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Measures of Changes in Demand for Beef, Pork, and Chicken, 1975-2000

by

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Measures of Changes in Demand for Beef, Pork, and Chicken, 1975-2000

Wayne D. Purcell

Background

The past 25 years have seen changes of huge proportions in the meat and poultry sectors. Few agricultural commodities have received more attention from private firms and public policy-making sectors, and these tightly intertwined sectors have been the subject of considerable investigation and discussion by professional economists and market analysts. From a starting point of the mid-1970s, beef has lost its preeminent position in an increasingly competitive marketplace. On a retail weight basis, per-capita consumption of beef plunged from nearly 95 lb in 1976 to just above 65 lb in the early 1990s. Projections in late 2000 suggest that per-capita beef offerings, and therefore per-capita consumption for the year 2000, will be near 69.6. The long-term change in per-capita consumption from 95 lb to the mid 60s, suggests that major challenges faced the beef industry. Indeed, the total cattle inventory that had exceeded 132 million head in 1975 declined to just over 95 million head in the early 1990s. The beef cow herd declined from above 45.7 million to near 32.4 million head across the same time period. There has been widespread discussion in the popular press, trade magazines, and within the leadership circles of the beef industry about a 30 to 40 percent loss in market share. Significant economic pain, in the form of low prices and producer-level losses, has accompanied these developments.

The picture in the poultry sector is different and roughly inverse to what has happened in beef. Since the mid-1970s, per-capita offerings for chicken measured on a ready-to-cook weight basis have gone from around 40 lb to 77.1 lb in 1999. The 2000 level is expected to be near 78.7 lb with a 5 to 6-percent increase projected for 2001. Without suggesting that resources that were forced out of the beef sector simply moved into the poultry sector, the two trends are clearly in opposite directions and do, in fact, roughly parallel each other in terms of magnitude. The 30 lb or so of per-capita offerings that have been lost by beef have been more than matched by a 40-lb increase in per-capita offerings in chicken. Significantly larger increases would be apparent if the entire poultry sector, including turkey, was examined.

Developments in pork fall more nearly between the two extremes seen in beef and in poultry. The data show a clear reduction in industry capacity and output, as measured by per-capita consumption, starting in about 1980. Per-capita offerings that were near 57 lb on a retail-weight basis in 1980 had dipped to something below 48 lb in 1986. Since the mid-1980s, per-capita offerings have varied between 47 lb and 54 lb but then showed a significant change in direction and a significant year-to-year increase in 1998 from 48.7 to 52.6 lb. The measure increased again in 1999 to 53.8 lb before a projected cyclical reduction to 52.5 lb in 2000.

In every sector, producers are searching for answers as to why the environment in which they are operating has changed and is changing. In the case of beef, it was increasingly an anxious search for answers in terms of what is needed to restore economic viability to an industry that has continued to see disinvestment. In the mid-1980s, there was a surge of interest in cost of beef production and the efficiency of the production-marketing system as answers. In spite of then-developing evidence that shifts in demand have been the real culprit, there were industry programs with an objective of reducing production costs and, in the process, bringing beef prices down to stimulate an increase in quantity consumed via lower

prices. In the mid-to-late 1990s, there has been increasing awareness that being cost effective is, at best, a necessary condition to economic viability. More and more industry leaders are coming to realize that decreases in demand have been, in fact, the major problem. Most analysts were agreeing that in 1997, demand for beef had decreased virtually each year since 1979 or 1980. A "demand study group" was organized in 1997 to look at what needed to be done. Their recommendations centered around renewed commitment to moving to "consumer friendly" product offerings.

In pork, industry-wide interests and concerns have revolved around a substantial relocation, prompted primarily by environmental considerations, as to where hogs can be and are being produced. Paralleling those relocations, there has been a substantial change in industry structure. While the independent hog producer still produced the majority of pork in the early 1990s, that was expected to change in the future. Large production entities, often affiliated with major processors, are dictating quality control measures via control of genetics, feeding, and management regimes. This has allowed the industry to turn more attention toward quality with an increased emphasis on serving a changing consuming public. The National Pork Producers Council adopted a posture in the mid-1990s that suggested pork would be the "meat of choice" by the year 2000. While that goal was not met, the significant increase in per-capita pork production in 1998 certainly changed the status quo in terms of per-capita offerings and consumption. The sector then, given its revised organizational structure, maintained much of that increased base of production even though hog prices were very low in late 1998. In late 2000, some analysts believe the majority of hogs are now produced under contract or in processor owned facilities, and these production units are not independently owned and operated.

In the poultry sector in general and specifically in chicken, which is the subsector of primary interest here, the question has been more nearly one of properly managing growth. Benefiting from consumer perceptions that chicken is healthier and/or more appropriate for modern diets and lifestyles, poultry integrators have also been astute enough to recognize and benefit from a changing consumer. The consumer of 2000 and 2001 and beyond will be caught up in an on-the-go lifestyle and will demand consistent high-quality foodstuffs and convenience in preparation. It could be argued that the poultry sector has either recognized this need much more clearly than have beef or pork, or because of the vertically integrated nature of the industry, has been more able to focus resources toward being consumer driven. Whatever the case, it is clearly true that poultry is in a growth mode and has been for decades, and the traditional red meats, beef and pork--especially beef--have continued to go through a long-standing period of periodic downsizing and disinvestment. There is more evidence that this picture is turning to the positive side across the past two to three years, and this makes empirical measures of demand change even more important.

With the focus of attention shifting to the demand side of the price equation, it is useful to look at some measures of the changes in demand for beef, pork, and chicken, respectively. Exactly why demand surfaces have been shifting is a rather complex question, and in this particular effort, there will be no attempt made to completely disaggregate demand changes and associate them with every possible specific demand "driver." For example, the current state of knowledge suggests that several product attributes, such as high quality, consistency in quality, and convenience in preparation, may be more important in driving changed buying behavior for beef than is price or beef price relative to the price of substitutes. Eventually, employing sophisticated modeling approaches, market analysts will be interested in allocating the changes in demand across the past two decades to different demand shifters. A useful effort in this regard by Ted Schroeder and his associates is in the Kansas State University website at <http://www.oznet.ksu.edu/library/agec2/mf2457.pdf>.

In the effort reported here, models that capture the traditional economic demand shifters--changes in consumer incomes, and changes in prices of competing meats--will be employed. The other major demand shifter, changes in tastes and preferences, cannot be measured directly. Rather, the considerations that suggest consumers are increasingly concerned about quality, consistency, and convenience will be grouped into a composite variable which allows for and measures shifts in demand. What this suggests is that focus group work and consumer survey work published by a number of researchers and a number of trade organizations have largely told us what modern consumers want and what they tend to react to. The next important question is one of the magnitudes of these shifts associated with the non-economic demand shifters, like changes in tastes and preferences, associated with changing lifestyles. It has not been a matter of not knowing what the modern consumer wants in the beef, pork, and poultry offerings. It is more a matter of having a universal and industry-wide understanding of those issues and then resolving the often-knotty economic problems of how the industry product offering can be changed. Measures of the demand changes that can be reasonably related to changing preferences and changing lifestyles may help to focus and expand private and public efforts to solve some of the persistent problems. **The objective here is to provide measures of the changes in demand for beef, pork, and chicken and to offer these measures as guidelines to those interested in the economic wellbeing of the respective sectors.**

Conceptual Issues in Analyzing Demand

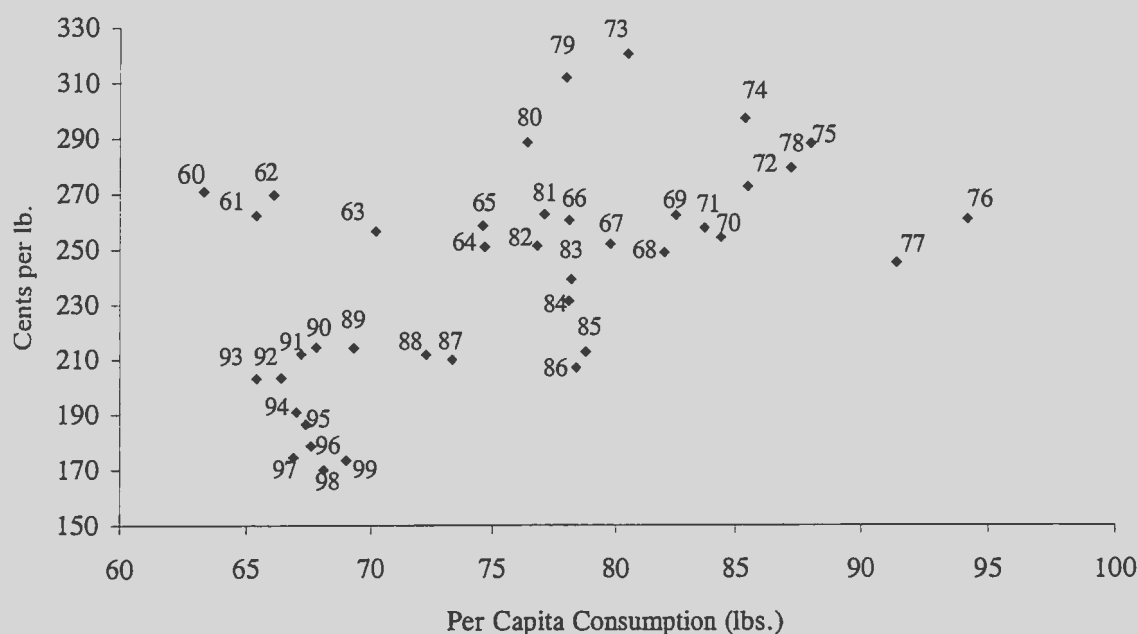
Looking at the data in a largely descriptive approach to analysis can be very revealing, but it also can create some difficulties in terms of assigning causation. Figure 1 shows a scatter plot of per-capita consumption of beef in retail weight equivalents with inflation-adjusted Choice retail beef prices in cents per pound.¹ Examination of the directions in which the price-quantity coordinates are moving over time certainly helps clarify what is happening to the beef sector. Recognizing that this price series is only representing fresh beef sold in retail supermarkets against all forms of per-capita consumption and recognizing that there are some data alignment issues here, there is nonetheless a bold message embodied in the data. Compared to 1979-1980, for example, we saw a sustained movement to lower inflation-adjusted prices with relatively constant per-capita offerings of beef through 1986 and then a sustained period of industry downsizing through 1993 as inflation-adjusted prices were maintained by a sharp reduction in per-capita offerings. Since 1993, the 1980s pattern has reemerged as prices have drifted lower in the face of per-capita offerings that have varied very little through 1999. Since the underlying demand curves are roughly negative with slope of about -45° (given the price and quantity levels of the 1990s, the scales on the graph, and an elasticity of about $-.67$), it would appear that 1997 was on the lowest demand curve ever seen in beef.

This suggestion that a scatter plot can and does tell what is happening to demand would be criticized by some analysts who understand the economic issue of *identification*. What is actually shown in Figure 1 is a path of price reduction from 1979-1980 through 1997 and some signs of stabilizing in 1998 and 1999, but it is not intuitively clear whether or not this is due to changes in demand or changes in supply. That is, in fact, the identification issue: Are we looking at shifts in supply or are we looking at shifts in demand as the causal force behind the price changes?

It is obviously possible that part of the general reduction in per-capita offerings across the past 20 years has come because resources were earning a better return in some other economic activity than they were earning in beef production. It is entirely possible, for example, that earnings in contract broiler

¹ Inflation-adjusted prices are used because we want to focus on what is happening in an economic supply-demand context and not have price changes due to shifts in demand, supply, or both intertwined with price changes that are just due to overall price inflation.

production at the farm level were sufficiently superior to earnings in beef cow-calf operations that some money was actually withdrawn from beef programs and invested directly in broiler production. Thus, we must recognize that changes in earnings and/or perceptions of future potential earnings can and will drive resources and investment dollars from one commodity to the next.

