



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Effects of Income Distribution on Meat Demand

William F. Hahn

Abstract. *Shifts in the distribution of income tended to increase the demand for beef and decrease the demand for pork and chicken in the early eighties. However, shifts in relative prices and other factors worked to decrease the demand for beef. Consequently, the demand for beef declined from 1980 to 1985. Despite only limited information on income distribution, one can estimate its effect on the demands for beef, pork, and chicken. The article shows how income distribution will affect market demand given the functional form selected for consumer demand.*

Keywords *Consumer demand, income aggregation, beef, pork, chicken*

The distribution of income is presumed to affect the demand for beef, pork, and chicken. The effects of the distribution of income on demand can be measured with a limited number of variables. I have estimated and tested a set of demand functions based on this analysis.

My results suggest that a person's pork consumption changes little as income changes and that a person's chicken consumption tends to grow at approximately the same rate as income. Shifting income from one person to another will do little to affect the demand for pork and chicken. Beef consumption also grows with a person's income. However, beef consumption is more sensitive to income changes for people with lower incomes. Decreasing the unemployment rate and transferring money from the rich to the poor will increase demand for beef.

Literature Review

Economic theory holds that consumer demand is a function of a consumer's tastes, income, and the prices of the goods purchased. The market demand for a consumer good is the sum of consumers' demands. Economists often estimate market demands using average consumer income as an explanatory variable. However, in only a few cases is average quantity demanded a function of average income only. In most cases, the

The author is an economist with the Commodity Economics Division, ERS.

market demand for a good depends on both the distribution of income and its average level. Market demand functions that are a function of only the average consumer income can be misspecified.

Theoretical discussions of the problem of aggregating individual demands into market demands appear in a number of sources. Two notable examples are Gorman (3) and Muellbauer (4).¹ Both discuss aggregation of demand systems consistent with the theory of utility maximization. Gorman demonstrated that, if all consumers' demands for all goods are linear in income, the average purchase of any good can be written as a function of average income, regardless of the distribution of income. If the demand for a good is not linear in income, that good's average demand will not generally be a function of average income.

Muellbauer demonstrated cases where the average amounts of all goods consumed in a market can be written as the demands of one consumer with some representative income. The representative income is the mean income only when consumers' demands are linear in income.

Articles by Berndt, Darrough, and Diewert (1), Blinder (2), Van Doorn (6), and Simmons (5) are examples of applied work where the problems of income distribution are addressed.

Berndt, Darrough, and Diewert were primarily interested in comparing three demand systems with one another. Each met Muellbauer's criteria for the existence of a representative income. Berndt, Darrough, and Diewert used information on proportions of consumers in income classes to approximate and eliminate the effects of aggregation bias.

Berndt, Darrough, and Diewert included effects of income distribution simply for the sake of theoretical consistency. Simmons was interested in actually measuring the effects of the income distribution on demand. Simmons had data on the proportion of British national income going to each of five income classes. He also had

¹ Italicized numbers in parentheses refer to items in the References at the end of this article.

data on aggregate British consumption and prices. He assumed that each member of a class had the same income and the same demand function. He worked out the implications for market demand. His study suggested that each income class had different demand functions, but that the demands of each class were linear in expenditure.

Blinder found that the distribution of income had an important effect on aggregate consumption. However, the effect was not the one he expected. His estimates showed that the rich had a higher propensity to consume than the poor. He concluded that this result was reasonable given the nature of his data. Blinder wished to measure the distribution of income. He actually measured the distribution of earnings of people who worked. He did not count the earnings of those without jobs. As women and youths began to participate in greater numbers of low-paying jobs, Blinder's measure of inequality increased. However, because the people entering low-paying jobs had been earning nothing, income inequality may have declined.

Van Doorn also attempted to measure the effects of the distribution of income on consumption. His study is interesting because it used the same type of demand function as I used here. He made strong assumptions about the distribution of income and its effect on consumption. His data suggested that information on income distribution did little if anything to improve the consumption estimate. The result is not surprising considering that he misspecified the effects of income distribution on demand. He erroneously showed that average consumption was related to the geometric mean of income. I show that the relationship between consumption and the income distribution is a more complicated function of the income distribution.

