0.06 (0.05)	0.02 (0.02)	0.04 (0.03)	0.04 (0.03)	0.01 (0.01)	-0.01 (0.05)	-0.01 (0.03)	-0.01 (0.04)	0.00 (0.02)	-0.06 (0.08)
Other fresh vegetables	0.04 (0.04)	0.02 (0.01)	0.03 (0.02)	0.03 (0.02)	0.01 (0.01)	-0.01 (0.03)	0.00 (0.02)	-0.01 (0.03)	0.00 (0.01)	0.09 (0.06)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of: Bananas	Citrus	Other fresh fruits	Potatoes	Lettuce	Tomatoes	Other fresh vegetable	Processed fruits and vegetables	Coffee and tea
Eggs	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)
Cheese	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	-0.01	-0.02
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)	(0.01)
Ice cream and froz. dessert	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	-0.01	-0.02
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.01)
Milk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.00)	(0.01)	(0.02)	(0.02)	(0.01)
Other dairy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Apples	-0.03	0.01	-0.08	-0.09	0.03	-0.06	0.24	-0.06	0.00
	(0.12)	(0.10)	(0.17)	(0.11)	(0.06)	(0.08)	(0.17)	(0.22)	(0.01)
Bananas	-1.01	-0.12	0.10	0.05	-0.13	-0.06	0.16	0.06	0.00
	(0.21)	(0.10)	(0.18)	(0.12)	(0.07)	(0.08)	(0.19)	(0.28)	(0.01)
Citrus	-0.10	-1.10	-0.11	-0.06	0.02	0.09	0.10	0.04	0.00
	(0.08)	(0.10)	(0.15)	(0.08)	(0.05)	(0.07)	(0.13)	(0.17)	(0.01)
Other fresh fruits	0.04	-0.05	-0.90	0.06	-0.04	-0.10	-0.07	0.27	0.00
	(0.07)	(0.07)	(0.15)	(0.07)	(0.04)	(0.06)	(0.11)	(0.14)	(0.01)
Potatoes	0.04	-0.07	0.16	-0.42	-0.01	0.09	-0.32	0.03	0.00
	(0.12)	(0.09)	(0.17)	(0.15)	(0.06)	(0.08)	(0.17)	(0.23)	(0.01)
Lettuce	-0.17	0.03	-0.13	-0.01	-0.84	0.04	0.16	0.08	0.00
	(0.09)	(0.08)	(0.14)	(0.09)	(0.07)	(0.07)	(0.15)	(0.18)	(0.01)
Tomatoes	-0.06	0.10	-0.24	0.09	0.03	-0.58	0.06	-0.45	0.00
	(0.08)	(0.08)	(0.15)	(0.07)	(0.05)	(0.09)	(0.14)	(0.17)	(0.01)
Other fresh vegetables	0.06	0.04	-0.06	-0.11	0.04	0.02	-0.94	0.07	0.00
	(0.06)	(0.05)	(0.10)	(0.06)	(0.04)	(0.05)	(0.14)	(0.13)	(0.01)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of							
	Carbonated beverages	Non-carbonated beverages	Frozen beverages	Sugar and sweets	Fats and oils	Soups	Frozen meals and snacks	Snacks
Eggs	0.02	0.03	0.00	0.05	0.03	0.00	0.03	0.01
	(0.01)	(0.02)	(0.00)	(0.02)	(0.01)	(0.00)	(0.01)	(0.00)
Cheese	-0.07	-0.09	0.00	-0.13	-0.07	-0.01	-0.08	-0.02
	(0.04)	(0.05)	(0.00)	(0.06)	(0.03)	(0.01)	(0.04)	(0.01)
Ice cream and froz. dessert	-0.07	-0.09	0.00	-0.13	-0.07	-0.01	-0.08	-0.02
	(0.04)	(0.05)	(0.00)	(0.06)	(0.03)	(0.01)	(0.04)	(0.01)
Milk	-0.05	-0.06	0.00	-0.09	-0.05	-0.01	-0.06	-0.01
	(0.02)	(0.04)	(0.00)	(0.04)	(0.02)	(0.01)	(0.03)	(0.00)
Other dairy	-0.05	-0.07	0.00	-0.10	-0.06	-0.01	-0.07	-0.01
	(0.03)	(0.04)	(0.00)	(0.05)	(0.02)	(0.01)	(0.03)	(0.01)
Apples	0.01	0.01	0.00	0.12	0.06	0.01	0.07	0.01
	(0.03)	(0.04)	(0.00)	(0.05)	(0.03)	(0.01)	(0.03)	(0.01)
Bananas	0.01	0.02	0.00	0.19	0.10	0.02	0.12	0.02
	(0.05)	(0.07)	(0.00)	(0.08)	(0.04)	(0.01)	(0.05)	(0.01)
Citrus	0.01	0.02	0.00	0.22	0.11	0.02	0.14	0.02
	(0.05)	(0.08)	(0.00)	(0.09)	(0.05)	(0.01)	(0.06)	(0.01)
Other fresh fruits	0.01	0.01	0.00	0.16	0.08	0.02	0.10	0.02
	(0.04)	(0.06)	(0.00)	(0.07)	(0.03)	(0.01)	(0.04)	(0.01)
Potatoes	0.01	0.01	0.00	0.11	0.06	0.01	0.07	0.01
	(0.03)	(0.04)	(0.00)	(0.05)	(0.03)	(0.01)	(0.03)	(0.01)
Lettuce	0.01	0.01	0.00	0.15	0.08	0.02	0.10	0.02
	(0.04)	(0.05)	(0.00)	(0.07)	(0.03)	(0.01)	(0.04)	(0.01)
Tomatoes	0.01	0.02	0.00	0.22	0.12	0.02	0.14	0.03
	(0.05)	(0.08)	(0.00)	(0.09)	(0.05)	(0.01)	(0.06)	(0.01)
Other fresh vegetables	0.01	0.01	0.00	0.15	0.08	0.02	0.10	0.02
	(0.04)	(0.05)	(0.00)	(0.07)	(0.03)	(0.01)	(0.04)	(0.01)

