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INCOME DISTRIBUTION AND STRUCTURAL CHANGE IN U.S. MEAT DEMAND

*Laurian J. Unnevehr**

Livestock price forecasters have noted a change in meat demand between the 1970s and the 1980s. Red meat demand appears to be less income elastic in the 1980s than in the 1970s, while the income response of chicken consumption appears to have increased (Hieronymous, Grimes). Regressions of meat consumption on prices and income show positive residuals in the 1970s and negative residuals in the early 1980s for beef demand, while chicken demand residuals show the opposite pattern. Forecasters using past demand parameters to predict consumption in the 1980s have overestimated beef demand and underestimated chicken demand.

Several recent studies have reported evidence of structural change in meat demand (Chavas, Nyankori and Miller, Moschini and Meilke, Braschler, Frank, Hudson and Vertin). Although the results of these studies are not always comparable because of differences in methodology and data, most results indicate that in the mid- to late-1970s beef demand became less elastic with respect to own-price (Chavas, Nyankori and Miller) and income (Chavas, Nyankori and Miller, Frank, Hudson and Vertin) while chicken became a stronger substitute for beef (Braschler, Moschini and Meilke, Frank) or more responsive to income (Chavas, Hudson and Vertin). Evidence of change in pork demand is much weaker, but it might have become less elastic with respect to own-price (Braschler, Nyankori and Miller). These findings generally suggest a saturated but stable market for red meat and an increased preference for poultry.

Several hypotheses have been proposed to explain changes in meat demand, but few studies have actually tested the causes of change. A widely cited cause is a change in tastes due to health concerns about cholesterol and fat in red meats. Apparent change in elasticities, however, may also result from a change in demographics. Recent changes include the aging of the population, the increased share of emigrants in the population, the increase in women working outside the home, and the decline in household size. This paper will focus on the impact of changes in income distribution on meat demand. If consumption response to income varies by income level, then aggregate income elasticities will change as the distribution of income shifts (Allen). Income distribution in the U.S. changed after 1978, which should alter the observed aggregate income response. As the observed response of aggregate quantity demanded to prices is also influenced by the income effect, changes in the aggregate income response could alter the entire matrix of income and price elasticities.

In order to investigate the influence of income distribution on demand for beef, pork, and chicken in the U.S., a simple model to predict consumption from income distribution data is developed. Time-series data on income distribution are combined with cross-sectional survey data on meat consumption by income level to simulate the change in average meat consumption over time as income grows and its distribution changes. These

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estimates are then incorporated in time-series demand curves to see if predictive ability is improved when income distribution effects are included. Alternative estimates of future income distribution patterns are then used to analyze the possible future patterns of meat demand.

Model and Methodology

Allen reviews the problems that arise in the use of average income in aggregate demand curves. The true aggregate demand curve is:

$$\frac{\sum_{j=1}^{n} q_j}{n} = \frac{\sum_{j=1}^{n} a_j}{n} + \frac{\sum_{j=1}^{n} b_j y_j}{n} + \frac{\left(\sum_{j=1}^{n} c_j\right) P}{n} \qquad (1)$$

where

q_j = quantity consumed by individual j

a_j, b_j, c_j = demand parameters for individual j

y_j = income of individual j

P = price

n = number of individuals in population

The estimated relationship, however, is:

$$Q = A + BY + CP \qquad (2)$$

where

Q = average per capita consumption for n individuals

Y = average per capita income for n individuals

A,B,C = aggregate demand parameters

Price is the same for all consumers so the aggregate measure of the price coefficient is the same as the average of the individual coefficients. Income differs across consumers, so the aggregate parameter estimate is equal to the true estimate in equation 1 only when:

$$BY = \frac{\sum_{j=1}^{n} b_j y_j}{n} \qquad (3)$$

Equation 3 is true when the b_j are equal for all consumers, an unlikely occurance for most commodities. It is also true when each income observation is weighted by the ratio of the individual b_j to the average B:

$$BY = \frac{\frac{\sum_{j=1}^{n} b_j}{n}}{\frac{\sum_{j=1}^{n} b_j / B \; y_j}{n}} = B \; 1/B \; \frac{\sum_{j=1}^{n} b_j y_j}{n} = \frac{\sum_{j=1}^{n} b_j y_j}{n} \qquad (4)$$

Since it is impossible to observe the individual b_j over time, it is also impossible to estimate the true income-demand relationship.

