Measures of Changes in Demand for Beef, Pork, and Chicken, 1975-1998

by

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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 for 1999 suggest that per-capita beef offerings, and therefore per-capita consumption, will decline still further to near 63 lb, a precipitous decline from about 68 lb in 1998. That type of change in per-capita consumption, which is a reflection of per-capita supply, suggests that major challenges face the underlying 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 34 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 83.7 lb in 1997. The 1998 level is expected to be near 84.6 lb with a 5 to 6-percent increase projected for 1999. 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 matched and more than offset 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 will show a significant change in direction and a significant year-to-year increase in 1998 from 48.7 to a projected 52 lb. Another increase to a projected 53.7 lb is expected in 1999 according to USDA reports.

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 is 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- and state-level programs that attempted to reduce production costs and, in the process, bring 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 are now agreeing that demand for beef has decreased virtually each year since 1979 or 1980.

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 produces the majority of pork, that will 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 it appears that goal will not be met, the significant increase in per-capita pork production in 1998 will certainly change the status quo in terms of per-capita offerings. The sector could, given its revised organizational structure, maintain much of that increased base of production even though hog prices are very low in late 1998.

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 1998 and the year 2000 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 able to focus resources toward being consumer driven. Whatever the case, it is clearly true that poultry is in a growth mode and the traditional red meats, beef and pork--especially beef--have continued to go through a long-standing period of periodic downsizing and disinvestment.

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.

In this particular effort, models that capture the traditional economic demand shifters--changes in consumer incomes, and changes in quantity levels (and therefore 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 is not 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 private and public efforts to solve some of the persistent problems.*

The objective here, then, 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. Perhaps this approach will prompt a sense of urgency regarding the problems that beef and pork are facing and a sense of the need for continued adaptation, in the case of chicken, in the years ahead.

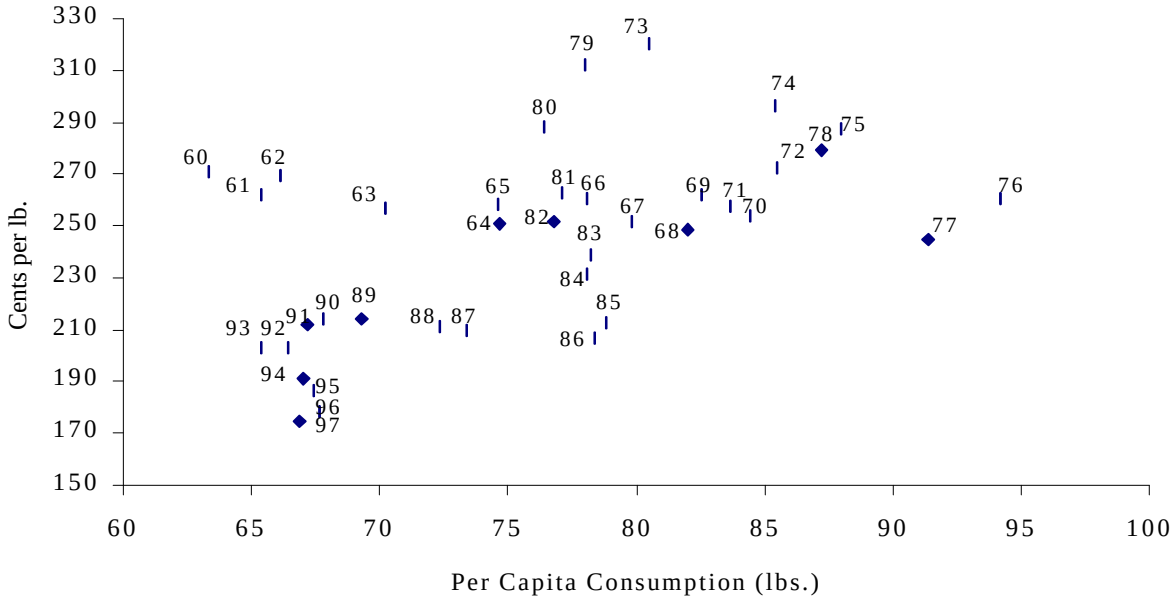
Conceptual Issues in Analyzing Demand

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 no more than a pound per year from 1994 through 1997. This pattern is destined to be continued when the final prices and per-capita consumption data are in for 1998. With the per-capita consumption level expected to be near 68 lb, a new record-low inflation-adjusted price will be recorded.

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, 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?

[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.

It is obviously possible that part of the reduction in per-capita offerings across the past 18 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 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.

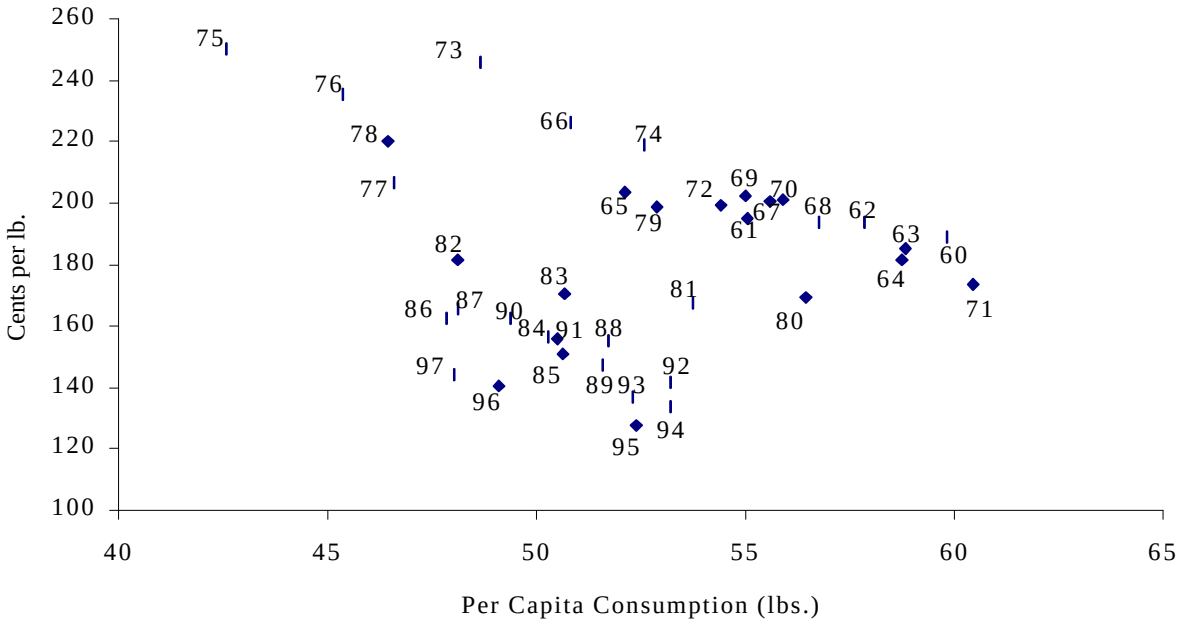


Source: *Livestock, Dairy, and Poultry Situation and Outlook*, ERS, USDA

Figure 1. Per-Capita Consumption and Inflation-Adjusted (CPI, 1984-82=100) Prices for Beef, 1960-97

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 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, and therefore 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.