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of							With respect to expenditure
	Condiments, sauces, season.	Miscella-neous FAH	Alcoholic beverages	Limited-service FAFH	Full-service FAFH	Other FAFH	Nonfood	
Eggs	0.02	0.05	0.03	0.04	0.05	0.01	-0.29	0.03
	(0.01)	(0.02)	(0.06)	(0.08)	(0.09)	(0.02)	(0.32)	(0.05)
Cheese	-0.06	-0.14	0.07	0.09	0.11	0.02	-0.25	0.13
	(0.03)	(0.06)	(0.10)	(0.13)	(0.16)	(0.03)	(0.40)	(0.06)
Ice cream and froz. dessert	-0.06	-0.13	0.06	0.08	0.10	0.02	-0.25	0.12
	(0.03)	(0.06)	(0.10)	(0.13)	(0.16)	(0.03)	(0.40)	(0.06)
Milk	-0.04	-0.09	0.05	0.06	0.07	0.01	-0.17	0.09
	(0.02)	(0.04)	(0.06)	(0.09)	(0.10)	(0.02)	(0.26)	(0.04)
Other dairy	-0.05	-0.10	0.05	0.07	0.08	0.01	-0.19	0.10
	(0.02)	(0.05)	(0.07)	(0.09)	(0.11)	(0.02)	(0.29)	(0.05)
Apples	0.05	0.12	0.04	0.06	0.07	0.01	0.03	0.03
	(0.02)	(0.05)	(0.08)	(0.10)	(0.13)	(0.02)	(0.32)	(0.04)
Bananas	0.08	0.19	0.07	0.10	0.12	0.02	0.05	0.04
	(0.03)	(0.08)	(0.13)	(0.17)	(0.20)	(0.04)	(0.51)	(0.07)
Citrus	0.09	0.22	0.08	0.11	0.13	0.02	0.06	0.05
	(0.04)	(0.09)	(0.15)	(0.19)	(0.23)	(0.04)	(0.58)	(0.08)
Other fresh fruits	0.07	0.16	0.06	0.08	0.10	0.02	0.04	0.04
	(0.03)	(0.07)	(0.11)	(0.14)	(0.17)	(0.03)	(0.42)	(0.06)
Potatoes	0.05	0.12	0.04	0.06	0.07	0.01	0.03	0.03
	(0.02)	(0.05)	(0.08)	(0.10)	(0.12)	(0.02)	(0.31)	(0.04)
Lettuce	0.07	0.16	0.06	0.08	0.09	0.02	0.04	0.04
	(0.03)	(0.07)	(0.10)	(0.14)	(0.16)	(0.03)	(0.41)	(0.06)
Tomatoes	0.10	0.22	0.08	0.11	0.13	0.02	0.06	0.05
	(0.04)	(0.09)	(0.15)	(0.19)	(0.23)	(0.04)	(0.58)	(0.08)
Other fresh vegetables	0.07	0.16	0.06	0.08	0.09	0.02	0.04	0.04
	(0.03)	(0.06)	(0.10)	(0.14)	(0.16)	(0.03)	(0.41)	(0.06)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand

Demand for	With respect to price of: Flour, prep. mixes	Breakfast cereals	Rice and pasta	Non-white bread	White bread	Biscuits, rolls, muff.	Cakes and cookies	Other bakery products	Beef
Proc. fruits and vegetables	-0.02	-0.03	-0.04	-0.02	-0.02	-0.02	-0.05	-0.04	0.06
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.05)
Coffee and tea	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	-0.02	-0.02	0.06
	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.05)	(0.04)	(0.04)
Carbonated beverages	-0.02	-0.03	-0.04	-0.02	-0.02	-0.02	-0.05	-0.04	0.12
	(0.03)	(0.05)	(0.07)	(0.03)	(0.04)	(0.03)	(0.09)	(0.07)	(0.07)
Noncarb. beverages	-0.02	-0.03	-0.04	-0.02	-0.02	-0.02	-0.05	-0.04	0.14
	(0.04)	(0.06)	(0.07)	(0.04)	(0.04)	(0.03)	(0.09)	(0.08)	(0.08)
Frozen beverages	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	-0.03	-0.03	0.09
	(0.03)	(0.04)	(0.05)	(0.03)	(0.03)	(0.02)	(0.07)	(0.06)	(0.07)
Sugar and sweets	0.02	0.03	0.03	0.02	0.02	0.01	0.04	0.04	0.15
	(0.02)	(0.04)	(0.05)	(0.02)	(0.03)	(0.02)	(0.06)	(0.05)	(0.07)
Fats and oils	0.01	0.02	0.02	0.01	0.01	0.01	0.03	0.02	0.09
	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.04)	(0.03)	(0.04)
Soups	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.05
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)
Frozen foods	0.01	0.02	0.02	0.01	0.01	0.01	0.03	0.02	0.10
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.01)	(0.04)	(0.03)	(0.05)
Snacks	0.01	0.02	0.02	0.01	0.01	0.01	0.03	0.02	0.08
	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.04)	(0.03)	(0.04)
Condiments, sauces, seas.	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.08
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.04)
Misc. FAH	0.01	0.02	0.03	0.01	0.02	0.01	0.04	0.03	0.12
	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.05)	(0.04)	(0.06)
Alcoholic beverage	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.03
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.07)