Time-series demand estimates of income elasticities will vary depending on the particular distribution of income growth during the period of estimation. For example, if income growth is concentrated among those consumers that have a higher b_j, then the estimated aggregate income elasticity will increase. Use of time-series estimates to forecast demand implicitly assumes that the distribution of income growth will remain the same in the future. When the distribution of income growth changes, aggregate observed income elasticities will change and forecasts based on past elasticity estimates will be inaccurate.

Ideally the aggregation problem could be overcome by estimating the coefficients in equation (1) separately for different income levels. Time-series data on how many individuals received particular levels of real income in different years are available. Consumption observations by income group are only available for 1977, however, so this paper uses a simplified approach to estimate the impact of income distribution on demand. It is assumed that cross-section observations of consumption for each income group i represent the average q_j for individuals in the income group.

$$q_i = \frac{\sum_{j=1}^{N_i} q_j}{N_i} \qquad (5)$$

where:

N_i = number of individuals in income group i

As prices are constant in the cross-section sample, the q_i vary only with income. Predicted changes in consumption over time due to changes in average income and income distribution can then be estimated from the following equation:

$$Q^t = \frac{\sum_{i=1}^{m} N_i{}^t q_i}{\sum_{i=1}^{m} N_i{}^t} \qquad (6)$$

where Q^t = average quantity of meat consumed per capita in year t

$N_i{}^t$ = number of persons in income group i in year t

q_i = average per capita consumption for income group i.

m = number of income groups

Actual consumption in different years will vary from the estimated Q^t due to changes in relative prices. The Q^t include the influence of rising average income as this is reflected in a larger population in the upper income groups. It is assumed that the q_i do not vary or in other words that preferences at a particular real income level do not vary over time.

The cross-section consumption observations used for the q_i should represent the long run response of consumers to income changes. The variance in income across income groups in a cross-section sample is much larger than the variance in income over time for individual consumers. Most consumers within an income group have been at the same real relative level of income long enough to have fully adjusted their consumption. As consumers reach higher real income levels over time, the long run time-series consumption response should reflect the cross-section elasticity, unless there is a change in tastes and preferences.

The estimated Q^t are used in place of average income in time-series demand equations and the results compared with ordinary estimates based on average income. This substitution allows a test of the statistical significance of income distribution effects for each meat and tests whether income distribution can improve the predictive ability of time-series estimates of demand.

Cross-section estimates of meat consumption by income group are from the 1977-78 USDA National Food Consumption Survey (NFCS) of 14,000 U.S. households. Published data from the survey report at-home consumption of beef, pork, and poultry in pounds per household per week for 13 income classifications. These are converted to per capita consumption (q_i) by dividing by the average household size for each income group. Time-series data on the distribution of US households by income (in constant dollars) are taken from the Statistical Abstracts published by the U.S. Bureau of the Census. This series started in 1967. The number of households in each income level is multiplied by the average household size for that income group in order to obtain the distribution of population by income level (N_i). Time-series demand data for 1967 to 1983 for annual per capita consumption, deflated retail meat prices, and deflated income are from USDA (1982) and USDA (1985). Prices and income are in 1972 dollars. Linear demand curves are estimated for each meat product with quantity as the dependent variable.

Results

Cross-section meat consumption by 1983 dollar income categories is shown in Table 1. Haidacher et. al. estimated the response of at-home meat consumption to income with the NFCS data and found income-quantity elasticities of .7 for beef, -.06 for pork, and -.05 for chicken. Per capita beef consumption rises with greater income, and consumption continues to increase even when incomes are over $50,000 per household (Table 1). Pork and chicken consumption fall with greater income up to a certain level (Table 1). Pork declines rapidly as income rises up to $25,000 per household and then stabilizes (Table 1). This is primarily due to the decline in

Table 1. Meat Consumption by Income Group in 1977-78 (lbs/week)

Income Group[a]	Beef		Pork		Chicken		Household Size
	Household	Per Capita	Household	Per Capita	Household	Per Capita	
<$5000	2.71	1.53	2.12	1.20	2.00	1.13	1.77
5,000-9,999	3.46	1.66	2.28	1.09	2.09	1.00	2.09
10,000-14,999	4.34	1.73	2.62	1.04	2.26	.90	2.51
15,000-19,999	4.87	1.79	2.69	.99	2.34	.86	2.73
20,000-24,999	5.41	1.83	2.83	.96	2.35	.80	2.96
25,000-34,999	6.01	1.91	2.93	.93	2.31	.74	3.14
35,000-49,999	6.23	1.97	2.94	.93	2.42	.76	3.16
>50,000	7.41	2.34	2.95	.93	2.53	.80	3.17

[a] Income expressed in 1983 constant dollars.

