Effects of Simulated Changes in Consumer Preference on the Meat and Poultry Industries

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Abstract

Consumer preferences for meat may be changing, if so, market clearing retail prices will be higher or lower than if no such changes occurred It will be several years before statistical analysts have enough price-quantity observations to determine whether these alleged shifts in preference for meat products began in the eighties This article reports the simulated impacts on the livestock and crops sectors of several combinations of assumed shifts in consumer preference for beef, pork, and frying chickens over a 10-year period

Keywords

Demand, prices, simulation

U S consumption of meat and poultry products has been increasing for many years Per capita consumption of beef, pork, and chicken rose from only 120 pounds per person (retail weight basis) in 1950 to 183 pounds in 1970 and 192 pounds in 1980 [1] Because of the perishable nature of these products, all production is consumed in the short run at a price which clears the market In the longer run, consumers' incomes support their tastes and preferences for meat and poultry, and production adjusts to aggregate consumer demand

Lower real per capita incomes in the early eighties led to lower retail prices of beef, pork, and chicken clearing the markets than they would have if the economy had not been in recession Consumer preference for meat and poultry products relative to other foods may also be starting to decline slightly Because numerous observations are needed to verify this hypothesis, it will be several years before conventional econometric analyses can identify the presence or absence of such a demand change But analysts can conduct simulation experiments on a comprehensive model of the red meat-poultry-feed grain complex immediately to ascertain the effects of a shift in consumer preference on the agricultural sector

Aggregate consumer preference is the sum of individual preferences If aggregate consumer preference for meat is changing, it may be a combination of (1) some consumers not wanting to purchase the product at all (price is irrelevant for this group), (2) some who want to purchase a different quantity than previously at the same level of prices and incomes, (3) some who have not changed their price-quantity reaction but whose incomes have changed, and (4) others who have not changed their levels of consumption given product prices and whose incomes have not changed Some combination of these shifts in consumer preference and incomes has probably occurred In the short run, these shifts in demand among the types of consumers identified above require that retail prices be readjusted so that the latter three groups of consumers will clear the market of the predetermined quantity of product produced In the longer term, production can be adjusted to this change in aggregate demand

I selected four scenarios to measure the impacts of alternative hypotheses regarding changing consumer preferences for beef, pork, and chicken

1 Consumer preference is declining for all three meats

2 Consumer preference is declining for beef and increasing for chicken, with no change in consumer preference for pork

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[1] Chicken at retail refers to frying chickens (broilers) The retail price index used is for frying chickens only Other chicken primarily spent laying hens, is not included

3 Consumer preference for both beef and pork, the major red meats, is declining, whereas consumer preference for chicken is increasing
4 Consumer preference for beef resumes its previous upward trend, with no change in consumer taste for pork and chicken

Method of Analysis

The choice of a model for conducting these simulation experiments involved several criteria (1) comprehensive coverage of the livestock-feed grain complex, (2) ability to make a 10-year projection, and (3) a structure adaptable to introducing endogenous change

The U S Department of Agriculture's Food and Agricultural Policy Simulator (FAPSIM) (*1, 2*) was selected because it meets all three criteria [2] It is an annual econometric model containing 360 endogenous and 265 exogenous variables In addition to estimating equilibrium livestock and crop prices and production, the model also endogenously determines farm production expenses, cash receipts, net farm income, Government deficiency and reserve storage payments, and consumer price indexes for food products

Livestock commodities in FAPSIM include beef, pork, dairy, chickens, eggs, and turkeys Each individual livestock submodel consists of a set of equations to estimate production (slaughter), farm and retail prices, civilian consumption, and ending stocks It also includes equations for predicting the stock of breeding animals, additions to the breeding herd, and slaughter of breeding animals

The model uses identities to ensure that changes in the number of market animals and breeding animals reflect changes in animal births, deaths, and slaughter The number of breeding animals slaughtered and additions to the breeding herd are functions of the price of livestock relative to the price of feed and the stock of available animals The size of the livestock crop is a function of the stock of breeding animals Livestock slaughter depends on the ratio of the price of livestock to feed costs and on the number of market animals on farms The livestock and feed grain sectors are linked so that a change in feed demand affects grain prices, conversely, a shift in grain supplies available for feeding affects prices that livestock producers must pay

Civilian consumption of meat is calculated as total supply less military consumption, exports, and ending stocks Military consumption, imports, and exports are treated as exogenous Ending stocks are expressed as a function of total supply and the ratio of current to lagged retail price

The retail price index of each type of meat is determined by an econometric relationship expressing real retail price as a function of its own per capita consumption, real per capita disposable income, and real retail prices of competing meats Farm prices of each livestock commodity are expressed as functions of the corresponding retail price index and variables reflecting meat processing and marketing costs