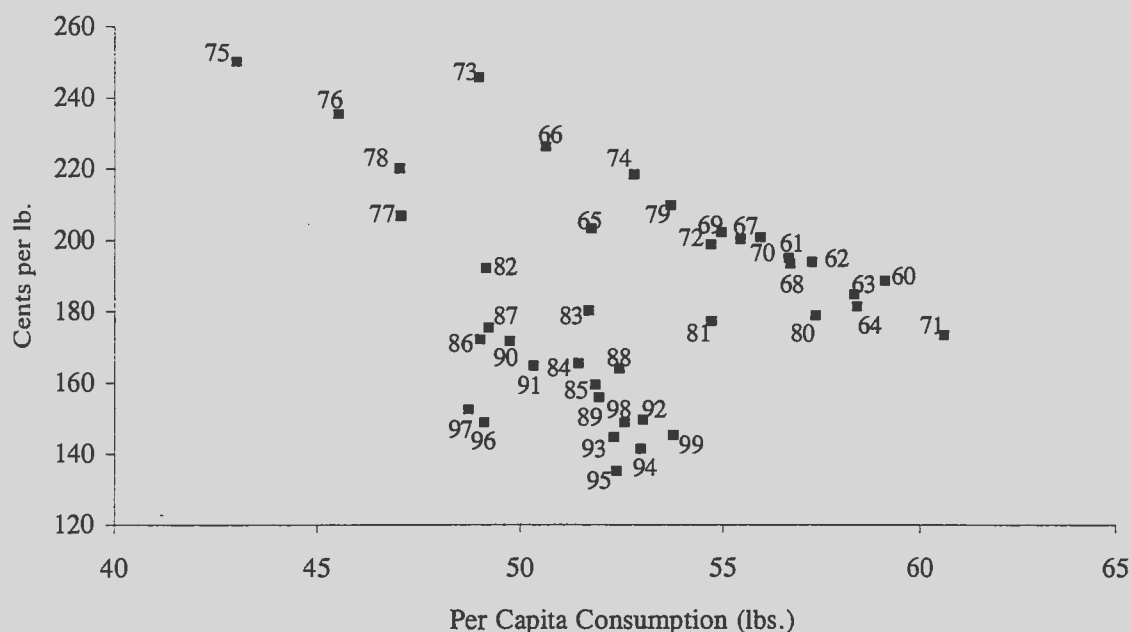


Source: *Livestock, Dairy, and Poultry Situation and Outlook*, ERS, USDA

Figure 1. Per-Capita Consumption and Inflation-Adjusted (CPI, 1984-82=100) Prices for Beef, 1960-99

Having suggested that the catalyst for the dramatic changes we have seen in beef could in fact have come partly from the supply side of the price equation, it is, nonetheless, very logical and very possible to view this scatter plot as indicative of what is happening to demand. In 1997, for example, something near 67 lb moved into consumption at inflation-adjusted prices a little above \$1.70 per lb. Irrespective of how the industry got to that position, *the 1997 price-quantity coordinates are clearly on a lower demand surface than, for example, in 1987 or 1988, some 10-11 years earlier.* Note that any negatively sloping demand surface that passes through the price-quantity coordinates for 1997 is clearly well below a negatively sloping demand surface that would pass through or near the coordinates for 1987 and 1988. If we assume that price elasticity of demand has changed very little in the past 10 years, it is true that the slope of the demand curve passing through 1988 would be somewhat different than the slope of the demand curve passing through 1997. This would be the case because the point of departure on both the per-capita consumption scale and price scale is lower in 1997, and percentage changes would be different in 1997 as compared to 1988. *But the fact that the slope of the negatively sloping curves would be slightly different does not in any way invalidate the ability to conclude that the price-quantity coordinates for 1997, however the conditions of 1997 were prompted, is on a substantially lower demand surface than was the industry in 1988.* Using the same reasoning, it would appear that 1999 is on a higher demand surface. Visualize two lines roughly parallel with slopes of about -45° and the demand "curve" running through 1999 must be on a higher demand surface than in 1997 or 1998--no matter how we got there.

Figure 2 shows the scatter plot for pork with inflation-adjusted prices and per-capita consumption since 1960. It is fairly easy to conclude that compared to 1979 or 1980, which was the same starting point employed in discussing beef, price-quantity coordinates in pork through 1997 are on a lower demand surface than they were in the early 1980s. For example, 1997 as compared to 1988 is clearly on a substantially lower demand curve. That same identification issue is pertinent here, and the same discussion could be repeated, but it would be redundant. Regardless of whether the impetus for change came from moving resources out of pork production because of poor returns or because of decreases in demand as consumers increasingly found fault with the fresh pork offering, the story for 1997 is still the same. *The demand surface in 1997 was substantially lower than it was earlier in the decade and in the 1980s, especially in the early 1980s. And it is clear that 1998 in particular is on a higher demand surface, and that 1999 would appear to be on that same "curve" coming through 1998. It also appears that the curve that represents 1998 and 1999 is well up and to the right of 1997—an increase in demand.*



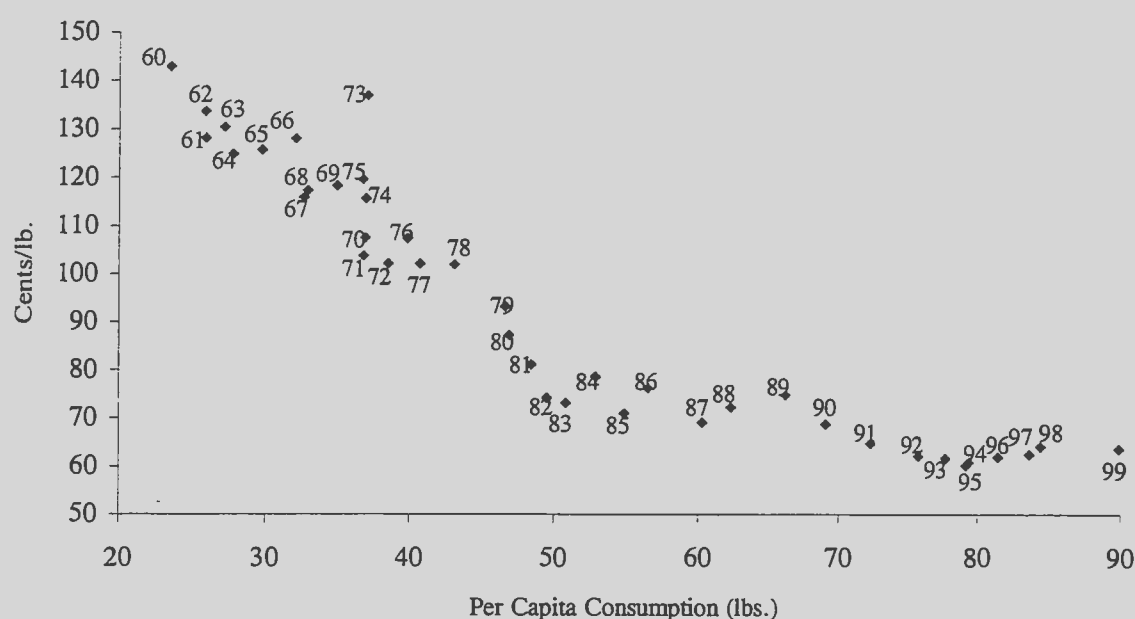
Source: *Livestock, Dairy, and Poultry Situation and Outlook*, ERS, USDA

Figure 2. Per-Capita Consumption and Inflation-Adjusted (CPI, 1984-82=100) Prices for Pork, 1960-99

A glance at Figure 3 indicates the situation is substantially different in broilers. This particular scatter plot goes back to 1960 and to get that extended period of data, whole bird prices have to be used. Only 15-20 percent of chickens are now bought in the form of whole birds, but the USDA's price series that examines a weighted average price of chicken cuts only goes back to 1980. Using the later-developed price series does show more clearly that demand for chicken is increasing in recent years, but the scatter plot in Figure 3 certainly gives us the same picture. A demand surface for the early 1980s, one that passed through or was close to the 1982-83 coordinates, for example, would have a slope of roughly 45 degrees. This is based on research evidence that suggests the price elasticity of demand for broilers at retail has historically been around $-.8$ in absolute value.² If we move out to the more recent years where inflation-

² Reuben C. Buse, Editor, *The Economics of Meat Demand*, University of Wisconsin, 1986. Table 3, pp. 108-111.

adjusted price has been relatively constant, near \$.60 per lb, the quantity base has moved up to about 85 lb. The slope of the demand surface passing through 1996 and 1997 would have to be somewhat below 45 degrees to reflect that same -.8 elasticity of demand. Having said that, it is clear that the demand surface or curve would have a significant negative slope and that the demand curve passing through 1997 was up and to the right compared to 1996 and certainly compared to 1995. The same could be said for 1998. Indeed, the demand surface present in the mid-to-late 1990s is substantially up and to the right of that for the mid-to-late 1980s. There has been, then, a significant and sustained increase in demand for chicken across the past 18-20 years. Note, for example, that in 1982-83, consumers took about 50 lb of chicken on a ready-to-cook weight basis at an inflation-adjusted price of about \$.70 per lb. In 1999, the per-capita offering that consumers were buying was up by 40 lb, an 80 percent increase in quantity, and price was down only about 10 percent. Across this long time period, those changes argue for significant increases in demand for chicken. This, of course, is a primary reason that resources have continued to be attracted into broiler production and why that sector has grown significantly compared to beef and pork.



Source: *Livestock, Dairy, and Poultry Situation and Outlook*, ERS, USDA

Figure 3. Per-Capita Consumption and Inflation-Adjusted (CPI, 1984-82=100) Prices for Broilers, 1960-99

In addition to the question of "identification," the conceptual issue of simultaneity emerges when analyzing demand for beef, pork, or chicken. It is a complex issue, but the essence is one of what causes what with regard to quantity and price. Is the causal flow from quantity to price or vice versa?

When dealing with annual data, the question of direction of causal flow can be a difficult one. A simple model of the form $PC_B = f(Inv.)$ where

PC_B = annual per capita beef consumption

$Inv.$ = January 1 total cattle inventories

will show that 80 percent of the variation in per-capita beef consumption is explained by variation in the January 1 total cattle inventory. There is still, however, some room for the causal flow to run from price

to quantity within the year. High fed cattle prices in the first quarter of the year can influence the number of cattle placed on feed (and therefore influence beef quantity) later in the year.

In pork, beginning inventories at the first of the year will also be an important determinant of production, and the same would hold for chicken. There will be variation in pork and chicken supplies depending on whether expansion or liquidation is going on, however, and there could therefore be some causal flow from price to quantity within the year when annual data are used.

If the time period for which data are used is a calendar quarter, the issue of simultaneity essentially disappears. *Quantity for any particular quarter is largely predetermined* by the overall inventory and by management decisions on the number of cattle placed on feed, decisions on breeding or selling gilts in the pork sector, and by the eggs set and chicks placed in the chicken sector. In this setting, quantity (as measured by quarterly per-capita consumption) is largely predetermined, and *it is price that adjusts to find a market-clearing price for the predetermined quantity*. A single-equation model with price as the dependent variable and quantity (plus other economic factors) as an explanatory variable is an effective way to model what is happening. Such price-dependent models for beef, pork, and chicken are used in this analysis.

Measures of Change in Demand

The scatter plots give a general impression of what has been happening to demand, an impression that extends beyond the direction of movement. Even a casual examination of the scatter plot for beef suggests a substantial decline in demand since the late 1970s or 1980. Much the same type of qualitative inference can be drawn by examining the scatter plots for pork and for chicken. But qualitative and directional inferences are not always sufficient. For those who are responsible for industry programs to try to correct or improve demand-side problems or for-profit firms that must make investments to change the products being offered or to develop new products and markets, some measure of magnitude and some way to monitor what is happening is often needed.

Table I shows a quantity-adjusted index for beef demand from 1980 through 1999. This index was calculated at the request of the Demand Studies Group of the National Cattlemen's Beef Association (NCBA) and the Cattlemen's Beef Promotion and Research Board (CBB) and was commensurate with their interest in having a single and simple indicator of what was happening to demand. Many marketing economists' initial reaction to such a simple approach would be negative. It is, in fact, an oversimplification and leaves one wondering why those shifts in demand as measured by the index have occurred. The advocate of such a measure, on the other hand, would argue that surveys and descriptive data are widely available that suggest the nature of the problems. Beef has suffered from a problem of quality inconsistency, with tenderness in particular varying a great deal within the Choice grade. With most consumers indicating they want convenience in preparation, the sparsity of precooked beef items that can go in the microwave suggests that lack of convenience in preparation is another problem that has plagued beef across the years. It is possible, it can be argued, to have at least an educated assessment of why problems have occurred and still have a need for a single measure of demand change.