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, recent price-quantity coordinates in pork 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 is substantially lower than it was earlier in the decade and in the 1980s, especially in the early 1980s.*

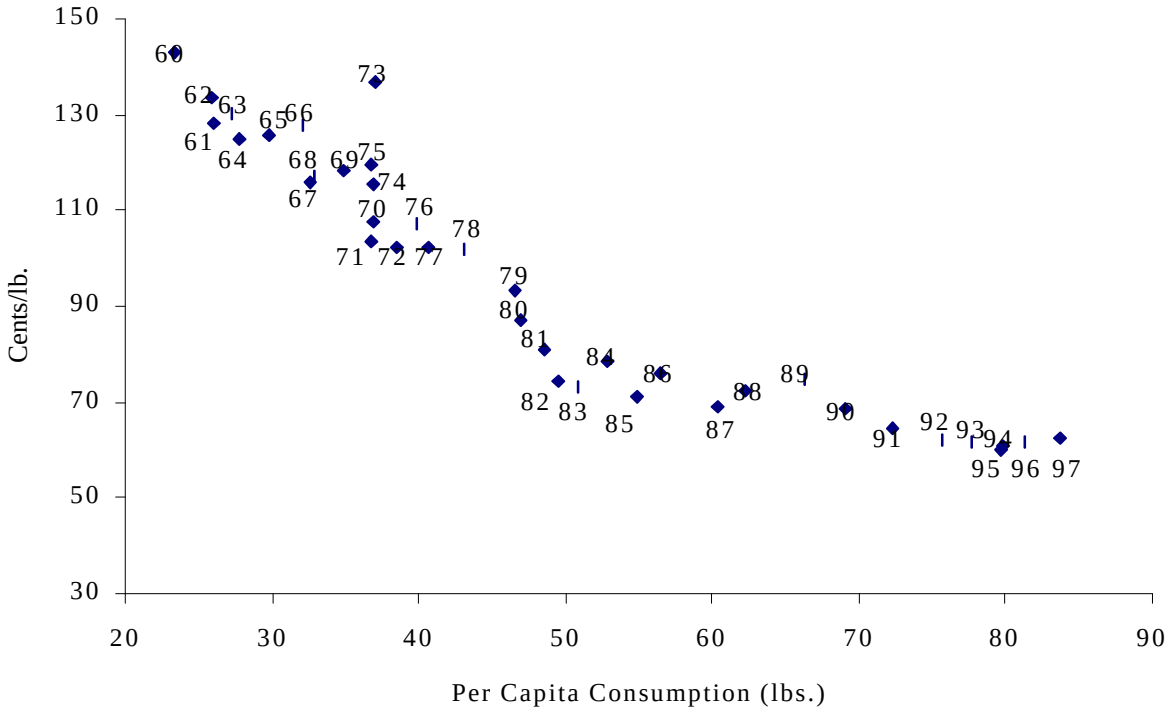


Source: *Livestock, Dairy, and Poultry Situation and Outlook*, ERS, USDA

Figure 2. Per-Capita Consumption and Inflation-Adjusted (CPI, 1984-82=100) Prices for Pork, 1960-97

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-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. 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 15-16 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 1997, the per-capita offering that consumers were buying was up by 35 lb, a 70 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.

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



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, 1960-97

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 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 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.

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 1997. This index was calculated at the request of the Beef Production and Research Board of the National Cattlemen's Beef Association 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 51.32 by 1997. Basically, this suggests that the demand for beef has declined some 48.68 percent since the 1980 base year. Note that when the index is converted to 1997=100 as a base to facilitate comparisons in future years, the 100 for 1997, as a proportion of the 194.9 for 1980, would again give the 48.68 percent decline (100÷194.9=.513, and 1.00 less .513 = .487, the 48.68% decline).

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

Table I. Quantity Adjusted Index for Beef Demand: All Changes vs. 1980 Price and Consumption*

Year	Per-Capita Consumption	Deflated Price (cents/lb)	Constant Demand Price (cents/lb)	Percent Change in Price Due to Demand Shifts** (%)	Index (1980=100)	Index (1997=100)
1980	76.4	288.3	--	--	100.00	194.9
1981	77.1	262.6	284.35	-7.65	92.35	179.9
1982	76.8	251.3	286.05	-4.50	87.85	171.2
1983	78.2	239.1	278.16	-1.89	85.96	167.5
1984	78.1	231.3	278.73	-2.97	82.99	161.7
1985	78.8	212.7	274.78	-5.58	77.41	150.8
1986	78.4	206.9	277.03	-2.72	74.69	145.5
1987	73.4	209.9	305.20	-6.04	68.65	133.8
1988	72.3	211.6	311.36	-.69	67.96	132.4
1989	69.3	214.3	328.29	-2.67	65.29	127.2
1990	67.8	214.5	336.74	-1.58	63.71	124.1
1991	67.2	212.0	340.12	-1.37	62.34	121.5
1992	66.4	203.3	344.62	-3.34	59.00	115.0
1993	65.4	203.1	350.25	-1.00	58.00	113.0
1994	67.0	190.9	341.24	-2.05	55.95	109.0
1995	67.4	186.6	338.98	-.89	55.06	107.3
1996	67.6	178.6	337.51	-2.13	52.93	103.1
1997	67.2	174.5	340.12	-1.61	51.32	100.0

*Calculations are always from 1980 per-capita consumption and deflated price.

**These yearly changes sum to 48.68%, the same as 100 - 51.32 (the index for 1997 when 1980=100) and is the same number you get if you analyze 1997 vs. 1980 directly using the -.67 elasticity. The -7.65% in the "Percent Change in Price Due to Demand Shifts" is 262.6-284.35/284.35=-.0765. For 1982, the calculation is 251.3-286.05/286.05=-.1215, or 12.15%. Since 7.65% of this is already accounted for in 1981, the yearly percentage price shift attributable to 1992 is 12.15-7.65=4.50%. It is, of course, negative.

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.