In the four applied studies mentioned above, the researchers used information on the class distributions of income or earnings to measure the effects of income aggregation on market demand. In this study, I used a limited number of variables to estimate the effects of income dispersion on demand.

Aggregation of Linear in Logarithm Demand Functions

Assume that consumer i 's demand for good Q can be written

$$\ln(Q_i) = B_0 + B_1 \ln(P_1) + \dots + B_j \ln(P_j) + B_n \ln(P_n) + B_y \ln(Y_i) \quad (1)$$

where the subscript i refers to the i 'th consumer, P_j is the price of the j 'th good, Y_i is the i 'th consumer's

income, and B_j and B_y are the consumer's elasticities of demand with respect to the j 'th price and income, respectively. Assume also that all consumers have identical demand functions and face identical prices. Assume also that consumers have different incomes. Note that equation 1 implies that the quantity demanded of good Q can be expressed

$$Q_i = \exp(B_0 + B_1 \ln(P_1) + \dots + B_n \ln(P_n) + B_y \ln(Y_i)) \quad (2)$$

where the function $\exp(\)$ is the base of the natural logarithms raised to the power in the parentheses.

Equations 1 and 2 are demand equations for individual consumers. Many of the data on consumption are time series data showing total consumption or per capita consumption for large groups of consumers. The consumption information is aggregated over consumers. Consider the average quantity demanded by all consumers in the market. The average quantity purchased is

$$Q = \frac{\sum_{i=1}^M \exp(B_0 + B_1 \ln(P_1) + \dots + B_n \ln(P_n) + B_y \ln(Y_i))}{M} \quad (3)$$

where R is the number of consumers and Q is the average consumption of good Q . The average consumption of good Q is a function of the prices of goods 1 through N and of every consumer's income.

For equation 3 to be estimated with aggregate time series data, one would need a series of observations on each consumer's income in the market. In most empirical studies using linear in logs demand functions, the logarithm of the average quantity purchased is written as

$$\ln(Q) = B_0 + B_1 \ln(P_1) + \dots + B_n \ln(P_n) + B_y \ln(\bar{Y}) \quad (4)$$

For equation 4 to follow from equation 3, the following equality must hold

$$\frac{1}{R} \sum_{i=1}^R \exp(B_y \ln(Y_i)) = \exp(B_y \ln(\bar{Y})) \quad (5)$$

Equality 5 is true only if one of the following three conditions holds: (1) if the income elasticity of demand for good Q is exactly 1, (2) if the income elasticity is exactly zero, or (3) if all consumers have the same income. If none of these conditions is met, equation 5 is invalid. Replacing the left side of equation 5 with the right side, when consumer demands are estimated, can

cause aggregation bias, and the estimates of the price and income elasticities of demand may be biased

The problem facing the researcher is how to eliminate the potential aggregation bias with only limited information about the distribution of income. Under certain circumstances, limited information may be enough. The distribution of income is a statistical distribution. Many statistical distributions are specified with one or two parameters. If the functional form of the income distribution is fixed over time, simply knowing the values of some relevant parameters could be enough to deal with the income aggregation problem.

The average quantity demanded, equation 3, can be specified as a function of the moment-generating function of income. Moment-generating functions are often used with statistical distributions as a relatively simple way to derive a distribution's mean, variance, and other moments. The distribution of income can be treated as any other statistical distribution. The moment-generating function, $M(w)$, is an explicit function of the variable w and an implicit function of a statistical distribution. The moment-generating function for the variable X is defined as

$$M(w) = \sum_{i=1}^A \exp(wX_i)/A \quad (6)$$

In equation 6, A is an indexing number representing the total number of the X 's. Now consider the left side of equation 5. It is the moment-generating function for the log of income evaluated at By