SOURCE: USDA (1983).

bacon consumption (Haidacher et al., pg. 27). Total chicken consumption declines with income growth up to $35,000 per household and then increases slightly (Table 1). Higher income consumers shift from whole birds to cut chicken and processed products (Haidacher et al., pg. 27). In 1977/78, whole birds accounted for two-thirds of at-home consumption. It is likely that other chicken products now account for a larger share of chicken production, and thus chicken may be shifting from an inferior to a normal good.

Average per capita income grew at different rates from 1967 to 1983, but increased steadily throughout the period (Figure 1), except for small declines in 1974, 1980 and 1982. The distribution of income growth was not constant, however, as revealed by the distribution of the population by income group in selected years (Table 2). From 1967 to 1978 the top two income groups grew larger while the proportion in the bottom three groups declined. From 1978 to 1983, the bottom two groups grew larger while the top three groups declined. Income growth was apparently concentrated in the very highest income group during this recent period. The change in income distribution since 1978 should favor the consumption of inferior goods like pork and chicken and reduce the consumption of normal goods like beef.

The impact of income growth and changes in income distribution on meat consumption estmated from equation (6) are shown in Table 3. The estimated Q^t show increased beef consumption from 1967 to 1978 with the exception of 1971 and 1974-5, and then a decline from 1978 to 1983. The percentage decline in beef from 1978 to 1983 is almost as large as the percentage increase from 1967 to 1978. Predicted chicken consumption generally declined from 1967 to 1978 but then increased to more than the 1967 level by 1983. Predicted pork consumption also fell from 1967 to 1978 and then increased slightly from 1978 to 1983.

The change in income distribution may explain why income elasticities estimated from time-series data for the 1967-83 period are implausible. Regression parameter estimates for per capita income show income elasticities of .02 for beef (not significant), -.47 for pork, and .92 for chicken (Table 4). The cross-section data suggest that a larger, significant response of beef to income and a smaller response of chicken to income would be more plausible. These estimates are biased because they average response over a period of changing income distribution. The beef estimate may be insignificant because the Q^t show that beef consumption both rose and fell while average income was growing. The increase in chicken Q^t while income growth slowed in the early 1980s would increase the apparent response of chicken to income growth. The change in income distribution may explain the pattern of beef and chicken residuals in Figure 1 and the low Durbin Watson statistics.

The estimated Q^t based on income distribution were substituted into the time-series regressions in place of average per capita income. The first set of regressions in Table 5 has per capita income as an independent variable, and Q^t is substituted for income in the second set of regressions. In the second set of regressions the Durbin-Watson statistic is closer to 2.0 for all three meats, indicating that income distribution is causing some of the autocorrelation in the residuals (Table 5). The coefficients of the Q^t variables are expected to be positive and the elasticity should be close to

Figure 1. Average Per Capita Income in 1972 Constant Dollars, 1967-1983.