Crop commodities in FAPSIM include corn, oats, barley, grain sorghum, wheat, soybeans, soybean meal, soybean oil, and cotton Each crop submodel consists of a set of equations to estimate production, total supply and demand, and ending stocks Finally, some aggregate indicators of the performance of the agricultural sector such as cash receipts and farm income are calculated

FAPSIM estimates retail prices for beef, pork, and chicken simultaneously, each as a function of prices of the other two competing meats, income, per cap ita supply of product available for consumption, and the Consumer Price Index (CPI) For each simulation experiment, I modified the appropriate pricing equations as follows

Any change in consumer preference is usually a slow, long-term trend—perhaps 1 percent per year at most So, for these experiments on the model, I decreased (increased) the price estimate by 1 percent per year for each meat for which a demand change was postulated in the experiment, after accounting for changes in per capita supply of product available for consumption, income, and competing meat prices In other words, I assumed that the market-clearing price was successively 1 percent less each year because of a change in aggregate con sumer preference Because these prices interacted in the simultaneous solution for each time period (year), the final price estimate differed from a 1-percent change each year

[2] Italicized numbers in parentheses refer to items in the References at the end of this article

An example may further clarify the model modification For the experiments where the market-clearing price of beef was assumed to decrease by 1 percent per year (not including an adjustment for inflation) from the baseline value over the 1982-91 simulation period, I took the 1982 value of the retail beef and veal index (2 74) as an initial value Then, I reduced the intercept of the price-estimating function by an amount equal to 1 percent (of the beef and veal index) for 1982 (0 027) For 1983, the reduction in the intercept was 2 × 0 027, plus an adjustment (increase) for inflation The 10th year adjustment (1991) was 10 × 0 027 = 0 27 plus the increase for inflation of 1 59 (0 27 × 1 59 = 0 43)

Because the annual FAPSIM model is recursive (or block recursive), it can be used to simulate the agricultural economy for a period of years The model was allowed to run for 10 years (1982-91) to simulate the dynamic supply and further price-supply interactions within the livestock sector and the interaction with the crops sector Then, I compared the simulated prices and outputs with those of the base projection of the model

Model Baseline

Overall, the baseline values of the projected variables indicate directional trends, mostly moderate increases due mainly to inflation and population growth However, their chief function in this analysis is to serve as a base for measuring changes that occur as the model is "shocked" with a combination of changing trends in the functions used to estimate annual values of market-clearing retail prices

The FAPSIM model was given initial endogenous data and projected exogenous data to operate it through 1991 This 10-year projection provides baseline estimates of the price production sequence in the crops-livestock sectors which one can use to compare the projected estimates of prices and production under the postulated alternatives [3]

These model experiments are performed in a projection time frame for two reasons (1) information is provided relative to the possible nature of future events, and (2) the estimates are not affected by historical shocks because of aberrations in the exogenous variables Therefore, the projected variables usually show less cyclical and seasonal volatility when I compare them with their historical values