The index, with 1980=100, indicates a movement down to 50.88 by 1997. Basically, this suggests that the demand for beef has declined some 49.12 percent since the 1980 base year. The index is also shown with a base year of 1997 (=100) to facilitate monitoring changes compared to 1997 when NCBA and the CBB focused more attention on the issue.

Table I. Quantity Adjusted Index for Beef Demand

Year	Per-Capita Consumption	Deflated Price (cents/lb.)	Constant Demand Price (cents/lb.)	Index (1980=100)	Index (1997=100)
1980	76.6	288.3	--	100.00	196.5
1981	78.3	262.6	278.80	94.19	185.1
1982	77.1	251.3	285.54	88.01	173.0
1983	78.6	239.1	277.11	86.27	169.5
1984	78.5	231.3	277.67	83.29	163.7
1985	79.3	212.7	273.18	77.84	153.0
1986	78.9	206.9	275.43	75.13	147.7
1987	73.9	209.9	303.52	69.14	135.9
1988	72.7	211.6	310.26	68.19	134.0
1989	69.3	214.3	329.36	65.06	127.9
1990	67.8	214.5	337.79	63.50	124.8
1991	66.8	212.0	343.41	61.73	121.3
1992	66.5	203.3	345.10	58.91	115.8
1993	65.1	203.1	352.96	57.54	113.1
1994	67.0	190.9	342.29	55.77	109.6
1995	67.5	186.6	339.48	54.96	108.0
1996	68.2	178.6	335.54	53.22	104.6
1997	66.9	174.5	342.85	50.88	100
1998	68.1	170.0	336.67	50.58	99.4
1999	69.0	173.4	329.93	52.37	102.9

The index calculation is based on demand constant prices compared to 1980 using an elasticity of -0.67. The index was then rescaled to 1997=100 so that changes from 1997 can be easily monitored. A current index of 105 would mean demand has increased 5% since 1997, or an index of 96 would mean demand has decreased 4% in the same time span. The index values show how demand is changing but give no information on why it is changing. The index values are also a function of the -0.67 retail level demand elasticity, but the index does not change drastically for elasticity parameters of -0.5 to -0.8.

The per-capita consumption and deflated price data used in calculating the index are shown in the table. Using an elasticity of $-.67$, all of the year-to-year changes are compared to 1980 as a base year and are all converted to price changes after adjusting to the 1980 levels, a “constant-quantity” approach. That is, each year the observed deflated price is compared to a constant-quantity price that would have occurred if the 76.4 lb of 1980 had still been the quantity offered. This is done by taking the quantity-induced price changes through the elasticity framework, thus accounting for price changes that would be due to quantity changes if demand were constant. The column that shows the percent change in price due to demand shifts suggests, as does the scatter plot, acute problems in the 1980s, certainly through 1987, and then a resurgence of more significant year-to-year problems in the early 1990s. This column is calculated by using the demand-constant price and comparing that derived price to the actual observed price.

The use of a simple index is complicated, as suggested earlier, by the realization that there is no indication as to why demand has declined. Was the decline primarily a function of changes in consumers’ incomes and changes in relative prices, as some industry observers continue to suggest? Or were the declines more nearly coming from the taste and preference demand shifter where substantial decreases in demand were being recorded even after accounting for the demand-shifting influences of changes in consumers’ incomes and changes in relative prices vis-à-vis substitute products? Without getting complex and too sophisticated in mathematical terms, and in modeling efforts, there are alternative ways to look at what is happening to the demand surface for beef, pork, and chicken without all of the simplifying assumptions employed in an index calculation. Econometric models can be employed to account for the traditional demand shifters of changes in consumers’ incomes and changes in relative prices and still be specified in such a way as to give a measure of the shift in the demand surface after those two primary economic demand shifters have been accounted for.

Econometric Models of Demand Shifts Measured in Terms of Price Changes

A traditional and common way to model beef prices for a time period as short as a calendar quarter is to specify beef prices as a function of a measure of predetermined beef quantity and measures of the quantities available in substitute meats such as pork and chicken. Beef demand changes with changes in prices of competing meats such as pork. If quantities of competing meats change, their prices will move in the opposite direction. Thus, using quantity measures for substitute meats incorporates the “substitute product” or “relative price change” demand shifter for beef. Consumers’ incomes would also typically be included since this is expected to be a demand shifter over time. When working with quarterly data, there will typically be additional measures of repetitive seasonal changes in beef price that are not accounted for by changes in beef quantity, changes in pork and chicken, or changes in consumers’ incomes. In terms of a general specification, then, the model would be as follows:

$$P_{\text{beef}} = f(Q_{\text{beef}}, Q_{\text{pork}}, Q_{\text{chick}}, C_{\text{income}}, D_2, D_3, D_4)$$

This model shows beef price (P_{beef}) as the dependent variable. The explanatory variables are beef quantity as measured by per-capita beef consumption (Q_{beef}), pork quantity as measured by per-capita consumption (Q_{pork}), chicken quantity as measured by per-capita consumption (Q_{chick}), plus per-capita consumers’ disposable incomes (C_{income}) and three dummy variables (D_2 , D_3 , and D_4) to account for seasonal changes. For statistical reasons, only three of the quarterly seasonal dummies can be used, and the impact of the quarter that is allowed to be the base (quarter 1 here) for comparison purposes is effectively in the intercept term in the estimated model.

When the model is estimated, the coefficient on the measure of beef quantity should be negative. This is merely a reflection of the inverse relationship between price and quantity as supply shifts along a negatively sloping demand surface. You would also expect negative coefficients on the measures of pork and chicken quantities. This is true because an increase in pork quantity, to illustrate, should drive the price of pork down with the magnitude of the price decline a function of demand elasticity for pork. Other things equal, a decline in the price of pork, which is widely recognized as a potential substitute for beef, would tend to shift the demand for beef down and for given and predetermined beef production levels, decrease beef price. This same reasoning, of course, would apply to the measure of chicken quantity, so the coefficient on the measure of chicken per capita quantity should also be negative.

The coefficient on consumers' incomes should be positive. This is reflective of the fact that beef is what is known as a superior product in the sense that demand for beef tends to be positively related to consumers' incomes over time. Economists estimate income elasticities, which generally show that as incomes go up, consumers tend to take an increased quantity of beef at constant beef prices (and constant prices of the other meats). Thus, rising consumer incomes would be expected to shift the demand surface for beef up and to the right, and the coefficient should be positive. For predetermined quantities of beef, increases in consumers' incomes should increase beef prices.

The signs on the dummy variables to account for any seasonal price movement that is not accounted for by the already included economically based demand shifters will depend on which quarters are included. For example, there is usually some expectation that beef prices would get a positive boost in the summer months when the grilling season is running full force. If this seasonal phenomenon does in fact affect beef demand, it will not necessarily be captured by the pork, chicken, or income demand shifters. This could mean that the second or third calendar quarters might show a positive coefficient on these shift or dummy variables, and perhaps a negative coefficient on the fourth quarter when the grilling season is over and this impetus to the demand side of the price equation disappears.

Table II shows the statistical properties of this preliminary model specification when estimated using quarterly data for 1960 through the first quarter of 2000. The model is not, even on a cursory examination, a well-specified model. The signs on the measures of beef, pork, and chicken consumption are theoretically correct as is the sign on consumers' incomes, but the Durbin-Watson statistic suggests the presence of very significant levels of positive autocorrelation. This means that the residuals, which are calculated by subtracting the predicted quarterly price from the actual quarterly price, are not independent of each other and are not demonstrating a random pattern over time. The initial impression for most analysts when these types of results are generated is that something is missing from the model that should be included to pick up the time-related components the presence of autocorrelation is suggesting.

A useful way to examine the effectiveness of any particular model specification, therefore, is to plot and examine the residuals. Random residuals are an important requirement of an effective model specification. Being random means that there would be no sustained "runs" in the residuals such that the direction of change (positive or negative) in residuals over time stays the same for a prolonged time period across a number of calendar quarters.

Table II. Statistical Properties of the Preliminary Beef Price Model, 1960-2000

Ordinary Least Squares						
Dependent Variable	BEEFDEF	Number of Observations	161			
Mean of Dep. Variable	239.4989	Std. Dev. Of Dep. Var.	38.014589			
Durbin-Watson Statistic	.3084	Estimated Autocorrelation	.84578			
Std. Error of Regr.	18.7229	Sum of Squared Residuals	53633.8			
Total Variation	.23122E+06	Regression Variation	.17758E+06			
Regression degrees of freedom	7	Residual degrees of freedom	153			
R squared	.76804	Adjusted R squared	.75742			
F (7, 145)	72.3699	Prob. Value of F	.00000			
Variable	Coefficient	Std. Error	t-ratio	Prob t > x	Mean of X	Std. Dev. of X
Constant	277.546	37.32	7.438	.00000		
BEEFCON	-2.86326	1.451	-1.973	.05030	18.96211	2.07575
PORKCON	-1.40720	1.637	-0.860	.39134	13.14161	1.22956
BRCON	-16.0274	2.105	-7.615	.00000	12.71118	4.98806
DEFINC	.0221774	0.005	4.815	.00000	10463.99169	2084.05236
QDUM2	14.7711	4.647	3.179	.00179	.24845	.43346
QDUM3	12.8476	4.834	2.658	.00870	.24845	.43346
QDUM4	-1.85186	4.389	-.422	.67369	.24845	.43346
Where:						
	BEEFDEF	= deflated (CPI, 1982-84=100) retail Choice beef price (cents/lb)				
	BEEFCON	= per-capita beef consumption, retail weight (lb)				
	PORKCON	= per-capita pork consumption, retail weight (lb)				
	BRCON	= per-capita chicken consumption, carcass weight (lb)				
	DEFINC	= deflated per-capita disposable income (\$)				
	QDUM2	= seasonal shift variable, quarter 2				
	QDUM3	= seasonal shift variable, quarter 3				
	QDUM4	= seasonal shift variable, quarter 4				

Figure 4 shows a plot of the residuals from this preliminary model estimation. It is apparent that there are sustained periods across the 1960-2000 time frame in which residuals are moving in the same direction. Such a pattern starts in 1977 when the residuals bottom and move up for a number of consecutive quarters. Then, in the 1978 through early 1986 time period, with the exception of a few short-term gyrations back to the upside, the residuals are all coming down. When there is a "trend" in these data, the residual for one quarter will be related to the residual for the prior quarter or prior quarters as they all show negative quarter-to-quarter changes or first differences in the sustained runs shown in the plot. The fact that the residuals from early 1979 to mid-1986 are all declining indicates that for that entire time period, the observed prices were coming down toward the model-predicted price from a supply-induced cyclical price peak in 1979. By 1986, the observed price was well below the predicted price from this preliminary model specification. This preliminary finding is very consistent with what we observed in examining the scatter plot discussed earlier. It would certainly appear that something other than relative prices, consumers' incomes, and seasonal patterns in beef prices were acting on the beef market during the late 1970s to mid-1980s. The pattern of residuals from about 1986 into the early 1990s again does not suggest a random pattern and indicates that the problem of some missing explanatory variable is still present. Note the sustained upward trend in the residuals from 1986 into the early 1990s and then a reversion to the downward trending pattern into early 1998 and then an increasing pattern through early 2000.