$$\sum_{i=1}^R \exp(By \ln(Y_i)) / M = M(By) \quad (7)$$

Over time, the income distribution may shift, which will also shift the moment-generating function. Assume there is a set of variables, represented by the vector Z , that contains information about the distribution of income. The variables in Z may be the parameters of the distribution of income or variables that could be used to derive those parameters. The moment-generating function is a function of the income distribution information vector Z as well as the variable w , so that the moment-generating function of the log of income may be written $M(w, Z)$

$$\ln(Q) = B_0 + B_1 \ln(P_1) + B_n \ln(P_n) + \ln(M(By, Z)) \quad (8)$$

The demonstration above shows that when consumers' demands are log linear, market demand can be written as a function of the moment-generating function of

income. Given the moment-generating function and the appropriate data, estimating market demand functions based on equation 8 would be fairly straight-forward. However, I had no *a priori* information on the appropriate form for the moment-generating function. Therefore, I specified a simple, *ad hoc* form for the moment-generating function. The form I selected is consistent with statistical theory.

The moment-generating function for the log of income must meet the following two restrictions

- (1) $M(1, Z) = \bar{Y}$ for when $w = 1$, $\exp(1 \cdot \ln(Y_i)) = Y_i$,
- (2) $M(0, Z) = 1$ for when $w = 0$, $\exp(0 \cdot \ln(Y_i)) = 1$

The first restriction implies that, when the income elasticity is 1, the log of the moment-generating function will be the log of the average income. When the income elasticity is 1, one needs to know only the average income to correctly specify the market demand. The second restriction implies that when the income elasticity is zero, the log of the moment-generating function is also zero and the market demand is independent of the level or distribution of income.

The information about the income distribution used in this study is the mean disposable income deflated by the CPI, \bar{Y} , the ratio between the mean and median family income, R , and the unemployment rate, U .

$$M(w, Z) = \bar{Y}^w \exp[(w^2 - w) (A \ln(R) + B \ln(U) + C \ln(R)^2 + D \ln(U)^2 + E \ln(R) \ln(U) + F)] \quad (9)$$

The interpretation of equation 9 is fairly straightforward. The variables R and U determine the shape of the income distribution, whereas \bar{Y} determines the absolute level of the income distribution.

Yearly observations have been collected for the 1960-84 period. The per capita disposable income, the CPI, and the yearly unemployment rates are U.S. Department of Commerce data, and the mean and median family incomes are reported by the Census Bureau. Per capita disposable income is calculated as a residual from the national income accounts whereas the mean and median family incomes are derived from household surveys. Per capita income has trended upward though the sample period. The unemployment rate has generally increased since 1960, peaking in the early eighties and declining slightly toward the end. Throughout the sample period, mean family income has exceeded median income. This relationship implies that the income distribution is skewed toward higher incomes, with a few very large family incomes causing the mean to be larger than the median. The ratio was fairly stable throughout the early

part of the sample period. However, since the late seventies, the two measures of family income have diverged. Real median family income has actually declined, whereas real mean income has grown.

Substituting equation 9 into equation 8 and introducing a random component, e , gives

$$\begin{aligned} \ln(Q) = & B_0 + B_1 \ln(P_1) + \dots + B_n \ln(P_n) \\ & + B_y \ln(Y) + (B_y^2 - B_y) (\ln(R) + \ln(U)) \\ & + C \ln(R)^2 + D \ln(U)^2 + E \ln(R) \ln(U) + F \\ & + e \end{aligned} \quad (10)$$

Equation 10 is a function of prices, average income, and the variables R and U . Except for the parameters B_0 and F , the parameters of the model are exactly identified. One can estimate the model using least squares regression. However, if demand equations for more than one commodity are estimated, the parameters of the model are over-identified and one can estimate the equations simultaneously. The simultaneous estimation should increase the efficiency of the estimates.

Equation 10 defines the model developed in this article. Equation 10 will be referred to as the Moment-Generating Function model or the MGF model.

Demand functions based on the MGF model were estimated for beef, pork, and chicken. The dependent variables are per capita disappearances of beef, pork, and broiler meat. These variables were regressed against deflated average retail prices of beef, pork, and broilers and the moment-generating function. The quantity and price data were taken from USDA statistics.