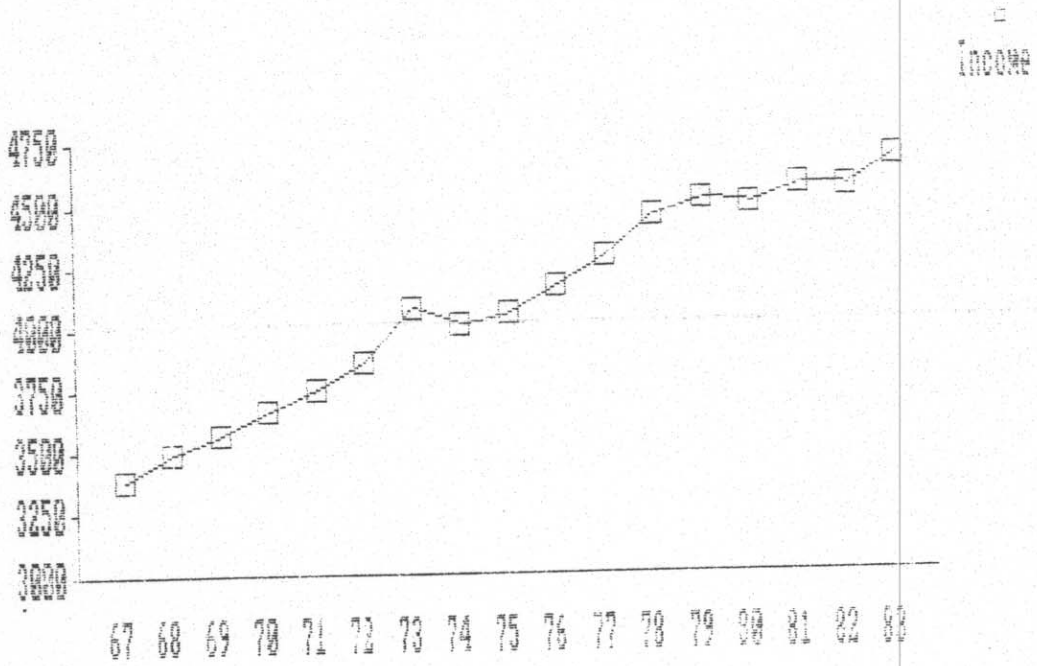

Table 2. Income Distribution of U.S. Population in 1967, 1970, 1975, 1978 and 1983 (% of population).

Income Group[a]	Individuals				
	1967	1970	1975	1978	1983
<$15,000	24.6	23.8	26.1	24.6	29.0
15,000-24,999	27.3	24.4	23.2	22.3	22.5
25,000-34,999	27.0	27.7	23.2	22.7	19.0
35,000-49,999	12.6	13.7	16.0	16.8	16.7
>50,000	8.6	10.5	11.5	13.6	12.9

[a] Income per household expressed in constant 1983 dollars.

SOURCE: U.S. Bureau of Census (1984).

Table 3. Projections of Meat Consumption with Constant Prices Based on Income Distribution Data (lbs./cap/annum).

Year	Beef	Pork	Chicken
1967	96.93	58.03	43.44
1968	97.01	57.71	43.36
1969	97.44	57.35	43.23
1970	97.69	57.03	43.21
1971	97.23	57.38	43.40
1972	97.89	56.86	43.23
1973	98.12	56.74	43.27
1974	97.94	55.98	43.36
1975	97.85	55.98	43.40
1976	98.20	55.75	43.29
1977	98.42	55.60	43.29
1978	98.59	55.60	43.22
1979	98.46	55.48	43.42
1980	97.84	55.94	43.65
1981	97.59	56.02	43.78
1982	97.51	56.15	43.92
1983	97.76	56.12	43.88
% Change			
1967-1978	1.71	-4.19	-0.51
1978-1983	-0.84	0.94	1.53

1 if the q_i are constant over time. This expected result is found in the beef regression. The explanatory power of the beef regression is significantly improved when the Q^t are substituted for average income, indicating that income distribution effects had the biggest impact on beef demand. In the pork regression Q^t is insignificant. Own-price is the most important variable influencing pork demand and changes in income do not seem to have had much influence in either regression.

Q^t is significant in the chicken regression, and its inclusion makes the cross-price elasticities more significant. The increase in the proportion of the population in the lower income groups makes relative price effects more important in the 1980s. Although the Q^t explains much of the variance in the rate of growth of chicken, the high Q^t elasticity of seven indicates that the assumption of constant q_i over time for chicken is not supported. The results suggest there has been a shift in preference for chicken such that consumption has increased over time more than predicted by the deterioration in income distribution. The change in chicken product mix mentioned above may partly explain the shift in preferences.

Income distribution changes may account for the findings of structural change in income elasticities reported in previous studies. A change in the beef income elasticity could also explain the findings of changes in price elasticities. The observed beef own-price response includes the pure substitution effect and the income effect, which depends on the income elasticity and the budget share. If the aggregate income response has declined, it would presumably lead to a smaller income effect and a smaller observed own-price response. This might explain the frequent finding of reduced own-price elasticity for beef. The observed effect of changes in the chicken price on beef consumption also depend on the beef income elasticity. A smaller beef income response will increase the observed substitution effect, contributing to the finding of greater substitutability between beef and chicken in recent studies. The small impact of income distribution on pork in the results here accords with the inconclusive findings for pork in studies of structural change.