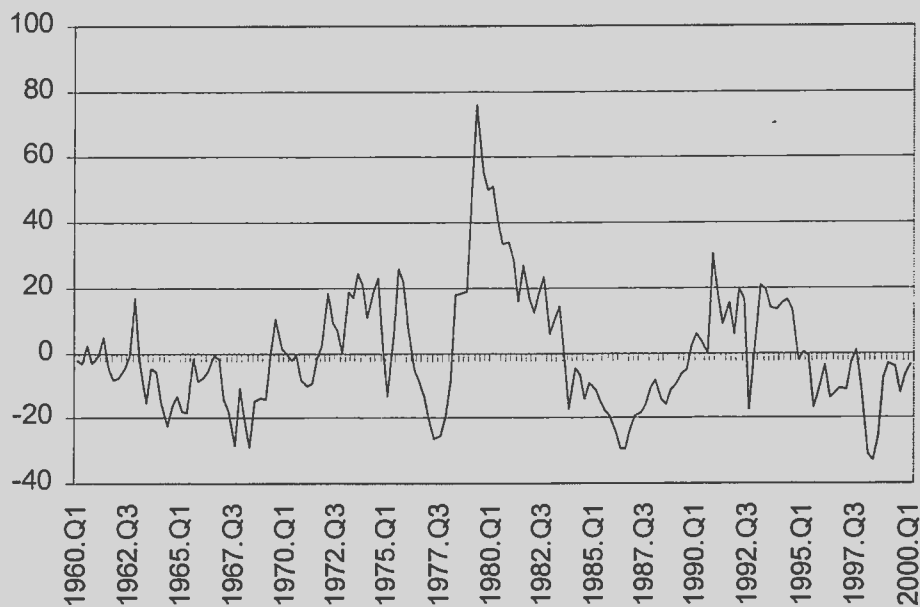


Figure 4. Residuals for the Preliminary Beef Price Model, 1960-2000

A re-specification of the model that can be guided by examination of the performance of the preliminary model involves inserting 0-1 or dummy variables for the four quarters in any period of years for which the residuals are showing a non-random pattern. In the data matrix, there will be a column of data for a particular variable that has 1's in each of the four quarters for a particular year and 0's in the calendar quarters for all other years. This allows a shift in the price surface, or more specifically a shift in the model intercept for beef prices, to be picked up by the 0-1 or dummy variable. Any non-zero coefficient on these shift variables would suggest a change in price in that particular year that is not being explained by competition of substitute meats, changes in consumers' incomes, changes in beef quantity, or a regular rhythmic seasonal pattern as measured by the seasonal dummy variables. This process can be repeated such that each year has the potential to shift for reasons other than those represented by the other explanatory variables in the model. *The coefficient on these yearly dummy variables will give a specific measure of what is happening to beef prices for reasons other than those provided for by changing consumer incomes; changing relative prices in beef, pork, and chicken; beef quantity; and seasonal price patterns.*

Table III shows a model run that allowed the annual dummy variables to be introduced for years 1975 (DUM75) through 2000 (DUM00) with only the first quarter of 2000 in the data set. There are a number of differences in this model that stand out in comparison to the preliminary model where the yearly dummies were not included.

Table III. Statistical Properties for a More Extensive Beef Price Model, 1960-98

Ordinary Least Squares						
Dependent Variable	BEEFDEF		Number of Observations		161	
Mean of Dep. Variable	239.4989		Std. Dev. Of Dep. Var.		38.014589	
Durbin-Watson Statistic	1.6169		Estimated Autocorrelation		.19155	
Std. Error of Regr.	7.6343		Sum of Squared Residuals		7401.83	
Total Variation	.23122E+06		Regression Variation		.22382E+06	
Regression degrees of freedom	33		Residual degrees of freedom		127	
R squared	.96799		Adjusted R squared		.95967	
F (31, 121)	116.3699		Prob. Value of F		.00000	
Variable	Coefficient	Std. Error	t-ratio	Prob t > x	Mean of X	Std. Dev. of X
Constant	331.308	18.16	18.242	.00000		
BEEFCON	-10.7701	1.046	-10.296	.00000	18.96211	2.07575
PORKCON	-3.06137	.9284	-3.298	.00126	13.14161	1.22956
BRCON	-.661127	1.790	-.369	.71245	12.71118	4.98806
DEFINC	.0225623	.002388	9.449	.00000	10463.99169	2084.05236
QDUM2	.695210	2.341	.297	.76693	.24845	.43346
QDUM3	4.64427	2.244	2.069	.04055	.24845	.43346
QDUM4	-2.36477	1.896	-1.247	.21466	.24845	.43346
DUM75	10.0993	4.905	2.059	.04156	.02484	.15614
DUM76	-3.40974	4.923	-.693	.48983	.02484	.15614
DUM77	-30.7022	4.574	-6.713	.00000	.02484	.15614
DUM78	-15.5412	4.895	-3.175	.00188	.02484	.15614
DUM79	.815878	6.705	.122	.90335	.02484	.15614
DUM80	-16.3019	6.884	-2.368	.01940	.02484	.15614
DUM81	-38.0419	6.977	-5.452	.00000	.02484	.15614
DUM82	-54.9611	7.540	-7.289	.00000	.02484	.15614
DUM83	-67.5285	7.529	-8.969	.00000	.02484	.15614
DUM84	-86.5982	8.159	-10.614	.00000	.02484	.15614
DUM85	-101.676	8.832	-11.512	.00000	.02484	.15614
DUM86	-119.424	9.259	-12.898	.00000	.02484	.15614
DUM87	-133.347	11.36	-11.736	.00000	.02484	.15614
DUM88	-139.654	12.42	-11.247	.00000	.02484	.15614
DUM89	-156.699	14.60	-10.730	.00000	.02484	.15614
DUM90	-157.389	15.86	-9.924	.00000	.02484	.15614
DUM91	-166.444	16.89	-9.853	.00000	.02484	.15614
DUM92	-177.731	17.53	-10.137	.00000	.02484	.15614
DUM93	-185.292	19.18	-9.663	.00000	.02484	.15614
DUM94	-195.830	19.61	-9.988	.00000	.02484	.15614
DUM95	-209.728	19.13	-10.966	.00000	.02484	.15614
DUM96	-220.827	19.65	-11.241	.00000	.02484	.15614
DUM97	-228.499	20.72	-11.029	.00000	.02484	.15614
DUM98	-246.320	20.90	-11.786	.00000	.02484	.15614
DUM99	-246.201	22.59	-10.898	.00000	.02484	.15614
DUM00	-251.846	24.15	-10.429	.00000	.00621	.07881

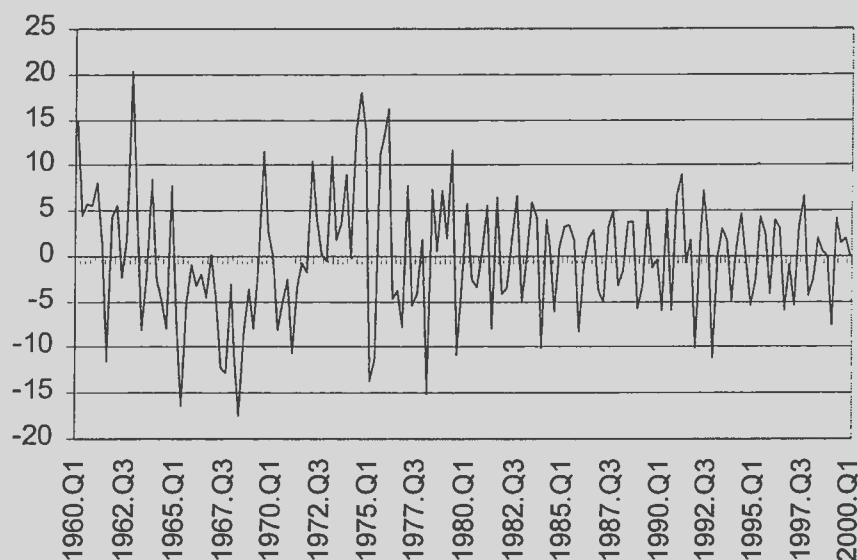


Figure 5. Residuals for a More Extensive Beef Price Model, 1960-2000

The Durbin-Watson statistic now suggests that the major problem of autocorrelation is gone (the statistic is in the indeterminate range). The R^2 , which measures the percentage of variation in quarterly beef prices explained by the model, is now above 96 percent as compared to 76 percent in the preliminary model. Even after "penalizing" the model for including the additional explanatory variables as represented by the yearly dummies, the adjusted R^2 exceeds 95 percent. On the surface, this model appears to be far superior to the preliminary model for statistical reasons and for reasons of economic reasoning. Note that the huge negative coefficient on the measure of broiler consumption that was highly significant in statistical context in the first model with a t-ratio of -7.615 (where a t-ratio of some 1.96 indicates statistical significance at the $.05$ level) is changed substantially in this latter run. The coefficient is still negative, but broiler consumption no longer shows up as statistically significant in terms of being an explanatory variable for beef prices. The t-ratio is only -0.369 . Pork, instead, becomes the significant factor with a t-ratio of -3.298 , showing the expected negative sign. The negative sign, recall, means that an increase in pork quantities will bring lower pork prices, and lower pork prices decreases beef demand and prompts lower beef prices for given beef quantities.

The "consumer incomes" variable shows the theoretically expected positive sign. The t-ratio is 9.449 , suggesting that consumer incomes have been an important force in explaining changes in beef prices over time.

These findings are very consistent with what many analysts have observed with difficulty in finding statistically significant evidence that chicken is in fact a direct substitute for beef. It may well be that chicken competes for certain cuts of beef and that the crossover influence is masked by the use of an aggregate price for beef and the whole bird broiler price, but this whole bird series is the only price series we have back to 1960 for chicken. In most past studies (see references at the end), pork has been an important substitute and consumers' incomes have shown a positive and statistically significant influence.

Perhaps much more importantly, the residuals for this model, as shown in Figure 5, look significantly different compared to the residuals from the preliminary model. This is especially true, as one would expect, for the period 1975 and later when the yearly dummy variables were allowed. Note the tendency for the residuals to fluctuate around zero with few circumstances in which the residuals are moving in the same direction for more than two consecutive quarters in this plot of residuals. The take-away from Figure 5 is that whatever explanatory factor might have been left out of the initial model that tried to account for changes in beef prices—an influence that could not be attributed to beef quantity, changes in the substitute meat market, consumers' incomes, and quarterly seasonal dummies—has now been eliminated.

It is very important to recognize that this approach to model specification, while it measures the impact of price shifts to some not-included reasons such as a change in preference patterns for beef, *does not indicate specifically why beef prices have declined and why the demand surface for beef has shifted down*. The reasons, as was suggested earlier, could be attributed to what we know from consumer surveys and focus group work and relate back to the problems associated with level of quality, consistency of quality, convenience in preparation, concerns about fat/cholesterol, etc., but we cannot attribute the improved model performance here to any one or any subset of those specific factors. *What one can say is that there is something acting on demand for beef and prompting prices to go down over time over and above the influence from changes in the level of beef quantity, the impact of meat substitutes, changes in consumers' incomes, and any regular and rhythmic seasonal pattern in beef prices.*

With the t-ratio on chicken below 1.0 in absolute value, many analysts would argue it should be eliminated. The model was re-estimated with BRCON eliminated, but there were no differences of consequence. Coefficients and t-ratios on the other explanatory variables were virtually identical. It did appear that the broiler variable is correlated with the seasonal dummies since the size of the coefficients and t-ratios (but not the signs) on the seasonal dummies did change slightly. The statistical properties for this revised model and a plot of the model residuals are shown in Table IV and Figure 6 respectively. In the interest of conceptual completeness, the discussion of the results that follows will employ the model specification in Table III that includes the measure of broiler consumption.

While it is impossible to associate the changes in beef prices with any specific demand shifter outside of those included in the model, the coefficients for the shift variables DUM75 through DUM99 do give a direct measure of the extent to which the price for beef has changed for reasons beyond those traditional forces that were included in the model. Note that the coefficient on DUM75 is positive, which means beef prices were higher in 1975 than the regular economic shifters in the model would have suggested. But the coefficient is negative in 1977, the year in which the residual plot from the preliminary model showed the sustained upward movement. The coefficient on DUM78 is also negative, but the coefficient on DUM79 is close to zero, and note, with a t-ratio of only -.101, that it is not statistically significant. It is after 1979, starting with 1980, that the coefficients on the yearly shift dummies are 1) all negative, and 2) all statistically significant as evidenced by t-ratios of at least 3.2 and higher in absolute value. The changes in the coefficient levels from DUM80 through DUM87 pick up the substantial decrease in demand for beef during the 1980s that was apparent from examination of the scatter plot and the index calculations. The yearly changes toward the negative direction then subside somewhat but continue to move larger in absolute terms and stand at -\$2.53 for DUM99. Technically, the coefficient on DUM99 suggests that the intercept for the model is \$2.53 per lb below where it would have been if shifts in the demand surface that cannot be attributed to the traditional economic demand shifters had not occurred.