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of									
	Pork	Other red meat	Poultry	Fish	Eggs	Cheese	Ice cream and frozen desserts	Milk	Other dairy	Apples
Proc. fruits and vegetables	0.03	0.01	0.02	0.02	0.00	-0.01	0.00	0.00	0.00	-0.02
	(0.03)	(0.01)	(0.02)	(0.02)	(0.00)	(0.03)	(0.01)	(0.02)	(0.01)	(0.07)
Coffee and tea	0.04	0.01	0.02	0.02	0.01	-0.05	-0.03	-0.04	-0.02	0.00
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)
Carbonated beverages	0.07	0.03	0.04	0.04	0.01	-0.10	-0.05	-0.08	-0.03	0.00
	(0.04)	(0.02)	(0.03)	(0.03)	(0.01)	(0.06)	(0.03)	(0.04)	(0.02)	(0.01)
Noncarb. beverages	0.08	0.03	0.05	0.05	0.01	-0.11	-0.06	-0.09	-0.04	0.00
	(0.04)	(0.02)	(0.03)	(0.03)	(0.01)	(0.06)	(0.03)	(0.05)	(0.02)	(0.01)
Frozen beverages	0.05	0.02	0.03	0.03	0.01	-0.07	-0.04	-0.05	-0.02	0.00
	(0.04)	(0.01)	(0.02)	(0.02)	(0.01)	(0.05)	(0.03)	(0.04)	(0.02)	(0.01)
Sugar and sweets	0.08	0.03	0.05	0.05	0.01	-0.10	-0.05	-0.08	-0.03	0.03
	(0.04)	(0.02)	(0.03)	(0.03)	(0.01)	(0.04)	(0.02)	(0.03)	(0.02)	(0.01)
Fats and oils	0.05	0.02	0.03	0.03	0.01	-0.06	-0.03	-0.05	-0.02	0.02
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.03)	(0.01)	(0.02)	(0.01)	(0.01)
Soups	0.03	0.01	0.02	0.02	0.00	-0.03	-0.02	-0.03	-0.01	0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Frozen foods	0.06	0.02	0.04	0.04	0.01	-0.07	-0.04	-0.05	-0.02	0.02
	(0.03)	(0.01)	(0.02)	(0.02)	(0.00)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)
Snacks	0.05	0.02	0.03	0.03	0.01	-0.06	-0.03	-0.05	-0.02	0.02
	(0.02)	(0.01)	(0.02)	(0.02)	(0.00)	(0.03)	(0.01)	(0.02)	(0.01)	(0.01)
Condiments, sauces, seas.	0.04	0.02	0.03	0.03	0.01	-0.05	-0.03	-0.04	-0.02	0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Misc. FAH	0.07	0.03	0.04	0.04	0.01	-0.08	-0.05	-0.07	-0.03	0.02
	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.04)	(0.02)	(0.03)	(0.01)	(0.01)
Alcoholic beverage	0.02	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.00
	(0.04)	(0.01)	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of								
	Bananas	Citrus	Other fresh fruits	Potatoes	Lettuce	Tomatoes	Other fresh vegetable	Processed fruits and vegetables	Coffee and tea
Proc. fruits and vegetables	0.02	0.01	0.20	0.01	0.02	-0.14	0.06	-0.77	0.00
	(0.08)	(0.06)	(0.11)	(0.07)	(0.04)	(0.05)	(0.11)	(0.20)	(0.01)
Coffee and tea	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	-0.12
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.21)
Carbonated beverages	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	-0.01
	(0.02)	(0.03)	(0.04)	(0.01)	(0.01)	(0.02)	(0.05)	(0.04)	(0.13)
Noncarb. beverages	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	-0.07
	(0.02)	(0.03)	(0.05)	(0.01)	(0.01)	(0.03)	(0.05)	(0.05)	(0.11)
Frozen beverages	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	-0.08
	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)	(0.04)	(0.03)	(0.49)
Sugar and sweets	0.04	0.05	0.09	0.02	0.02	0.05	0.10	0.09	0.02
	(0.02)	(0.02)	(0.04)	(0.01)	(0.01)	(0.02)	(0.04)	(0.04)	(0.02)
Fats and oils	0.02	0.03	0.05	0.01	0.01	0.03	0.06	0.05	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Soups	0.01	0.02	0.03	0.01	0.01	0.02	0.03	0.03	0.01
	(0.01)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)	(0.02)	(0.01)
Frozen foods	0.03	0.04	0.06	0.02	0.02	0.03	0.07	0.06	0.02
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.01)
Snacks	0.02	0.03	0.05	0.01	0.01	0.03	0.06	0.05	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.01)
Condiments, sauces, seas.	0.02	0.03	0.05	0.01	0.01	0.03	0.05	0.05	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Misc. FAH	0.03	0.05	0.08	0.02	0.02	0.04	0.08	0.07	0.02
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)	(0.03)	(0.03)	(0.02)
Alcoholic beverage	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.01)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of: Carbonated beverages	Non-carbonated beverages	Frozen beverages	Sugar and sweets	Fats and oils	Soups	Frozen meals and snacks	Snacks
Proc. fruits and vegetables	0.01	0.01	0.00	0.12	0.06	0.01	0.07	0.01
	(0.03)	(0.04)	(0.00)	(0.05)	(0.03)	(0.01)	(0.03)	(0.01)
Coffee and tea	-0.02	-0.19	-0.01	0.09	0.05	0.01	0.06	0.01
	(0.27)	(0.27)	(0.06)	(0.08)	(0.04)	(0.01)	(0.05)	(0.01)
Carbonated beverages	-0.30	-0.35	-0.01	0.18	0.09	0.02	0.11	0.02
	(0.38)	(0.39)	(0.07)	(0.15)	(0.08)	(0.02)	(0.09)	(0.02)
Noncarb. beverages	-0.27	-0.44	0.02	0.20	0.11	0.02	0.13	0.02
	(0.30)	(0.37)	(0.07)	(0.16)	(0.09)	(0.02)	(0.10)	(0.02)
Frozen beverages	-0.09	0.32	-0.61	0.12	0.07	0.01	0.08	0.01
	(1.09)	(1.30)	(0.91)	(0.13)	(0.07)	(0.02)	(0.08)	(0.02)
Sugar and sweets	0.09	0.13	0.00	-0.56	-0.01	-0.66	-0.74	0.03
	(0.07)	(0.10)	(0.00)	(0.76)	(0.26)	(0.23)	(0.49)	(0.14)
Fats and oils	0.05	0.08	0.00	-0.02	-0.21	-0.16	-0.23	0.03
	(0.04)	(0.06)	(0.00)	(0.29)	(0.18)	(0.11)	(0.26)	(0.06)
Soups	0.03	0.04	0.00	-2.08	-0.47	0.19	0.96	0.06
	(0.03)	(0.04)	(0.00)	(0.74)	(0.31)	(0.60)	(0.77)	(0.28)
Frozen foods	0.06	0.09	0.00	-0.81	-0.23	0.33	-1.05	-0.22
	(0.05)	(0.07)	(0.00)	(0.53)	(0.25)	(0.27)	(0.72)	(0.15)
Snacks	0.05	0.08	0.00	0.16	0.13	0.09	-1.00	-1.14
	(0.05)	(0.06)	(0.00)	(0.70)	(0.28)	(0.44)	(0.70)	(0.46)
Condiments, sauces, seas.	0.05	0.07	0.00	0.84	0.10	0.12	0.13	0.27
	(0.04)	(0.06)	(0.00)	(0.45)	(0.16)	(0.23)	(0.43)	(0.15)
Misc. FAH	0.08	0.11	0.00	-0.09	-0.23	0.15	0.71	-0.02
	(0.06)	(0.09)	(0.00)	(0.48)	(0.21)	(0.19)	(0.41)	(0.10)
Alcoholic beverage	0.00	0.00	0.00	0.06	0.03	0.01	0.04	0.01
	(0.03)	(0.04)	(0.00)	(0.05)	(0.03)	(0.01)	(0.03)	(0.01)