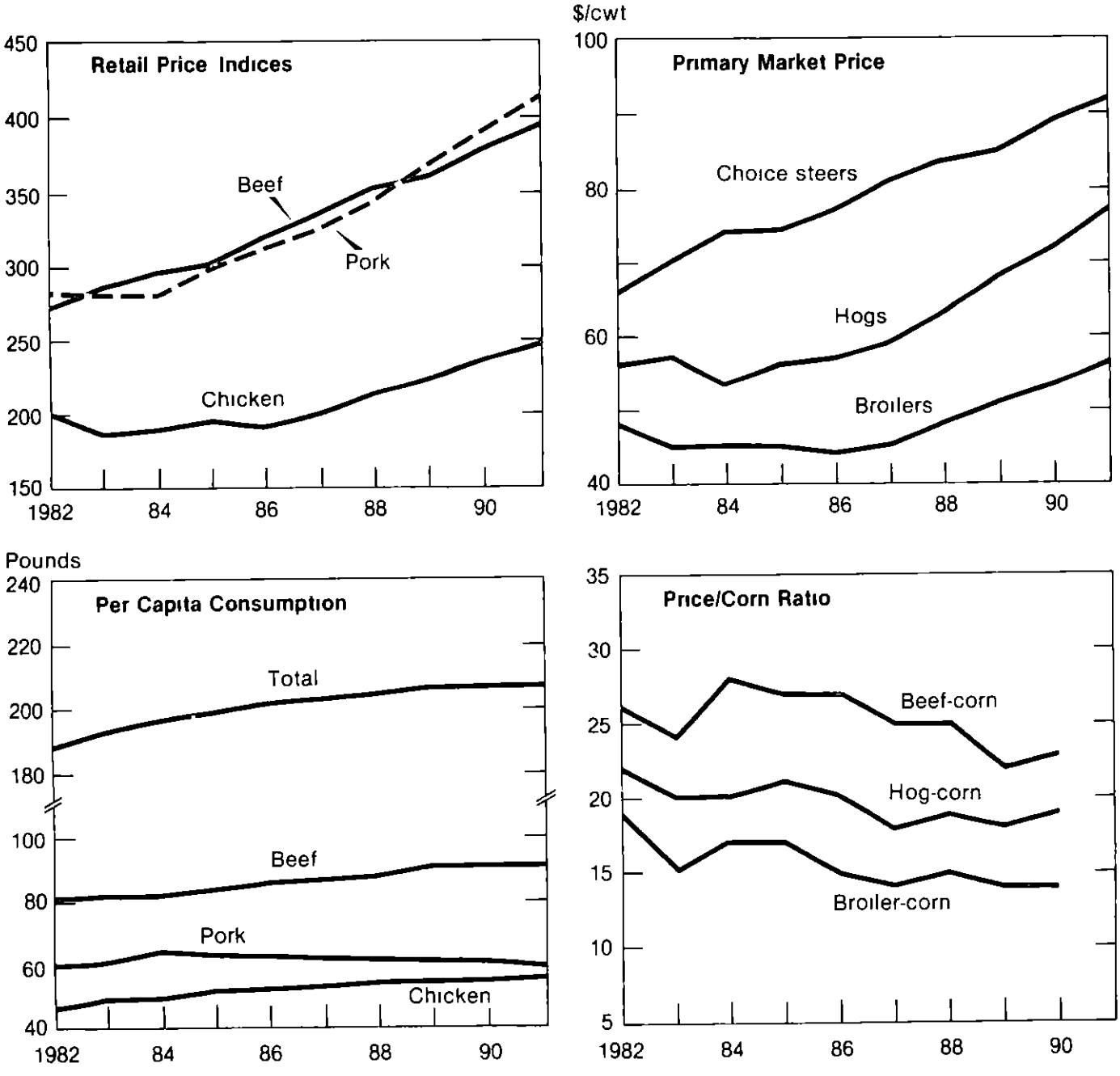
Projected values of beef, pork, and chicken retail price indexes, primary market prices, price-corn ratios, and per capita consumption are shown in the figure The projected baseline prices increase substantially, especially after the mideighties, as inflation moderates However, the price-corn ratios decrease because meat prices actually decrease in real terms, whereas the corn price holds rather constant when deflated All values of the price-corn ratio for cattle, hogs, and broilers fall in an "indeterminant" range which provides no signals for rapid expansion or contraction of production Thus, the projected beef cow inventory increases gradually from 40 5 million head in 1982 to 50 5 million head in 1991, with the rate of increase slowing toward the end of the period The inventory of hogs kept for breeding increases and then declines somewhat, but holds around 9 1 to 9 3 million head

Per capita consumption of the three types of meat increases moderately from just under 190 pounds, retail weight basis, to 207 pounds at the end of the 10-year period Overall, projected beef and chicken consumption increases (see figure), whereas pork consumption declines after an initial increase The combined increase in per capita consumption of only 19 pounds is the result of the compensating shifts among the three types of meat and the pressure of increasing population on the production base

Projected values of several other variables serve to measure the performance of the agricultural sector over this 10-year simulated baseline projection The Consumer Price Index for Food increases from 288 to 439, just over a 5 percent average increase per year The percentage of beef production that came from fed cattle ranged from 72 to 77 percent Corn used for feed was 4 2 billion bushels in 1982 and increased to 4 6 billion bushels in 1990 Net farm income increased in nominal terms, but decreased in real dollars

[3]The baseline projections do not represent official U S Department of Agriculture forecasts, but are used only to compare alternative scenarios

Model Baseline



Simulated Experiments Reflecting Changes in Consumer Preference

I performed four experiments involving demand shifts on the model, each beginning in 1982 and ending with the 10th year of the projections (1991)

The experiments represent varying combinations of changing consumer preference for the three types of meat

The first experiment, which probably represents a maximum decrease in demand, simulates the effects

of a 1-percent decrease per year in the estimated price of each of the three types, after accounting for competing meat prices, per capita supply available for consumption, and consumer income Such a price reduction is assumed necessary to increase the consumption by other segments of the population after one segment had shifted away from meat consumption because of a preference for other foods

