The Demand for Food in the United States: A Review of the Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand

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Several studies that address policies related to food consumption and nutrition use estimates of elasticities of demand with respect to price and expenditure from the literature to quantify the effects of actual or hypothetical changes in food prices or expenditure (or income). Consequently, many findings and policy recommendations in the academic literature are influenced by published estimates of elasticities of demand for food. We present new estimates of first-stage Marshallian elasticities of demand, estimated using multiple data sources. We compare our estimates with estimates in the food demand literature using the mean absolute error (MAE) in elasticity-based predictions of quantity responses to actual changes in prices and expenditures.

Barten's Synthetic Model

Barten (1993) nested the Rotterdam model and the First-differenced Linearized Almost Ideal Demand System (FDLAIDS) with the Central Bureau of Statistics (CBS) and the National Bureau of Research (NBR) demand systems:

$$w_{n,t} d\ln q_{n,t} = (a_n + \delta_1 w_{n,t}) d\ln Q_t + \sum_{j=1}^{N} \left[b_{nj,t} - \delta_2 w_{n,t} (\delta_{nj,t} - w_{j,t}) \right] d\ln p_{j,t},$$

where $q_{n,t}$, $w_{n,t}$, and $P_{n,t}$ are quantities, budget shares, and prices of good n at time t, respectively, $d \ln Q_t$ is a Divisia volume index at time t, δ_1 and δ_2 are nesting parameters, and δ_{ij} is the Kronecker delta.

Parameters can be restricted such that:

Rotterdam Model	δ_1=0, δ_2=0
FDLAIDS	δ_1=1, δ_2=1
CBS Model	δ_1=1, δ_2=0
NBR Model	δ_1=0, δ_2=1
Homogeneity	$\sum_{j=1}^{N} b_{nj} = 0, \forall n = 1,...,N$
Symmetry	$b_{nk} = b_{kn}, \forall n,k = 1,...,N$
Adding-up	$\sum_{n=1}^{N} a_n = 1 - \delta_1, \sum_{n=1}^{N} b_{nj} = 0, \forall j = 1,...,N$

Marshallian price and expenditure elasticities of demand, η_{nk} and η_{nM}, respectively, are

$$\eta_{nk} = -\left(\frac{a_n + \delta_1 w_n}{w_n} \right) w_k + \frac{b_{nk} - \delta_2 w_n (\delta_{nk} - w_k)}{w_n},$$

$$\eta_{nM} = \frac{a_n + \delta_1 w_n}{w_n}.$$

To estimate Barten's Synthetic Model we impose homogeneity and symmetry restrictions and approximate the continuous time differentials with discrete time, i.e. $d\ln q_{n,t} \approx \ln q_{n,t-1} - \ln q_{n,t}$ for annual data or $d\ln q_{n,t} \approx \ln q_{n,t-12} - \ln q_{n,t}$ for monthly data.

Estimates of Marshallian Elasticities of Demand Using Barten's Synthetic Model

We use annual personal consumption expenditures per capita with Fisher-Ideal price indexes (National Income and Product Accounts, BEA) and monthly average household expenditures (Consumer Expenditure Survey, BLS) with Consumer Price Indexes (BLS) to estimate the model. The elasticities of demand based on monthly BLS data are considerably different from elasticities of demand based on annual BEA data. For the most part, both types of data yield estimates that are consistent with demand theory but the magnitudes of the estimates differ considerably.

Table 1 . Marshallian Own-price and Expenditure Elasticities of Demand Using Barten's Synthetic Model

	Annual BEA data 1960-2007		Monthly BLS data 1986-2006	
	Own-price	*Expenditure*	*Own-price*	*Expenditure*
Cereals and baked goods	-0.86*	0.19	-0.23	0.09*
Red meats	-0.54*	0.39	-0.22	0.03
Poultry and seafood	-0.73*	0.34	-0.59*	0.12*
Eggs	-0.75*	-0.15	0.05	-0.15
Dairy	-0.80*	0.86*	-0.50*	0.08*
Fruits and vegetables	-0.52*	0.25	-0.59*	0.16*
Other foods	-0.54*	0.63*	-1.19*	0.11*
Nonalcoholic beverages	-0.76*	0.56*	-0.86*	0.14*
FAFH	-0.4*	0.53*	1.20	0.20*
Alcoholic beverages	-0.56*	0.32*	-0.62	0.16
Nonfood	-1.05*	1.31*	-0.87*	1.27*

Average Own-price Elasticities of Demand

Table 2. Average Own-price Elasticities of Demand for Selected Demand System Estimates Conditional on Food and /or Goods