The independent variables also included a trend and trend-squared terms. The time trend variable starts at -1.2 in 1960 and advances one-tenth each time period. The value of the trend variable is zero in 1972, the midpoint of the observation period. I included the trend terms to pick up the influences of excluded variables, such as changes in tastes or shifts in the income distribution that are unexplained by the income ratio and the unemployment rate.

As noted, the moment-generating function I specified is *ad hoc*. To evaluate the effectiveness of the MGF model we have compared it with two alternative hypotheses. The first alternative, alternative 1, excluded the ratio and unemployment terms from the regression analysis. If shifts in the distribution of income are important and if the specified moment-generating function is able to account for those shifts, then the MGF model should perform significantly better than alternative 1.

The MGF model also implies a series of cross-equation restrictions on the effects of the variables R and U . Alternative 2 tested the significance of the cross-equation restrictions on the variables R and U . If the MGF model is correct, alternative 2 will not perform significantly better than the MGF model.

Results

I estimated the MGF model and its two alternatives using a full information maximum likelihood package from the PC-based econometrics program, SORITEC. The estimation algorithm did not converge after more than 400 iterations. I "renormalized" the data by replacing the log income ratio and the log unemployment rate with their deviations from their mean values. The renormalization allowed the algorithm to converge in fewer than 50 iterations.

Table 1 contains the estimates of the coefficients of the renormalized MGF model and the results of the hypothesis tests. Table 2 shows the estimates for the alternative models. I compared the models with one another using the log likelihood ratio test. The log likelihood ratio test has an asymptotic chi-square distribution. The test statistic comparing the MGF model with alternative 1 is much larger than the 5-percent critical value, while the test statistic comparing the MGF model with alternative 2 is much smaller than the 5-percent critical value. Alternative 1 is rejected compared with the MGF model, whereas the MGF model is accepted compared with alternative 2. I conclude that the MGF model is a success. The distribution of income has a statistically significant effect on meat demand. I also conclude that the MGF model measures the effects of the income distribution.

Comparing alternative 1 with the model also allows one to investigate the effects of aggregation bias on the estimated elasticities of demand. The price and cross-price elasticities are similar for both sets of equations. However, the beef and chicken income elasticities are much different. Aggregation bias seems to have decreased the estimated income elasticities for beef and chicken.

The hypothesis tests imply that the distribution of income has a significant effect on demand. The variables R , U , and their cross-products are significant as a group. However, none of the estimates of the parameters of the moment-generating function is significant at the 5-percent level.

Each demand equation contains at least one significant trend variable. The trend implies that there are strong forces affecting the demand for meats that have not been captured by my analysis.

Table 1—Demand parameter and elasticity estimates and hypothesis test

Item	Standard error	
	Estimate	Standard error
Beef equation		
Constant	1 294*	0 609
Beef price	- 580**	054
Pork price	076	039
Broiler price	049	038
Income	924**	172
Trend	- 114**	040
Trend squared	- 108**	018
Pork equation		
Constant	3 972**	132
Beef price	437**	059
Pork price	- 784**	046
Broiler price	071	046
Income	- 016	036
Trend	013	015
Trend squared	- 060	012
Broiler equation		
Constant	3 637**	427
Beef price	150	082
Pork price	- 075	061
Broiler price	- 140*	062
Income	- 057	119
Trend	312**	031
Trend squared	- 020	018
Moment-generating function parameters		
A	- 83 993	191 639
B	- 1 519	3 323
C	- 192 052	426 467
D	566	1 066
E	621 031	1419 160
Log likelihood	201 08	
	Test statistic	5-percent critical value
df		
Comparisons		
MGF vs alternative 1	36 62	11 070
MGF vs alternative 2	9 88	18 307