Table II shows an index calculated using a different analytical procedure. Going back to a base year of 1980 and always using 1980 per-capita consumption and deflated price as the denominator in the percentage calculations may understate the declines in demand in later years given the substantially smaller per-capita consumption. A one-pound year-to-year change in per-capita consumption, for example, is a significantly larger percentage when the base is 65 lb to 67 lb as has been the case in the 1990s than for the 76.4 lb of 1980. By switching the base period to the most recent year, a "constant-quantity" methodology is possible that reflects the changes in the "base" quantity and base price. Using the same -.67 price elasticity of demand, the "percentage change in price due to demand shift column" shows larger numbers than was the case in Table I. The cumulative reduction turns out to be nearly 68 percent with an index value of 32.03 for 1997 when 1980 is used as a base year and assigned the value 100. It could be argued that this calculation is the more appropriate one since the price-quantity coordinates realized for any particular year, such as 1997, were in fact a departure from the prior year coordinates and only incidentally were a departure from the original base period of 1980. This approach is a bit more cumbersome, however. It is not simply a matter of comparing any particular year to the 1980 base year and working through the elasticity framework to get the change in price associated with demand shifts as in the original table that showed a cumulative decline of about 48.68 percent.

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. 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:

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

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

Table II. Quantity Adjusted Index for Beef Demand: Price and Consumption Base Changes Year-to-Year

Year	Per-Capita Consumption	Deflated Price (cents/lb)	Constant Demand Price (cents/lb)	Percent Change in Price Due to Demand Shifts (%)	Index (1980=100)	Index (1997=100)
1980	76.4				100.00	312.2
1981	77.1	262.6	284.35	-7.65	92.35	288.3
1982	76.8	251.3	264.13	-4.86	87.49	273.2
1983	78.2	239.1	244.52	-2.22	85.27	266.2
1984	78.1	231.3	239.56	-3.45	81.82	255.4
1985	78.8	212.7	228.21	-6.80	75.02	234.2
1986	78.4	206.9	214.31	-3.46	71.56	223.4
1987	73.4	209.9	226.60	-7.37	64.19	200.4
1988	72.3	211.6	214.60	-1.40	62.79	196.0
1989	69.3	214.3	224.70	-4.63	58.16	181.6
1990	67.8	214.5	221.22	-3.04	55.12	172.1
1991	67.2	212.0	221.19	-4.15	50.97	159.1
1992	66.4	203.3	215.77	-5.78	45.19	141.1
1993	65.4	203.1	207.87	-2.30	42.89	133.9
1994	67.0	190.9	195.68	-2.45	40.44	126.3
1995	67.4	186.6	189.20	-1.37	39.07	122.0
1996	67.6	178.6	185.77	-3.87	35.20	109.9
1997	67.2	174.5	180.21	-3.17	32.03	100.0

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, for example, 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. 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 III shows the statistical properties of this preliminary model specification, when estimated using quarterly data for 1960 through the first quarter of 1998. 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.[3] 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 III. Statistical Properties of the Preliminary Beef Price Model, 1960-98

Ordinary Least Squares			
Dependent Variable	BEEFDEF	Number of Observations	153
Mean of Dep. Variable	243.0289	Std. Dev. Of Dep. Var.	35.614173
Durbin-Watson Statistic	.3160	Estimated Autocorrelation	.84198
Std. Error of Regr.	18.8271	Sum of Squared Residuals	51396.6
Total Variation	.19279E+06	Regression Variation	.14140E+06
Regression degrees of freedom	7	Residual degrees of freedom	145
R squared	.73341	Adjusted R squared	.72054
F (7, 145)	56.9863	Prob. Value of F	.00000

Variable	Coefficient	Std. Error	t-ratio	Prob|t|>x	Mean of X	Std. Dev. of X
Constant	260.046	38.34	6.782	.00000		
BEEFCON	-3.44178	1.502	-2.292	.02334	19.00196	2.05226
PORKCON	-.659447	1.619	-.407	.68435	13.05020	1.31933
BRCON	-17.0613	2.193	-7.779	.00000	12.22288	4.61912
DEFINC	.251737E-01	.4867E-02	5.173	.00000	10260.91209	1928.26195

[3] All residuals plotted in this bulletin are standardized residuals, which means they have been scaled by their variance. The need here is to be able to examine patterns in the plots, and there is no focus of attention on the size of the residuals. Thus, standardized residuals were deemed to be most appropriate.

QDUM2	16.7972	4.819	3.486	.00065	.24837	.43348
QDUM3	14.9225	5.044	2.959	.00361	.24837	.43348
QDUM4	-2.63978	4.500	-.587	.55842	.24837	.43348

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 1960-1998 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. That is, the residual for one quarter would 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 then relative prices, consumers' incomes, and seasonal patterns in beef prices was 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.

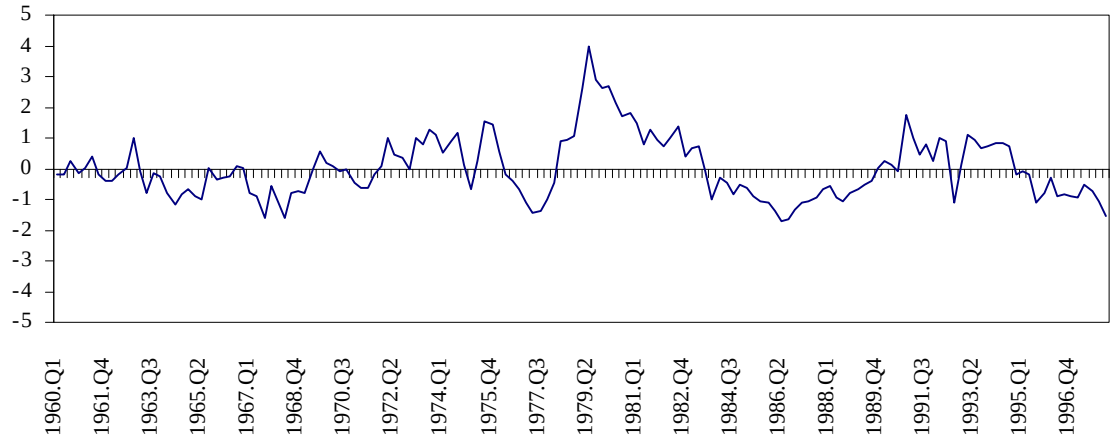


Figure 4. Residuals for the Preliminary Beef Price Model, 1960-98

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, relative prices, beef quantity, and seasonal price patterns.*

Table IV shows a model run that allowed the annual dummy variables to be introduced for years 1975 (DUM75) through 1998 (DUM98) with only the first quarter of 1998 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.

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 73 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 -.7.779 (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. Pork, instead, becomes the significant factor with a t-ratio of -2.777, 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.