The question for meat price forecasting is whether the demand patterns of the early 1980s will continue. The causes of the change in income distribution after 1978 are not completely clear. The overvalued dollar which led to a loss of manufacturing jobs was probably a contributor. Growth in jobs was concentrated in the lower paying service sector because the high dollar raised the incentives to produce non-traded services relative to incentives for traded industrial goods. High real interest rates also raised income for net savers in higher income groups relative to incomes in the lower groups. The decline in government welfare services and the increase in single-parent households may also have contributed to the change in distribution. Lower inflation should increase real incomes and the decline in the dollar should help industrial growth in the late 1980s, and might lead to broader based income growth.

Predicting income distribution is just as risky as predicting prices, but it is possible to show what would happen to consumption under alternative income distributions. The consumption change in the five years from 1978 to 1983 represents the case of deteriorating income distribution. If this continues over the next five years, Table 3 suggests that beef

Table 4. Price and Income Elasticities of Meat Demand, 1967-1983[a].

Dependent Variable	Regressions with Per Capita Income: Beef Price	Pork Price	Chicken Price	Per Cap Income
Beef	-.40	.41**	.00	.02
Pork	.45***	-.79***	.05	-.47***
Chicken	.26**	-.12	-.35**	.92***

	Regressions with Income Distribution Simulated Consumption: Beef Price	Pork Price	Chicken Price	Q^t Estimate
Beef	-.60***	.14	.14	.87***
Pork	.23	-.84***	.24*	1.54
Chicken	.81***	.28**	-.80***	7.09***

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

[a] Computed at the mean from regression parameters in Table 6.

Table 5. Results of Two Alternative Meat Demand Regressions, 1967-1983.[a]

	Beef Price	Pork Price	Chicken Price	Per Capita Income	Simulated Consumption[b] (Q^t)	R^2	Durbin-Watson
	(t-statistics in parantheses)						
Dependent Variable:							
Beef							
(1)	-.38	.53	.00	.001		.58	1.30
	(-1.65)	(2.42)	(0.00)	(0.10)			
(2)	-.57	.18	.35		10.48	.78	1.67
	(-4.82)	(1.07)	(1.40)		(3.26)		
Pork							
(1)	.26	-.61	.07	-.01		.97	2.82
	(4.40)	(-10.97)	(0.51)	(-4.34)			
(2)	.13	-.65	.38		1.84	.92	2.38
	(1.71)	(-6.20)	(1.98)		(1.37)		
Chicken							
(1)	.10	-.06	-.36	.01		.98	1.65
	(2.45)	(-1.67)	(-3.77)	(8.14)			
(2)	.30	.14	-.81		7.18	.92	1.79
	(5.63)	(2.25)	(-5.92)		(2.44)		

[a] Regressions (1) have per capita income as an independent variable and regressions (2) have simulated consumption changes due to income growth and distribution as an independent variable. The independent price variables are the same in all regressions.

[b] The data used for this variable are in Table 3.

consumption will decline while pork and chicken consumption will increase. The U.S. Bureau of the Census provides projections of income distribution given a positive distribution of income growth as in the 1970s and real income growth of 2% per year. This type of income growth would lead to an increase of .7% in beef consumption over five years, -.3% in pork consumption, and -.4% in chicken consumption, if preferences stayed the same as in 1977/78. The regression results indicate that a return to normal income distribution would increase beef consumption, but would only reduce the rate of growth in chicken consumption as chicken preferences have changed.

Conclusions

This paper offers a preliminary analysis of the causes of structural change in meat demand. Changes in the U.S. distribution of income after 1978 may explain the reduced income elasticity for beef and may partially explain the apparent increased preference for chicken in the 1980s. These results have important implications for meat price forecasters. As long as the macroeconomic factors that led to the change in income distribution remain in place, meat demand will respond to income growth as it has in the early 1980s. If the distribution of income growth returns to the pattern of the 1970s, beef demand response will approach previous levels and the rate of increase in chicken demand will decline.

This exercise has not considered all the potential causes of structural change. A major weakness is the use of at-home consumption data only for the consumption projections based on income distribution. The increasing importance of consumption away from home may also have contributed to changes in observed demand response, particularly for chicken. Other demographic sources of change in addition to income distribution need to be investigated.

Saleh and Sisler note in their study of meat demand in Iran that changes in income distribution may be particularly important in rapidly developing economies. The results presented above suggest that income distribution changes can be pronounced enough to influence demand in developed economies as well.

b The data used for this variable are in Table 3.

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