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand--continued

Demand for	With respect to price of: Condiments, sauces, season.	Miscella-neous FAH	Alcoholic beverages	Limited-service FAFH	Full-service FAFH	Other FAFH	Nonfood	With respect to expenditure
Proc. fruits and vegetables	0.05	0.12	0.04	0.06	0.07	0.01	0.03	0.03
	(0.02)	(0.05)	(0.08)	(0.10)	(0.13)	(0.02)	(0.32)	(0.04)
Coffee and tea	0.04	0.09	-0.01	-0.01	-0.01	0.00	0.07	0.01
	(0.03)	(0.08)	(0.07)	(0.10)	(0.12)	(0.02)	(0.24)	(0.03)
Carbonated beverages	0.08	0.18	-0.01	-0.02	-0.02	0.00	0.13	0.02
	(0.06)	(0.15)	(0.14)	(0.19)	(0.23)	(0.04)	(0.45)	(0.06)
Noncarb. beverages	0.09	0.20	-0.01	-0.02	-0.02	0.00	0.15	0.02
	(0.07)	(0.16)	(0.15)	(0.20)	(0.25)	(0.04)	(0.50)	(0.06)
Frozen beverages	0.05	0.12	-0.01	-0.01	-0.01	0.00	0.09	0.01
	(0.06)	(0.13)	(0.11)	(0.15)	(0.18)	(0.03)	(0.35)	(0.05)
Sugar and sweets	0.69	-0.11	0.15	0.20	0.24	0.04	-0.45	0.13
	(0.37)	(0.58)	(0.12)	(0.16)	(0.20)	(0.03)	(0.48)	(0.06)
Fats and oils	0.09	-0.30	0.09	0.12	0.14	0.02	-0.27	0.08
	(0.15)	(0.28)	(0.08)	(0.10)	(0.12)	(0.02)	(0.29)	(0.04)
Soups	0.32	0.57	0.05	0.06	0.08	0.01	-0.15	0.04
	(0.59)	(0.73)	(0.05)	(0.06)	(0.08)	(0.01)	(0.18)	(0.03)
Frozen foods	0.11	0.92	0.10	0.13	0.16	0.03	-0.31	0.09
	(0.38)	(0.54)	(0.09)	(0.12)	(0.14)	(0.02)	(0.32)	(0.05)
Snacks	1.10	-0.13	0.09	0.11	0.14	0.02	-0.26	0.08
	(0.61)	(0.63)	(0.08)	(0.10)	(0.12)	(0.02)	(0.29)	(0.04)
Condiments, sauces, seas.	-1.92	-0.28	0.08	0.11	0.13	0.02	-0.24	0.07
	(0.44)	(0.39)	(0.07)	(0.09)	(0.11)	(0.02)	(0.26)	(0.03)
Misc. FAH	-0.19	-1.48	0.13	0.17	0.20	0.03	-0.38	0.11
	(0.27)	(0.59)	(0.11)	(0.14)	(0.17)	(0.03)	(0.40)	(0.05)
Alcoholic beverage	0.02	0.06	-1.15	-2.17	2.37	-0.13	0.31	0.32
	(0.02)	(0.05)	(0.67)	(0.73)	(0.82)	(0.13)	(0.68)	(0.09)