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

Ordinary Least Squares			
Dependent Variable	BEEFDEF	Number of Observations	153
Mean of Dep. Variable	243.0289	Std. Dev. Of Dep. Var.	35.614173
Durbin-Watson Statistic	1.5953	Estimated Autocorrelation	.20234
Std. Error of Regr.	7.8248	Sum of Squared Residuals	7408.56
Total Variation	.19279E+06	Regression Variation	.18538E+06
Regression degrees of freedom	31	Residual degrees of freedom	121
R squared	.96157	Adjusted R squared	.95173
F (31, 121)	97.6700	Prob. Value of F	.00000

Variable	Coefficient	Std. Error	t-ratio	Prob|t|>x	Mean of X	Std. Dev. of X
Constant	322.714	17.85	18.083	.00000		
BEEFCON	-10.9011	1.089	-10.013	.00000	19.00196	2.05226
PORKCON	-2.48696	.8957	-2.777	.00637	13.05020	1.31933
BRCON	-1.05265	1.941	-.542	.58866	12.22288	4.61912
DEFINC	.232531E-01	.2487E-02	9.350	.00000	10260.91209	1928.26195
QDUM2	1.02620	2.488	.412	.68077	.24837	.43348
QDUM3	4.82719	2.362	2.044	.04316	.24837	.43348
QDUM4	-3.28726	1.952	-1.684	.09467	.24837	.43348
DUM75	11.2132	5.018	2.235	.02728	.02614	.16009
DUM76	-2.16451	5.014	-.432	.66674	.02614	.16009
DUM77	-29.9875	4.677	-6.411	.00000	.02614	.16009
DUM78	-15.3581	5.034	-3.051	.00281	.02614	.16009
DUM79	.360635	.7025	.051	.95914	.02614	.16009
DUM80	-16.6214	7.201	-2.308	.02268	.02614	.16009
DUM81	-41.1544	7.520	-5.473	.00000	.02614	.16009
DUM82	-54.0585	7.945	-6.804	.00000	.02614	.16009
DUM83	-67.6419	7.977	-8.480	.00000	.02614	.16009
DUM84	-86.9178	8.634	-10.067	.00000	.02614	.16009
DUM85	-102.190	9.394	-10.879	.00000	.02614	.16009
DUM86	-119.703	9.817	-12.193	.00000	.02614	.16009
DUM87	-133.630	12.11	-11.038	.00000	.02614	.16009
DUM88	-140.005	13.24	-10.573	.00000	.02614	.16009
DUM89	-155.284	15.51	-10.013	.00000	.02614	.16009
DUM90	-155.346	16.88	-9.201	.00000	.02614	.16009
DUM91	-163.132	17.98	-9.075	.00000	.02614	.16009
DUM92	-175.639	18.74	-9.371	.00000	.02614	.16009
DUM93	-182.445	20.47	-8.911	.00000	.02614	.16009
DUM94	-191.575	20.87	-9.179	.00000	.02614	.16009
DUM95	-207.147	20.38	-10.162	.00000	.02614	.16009
DUM96	-221.044	21.09	-10.479	.00000	.02614	.16009

DUM97	-232.184	21.98	-10.565	.00000	.02614	.16009
DUM98	-241.161	22.79	-10.580	.00000	.00654	.08085

The "consumer incomes" variable shows the theoretically expected positive sign. The t-ratio is 9.350, 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 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.

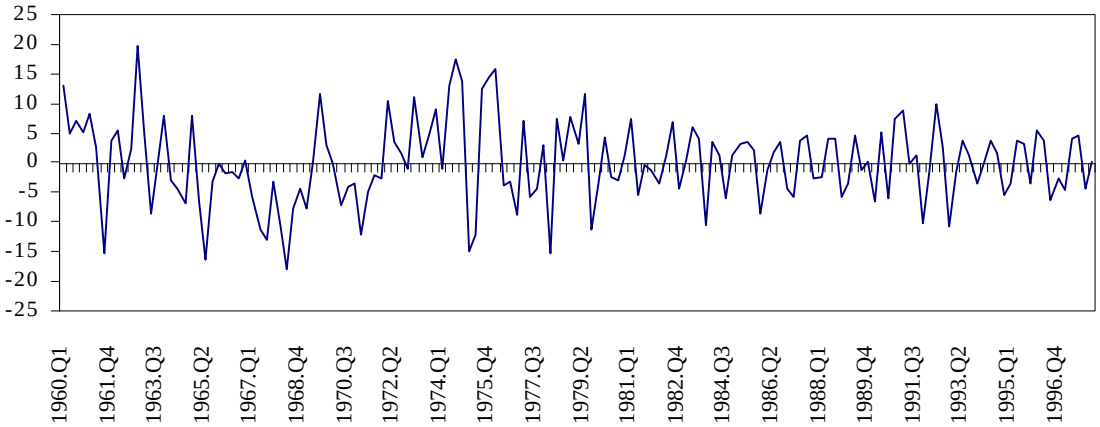


Figure 5. Residuals for a More Extensive Beef Price Model, 1960-98

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 V and Figure 6 respectively. In the interest of conceptual completeness, the discussion of the results that follows will employ the model specification in Table IV 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 DUM98 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 and relatively large, but the coefficient on DUM79 is close to zero, and note, with a t-ratio of only .051, 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 2.3 and higher. 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 $2.32 for DUM97. Technically, the coefficient on DUM97 suggests that the intercept for the model is $2.32 below where it would have been if shifts in the demand surface that cannot be attributed to the more traditional economic demand shifters had not occurred.

Expressing the cumulative shift in the price surface of $2.32 as estimated by DUM97 as a percentage of the constant or intercept term for the model, which is essentially $3.23, it would appear that price of beef has declined by about 72 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. 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. 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.