	FAH Separated from FAFH		FAH not separated from FAFH	
Food product	*Obs*	*Average elasticity*	*Obs*	*Average elasticity*
FAH	3	-0.48	--	--
Cereals & baked goods	3	-0.86	18	-0.51
Baked goods	8	-0.33	1	-0.15
Cereals	8	-0.41	4	-0.27
Dairy products	8	-0.85	4	-0.10
Eggs	5	-0.17	8	-0.18
Fats and oils	9	-0.62	6	-0.07
Fruits & vegetables	4	-0.91	15	-0.38
Fruits	6	-0.61	3	-0.42
Vegetables	6	-0.61	2	-0.11
Meats	3	-0.86	18	-0.63
Beef	7	-0.42	13	-0.70
Pork	8	-0.78	15	-0.68
Meats other	5	-0.44	1	-1.37
Poultry & fish	--	--	4	-0.69
Poultry	9	-0.67	7	-0.37
Fish	8	-0.73	2	-0.11
Sweets	2	-0.99	5	-0.03
FAFH	8	-1.02	--	--
Nonfood	2	-0.93	17	-1.10

Some estimates of elasticities of demand in the food demand literature are based on data that makes a clear distinction between food away from home (FAFH) and food at home (FAH); other estimates are based on data that does not make this distinction. Average own-price elasticities are generally found to be more elastic for estimates based on data that makes this distinction.

Conditional-on-point Forecasts

Kastens and Brester (1996) suggested forecasting the effects of prices on demand for foods using a conditional-on-price consumption forecast, i.e.

$$d\ln q_{n,t} = \sum_{k=1}^{N} \eta_{nk} d\ln p_{k,t} + \eta_{nM} d\ln M_t.$$

Given the actual proportional changes in p and M, price and expenditure elasticities of demand can be tested for predictive accuracy by comparing the predictions of proportionate change in q, $\Delta \ln q$, with the actual proportional change in q. The performance of the various demand systems can be assessed by calculating the mean absolute error (MAE) for each good i in the system,

$$MAE_n = \sum_{t=1}^{T} \left| \Delta\ln q_{n,t} - \Delta\ln q_{n,t} \right| \times 100\%, \forall n = 1,...,N.$$

We proxy for 'actual' quantities using per capita disappearance (USDA, ERS) for studies that do not separate FAFH from FAH and implicit quantity indexes based on annual average household expenditures (CEX, BLS) and consumer price indexes for studies that make this separation.

MAE of Elasticity-based Predictions

The mean absolute error (MAE) in changes in quantities predicted using elasticities of demand based on cross-section data is generally greater than five percent for individual food products while the MAE in changes in quantities predicted using elasticities of demand based on time-series data is generally less than five percent.

Table 3. Mean Absolute Error for Selected Studies

Study	*Table*	*Number of Goods*	*% of Goods with MAE>5%*	*Average MAE*
Studies that Separate FAH from FAFH				
Park et al. (1996)	7	12	17	4.10
Huang and Lin (2000)	4	13	0	3.30
Feng and Chern (2000)	3	8	0	3.45
Raper, Wanzala, Nayga (2002)	6	9	0	3.50
Reed, Levendahl, Hallahan (2005)	3	7	14	3.61
Okrent and Alston (2010)	Annual	11	0	2.65
	Monthly	11	82	7.80
Studies that Do Not Separate FAH from FAFH				
Heien (1982)	3	13	31	5.93
Heien (1983)	3	5	20	2.92
Blanciforti and Green (1983)	1	4	0	2.32
Huang (1985)	2	8	0	2.23
Eales and Unnevehr (1988)	4	5	0	2.22
Choi and Sosin (1990)	2	3	0	2.84
Huang (1993)	1	8	0	2.16
Eales and Unnevehr (1988)	A2	5	0	2.03
Moschini, Moro, Green (1994)	4	7	0	2.10
Brester and Schroeder (1995)	3	4	25	3.01
You, Epperson, and Huang (1996)	1	11	9	2.21
Kastens and Brester (1996)	1	7	0	2.36
	2	7	29	3.41
	3	7	0	2.34
Wang and Bessler (2003)	1	5	0	2.08

Conclusion

The conditional-on-price forecasts using our estimates of Marshallian elasticities of demand based on Barten's Synthetic model and annual BEA data have relatively small MAE compared with the other studies that al data that separated FAFH from FAH.

Reference

Okrent, A. and J.M. Alston. "Demand for Food in the United States: A Review of the Literature, Evaluation of Previous Estimates and Presentation of New Estimates of Demand." Working Paper (2010).

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