Table IV. Statistical Properties for a More Extensive Beef Price Model, 1960-2000: Broiler Consumption not Included

Ordinary Least Squares						
Dependent Variable	BEEFDEF		Number of Observations		161	
Mean of Dep. Variable	239.4989		Std. Dev. Of Dep. Var.		38.014589	
Durbin-Watson Statistic	1.6179		Estimated Autocorrelation		.19105	
Std. Error of Regr.	7.6085		Sum of Squared Residuals		7409.79	
Total Variation	.23122E+06		Regression Variation		.22381E+06	
Regression degrees of freedom	32		Residual degrees of freedom		128	
R squared	.96795		Adjusted R squared		.95994	
F (31, 121)	120.8173		Prob. Value of F		.00000	
Variable	Coefficient	Std. Error	t-ratio	Prob t > x	Mean of X	Std. Dev. of X
Constant	332.498	17.81	18.665	.00000		
BEEFCON	-10.8669	1.009	-10.768	.00000	18.96211	2.07575
PORKCON	-3.05018	.9247	-3.298	.00126	13.14161	1.22956
DEFINC	.0220302	.001898	11.607	.00000	10463.99169	2084.05236
QDUM2	.130785	1.767	.074	.94111	.24845	.43346
QDUM3	4.22363	1.928	2.191	.03025	.24845	.43346
QDUM4	-2.39653	1.888	-1.269	.20659	.24845	.43346
DUM75	10.3764	4.831	2.148	.03362	.02484	.15614
DUM76	-3.36026	4.905	-.685	.49451	.02484	.15614
DUM77	-30.7808	4.553	-6.760	.00000	.02484	.15614
DUM78	-16.0149	4.709	-3.401	.00090	.02484	.15614
DUM79	-.559090	5.558	-.101	.92004	.02484	.15614
DUM80	-17.8238	5.497	-3.243	.00151	.02484	.15614
DUM81	-39.8085	5.063	-7.862	.00000	.02484	.15614
DUM82	-57.0076	5.097	-11.184	.00000	.02484	.15614
DUM83	-69.5328	5.203	-13.365	.00000	.02484	.15614
DUM84	-88.7009	5.825	-15.228	.00000	.02484	.15614
DUM85	-104.085	5.938	-17.528	.00000	.02484	.15614
DUM86	-121.847	6.514	-18.705	.00000	.02484	.15614
DUM87	-136.421	7.709	-17.697	.00000	.02484	.15614
DUM88	-142.953	8.597	-16.629	.00000	.02484	.15614
DUM89	-160.676	9.836	-16.336	.00000	.02484	.15614
DUM90	-162.012	9.707	-16.691	.00000	.02484	.15614
DUM91	-171.426	10.14	-16.909	.00000	.02484	.15614
DUM92	-182.822	10.80	-16.924	.00000	.02484	.15614
DUM93	-190.979	11.39	-16.760	.00000	.02484	.15614
DUM94	-201.725	11.35	-17.768	.00000	.02484	.15614
DUM95	-215.212	12.02	-17.908	.00000	.02484	.15614
DUM96	-226.570	11.97	-18.929	.00000	.02484	.15614
DUM97	-234.667	12.22	-19.199	.00000	.02484	.15614
DUM98	-252.141	13.68	-18.426	.00000	.02484	.15614
DUM99	-252.695	14.14	-17.868	.00000	.02484	.15614
DUM00	-258.535	15.92	-16.236	.00000	.00621	.07881

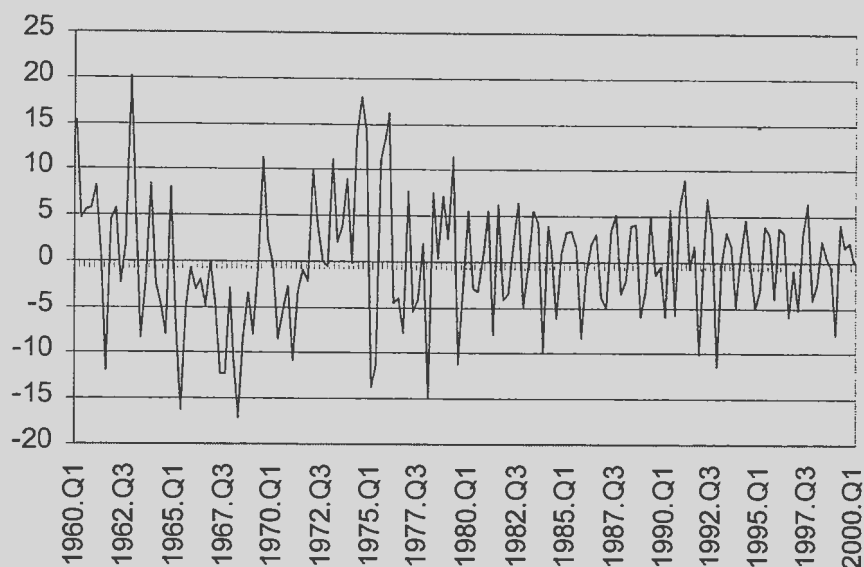


Figure 6. Residuals for a More Extensive Beef Price Model, 1960-2000: Broiler Consumption not Included

Expressing the cumulative shift in the price surface of \$2.53 as estimated by DUM97 as a percentage of the constant or intercept term for the model, which is essentially \$3.32, it would appear that price of beef has declined by about 76 percent after accounting for the price moving impacts of changes in quantity of substitute meats (which captures relative prices), consumers' incomes, and the quantity of beef being produced. This measurement of the shift in demand that might be associated with the lack of progressiveness in terms of moving to a consumer-friendly product offering over time for fresh beef actually exceeds the shift implied in the earlier index work. In the index work, the price implications of the change in beef quantities was accounted for and none of the possible demand shifters, even the traditional economic shifters, were brought into the analysis. Consumers' incomes have gone up over time, and other things equal, that should have boosted the demand for beef and pushed beef prices up at any particular beef quantity being considered. This may explain why the demand index shows demand improving in 1999. The coefficients on the dummy variables only show the possible "preference" related impacts and do not negate the possibility that the income shifter was pushing demand up. The price of pork has trended down over time, periodically relative to beef prices, and that would have tended to decrease the demand for beef and tended to decrease beef prices. Again, the 1999 picture was different. Prices for pork recovered significantly during 1999 from the depressed levels of 1998. This would also tend to increase beef demand during 1999. The price of chicken, which, after declining modestly in the post-1980 period, has been fairly constant in recent years, would have been a traditional economic source of demand-boosting influence for beef. Chicken prices have increased relative to beef prices. But we need to remember that the influence of the chicken sector, as reflected in the model by per-capita chicken consumption, was not a statistically significant factor in terms of explaining changes in beef prices over time.

It is interesting to note that expressed as a percentage of the mean beef price (\$2.39) for the entire period, the -\$2.53 coefficient on the DUM99 shift variable is over 100 percent of the mean price.

Technically, of course, the shift dummies measure changes in the intercept. The 76 percent decline in beef prices on that basis is thus arguably the best measure of change.

In using the results of this model, it is important to recognize that the model has been configured primarily to explain changes in beef prices over time. It does that quite well with an adjusted R^2 in excess of 95 percent. What has not been done is any detailed analysis of any multicollinearity problems in explanatory variables which might influence the precision with which the model estimates any particular parameter. For example, before taking the -10.8669, which is the coefficient on per-capita beef consumption, and using that to calculate a price flexibility coefficient, any analyst would want to examine the model in more detail and look at the diagnostic statistics, especially for multicollinearity, to see whether or not a somewhat different model specification might be needed. If, for example, there is a high level of correlation and a collinear relationship between per-capita chicken consumption and per-capita beef consumption, then you might want to eliminate the broiler consumption variable from the model and re-estimate the model to see what influence it has on the coefficient on per-capita beef consumption. (The influence was minor: note Tables III and IV.) One would not expect, however, to see any major impact on the accumulating and increasingly negative measures in the form of coefficients on the yearly dummy variables. With 96 percent of the variation in beef price explained, and much of this explanatory power coming from the shift dummies, *the model provides measures of the change in beef prices which can reasonably be attributed to preference shifts and problems associated with the consumer-level attractiveness of product offerings.*³

Measures of Changes in Demand for Pork

The scatter plot for pork suggested that, like beef, the early 1980s was a very difficult period. Coming out of the late 1970s when there was an increased interest in what foodstuffs were being consumed and considerable publicity about fat and cholesterol in diets, it appears that changed buying behavior at the consumer level filtered through pork as well. If you compare, for example, 1980 with any of the more recent years, starting with 1981 and 1982, there was a substantial shifting down and to the left in terms of the implicit demand surface for pork (Figure 2). By the mid-1980s and moving into the 1990s, those rather dramatic year-to-year movements in the demand surface appeared to have subsided. There was a fairly extensive period in which per-capita consumption, which reflects per-capita supply, varied from about 47 lb to some 53 lb, and the inflation-adjusted price varied from a low around \$1.30 in 1995 to about \$1.70 in 1990.

Examination of the scatter plot might again give a basis for an inference as to the direction in which the demand surface is moving, but there is no direct evidence about why these movements are occurring. Both 1998 and 1999 look good relative to 1997, but the question of "why" remains. This is the same situation that we saw in beef and it raises a need to develop measures of the magnitude of the demand shifts. Following the same process and procedure employed in beef, a single equation price-dependent econometric model was estimated for pork. The intent, in terms of the model specification and as was the case for beef, was to account for the traditional demand shifters coming from substitute meats, from consumers' incomes, and to allow for a seasonal pattern in quarterly pork prices that are not explained by

³ Simple correlation coefficients, if high, can indicate multicollinearity. The correlation between BRCON and DEFINC is .95, suggesting a very high degree of collinearity. Not surprisingly, the variance inflation factors (VIF) were 119 and 42 for BRCON and DEFINC. The VIF measures were no larger than 4.0 for PORKCON, BEEFCON, and the seasonal dummies. The VIF measures *were* above 10 for some of the 0-1 shift variables, suggesting the size of the coefficients on the shift variables could be influenced by a collinear relationship to other explanatory variables.

those traditional economic measures. Yearly shift variables are then employed to measure demand surface shifts for reasons not explained by the traditional economic demand shifters.

Table V shows a preliminary model for deflated retail pork prices (PORKDEF) with a measure of pork, beef, and chicken quantities included as explanatory variables along with a measure of inflation-adjusted or deflated per-capita disposable consumer income and seasonal dummies for quarters 2, 3, and 4 for each year. The model generates some interesting statistical measures. The Durbin-Watson statistic suggests that positive autocorrelation is indeed a problem, that the residuals are not independent of each other. The R^2 , after adjusting for degrees of freedom, is above 83 percent and suggests significant explanatory power with this traditional set of variables insofar as pork prices are concerned. Note the R^2 and adjusted R^2 levels are well above the levels shown by the preliminary model for beef in Table II, suggesting there is less price variation left to be accounted for in pork after allowing for the traditional factors included in the model.

Table V. Statistical Properties of the Preliminary Pork Price Model, 1960-2000

Ordinary Least Squares						
Dependent Variable	PORKDEF	Number of Observations	161			
Mean of Dep. Variable	183.5289	Std. Dev. Of Dep. Var.	30.240876			
Durbin-Watson Statistic	.5362	Estimated Autocorrelation	.73190			
Std. Error of Regr.	12.3085	Sum of Squared Residuals	23179.5			
Total Variation	.14632E+06	Regression Variation	.12314E+06			
Regression degrees of freedom	7	Residual degrees of freedom	153			
R squared	.84159	Adjusted R squared	.83434			
F (7, 145)	116.1170	Prob. Value of F	.00000			
Variable	Coefficient	Std. Error	t-ratio	Prob t > x	Mean of X	Std. Dev. of X
Constant	374.113	24.53	15.250	.00000		
PORKCON	-13.2226	1.076	-12.287	.00000	13.14161	1.22956
BEEFCON	-.279409	.9541	-.293	.77002	18.96211	2.07575
BRCON	-9.32628	1.384	-6.740	.00000	12.71118	4.98806
DEFINC	.00994632	.003028	3.285	.00127	10463.99169	2084.05236
QDUM2	-1.52817	3.055	-.500	.61762	.24845	.43346
QDUM3	2.35521	3.178	.741	.45973	.24845	.43346
QDUM4	11.0443	2.886	3.827	.00019	.24845	.43346

Examining the results of the estimation in more detail, notice the very strong inverse relationship between pork per-capita consumption as a measure of pork quantity and pork prices. The expected negative or inverse relationship is extremely significant in a statistical context. The t-ratio is above 13 in absolute value. Interestingly, in this initial formulation, beef does not emerge as a statistically significant substitute product. Notice the sign on the regression coefficient for per-capita beef consumption is negative, and therefore theoretically correct, but the t-ratio is only -0.293. Chicken, on the other hand, as measured by per-capita consumption, shows the expected negative sign and a relatively large t-ratio at -6.740 indicating a statistically significant relationship with pork prices. Even before examining residuals to see whether or not there is evidence of model misspecification in the form of missing explanatory variables, it should be noted in passing that the extremely strong statistical relationship showing up for chicken and the lack of any such relationship for beef would raise theoretical questions about the model.