Table V. Statistical Properties for a More Extensive Beef Price Model, 1960-98: Broiler Consumption not Included

Ordinary Least Squares			
Dependent Variable	BEEFDEF	Number of Observations	153
Mean of Dep. Variable	243.0289	Std. Dev. Of Dep. Var.	35.614173
Durbin-Watson Statistic	1.5953	Estimated Autocorrelation	.20222
Std. Error of Regr.	7.8021	Sum of Squared Residuals	7426.56
Total Variation	.19279E+06	Regression Variation	.18537E+06
Regression degrees of freedom	30	Residual degrees of freedom	122
R squared	.96148	Adjusted R squared	.95201
F (31, 121)	101.5032	Prob. Value of F	.00000

Variable	Coefficient	Std. Error	t-ratio	Prob|t|>x	Mean of X	Std. Dev. of X
Constant	324.098	17.61	18.402	.00000		
BEEFCON	-11.0599	1.046	-10.578	.00000	19.00196	2.05226
PORKCON	-2.43800	.8885	-2.744	.00699	13.05020	1.31933
DEFINC	.224247E-01	.1957E-02	11.460	.00000	10260.91209	1928.26195
QDUM2	.125001	1.846	.068	.94617	.24837	.43348
QDUM3	4.17457	2.026	2.060	.04152	.24837	.43348
QDUM4	-3.34708	1.943	-1.723	.08745	.24837	.43348
DUM75	11.7382	4.909	2.391	.01833	.02614	.16009
DUM76	-2.02208	4.993	-.405	.68618	.02614	.16009
DUM77	-30.0651	4.662	-.6450	.00000	.02614	.16009
DUM78	-16.0778	4.842	-3.321	.00119	.02614	.16009

DUM79	-1.84876	5.706	-.324	.74647	.02614	.16009
DUM80	-19.0794	5.578	-3.420	.00085	.02614	.16009
DUM81	-44.0244	5.326	-8.266	.00000	.02614	.16009
DUM82	-57.2869	5.245	-.10921	.00000	.02614	.16009
DUM83	-70.8346	5.366	-13.201	.00000	.02614	.16009
DUM84	-90.2723	6.005	-15.033	.00000	.02614	.16009
DUM85	-106.040	6.132	-17.293	.00000	.02614	.16009
DUM86	-123.561	6.744	-18.323	.00000	.02614	.16009
DUM87	-138.543	8.006	-17.305	.00000	.02614	.16009
DUM88	-145.309	8.898	-16.330	.00000	.02614	.16009
DUM89	-161.657	10.09	-16.027	.00000	.02614	.16009
DUM90	-162.729	9.955	-16.347	.00000	.02614	.16009
DUM91	-171.088	10.35	-16.528	.00000	.02614	.16009
DUM92	-183.811	11.11	-16.543	.00000	.02614	.16009
DUM93	-191.554	11.67	-16.415	.00000	.02614	.16009
DUM94	-201.003	11.51	-17.463	.00000	.02614	.16009
DUM95	-215.942	12.31	-17.541	.00000	.02614	.16009
DUM96	-230.230	12.53	-18.372	.00000	.02614	.16009
DUM97	-241.770	13.02	-18.573	.00000	.02614	.16009
DUM98	-250.389	15.12	-16.558	.00000	.00654	.08085

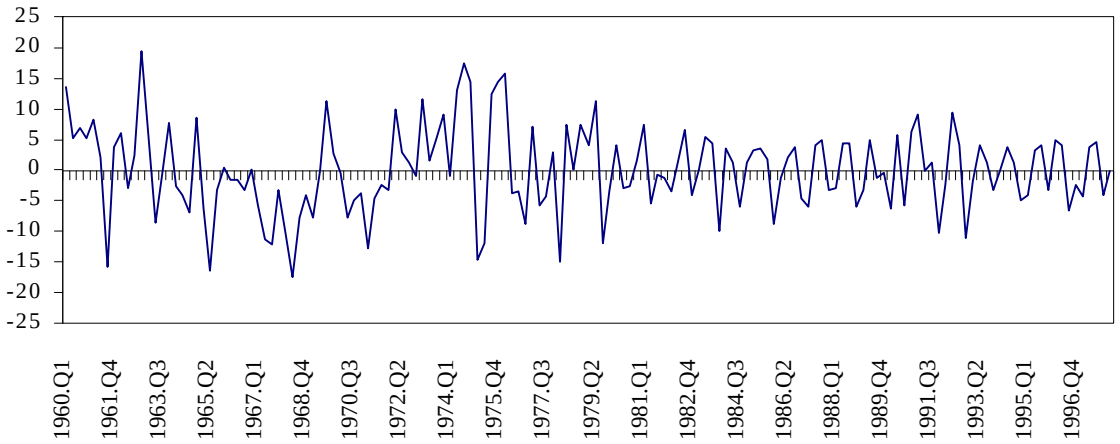


Figure 6. Residuals for a More Extensive Beef Price Model, 1960-98: Broiler Consumption not Included

It is interesting to note that expressed as a percentage of the mean beef price ($2.42) for the entire period, the -$2.32 coefficient on the DUM97 shift variable is almost 96 percent of the mean price. Technically, of course, the shift dummies measure changes in the intercept. The 72 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 multicolinearity problems in explanatory variables which might influence the precision with which the model estimates any particular parameter. For example, before taking the -10.9011, 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 multicolinearity, 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 IV and V.) 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 95 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*.[4]

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. 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 has been a fairly extensive period in which per-capita consumption, which reflects per-capita supply, has varied from about 47 lb to some 53 lb, and the inflation-adjusted price has varied from a low around $1.25 in 1995 to about $1.60 in 1990.

[4] 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 44 and 37 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 slightly by relationship to other explanatory variables.

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. 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 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 VI 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 82 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 III, suggesting there is less price variation left to be accounted for in pork after accounting for the traditional factors included in the model.

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 10 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 positive, and therefore theoretically incorrect, and the t-ratio is only .363. Chicken, on the other hand, as measured by per-capita consumption, shows the expected negative sign and a relatively large t-ratio at 5.898 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 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 consistently trended downward and per-capita chicken consumption has consistently 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, -.43. It is those types of relatively high levels of correlation that can present multicollinearity problems in the estimation process.

Table VI. Statistical Properties of the Preliminary Pork Price Model, 1960-98

Ordinary Least Squares						
Dependent Variable	PORKDEF		Number of Observations	153		
Mean of Dep. Variable	180.9018		Std. Dev. Of Dep. Var.	32.761111		
Durbin-Watson Statistic	.5214		Estimated Autocorrelation	.73930		
Std. Error of Regr.	13.8755		Sum of Squared Residuals	27916.7		
Total Variation	.16314E+06		Regression Variation	.13522E+06		
Regression degrees of freedom	7		Residual degrees of freedom	145		
R squared	.82888		Adjusted R squared	.82062		
F (7, 145)	100.3361		Prob. Value of F	.00000		
Variable	**Coefficient**	**Std. Error**	**t-ratio**	**Prob|t|>x**	**Mean of X**	**Std. Dev. of X**
Constant	365.033	28.26	12.917	.00000		
PORKCON	-12.3214	1.193	-10.327	.00000	13.05020	1.31933
BEEFCON	.401554	1.107	.363	.71725	19.00196	2.05226
BRCON	-9.53412	1.616	-5.898	.00000	12.22288	4.61912
DEFINC	.806313E-02	.3587E-02	2.248	.02608	10260.91209	1928.26195
QDUM2	-.665525	3.552	-.187	.85162	.24837	.43348
QDUM3	2.01346	3.717	.542	.58890	.24837	.43348
QDUM4	10.0650	3.317	3.035	.00286	.24837	.43348

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 standardized residuals come down from a level of about 2 on the plot to eventually, a few years later, -2. 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, all 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.