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand

Demand for	With respect to price of							
	Flour, prep. mixes	Breakfast cereals	Rice and pasta	Non-white bread	White bread	Biscuits, rolls, muff.	Cakes and cookies	Other bakery products
Limited service	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Full service	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Other FAFH	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Nonfood	0.03	-0.06	0.06	-0.03	0.01	-0.02	0.03	-0.03
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand

Demand for	With respect to price of							
	Beef	Pork	Other red meat	Poultry	Fish	Eggs	Cheese	Ice cream and frozen desserts
Limited service	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01
	(0.04)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Full service	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01
	(0.04)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Other FAFH	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01
	(0.05)	(0.03)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Nonfood	0.08	0.01	-0.05	-0.05	-0.02	0.06	0.03	-0.08
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.02)	(0.03)
						0.01	0.01	0.01

See notes at end of table.

Appendix table A.10

Estimated unconditional elasticities of demand

Demand for	With respect to price of							
	Beef	Pork	Other red meat	Poultry	Fish	Eggs	Cheese	Ice cream and frozen desserts
Limited service	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01
	(0.04)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Full service	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01
	(0.04)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Other FAFH	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01
	(0.05)	(0.03)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Nonfood	0.08	0.01	-0.05	-0.05	-0.02	0.06	0.03	-0.08
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.02)	(0.03)
						0.01	0.01	0.01

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand

Demand for	With respect to price of Milk	Other dairy	Apples	Bananas	Citrus	Other fresh fruits	Potatoes	Lettuce
Limited service	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)
Full service	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)
Other FAFH	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
	(0.01)	(0.00)	(0.01)	(0.01)	(0.02)	(0.00)	(0.00)	(0.01)
Nonfood	-0.02	-0.02	0.01	0.03	0.00	-0.02	0.00	0.03
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand

Demand for	With respect to price of Tomatoes	Other fresh vegetable	Processed fruits and vegetables	Coffee and tea	Carb. beverages	Non-carbonated beverages	Frozen beverages	Sugar and sweets
Limited service	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.03
	(0.01)	(0.02)	(0.01)	(0.00)	(0.02)	(0.02)	(0.00)	(0.03)
Full service	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.04
	(0.02)	(0.02)	(0.01)	(0.00)	(0.02)	(0.02)	(0.00)	(0.03)
Other FAFH	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.04
	(0.02)	(0.02)	(0.02)	(0.00)	(0.02)	(0.03)	(0.00)	(0.03)
Nonfood	0.00	0.06	-0.06	-0.08	0.02	0.05	0.00	0.06
	(0.01)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)	(0.03)
	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.03

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand

Demand for	With respect to price of Fats and oils	Soups	Frozen foods	Snacks	Condiments, sauces, seas.	Misc. FAH	Alcoholic beverages
Limited service	0.02	0.00	0.02	0.00	0.01	0.03	-0.90
	(0.01)	(0.00)	(0.02)	(0.00)	(0.01)	(0.03)	(0.31)
Full service	0.02	0.00	0.02	0.00	0.02	0.04	0.91
	(0.02)	(0.00)	(0.02)	(0.00)	(0.01)	(0.03)	(0.31)
Other FAFH	0.02	0.00	0.02	0.00	0.02	0.04	-0.32
	(0.02)	(0.00)	(0.02)	(0.00)	(0.01)	(0.03)	(0.32)
Nonfood	-0.03	-0.03	-0.01	-0.01	-0.04	0.03	0.07
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.02)
	0.02	0.00	0.02	0.00	0.01	0.03	-0.90

See notes at end of table.