Once again, it may be a matter of a collinear relationship between beef and chicken and/or some other explanatory variables that could be causing the problems. When collinear situations exist, the regression coefficients estimated for the collinear explanatory variables can be uncertain in terms of magnitude and can even change sign across alternative samples and estimations when two variables such as per-capita beef consumption and per-capita chicken consumption are highly correlated. The least-squares algorithm used in the estimation process cannot correctly allocate influence across the beef and chicken variables. Further, we know from prior discussion that across the most recent 20 years in this 39-year observation period, per-capita beef consumption has trended downward and per-capita chicken consumption has trended upward. Those patterns, in and of themselves, suggest that these two measures of beef and chicken quantities are highly, if negatively, correlated. The simple correlation for the entire analysis period was, in fact, around $-.40$. It is those types of relatively high levels of correlation that can present multicollinearity problems in the estimation process.

Figure 7 shows the residual plot for this preliminary model estimation. There are a number of periods in the plot in which four to five, or even six to eight quarters are showing residuals that are all positive or all negative when you examine them in a first difference or quarter-to-quarter change context. For example, the period starting in 1979 shows a number of quarters in which the first differences would be negative as the residuals come down from a level of above 30 on the plot to eventually, a few years later, -10 and then down again to -30 . Then, in 1985, the residual plot turns and moves in a sustained fashion to the upside until 1990. It does not appear that this residual plot presents a random pattern where the residual in one quarter is independent of prior residuals. There are rather long “runs” where the first differences of the residuals are all negative and, then in the later time period, mostly positive and trending higher. This suggests that the model is misspecified and that something is systematically, over time, influencing pork prices and that no measure for that influence has been incorporated in the model.

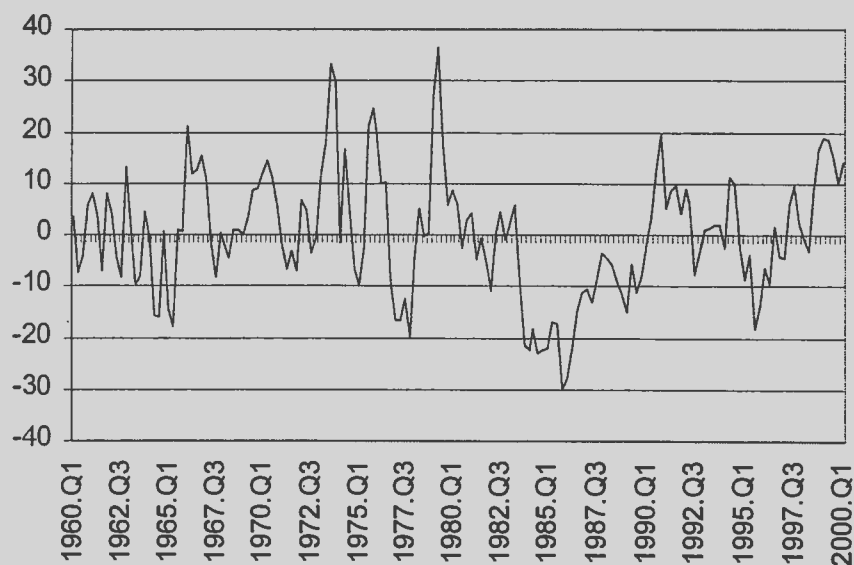


Figure 7. Residuals for the Preliminary Pork Price Model, 1960-2000

Table VI shows an extended price-dependent single equation econometric model with yearly dummies included for 1979 through the first quarter of 2000. The Durbin-Watson statistic no longer suggests the presence of autocorrelation. The R^2 measure moves up to above .92 before adjustment and is

Table VI. Statistical Properties of a More Extensive Pork Price Model, 1960-2000

Ordinary Least Squares							
Dependent Variable		PORKDEF	Number of Observations		161		
Mean of Dep. Variable		183.5289	Std. Dev. Of Dep. Var.		30.240876		
Durbin-Watson Statistic		1.1063	Estimated Autocorrelation		.44684		
Std. Error of Regr.		9.2555	Sum of Squared Residuals		11222.0		
Total Variation		.14632E+06	Regression Variation		.13510E+06		
Regression degrees of freedom		29	Residual degrees of freedom		131		
R squared		.92331	Adjusted R squared		.90633		
F (7, 145)		54.3821	Prob. Value of F		.00000		
Variable	Coefficient	Std. Error	t-ratio	Prob t > x	Mean of X	Std. Dev. of X	
Constant	406.847	21.22	19.170	.00000			
BEEFCON	-1.90278	1.094	-1.739	.08446	18.96211	2.07575	
PORKCON	-14.4404	.9287	-15.550	.00000	13.14161	1.22956	
BRCON	-4.04934	2.042	-1.983	.04946	12.71118	4.98806	
DEFINC	.00718123	.002819	2.547	.01202	10463.99169	2084.05236	
QDUM2	-6.32065	2.762	-2.289	.02371	.24845	.43346	
QDUM3	-1.08235	2.641	-.410	.68258	.24845	.43346	
QDUM4	12.0648	2.238	5.390	.00000	.24845	.43346	
DUM79	5.71744	7.286	.785	.43401	.02484	.15614	
DUM80	-11.9568	7.504	-1.593	.11347	.02484	.15614	
DUM81	-19.7349	7.646	-2.581	.01095	.02484	.15614	
DUM82	-24.1457	8.243	-2.929	.00401	.02484	.15614	
DUM83	-26.9176	8.196	-3.284	.00131	.02484	.15614	
DUM84	-44.3294	8.769	-5.055	.00000	.02484	.15614	
DUM85	-46.6634	9.481	-4.922	.00000	.02484	.15614	
DUM86	-45.8991	9.845	-4.662	.00001	.02484	.15614	
DUM87	-42.3893	12.02	-3.527	.00058	.02484	.15614	
DUM88	-42.5738	13.06	-3.261	.00142	.02484	.15614	
DUM89	-51.7066	15.32	-3.376	.00097	.02484	.15614	
DUM90	-39.1864	16.75	-2.340	.02082	.02484	.15614	
DUM91	-43.6561	17.84	-2.447	.01573	.02484	.15614	
DUM92	-50.0539	18.44	-2.714	.00753	.02484	.15614	
DUM93	-55.1314	20.20	-2.729	.00722	.02484	.15614	
DUM94	-53.8787	20.67	-2.606	.01021	.02484	.15614	
DUM95	-66.5897	20.03	-3.324	.00115	.02484	.15614	
DUM96	-63.1437	20.63	-3.061	.00268	.02484	.15614	
DUM97	-59.1049	21.81	-2.711	.00762	.02484	.15614	
DUM98	-54.0431	21.78	-2.482	.01434	.02484	.15614	
DUM99	-48.914	23.58	-2.074	.04004	.02484	.15614	
DUM00	-52.7659	25.55	-2.065	.04087	.00621	.07881	

still above 90 after adjusting for the degrees of freedom lost in the expanded model specification. Thus, the model explains over 90 percent of the variation in quarterly pork prices across the long observation period. Once again, however, it is different from beef. The increase in the explanatory power of the

model when the shift variables are added is far less than was the case with beef where the adjusted R^2 went from 76 to 96. The adjusted R^2 , remember, was above 83 percent for the preliminary pork model.

Figure 8 shows the plot of residuals from the extended model. There is less tendency to see patterns of prolonged movements in the same direction or a series of “runs” where the first differences between succeeding residuals stay positive for several quarters or stay negative for several quarters. About the most the residual plot suggests in terms of residual changes going in the same direction is two quarters, but these exceptions to the random pattern are not sufficient to argue that the model is still suffering from problems of misspecification. There is no longer the suggestion that something else needs to be included to account for the systematic patterns showing up in the residuals from the earlier model specification, especially for the 1980s and 1990s.

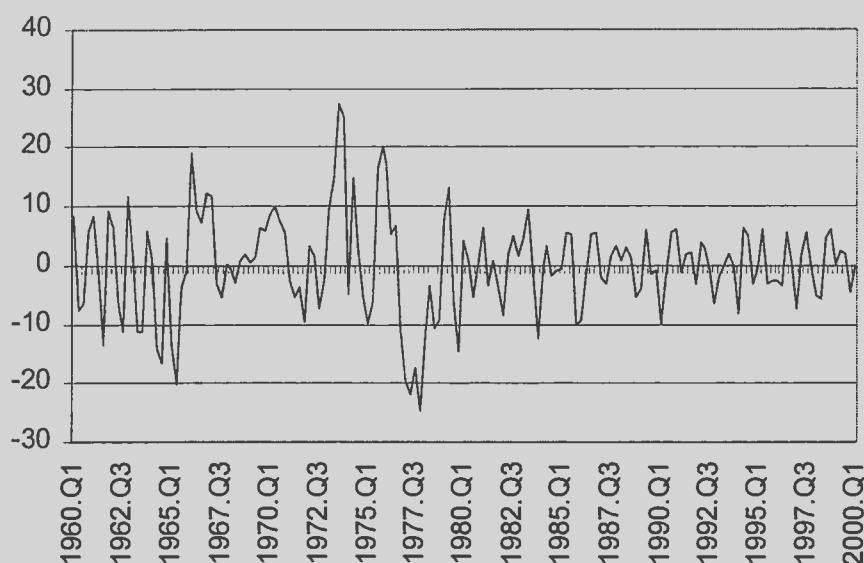


Figure 8. Residuals for a More Extensive Pork Price Model, 1960-2000

Note the coefficient on the yearly dummy or 0-1 variable is negative in 1980 but does not show a t-ratio that suggests it is statistically significant at the .05 level. The coefficients on succeeding dummy variables continued to get larger in absolute terms and stay negative until about 1985. This parallels the obvious and substantial shift in the demand surface that was gleaned from the scatter plot and parallels the time period in which there were major problems for beef. From 1985 through 1999, there has been no sustained increase in absolute size of this shift parameter. The 1999 coefficient is about the same in absolute value as those in the mid-1980s, and is smaller than those for the mid-1990s. What this suggests is that after accounting for the demand-shifting influence of the traditional economic explanatory variables and accounting for systematic seasonal variations in price outside of those demand-shifting influences, tastes and preferences—or whatever one might want to label the demand-shifting influence that is not included in the model—has not grown persistently worse during the 1990s as was the case in beef. The coefficient for 1999 is the smallest since 1991 in absolute value, raising the possibility that the more consumer friendly product offerings of recent years might be prompting improved consumer reactions to the product offering.

With this latter specification that allows for the yearly shifts in the price surface, note that the sign on both beef consumption and chicken consumption as measures of quantity in the substitute meats are the theoretically correct negative signs. The chicken influence is statistically significant at the .05 level and, in statistical terms, therefore, slightly more important than that for beef with a t-ratio of -1.739. The t-ratio for beef leaves about a 10 percent "probability" that this observed relationship could, in fact, just be due to chance and not due to any consistent and important economic relationship between beef and pork. In models of this type, analysts will often tend to leave the variable in if the sign is theoretically correct and if the t-ratio is above 1.0 in absolute value.

The income variable is positive, as would be expected, although it is quite small with the coefficient reading .007. This suggests that a \$1.00 increase in average per-capita disposable incomes would increase pork prices by .007 cents per lb. Conversely, of course, if that per-capita disposable income were to jump across a time period by, say, \$500 on a per-capita basis, then the price impact would start to look more important in economic terms at 3.5 cents per lb. But a \$500 increase in per-capita disposable incomes will take several years, and the coefficient relationship could change over time. All this is as would be expected with the income demand shifter being one that tends to be slow and persistent over time in terms of its influence on any particular commodity.

The quarterly dummies show significant impacts only in quarter 2 and 4. This suggests that since the coefficient is positive in quarter 4, the model-predicted price is consistently higher in quarter 4 for strictly time or seasonal reasons. Conversely, prices tend to be lower in quarter 2 and 3 on a seasonal basis after the demand shifters in the model have exerted their influence. Note that even though the t-ratios on DUM3 is smaller, even substantially less than 1, it is left in the model for theoretical and conceptual completeness in terms of picking up and recording the seasonal impact in price that is coming for reasons outside the other explanatory variables in the model.