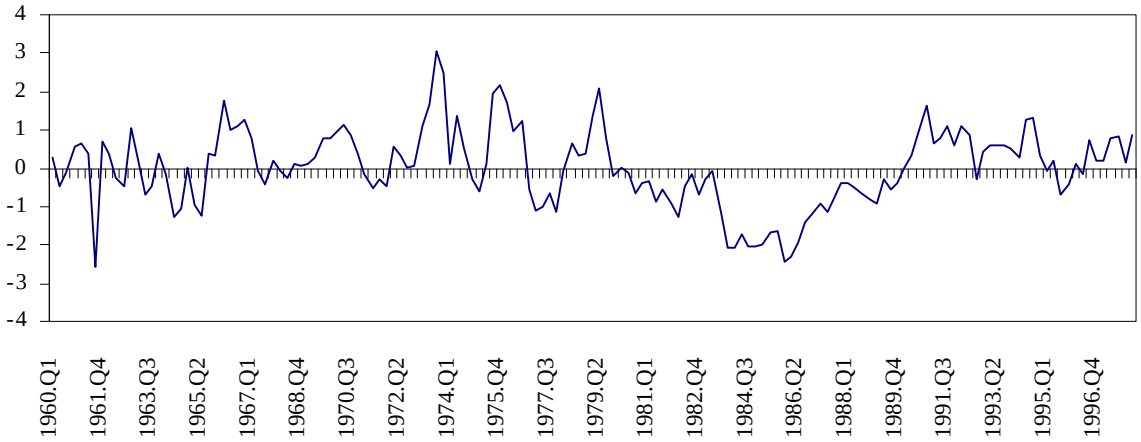


Figure 7. Residuals for the Preliminary Pork Price Model, 1960-98

Table VII shows an extended price-dependent single equation econometric model with yearly dummies included for 1979 through 1998. The Durbin-Watson statistic no longer suggests the presence of autocorrelation. The R^2 measure moves up to above 92 before adjustment and is 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 72 or 73 to 95. The adjusted R^2, remember, was above 82 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.

Note the coefficient on the yearly dummy or 0-1 variable is negative in 1979 but does not show a t-ratio that suggests it is statistically significant. 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 the first quarter of 1998, there has been no sustained increase in absolute size of this shift parameter. Indeed, the levels of 1996 and 1997 are about the same as those for 1985. 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.

Table VII. Statistical Properties of a More Extensive Pork Price Model, 1960-98

Ordinary Least Squares			
Dependent Variable	PORKDEF	Number of Observations	153
Mean of Dep. Variable	180.9018	Std. Dev. Of Dep. Var.	32.761111
Durbin-Watson Statistic	1.2048	Estimated Autocorrelation	.39758
Std. Error of Regr.	10.0899	Sum of Squared Residuals	12725.8
Total Variation	.16314E+06	Regression Variation	.15041E+06
Regression degrees of freedom	27	Residual degrees of freedom	125
R squared	.92199	Adjusted R squared	.90515
F (7, 145)	54.7206	Prob. Value of F	.00000

Variable	Coefficient	Std. Error	t-ratio	Prob|t|>x	Mean of X	Std. Dev. of X
Constant	378.388	22.31	16.957	.00000		
BEEFCON	-1.48953	1.201	-1.240	.21728	19.00196	2.05226
PORKCON	-13.0332	.9604	-13.571	.00000	13.05020	1.31933
BRCON	-6.06116	2.332	-2.599	.01047	12.22288	4.61912
DEFINC	.916508E-02	.3130E-02	2.928	.00405	10260.91209	1928.26195
QDUM2	-3.82845	3.116	-1.229	.22149	.24837	.43348
QDUM3	.113353	2.963	.038	.96955	.24837	.43348
QDUM4	10.4393	2.466	4.233	.00004	.24837	.43348
DUM79	-4.79213	8.057	-.595	.55306	.02614	.16009
DUM80	-21.5189	8.285	-2.597	.01052	.02614	.16009
DUM81	-28.7283	8.666	-3.315	.00120	.02614	.16009
DUM82	-30.3101	9.180	-3.302	.00125	.02614	.16009
DUM83	-33.8844	9.165	-3.697	.00032	.02614	.16009
DUM84	-50.8367	9.791	-5.192	.00000	.02614	.16009
DUM85	-52.3198	10.64	-4.919	.00000	.02614	.16009
DUM86	-51.3893	11.01	-4.665	.00001	.02614	.16009
DUM87	-45.0946	13.50	-3.341	.00110	.02614	.16009
DUM88	-44.2616	14.67	-3.018	.00309	.02614	.16009
DUM89	-49.3580	17.13	-2.881	.00467	.02614	.16009
DUM90	-35.2685	18.78	-1.878	.06273	.02614	.16009
DUM91	-37.2457	19.99	-1.863	.06480	.02614	.16009
DUM92	-42.0712	20.75	-2.028	.04472	.02614	.16009
DUM93	-45.6308	22.70	-2.010	.04660	.02614	.16009
DUM94	-43.7974	23.18	-1.889	.06116	.02614	.16009
DUM95	-57.4830	22.49	-2.556	.01177	.02614	.16009
DUM96	-53.9731	23.31	-2.316	.02219	.02614	.16009
DUM97	-52.9727	24.27	-2.182	.03095	.02614	.16009
DUM98	-46.8926	25.49	-1.840	.06816	.00654	.08085

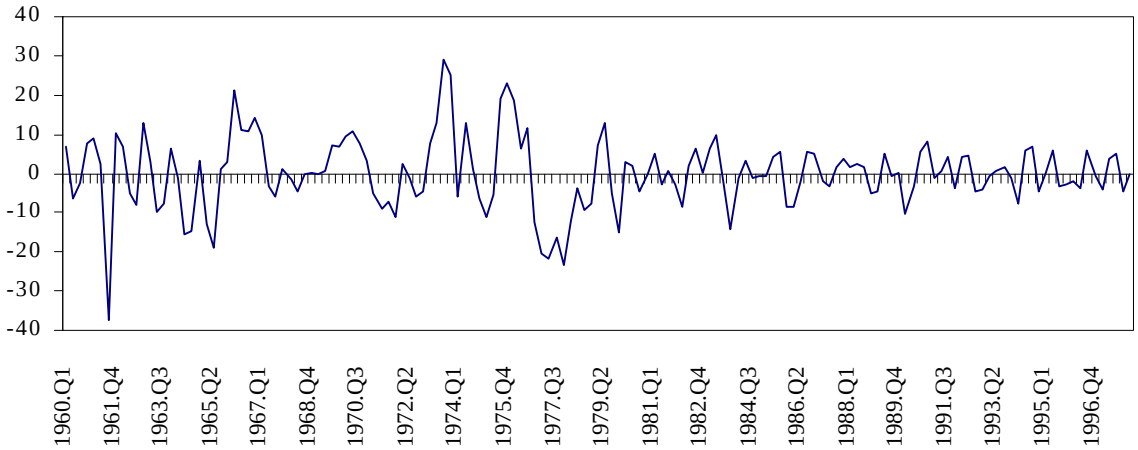


Figure 8. Residuals for a More Extensive Pork Price Model, 1960-98

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 and, in statistical terms, therefore, more important than that for beef. The t-ratio for beef is 1.24, which leaves about a 21 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.