Appendix table A.10
Estimated unconditional elasticities of demand

Demand for	With respect to price of: Limited-service FAFH	Full-service FAFH	Other FAFH	Nonfood	With respect to expenditure
Limited service	-0.13	0.42	0.01	0.17	0.18
	(1.08)	(1.15)	(0.07)	(0.37)	(0.05)
Full service	0.38	-1.96	-0.01	0.19	0.20
	(1.06)	(1.10)	(0.07)	(0.42)	(0.06)
Other FAFH	0.08	-0.04	-0.43	0.20	0.21
	(0.37)	(0.42)	(0.18)	(0.44)	(0.07)
Nonfood	-0.08	-0.05	0.00	-1.00	1.21
	(0.03)	(0.03)	(0.01)	(0.07)	(0.01)

Notes: Authors' calculations using first-stage elasticities from table 5, second-stage elasticities from tables A.3.-A.9., and Carpentier and Guyomard's formulas for approximating unconditional elasticities of demand, equations 12 and 13. Standard errors calculated using a residual bootstrap (Green, Hahn, and Rocke 1987).
FAFH = Food away from home, including limited-service and full-service restaurants; FAH = Food at home.

Appendix: Derivations of the Generalized Ordinary Differential Demand System (GODDS)

The GODDS is a reparameterization of a synthetic model developed by Barten (1993) that exploits the fact that the Rotterdam (R), the FDLAIDS (F), the NBR (N), and the CBS (C) models can be rewritten so they all have the same right-hand-side terms:

$$\text{(A.1.0)}\quad \mathbf{y}_R = \mathbf{w}_n d \ln \mathbf{q}_n = \theta_n\, d \ln \mathbf{Q} + \sum_{j=1}^{N} \pi_{nj} d \ln \mathbf{p}_j,$$

$$\text{(A.1.1)}\quad \mathbf{y}_F = d\mathbf{w}_n = \beta_n\, d \ln \mathbf{Q} + \sum_{j=1}^{N} \gamma_{nj} d \ln \mathbf{p}_j,$$

$$\text{(A.1.2)}\quad \mathbf{y}_C = \mathbf{w}_n(d \ln \mathbf{q}_n - d \ln \mathbf{Q}) = \beta_n\, d \ln \mathbf{Q} + \sum_{j=1}^{N} \pi_{nj} d \ln \mathbf{p}_j,$$

$$\text{(A.1.3)}\quad \mathbf{y}_N = d\mathbf{w}_n + \mathbf{w}_n d \ln \mathbf{Q} = \theta_n\, d \ln \mathbf{Q} + \sum_{j=1}^{N} \gamma_{nj} d \ln \mathbf{p}_j,$$

where w_n is the budget share for good n, q_n is quantity, p_n is price, and $d \ln Q$ is the Divisia volume index.[1,2]

Barten's general model takes the form:

$$\alpha_R \mathbf{y}_R + \alpha_C \mathbf{y}_C + \alpha_F \mathbf{y}_F + \alpha_N \mathbf{y}_N = \mathbf{X\Omega},$$

where $\mathbf{y}_i$, $i = R, C, N, F$ is a $t \times 1$ vector of transformed basic endogenous variables; $\mathbf{X}$ is a $t \times k$ matrix of exogenous price and expenditure variables; and $\Omega = \alpha_R\omega_R + \alpha_C\omega_C + \alpha_F\omega_F + \alpha_N\omega_N$ and ω_i, i=R, C, N, F compose a $k \times 1$ vector of coefficients. Without loss of generality, Barten set the sum of the α's to one and solved for α_R. Instead of solving for α_R in (A.1.4), Eales, Durham, and Wessells (1997) solved for α_F such that the term on the left-hand side of the final model is the same as the left-hand side term of the FDAIDS (i.e., $d\mathbf{w}_n$):

$$\text{(A.1.5)}\quad \alpha_F = 1 - \alpha_R - \alpha_C - \alpha_N.$$

Substituting α_F from (A.1.5) into (A.1.4) and solving for $\mathbf{y}_F$ yields,

$$\text{(A.1.6)}\quad \mathbf{y}_F = \alpha_C(\mathbf{y}_F - \mathbf{y}_C) + \alpha_R(\mathbf{y}_F - \mathbf{y}_R) + \alpha_N(\mathbf{y}_F - \mathbf{y}_N) + X\Omega.$$