Overall, observed shifts in demand for pork have been less sustained and less dramatic than those in beef, especially after accounting for the traditional economic demand shifters like substitute meats and consumers' incomes. The constant term in the model is above \$4.06 per lb for pork. The last full year for which quarterly data are entered is 1999, and the coefficient on the shift variable for 1999 was -48.9 or about \$.49. This says that the actual demand surface is some \$.49 down from the overall model intercept for reasons outside of the demand-shifting influences of the substitute meats and consumers' incomes. That \$.49 is about 12 percent of the model constant term, and this shift in the price surface for pork is obviously considerably smaller than was the cumulative shift recorded for beef.

Measures of Changes in Demand for Chicken

The scatter plot for broilers suggests that this industry was operating near a common demand surface for many years from 1960 to the early 1980s. Note the tendency for inflation-adjusted prices to decline as per-capita offerings increased. The levels in the early 1980s in the \$.70-.80 range were only about 50 percent of the prices recorded in 1960. By the mid-1980s, however, the pattern had changed. Periodically, there appear to be year-to-year increases in the demand surface for chicken. This would be evidenced by the move from 1983 to 1984, which showed increased per-capita offerings moving into consumption at higher inflation-adjusted prices. The same thing happened again from 1985 to 1986, and then a two-year period of apparent increases in the demand surface occurred in the 1987 to 1989 timeframe. In the 1990s, the industry has been basically maintaining inflation-adjusted prices near \$.60 per lb and has continued to increase offerings. If you compare, for example, 1992 to 1998, you see a move in per-capita offerings from just above 75 lb up to about 84 lb, and that substantial increase in product offering moved into consumption at a slightly higher inflation-adjusted price. The same pattern happened

again in 1999, but the move looks much stronger. Per capita consumption increased some 5 lb at essentially the same inflation-adjusted price.

Once again, however, we recognize that while the scatter plot suggests what is happening to the demand surface, there is no basis for concluding why it has occurred. Thus, the deflated retail price (BRDEF) and per-capita consumption data for chicken were analyzed using an econometric modeling approach similar to the approach that has been discussed for beef and for pork. The models account for the traditional demand shifters and give a measurement of the influence of changes in consumers' preferences, lifestyles, etc.

Table VII shows a preliminary model specification that continues the methodology applied for beef and pork and includes as explanatory variables chicken quantity, a measure of what is happening in the competing meats via per-capita pork and beef consumption data, and inflation-adjusted per-capita disposable incomes. The three quarterly seasonal dummies are also included to pick up any seasonal pattern in seasonal prices that are systematic and repetitive but are not explained by the more traditional demand shifters involving the substitute meats and consumers' income levels. The statistical properties show an adjusted R^2 above .85. The Durbin-Watson statistic shows the presence of positive autocorrelation, and with this statistical information on the model information, we would expect to see time-related and non-independent patterns in the residual plot. Figure 9 indicates that such is in fact the case.

Table VII. Statistical Properties of a Preliminary Chicken Price Model, 1960-2000

Ordinary Least Squares						
Dependent Variable	BRDEF	Number of Observations	161			
Mean of Dep. Variable	93.3721	Std. Dev. Of Dep. Var.	27.039518			
Durbin-Watson Statistic	.3953	Estimated Autocorrelation	.80235			
Std. Error of Regr.	10.4148	Sum of Squared Residuals	16595.5			
Total Variation	.11698E+06	Regression Variation	.10039E+06			
Regression degrees of freedom	7	Residual degrees of freedom	153			
R squared	.85814	Adjusted R squared	.85165			
F (7, 145)	132.2138	Prob. Value of F	.00000			
Variable	Coefficient	Std. Error	t-ratio	Prob t > x	Mean of X	Std. Dev. of X
Constant	232.223	20.76	11.188	.00000		
BRCON	-9.54897	1.171	-8.156	.00000	12.71118	4.98806
PORKCON	-2.06967	.9106	-2.273	.02442	13.14161	1.22956
BEEFCON	-4.57197	.8073	-5.664	.00000	18.96211	2.07575
DEFINC	.00885561	.002562	3.456	.00071	10463.99169	2084.05236
QDUM2	6.58632	2.585	2.548	.01182	.24845	.43346
QDUM3	9.35656	2.689	3.480	.00065	.24845	.43346
QDUM4	-.826524	2.442	-.339	.73544	.24845	.43346

Note the sharp increase in the residual for 1973, which was in the period of price ceilings in the Nixon administration. Subsequent to that time, up to about 1983, the residuals show a decided negative trend. Then, starting in 1983, the residuals have clearly trended higher through the first quarter of 2000. Trends in the residuals suggest something other than random patterns which require each successive residual to be independent of the prior residual or residuals. The plot suggests something substantial is going on in terms

of a determinant for chicken price that has not been incorporated into this preliminary model specification. By inference, it is possible to suggest it is a “preference” influence, perhaps the opposite of what has been happening in beef and pork in terms of direction of influence over the same time period.

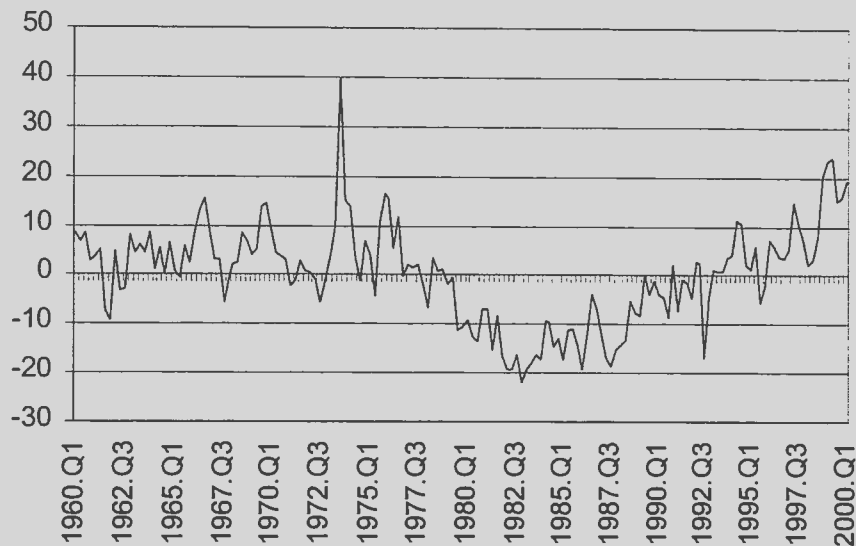


Figure 9. Residuals for the Preliminary Chicken Price Model, 1960-2000

Table VIII provides the statistical measures from a model that includes a shift dummy for 1973 to account for some of that dramatic development during the price ceiling period and then annual shift dummies starting in 1980 in a fashion comparable to the specifications employed earlier for beef and for pork. The first annual shift dummy that was statistically significant at the .05 level was DUM80 where the t-ratio was -2.191, suggesting statistical significance at the .05 level. Note that the coefficient is negative, suggesting that non-economic demand shifting influences were, like beef and pork, tending to pull prices down.

Through the 1997 period, we see less evidence of consistent t-ratios above 2.0 for the shift variables than was the case with beef and pork. Preliminary reaction to this overall patterns suggests that there is less going on in the chicken sector in terms of forces influencing price beyond those of changes in chicken quantity, demand shifters in the form of changes in competing meats and consumers' incomes, and seasonal price patterns. There appeared to be less explanatory power outside the preliminary model for pork than for beef (recall the R^2 comparisons) and that finding is accentuated with chicken. Note the adjusted R^2 moves from 85 to 96 percent in chicken as we compare the preliminary and the final models.

Table VIII. Statistical Properties of a More Extensive Chicken Price Model, 1960-2000

Ordinary Least Squares						
Dependent Variable	BRDEF	Number of Observations	161			
Mean of Dep. Variable	93.3721	Std. Dev. Of Dep. Var.	27.039518			
Durbin-Watson Statistic	1.6896	Estimated Autocorrelation	.15521			
Std. Error of Regr.	5.3401	Sum of Squared Residuals	3735.71			
Total Variation	.11698E+06	Regression Variation	.11325E+06			
Regression degrees of freedom	29	Residual degrees of freedom	131			
R squared	.96807	Adjusted R squared	.96100			
F (7, 145)	136.9376	Prob. Value of F	.00000			
Variable	Coefficient	Std. Error	t-ratio	Prob t > x	Mean of X	Std. Dev. of X
Constant	255.627	12.25	20.862	.00000		
BEEFCON	-2.04468	.5645	-3.622	.00042	18.96211	2.07575
PORKCON	-3.37376	.5309	-6.354	.00000	13.14161	1.22956
BRCON	-6.41750	1.107	-5.799	.00000	12.71118	4.98806
DEFINC	-.000086023	.001862	-.046	.96322	10463.99169	2084.05236
QDUM2	3.60497	1.568	2.299	.02307	.24845	.43346
QDUM3	5.29446	1.566	3.380	.00095	.24845	.43346
QDUM4	1.17352	1.284	.914	.36224	.24845	.43346
DUM73	21.3720	3.230	6.618	.00000	.02484	.15614
DUM80	-7.59357	3.466	-2.191	.03022	.02484	.15614
DUM81	-12.4169	3.545	-3.502	.00063	.02484	.15614
DUM82	-22.7179	3.846	-5.907	.00000	.02484	.15614
DUM83	-19.4421	3.753	-5.180	.00000	.02484	.15614
DUM84	-10.8276	3.885	-2.787	.00611	.02484	.15614
DUM85	-13.4454	4.148	-3.241	.00151	.02484	.15614
DUM86	-8.82460	4.250	-2.076	.03983	.02484	.15614
DUM87	-12.2736	5.005	-2.452	.01552	.02484	.15614
DUM88	-3.36737	5.312	-.634	.52727	.02484	.15614
DUM89	4.63230	6.137	.755	.45171	.02484	.15614
DUM90	.195730	6.790	.029	.97705	.02484	.15614
DUM91	.397578	7.215	.055	.95614	.02484	.15614
DUM92	2.35180	7.360	.320	.74982	.02484	.15614
DUM93	7.06414	8.082	.874	.38366	.02484	.15614
DUM94	11.4698	8.291	1.383	.16887	.02484	.15614
DUM95	8.64870	7.905	1.094	.27593	.02484	.15614
DUM96	11.9376	8.198	1.456	.14776	.02484	.15614
DUM97	14.9872	8.708	1.721	.08760	.02484	.15614
DUM98	21.6947	8.481	2.558	.01167	.02484	.15614
DUM99	31.5190	9.196	3.428	.00081	.02484	.15614
DUM00	31.3900	10.55	2.976	.00348	.00621	.07881

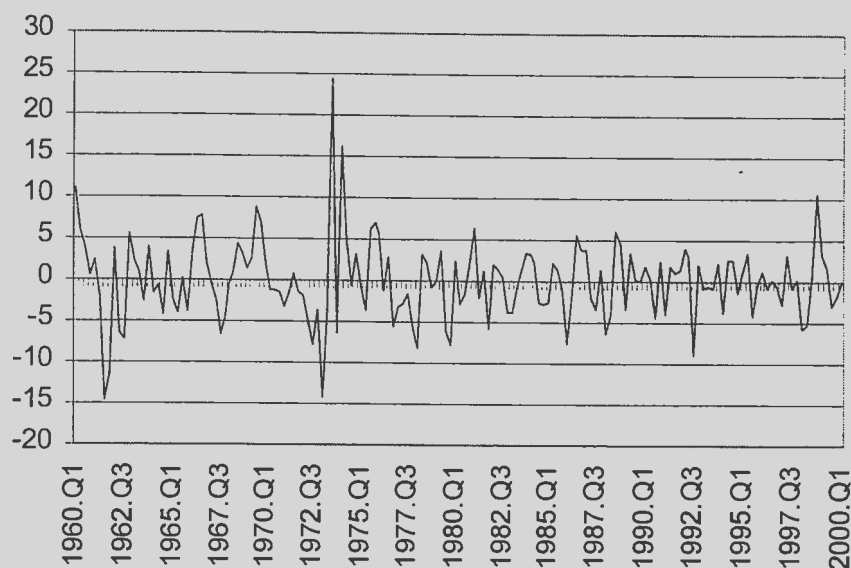


Figure 10. Residuals for a More Extensive Chicken Price Model, 1960-2000

For 1980 through the mid-1980s in general, and indeed up to 1987, the coefficients on the annual shift dummies are negative, vary somewhat in magnitude, and are significant at the .05 level. After 1987, the year 1988 appeared to have been a transition year. The coefficients switched to positive in 1989 and generally tend to increase across the time period with DUM99 standing at 31.519, suggesting an increase in price for chicken for reasons outside of those encompassed in the model specification. In beef and in pork, the negative coefficients that tended to be increasing in size over time, especially for beef, suggested that a preference factor was at work that was decreasing the willingness to pay for any specific quantity of beef. The results of that influence would be the marketplace discovering lower prices in order for the consumer to take the product and “clear” the market pipelines. This general inference switches with chicken and suggests some preference-related factors or forces that are encouraging consumers to pay higher prices for a specific available quantity of chicken, especially since 1988.