Note the coefficient on the BRCON is much larger than the coefficient for BEEFCON. These “beta” estimates can be converted to standardized betas by dividing by the standard error of the estimate. This gives a standardized measure of 2.6 for BRCON compared to 1.24 for BEEFCON, again suggesting broilers are a better substitute for pork.

The income variable is positive, as would be expected, although it is quite small with the coefficient reading .009. This suggests that a $1.00 increase in average per-capita disposable incomes would increase pork prices by .009 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 4.5 cents per lb. But a $500 increase in per-capita disposable incomes will take several years. 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 a highly significant impact only in quarter 4. This suggests that since the coefficient is positive, the model-predicted price is consistently higher in quarter 4 for strictly time or seasonal reasons. Note that even though the t-ratios on QDUM2 and QDUM3 are smaller, even substantially less than 1 in the case of QDUM3, they are 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 slightly above $3.78 per lb for pork. The last full year for which quarterly data are entered is 1997, and the coefficient on the shift variable for 1997 was -52.9, or about $.53. This says that the actual demand surface is some $.53 down from the overall model intercept of $3.78 for reasons outside of the demand-shifting influences of the substitute meats and consumers’ incomes. That $.53 is about 14 percent of the model constant term, and this shift in the price surface for pork is obviously considerably smaller than was the shift recorded for beef. If you analyze the $.53 downward shift at the mean price of $1.80 for pork, however, the decline is then some 29 percent and substantially more negative than when compared to the intercept term. If you go back to the beef situation and recognize that the coefficient on the DUM97 yearly shift dummy was -$2.32, we continue to see evidence that the demand shifts in beef have been and continue to be dramatic whether the $2.32 is expressed as a percentage of the intercept or of the mean price 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 1997, 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 essentially the same inflation-adjusted price. This would suggest moves up and to the right in the demand surface for chicken during the 1990s.

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 VIII 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 86. 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 VIII. Statistical Properties of a Preliminary Chicken Price Model, 1960-98

Ordinary Least Squares			
Dependent Variable	BRDEF	Number of Observations	153
Mean of Dep. Variable	94.9292	Std. Dev. Of Dep. Var.	26.841062
Durbin-Watson Statistic	.4365	Estimated Autocorrelation	.78173
Std. Error of Regr.	9.9020	Sum of Squared Residuals	14217.1
Total Variation	.10951E+06	Regression Variation	95290
Regression degrees of freedom	7	Residual degrees of freedom	145
R squared	.87017	Adjusted R squared	.86390
F (7, 145)	138.8381	Prob. Value of F	.00000

Variable	Coefficient	Std. Error	t-ratio	Prob|t|>x	Mean of X	Std. Dev. of X
Constant	235.972	20.17	11.701	.00000		
BRCON	-9.25850	1.154	-8.026	.00000	12.22288	4.61912
PORKCON	-2.01444	.8514	-2.366	.01931	13.05020	1.31933
BEEFCON	-4.21259	.7898	-5.334	.00000	19.00196	2.05226
DEFINC	.728658E-02	.2560E-02	2.847	.00506	10260.91209	1928.26195
QDUM2	6.59575	2.535	2.602	.01022	.24837	.43348
QDUM3	9.14419	2.653	3.447	.00074	.24837	.43348
QDUM4	-.875521	2.367	-.370	.71201	.24837	.43348

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 1998. 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.

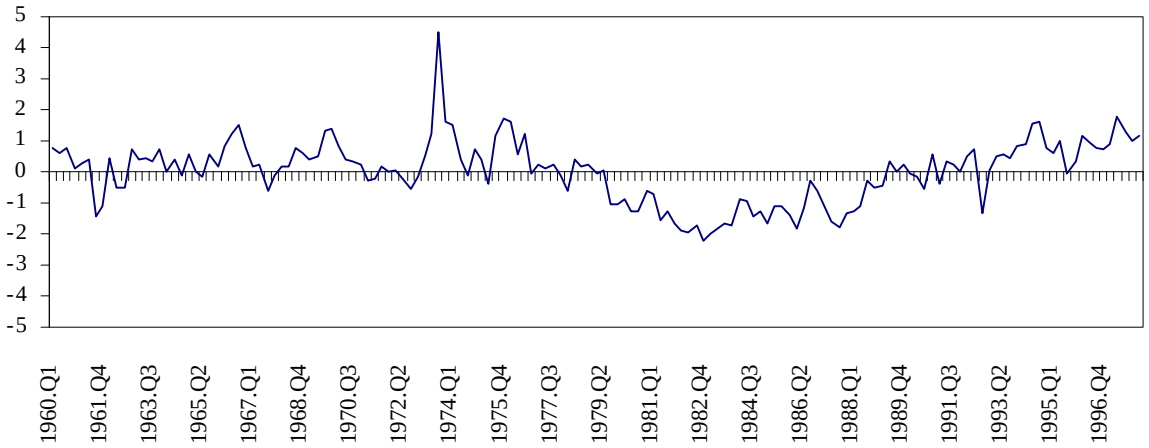


Figure 9. Residuals for the Preliminary Chicken Price Model, 1960-98

Table IX 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 -1.949, suggesting statistical significance at or near 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 1998 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 86 to nearly 96 percent in chicken as we compare the preliminary and the final models.

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 either are significant at the .05 level, as in the case of DUM86 and DUM87, or approach that significance level. After 1987, the year 1988 appeared to have been a transition year. The coefficients switched to positive and generally tend to increase across the time period with DUM97 standing at 22.74, 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 near 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 standardized betas for beef and pork are 3.4 and 5.5 respectively, suggesting pork is the better substitute. This is consistent with what we observed in the beef and pork models and is consistent with what other analysts have observed.