The second experiment simulates the effects of an annual 1-percent decrease in the price of beef, no change in the price of pork, and a 1-percent increase in the price of chicken, reflecting an assumed declining consumer preference for beef and an increasing preference for chicken This scenario may be the most likely of the four

The third experiment is a variation of the second, prices of both red meats are decreased by 1 percent per year, whereas the price of chicken is assumed to increase by 1 percent per year Here, consumer preference is assumed to shift away from both red meats in favor of chicken

The fourth experiment represents a return to conditions of the sixties and early seventies—consumers' preference for beef is assumed to increase In this simulation, the price of beef increases by 1 percent per year, whereas the prices of pork and chicken are unchanged

Empirical Results

The FAPSIM model was given initial (1981) values of endogenous variables and projections of exogenous variables through 1991, which enabled the model to produce a 10 year simulation of the alternative changes in the pricing structure Table 1 presents values of the relevant variables, some variables listed under the 1991 column heading are 1990 values as these variables are estimated on a crop-year, rather than a calendar-year, basis The table shows projected data for the beginning and ending years (1982 and 1991) and for the midpoint (1986), which enables the reader to see the developing trends without having to consider all 10 years of simulated values Price changes are expressed as a percentage change from the baseline projection Changes in consumption are presented as absolute values Values of price-corn ratios are shown as their absolute percentage values, since the general upper and lower limits of these values which lead to production change are established

Scenario 1: Consumer Preference Declines for All Three Types of Meat

One can simulate this decrease in consumer preference by reducing all retail prices by 1 percent per year for 10 years The values of the retail price indexes are reduced slightly in the first year, but become progressively lower from the base as further 1-percent price decreases are necessary to clear the market each year (table 1) The final values, ranging from a 15-percent decline in the retail pork price to a 25 percent decline in the retail chicken price, are obviously greater than the total 10-percent

Table 1—Scenario 1. Results of reducing retail prices of beef, pork, and chicken by 1 percent per year

Variable	1982	1986	1991
	Percentage change		
Retail price indexes			
Beef	−2	−10	−17
Pork	−6	−7	−15
Chicken	−3	−12	−25
CPI food	—[1]	−2	−4
Primary market prices			
Choice steers	−12	−11	−23
Barrows and gilts	−3	−10	−25
Broilers	−2	−7	−19
Corn (farm)	0	−4	−18[2]
Inventories			
Beef cows, Jan 1	0	−2	−7
Hogs (breeding), Dec 1	0	−3	−5
Corn fed	−2	−6	−5[2]
Net farm income	−6	−25	−29[2]
	Pounds		
Per capita consumption			
Beef	−2	−1 5	−4 7
Pork	0	−2 1	−3 4
Chicken	−1	−1 2	−2 1
Total	−3	−4 8	−10 2
	Ratios		
Performance indicators			
Beef corn ratio	25	24	22
Hog-corn ratio	21	17	16
Broiler-corn ratio	18	13	12
	Percent		
Portion of beef fed	73	74	71

[1]Sign indicates direction of change, but value is less than 1 percent
[2]Data for 1990

reduction built into the pricing structure This result occurs because retail prices are estimated by a simultaneous solution which allows interaction of the prices of competing meats each year Overall, these lower meat prices reduce the CPI for food by 4 percent below the baseline value after 10 years

Primary market prices are reduced somewhat more in percentage terms, generally by about 20-25 percent This somewhat greater percentage change is due to no change in exogenous variables affecting the marketing cost and the magnitude of the base value from which the percentage change is calculated The farm price of corn eventually falls by 18 percent by the 10th year, which reflects the reduction in the amount of corn used for feed, which declines by 5-6 percent below the baseline after the first few years

Because both primary market prices and the corn price decline in roughly similar proportions, the price-corn ratios do not change nearly so much as meat prices All price-corn ratios remain in an indeterminate range Beef production is usually not affected if the beef-corn ratio stays between 20 1 and 25 1 Hog production usually does not increase until the ratio exceeds 24 1 and is usually not curtailed drastically until the ratio falls below 16 1 The broiler-corn ratio did not change much from the baseline ratio Thus, relative profitability of livestock and poultry production was not affected enough to induce major shifts in production patterns This finding is supported by the data showing that basic breeding inventories changed substantially less Beef cow numbers declined by 7 percent in the 10th year, whereas the inventory of hogs kept for breeding declined by only 5 percent by the 10th year

The smaller change in inventory caused per capita consumption of the three major types of meat to decline by only 10 pounds by the 10th year of the simulation Beef consumption declined most per capita, and chicken consumption declined least The portion of beef produced from fed beef remained above 70 percent in this alternative, which is similar to that in the baseline