The statistical properties of the model are, as would be expected, now much more favorable. The adjusted R^2 is 96 percent. The Durbin-Watson statistic suggests no conclusive evidence of autocorrelation. This would suggest a residual plot that shows none of the systematic patterns and trends found in the plot in Figure 9. Indeed this proves to be the case. Figure 10 shows a residual plot that, with the possible exception of the aberration in 1973 during the price-ceiling year, would indicate a random pattern of residuals. Note the tendency for a positive and then a negative residual and then, in some instances, for two positives and then two negatives in some other time periods. There is no evidence of trend in these residuals as was the case for the preliminary model specification, and this finding suggests that the specification that used the yearly 0-1 variables has accounted for, or corrected for, those systematic patterns in the residuals. This correction does not, of course, tell us precisely what catalyst was changing the situation in terms of demand for chicken.

Both beef and pork are highly significant, in a statistical sense, substitutes for chicken. Comparing the influence of the two is a bit questionable without correcting for any presence of multicollinearity, but the correlation coefficient for BEEFCON and PORKCON is relatively small at -.27. Recognizing that

caution is still needed, the coefficient on PORKCON is more than 50 percent larger in absolute value than the coefficient on BEEFCON and the standard errors are close in magnitude. This gives some basis for suggesting that pork is a better substitute than beef for chicken.

The 31.519 coefficient on DUM99 is a 12.3-percent increase when evaluated in terms of the 255.627 constant term in the model. When evaluated in terms of the mean price of 94.92, however, that shift coefficient for 1999 is 33 percent of the mean price. This gives quantitative estimates of what has happened to chicken demand for reasons other than developments in competing meats and consumers' incomes. Without question, this is one of the reasons we have seen the significant growth in market share for poultry in general and chicken in particular. In addition to any cost-reducing technology that the poultry sector might have been introducing to improve margins over time and attract resources into production, it is clear that there has been a demand-boosting influence as well. *Consumers have shown a willingness to pay increased prices for the chicken offering as compared to the somewhat more negative pattern that pork shows and the decidedly more negative pattern present in beef.*

Overall Observations

Measures of changes in demand for beef, pork, and chicken may be needed to help prompt and guide industry programs and private firm investments. Analysis of demand across the 1980s and 1990s is complicated by the possibility that an important demand shifter has been changes in tastes and preferences--the one traditional "shifter" that cannot be readily quantified. Yet, price-dependent models that account for quantity, the impact of substitutes (the relative price "shifter"), and per-capita disposable incomes generate results that clearly indicate some important explanatory factor is missing. The initial R^2 values are relatively low, autocorrelation is present, and the model residuals show systematic time-related trends and non-random patterns.

Anecdotal and qualitative evidence suggest what is missing. Consumers' have moved to an on-the-go lifestyle where convenience in meal preparation is important, they worry about fat and cholesterol in their diets, they want high quality, and they increasingly demand consistent quality. Surveys and focus group discussions continue to identify these issues. Popular press coverage of the findings in the Food Marketing Institute's "Trends" survey for 1998 indicates 9 of 10 food shoppers express at least some concern about the nutritional content of food they eat. Such factors can and do change the preference pattern for the respective meats over time.

One way to correct the obvious misspecification problems is by including an explanatory variable to pick up the systematic portion of the unexplained variation in price or quantity. An index to pick up the "cholesterol issue" can be generated by counting the number of times that cholesterol is covered in medical journals or in popular science-based or consumer magazines. The number of two-worker households can be used in a time series analysis to capture the issue of less time to cook and the importance of convenience in meal preparation. Capps deals with convenience as an issue in the Proceedings edited by Buse, and Capps and Schmitz examine health and nutrition in demand analyses. Driscoll and McGuirk conclude that relative prices and expenditures (a proxy for incomes) alone cannot explain meat demand, and they indicate "diet variables" must be considered. Usually, proxies for diet-related issues and/or for convenience have to be used in model estimations.

The sophistication of such approaches may be peripheral at best. In a 20 or 30-year set of quarterly data, virtually anything that is correlated with the dependent variable will help, statistically speaking, "explain" changes in price. If, for example, the number of articles mentioning cholesterol increases throughout the analysis period, that explanatory variable would, or could, also pick up the

influence of the number of two-worker households--which is also trending higher. It could also, if highly correlated with consumer incomes (which have also trended up over time), pick up influence that should go to the income variable.

Getting the right "set" of variables to pick up the preference issue is, thus, problematic. An alternative approach, and the one used in this analysis, is to use yearly shift variables to measure the price-moving influence of any demand shifters not in the model. Model residuals can be examined to determine whether the shift variables account for systematic influences on the dependent variable and generate a random set of residuals. Then, inferences can be drawn which make the conceptual and theoretical connection to changing preferences, changing lifestyles, and problems of quality and lack of convenience in preparation.

In this analysis, price-dependent models for beef, pork, and chicken were estimated both before and after the yearly shift variables were included using quarterly data from 1960 through early 2000. *The results show the presence of important demand shifters over and above the traditional demand shifters involving changes in substitute meats and changes in consumers' incomes.* But the results were different across beef, pork, and chicken. More specific findings include:

- Based on R^2 measures before and after allowing for and measuring shifts in the demand surface, beef has experienced more preference-related problems than have pork or chicken. The percentage of the variation in beef prices that is explained by changes in beef quantity and by the demand shifting influences of changes in the competing meats and consumers' incomes is much less than the comparable measure in chicken and pork. Adjusted R^2 measures prior to the introduction of the yearly shift variables were 76, 83, and 85 percent for beef, pork, and chicken respectively.
- As would be expected, the improvement in R^2 levels was larger for beef when the shift-variable proxies for preference-change influences were included. Final adjusted R^2 measures were 96 for beef (up 20 points), 91 for pork (up 8 points), and 96 for chicken (up 11 points). This is further statistical evidence that preference-related demand shifts in beef may have been very large.
- The importance of the substitute relationships varies significantly. Chicken does not appear to be an important substitute for beef, but pork does. The potential for chicken to be a substitute *may* be masked by the level of aggregation in the data. A whole chicken may compete with ground beef, or a fillet of chicken breast may be a possible substitute for beef steak, but the data used in the analysis may not be refined enough to isolate and measure these relationships.
- Beef and pork appear to be substitutes for each other, and both appear to be a substitute for chicken--with pork appearing to play the stronger role.
- After accounting for the price-changing influence of quantity and the demand-shifting impact of substitute meats and consumer incomes, the demand surface for beef (measured in price changes) by 1999 was \$2.46 per lb below the model intercept of \$3.31 (a 74 percent decrease). For pork, the comparable shift down in the price surface was \$.49 from an intercept of \$4.07 (a 12 percent decrease) and the 1999 coefficient showed significant improvement compared to 1998.
- In chicken, the possible preference-related shift in price after accounting for quantity, substitutes, and consumer incomes was positive, measuring \$.32 in 1999 from an intercept of \$2.56 (a 12.5 percent increase).

- The beef analysis is consistent with the index measures that suggest demand for beef improved in 1999. The 1999 coefficient did not decrease relative to 1998, the first such stable measure of year-to-year change since 1979. This suggests the taste and preference problem was being successfully attacked by improved information in beef in modern diets, better quality control and more consumer friendly product offerings. Demand for beef in 1999 could increase, given this finding, from the positive influences of increasing incomes and higher pork prices.

There are ample grounds for inferences on future needs in the three meats. *In beef, the need to continue to move the fresh beef product offering toward the needs and preferences of the modern consumer in the export and domestic markets is readily apparent.* A devastating and prolonged decrease in demand for fresh beef appears to have been associated largely with preference issues, not with the impact of changing relative prices of substitutes or changing consumer incomes. The price implications of the preference-related demand shifts would appear to be far in excess of what could be done to stimulate consumption and protect or enhance market share via lower costs of production and related lower prices at retail. The major need is for change, investments, and programs to move toward a consumer-friendly product offering.

In pork, any demand shifts of recent years appear to be coming from the more traditional shifters, with competitive pressure from chicken likely to be the key. Preference and lifestyle-related issues decreased the demand surface substantially during the 1980s, and while that lost ground has not been regained, there is no compelling evidence of continuing and major preference related shifts in the 1990s. Indeed, the years 1998 and 1999 appear to be showing demand increases. Efficient production to keep prices competitive and continued and accentuated efforts and investments to change the product offering toward what consumers need and want will be necessary if pork is to regain market share. A start in the positive direction has apparently been made in 1998 and 1999, but the 1998 year brought painful producer losses.

In the case of chicken, it is a matter of continuing and perhaps accentuating the trends of recent years. The 1995-96 surge in grain prices destroyed margins for many broiler firms, and disease problems in chicken and turkey flocks raised costs and constrained growth in 1998 and into 1999. Both of these obstacles to growth are short-run in nature, and a sustained resurgence of growth and related efforts to stay "consumer-driven" are likely in poultry as evidenced by the increases in 1999. If that is in fact what we see, chicken will continue to command a large and growing market share and will be strong competition for consumers' food dollars.

Table IX summarizes the R^2 levels, the model intercepts, and the price change associated with coefficients on the shift variables. The improvement in adjusted R^2 measures is a proxy for how much observed change in prices has not captured by traditional economic demand shifters. The large change in beef is revealing. The price shifts from the model intercepts through 1998 are also much larger for beef. What is needed is the same in all three commodities: a consumer-friendly product offering and sustained investments to keep it "friendly" as consumers and lifestyles change. Chicken appears to be moving along that path. Both beef and pork need more of the change we have started to see in recent years, and the need and the related challenge appear to still be *much* larger in beef.

Table X. Measures of Demand Shifts, In Price Terms, That May Be Attributable to Preference Changes and the Lack of Product Offering Modernization, 1970s to 1999

Commodity	R ² Levels (%) Preliminary Model	R ² Levels (%) Final Model	Model Intercept and Price Change ()s Based on Shift Variable Coefficients (\$/lb)
Beef	74	96	\$3.31 (-\$2.46)
Pork	83	91	\$4.07 (-\$.49)
Chicken	85	96	\$2.56 (+\$.32)

The meats are no different than any other product or service. To be successful, a firm has to offer something buyers are willing to pay for. It is no different with an entire industry. The most encouraging developments for beef and pork have been the moves by large processors in recent years toward quality control, product development, branding and merchandising and resurgence, in 1999, of the export markets—especially in Japan. It was never good enough, as an industry strategy, to continually try to produce a commodity product cheaper and cheaper to boost quantity moving into consumption and, thereby, try to keep resources in production. Costs of producing a fed steer cannot be reduced 50 percent in a decade, but that is what would have been required in beef to offset the decreases in demand. The changes to "consumer driven" are being accompanied, perhaps allowed, by contracts and other non-price means of coordination. But that may be the only way in the presence of failed pricing systems with public grades and grading obsolete and inadequate, to get to quality control and a consumer-driven product offering. Demand is king in the marketplace, and the "king" *will* be served.

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Source: Price and quantity data are from USDA, ERS, *Livestock, Dairy, and Poultry Situation and Outlook*, various issues. These data can be found on the internet at

<http://usda.mannlib.cornell.edu/reports/erssor/livestock/ldp-mbb>.

The data are also in the "Primer on Beef Demand." This and other research publications from the Research Institute on Livestock Pricing are available at the Institute's internet site:

www.aaec.vt.edu/rilp