Unconstrained estimation of the αs is not possible since α_F is a linear combination of α_R, α_C, and α_N. However, (A.1.6) can be rewritten using the fact that

$$\text{(A.1.7)}\quad \mathbf{y}_R - \mathbf{y}_C + \mathbf{y}_F - \mathbf{y}_N = \mathbf{0},$$

or

$$\text{(A.1.8)}\quad (\mathbf{y}_F - \mathbf{y}_C) + (\mathbf{y}_F - \mathbf{y}_N) - (\mathbf{y}_F - \mathbf{y}_R) = \mathbf{0}.$$

[1]The Divisia volume index is defined as

$$d \ln Q = d \ln M - \sum_{n=1}^{N} w_n d \ln p_n,$$

where M is total expenditure on all goods. Equivalently, the Divisia volume index is

$$d \ln Q = \sum_{n=1}^{N} w_n d \ln q_n.$$

[2]The coefficient on the income term in the Rotterdam and NBR models (i.e., θ_n) is the marginal budget share and is constant, whereas the marginal budget shares for the FDLAIDS and CBS models (i.e., $\beta_n = \theta_n - w_n$) vary with the expenditure shares. Similarly, the Slutsky terms are considered to be constants in the Rotterdam and CBS models (i.e., ϖ_{nj}) but vary with expenditure shares in the NBR and FDLAIDS models.

Solving (A.1.8) for $\mathbf{y}_F - \mathbf{y}_R$ yields

$$\text{(A.1.9)} \quad (\mathbf{y}_F - \mathbf{y}_C) + (\mathbf{y}_F - \mathbf{y}_N) = (\mathbf{y}_F - \mathbf{y}_R),$$

and substituting this into (A.1.6) gives

$$\text{(A.1.10)} \quad \mathbf{y}_F = (\alpha_C + \alpha_R)(\mathbf{y}_F - \mathbf{y}_C) + (\alpha_R + \alpha_N)(\mathbf{y}_F - \mathbf{y}_N) + X\Omega,$$

$$= \varphi_1(\mathbf{y}_F - \mathbf{y}_C) + \varphi_2(\mathbf{y}_F - \mathbf{y}_N) + X\Omega.$$

The nesting coefficient φ_1 measures the difference between the price coefficients in the FDLAIDS model and the price coefficients in the CBS and Rotterdam models. The nesting coefficient φ_2 measures the difference between the marginal budget shares of the FDLAIDS model and marginal budget shares of the NBR and Rotterdam models.

Substituting (A.1.0)-(A.1.3) into (A.1.10) and using

$$\text{(A.1.11)} \quad d\mathbf{w}_n = \mathbf{w}_n d \ln \mathbf{q}_n + \boldsymbol{w}_n d \ln \mathbf{p}_n - \mathbf{w}_n d \ln \mathbf{M},$$

$$\text{(A.1.12)} \quad \mathrm{d} \ln \mathbf{M} = \sum_{n=1}^{N} \mathbf{w}_n d \ln \mathbf{p}_n + \sum_{n=1}^{N} \mathbf{w}_n d \ln \mathbf{q}_n,$$

the GODDS is

$$\text{(A.1.13)} \quad d\mathbf{w}_n = (c_n + \varphi_1 \mathbf{w}_n) d \ln \mathbf{Q} + \sum_{k=1}^{N} [d_{nk} + \varphi_2 \mathbf{w}_n(\delta_{nk} - \mathbf{w}_k)] d \ln \mathbf{p}_k,$$

where $c_\mathrm{n} = \varphi_1\beta_n + (1 - \varphi_1)\theta_n$ and $d_{nk} = \varphi_2\gamma_{nk} + (1 - \varphi_2)\varpi_n$ are expenditure and price coefficients to be estimated, respectively, φ_1 and φ_2 are nesting coefficients, δ_{nk} is the Kronecker delta, $\mathbf{w}_n$ is a $t \times 1$ vector of expenditure shares for good n, $\mathbf{p}_k$ is a $t \times 1$ vector of prices of good k, and $\mathbf{Q}$ is a $t \times 1$ vector of Divisia volume indexes.