* The coefficient estimate is significant at 5 percent

** The coefficient estimate is significant at 1 percent

Table 2—Parameter estimates for alternative models

Item	Alternative 1		Alternative 2	
	Estimate	Standard error	Estimate	Standard error
Beef equation				
Constant	3 489	- 0 941	1 885	0 902
Log beef price	- 436	- 075	- 586	057
Log pork price	138	- 064	096	454
Log broiler price	103	- 066	055	039
Log income	308	- 266	757	255
Trend	045	- 058	- 073	059
Trend squared	- 116	- 027	- 120	024
ln(R)	C		4 713	4 391
ln(U)	C		095	026
ln(R)ln(R)	C		11 510	9 265
ln(U)ln(U)	C		- 063	052
ln(R)ln(U)	C		- 35 443	31 815
Pork equation				
Constant	3 729	- 0 705	5 045	1 136
Log beef price	405	- 056	421	072
Log pork price	- 796	- 048	- 760	057
Log broiler price	064	- 049	064	049
Log income	052	- 199	- 325	322
Trend	- 007	- 043	077	074
Trend squared	- 065	- 020	- 094	031
ln(R)	C		- 346	5 528
ln(U)	C		- 051	033
ln(R)ln(R)	C		3 622	11 665
ln(U)ln(U)	C		- 004	066
ln(R)ln(U)	C		5 297	40 057
Chicken equation				
Constant	1 562	- 1 104	3 154	1 525
Log beef price	025	- 088	163	097
Log pork price	- 130	- 075	- 068	077
Log broiler price	- 190	- 077	- 127	066
Log income	526	- 312	085	432
Trend	165	- 068	302	099
Trend squared	- 009	- 032	007	041
ln(R)	C		- 9 117	7 425
ln(U)	C		- 075	044
ln(R)ln(R)	C		- 26 146	15 667
ln(U)ln(U)	C		021	089
ln(R)ln(U)	C		59 382	53 797
Log likelihood	182 77		206 02	

C in a coefficient's place means that it was constrained to zero.

Blanks indicate not applicable

Conclusions

The problems of aggregation of individuals into markets has received some attention in the economic literature. However, the problem is seldom addressed in applied studies. The problem of aggregation is often ignored because of data deficiencies. The technique used here allows one to estimate the effects of income aggregation using incomplete information. Using the unemployment rate and the ratio of mean to median family incomes provides a simple, but usable proxy for measuring the effects of the distribution of income on demand. The

sensitivity of this analysis could be improved with more complete time series information on income distribution.

This approach to correcting aggregation bias could easily be applied to other demand systems and to the study of the demand for other commodities. The technique could be generalized and adapted to the study of supply as well as demand. Accounting for the effects of aggregation provides an important link between the economic theory of individual behavior and its application to aggregate data.

References

- 1 Berndt, E R , M N Darrough, and WE Diewert "Flexible Functional Forms: An Application to Canadian Consumer Demand Functions," *International Economic Review*, Vol 18, No 3, 1977, pp 651-75
- 2 Blinder, A S "Distribution Effects and the Aggregate Consumption Function," *Journal of Political Economy*, Vol 83, No. 3, 1975, pp 447-75
- 3 Gorman, W "Community Preference Fields," *Econometrica*, Vol 21, 1953, pp 63-80
- 4 Muellbauer, J "Community Preferences and the Representative Consumer," *Econometrica*, Vol 44, 1976, pp 979-99
- 5 Simmons, P "Evidence on the Impact of Income Distribution on Consumer Demand in the UK, 1955-68," *Review of Economic Studies*, Vol 47, 1980, pp 893-906
- 6 Van Doorn, J "Aggregate Consumption and the Distribution of Incomes," *European Economic Review*, Vol 6, 1975, pp 417-23.

More P's and Q's

prices and quantities These are the most directly and readily observable attributes of commodities (goods and services produced for and exchanged on the market) Both price and quantity relate to a unit (piece, bushel, barrel, pound, etc), established usually by commercial practice as the customary unit of reckoning

The intrinsically numerical character of prices and quantities renders accounts and statistics, the incessant measurement of the stream of commodities, feasible This preoccupation is motivated by and yields motivation to business and economic interests It also seems to be responsible for the profound drive to develop economic theories with the aid of mathematical tools, applied already successfully to the exigencies of natural sciences

S Brody
The New Palgrave, Vol III, p 957

(See review on p. 34)