Table IX. Statistical Properties of a More Extensive Chicken Price Model, 1960-98

Ordinary Least Squares			
Dependent Variable	BRDEF	Number of Observations	153
Mean of Dep. Variable	94.9292	Std. Dev. Of Dep. Var.	26.841062
Durbin-Watson Statistic	1.6962	Estimated Autocorrelation	.15188
Std. Error of Regr.	5.5014	Sum of Squared Residuals	3783.20
Total Variation	.10951E+06	Regression Variation	.10572E+06
Regression degrees of freedom	27	Residual degrees of freedom	125
R squared	.96545	Adjusted R squared	.95799
F (7, 145)	129.3781	Prob. Value of F	.00000

Variable	Coefficient	Std. Error	t-ratio	Prob|t|>x	Mean of X	Std. Dev. of X
Constant	244.027	12.17	20.050	.00000		
BEEFCON	-1.99412	.5854	-3.406	.00089	19.00196	2.05226
PORKCON	-2.85101	.5182	-5.502	.00000	13.05020	1.31933
BRCON	-7.54956	1.186	-6.363	.00000	12.22288	4.61912
DEFINC	.135107E-02	.1972E-02	.685	.49461	10260.91209	1928.26195
QDUM2	4.90826	1.661	2.955	.00374	.24837	.43348
QDUM3	6.33029	1.660	3.814	.00021	.24837	.43348
QDUM4	.369583	1.338	.276	.78287	.24837	.43348
DUM73	20.7569	3.348	6.200	.00000	.02614	.16009
DUM80	-6.96822	3.576	-1.949	.05358	.02614	.16009
DUM81	-11.7049	3.716	-3.150	.00204	.02614	.16009
DUM82	-20.1374	3.997	-5.038	.00000	.02614	.16009
DUM83	-17.5330	3.911	-4.483	.00002	.02614	.16009
DUM84	-9.10173	4.040	-2.253	.02601	.02614	.16009
DUM85	-11.3867	4.332	-2.629	.00965	.02614	.16009
DUM86	-6.59548	4.421	-1.492	.13823	.02614	.16009
DUM87	-9.00442	5.213	-1.727	.08657	.02614	.16009
DUM88	.110357	5.539	-.020	.98414	.02614	.16009
DUM89	9.34363	6.370	1.467	.14494	.02614	.16009
DUM90	6.28912	7.070	.889	.37545	.02614	.16009
DUM91	7.55825	7.512	1.006	.31626	.02614	.16009
DUM92	9.08090	7.696	1.180	.24028	.02614	.16009
DUM93	14.7432	8.450	1.745	.08348	.02614	.16009
DUM94	19.5955	8.676	2.259	.02564	.02614	.16009
DUM95	15.7013	8.247	1.904	.05921	.02614	.16009
DUM96	19.2506	8.573	2.245	.02650	.02614	.16009
DUM97	22.7394	8.919	2.550	.01199	.02614	.16009
DUM98	24.3010	9.937	2.445	.01586	.00654	.08085

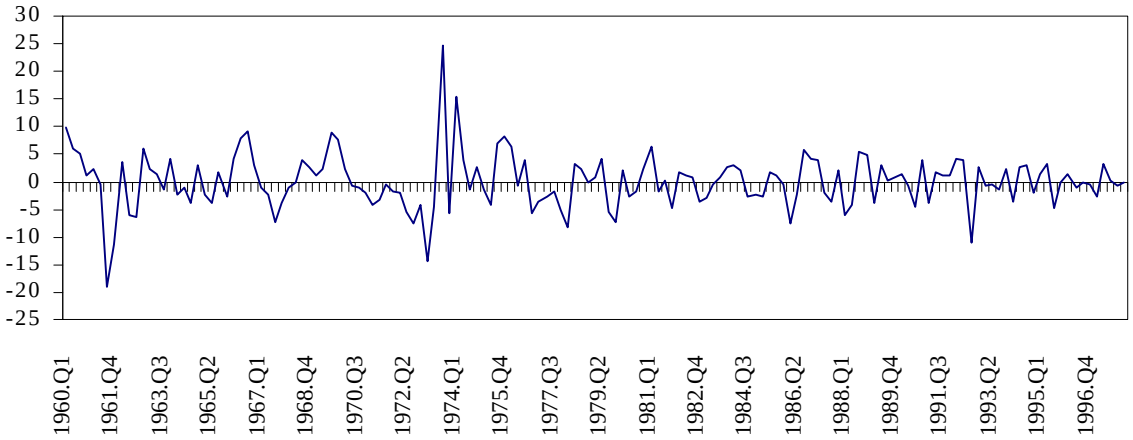


Figure 10. Residuals for a More Extensive Chicken Price Model, 1960-98

The 22.7394 coefficient on DUM97 is a 9.3-percent increase when evaluated in terms of the 244.027 constant term in the model. When evaluated in terms of the mean price of 94.92, however, that shift coefficient for 1997 is almost 24 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, 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 the 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 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. 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 1998. *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 72, 82, and 86 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 95 for beef (up 22 points), 90 for pork (up 8 points), and 96 for chicken (up 10 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 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 playing 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 1997 was $2.32 per lb below the model intercept of $3.23 (a 74 percent decrease). For pork, the comparable shift down in the price surface was $.53 from an intercept of $3.78 (a 14 percent decrease).

- In chicken, the possible preference-related shift in price after accounting for quantity, substitutes, and consumer incomes was positive, measuring $.23 in 1997 from an intercept of $2.44 (a 9.5 percent increase).

There are ample grounds for inferences on future needs in the three meats. *In beef, the need to move the fresh beef product offering toward the needs and preferences of the modern consumer is readily apparent.* A devastating and prolonged decrease in demand for fresh beef appears to be 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. If these things are not done, beef will continue to lose market share with a major loss in 1999 now largely predetermined.

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. 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.

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 have raised costs and constrained growth in 1998 and into 1999. Both of these obstacles to growth are short-run in nature, and a resurgence of growth and related efforts to stay "consumer-driven" are likely in poultry. 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 X 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 is not captured by traditional economic demand shifters. The large change in beef is revealing. The price shifts from the model intercepts, through 1997 as the last year of complete data, are also much larger for beef. What is needed is the same in all three commodities: a consumer-friendly product offering. Chicken appears to be moving along that path. Both beef and pork need change, but the need and the related challenge appear to 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 1997

Commodity	R^2 Levels (%) Preliminary Model	R^2 Levels (%) Final Model	Model Intercept and Price Change ( )s Based on Shift Variable Coefficients ($/lb)
Beef	72	95	$3.23 (-$2.32)
Pork	82	90	$3.78 (-$.53)
Chicken	86	96	$2.44 (+$.23)

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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