Net farm income dropped substantially (as much as 29 percent by the 10th year) because of the drop in prices and in cash receipts of both livestock and feed grains

Several implications can be drawn if prices do fall as they did in this experiment because of a decrease in consumer demand First, prices drop for consumers, but the availability of meat for consumption does not fall correspondingly Consumers who remain in the market will actually have a larger meat supply Meat production will probably fall more in future years if the trend continues, since production adjustment to lower price effects should increase in later years when prices drop by at least 5 percent Although primary market prices are down by the fifth year, livestock producers are not yet faced with disaster because feed input prices also dropped, however, livestock production would definitely be less profitable than under the baseline alternative Feed grain producers will be affected by lower prices, which demonstrates the importance of livestock, along with export demand, as major demand factors in feed grain markets Feed grain prices fall principally because grain production was not lowered perceptibly even by the 10th year, although feed grain use was down by 5 percent or more by the fifth year of the simulation Under this scenario, Government policy supporting grain production through target prices would have to be adjusted to avoid a large buildup in grain stocks

Scenario 2: Consumer Preference Decreases for Beef and Increases for Chicken

In the second scenario, retail beef prices are reduced by 1 percent per year, and retail chicken prices are increased by 1 percent per year for 10 years This scenario portrays the results of a slight decline in preference for beef with a rising preference for chicken Some industry analysts consider this scenario more likely than the baseline Note that pork pricing is unchanged As a result, the retail price index for pork declined by only 3 percent by the end of the simulation period, it was brought down by lower beef prices which fell by 11 percent by the 10th year (table 2) Despite the increase in chicken prices (1 percent per year over the baseline), the final price effect was only a 1-percent increase in the chicken price by the 10th year In the simultaneous solution, the declining beef price negates the rise in chicken prices Because of the counter effects of these variables, the CPI for food fell only slightly during the period

Primary market prices reflected the same pattern, with Choice steer prices declining the most (17 per cent by the 10th year) Corn prices again fell by 8

Table 2—Scenario 2 Results of changing retail price of beef (1-percent reduction per year) and retail price of chicken (1-percent increase per year)

Variable	1982	1986	1991
	Percentage change		
Retail price indexes			
Beef	−1	−6	−11
Pork	—[1]	−1	−3
Chicken	+	+	+1
CPI food	0	−1	−2
Primary market prices			
Choice steers	−1	−9	−17
Barrows and gilts	−1	−3	−7
Broilers	+	+	+1
Corn (farm)	0	−4	−8[2]
Inventories			
Beef cows, Jan 1	0	−1	−5
Hogs (breeding), Dec 1	0	−1	−1
Corn fed	−1	−2	−2[2]
Net farm income	−2	−12	−20[2]
	Pounds		
Per capita consumption			
Beef	−1	−9	−32
Pork	0	−4	−1
Chicken	0	+3	+8
Total	−1	−10	−25
	Ratios		
Performance indicators			
Beef corn ratio	26	25	21
Hog corn ratio	20	20	19
Broiler corn ratio	19	16	15
	Percent		
Portion of beef fed	73	75	70

[1]Sign indicates direction of change, but value is less than 1 percent
[2]Data for 1990

percent because of lower feed grain demand, which declined by 2 percent after the fifth year

Because of lower feed prices corresponding to the drop in livestock prices, the price-corn ratios remained in the intermediate range during the entire simulation period Thus, inventory response was considerably less than the price change, with beef cow numbers finally falling 5 percent below the baseline projection at the end of the period and with most of the change coming after the fifth year The change in the number of hogs kept for breeding was minimal Because the change in basic production inventories was less than under the first scenario, per capita consumption of beef, pork, and chicken declined by only 2 5 pounds by the 10th year Beef consumption fell 3 pounds per capita, but was offset somewhat by a slight increase in chicken consumption

Net farm income fell by 20 percent by the end of the period because of a major decline in Choice steer prices and a decline in corn prices

The major implication of this scenario is that consumers would enjoy substantial price reductions with little change in meat availability In fact, those who remained loyal beef consumers would probably find an increase in beef availability If the trend were to continue, lower beef prices would reduce pork prices, but chicken prices would change little, even though chicken consumption increased Although net farm income is not down so much as under the first scenario, the 20-percent drop reflects a loss of income by both beef producers and grain farmers, again demonstrating the importance of feed use by livestock on corn prices and indicating a rather slow response by corn producers to change production, even when feed demand is down Finally, this scenario shows that market structure is more affected by a change in beef prices than by a change in pork and chicken prices

Scenario 3: Consumer Preference Decreases for Beef and Pork, but Increases for Chicken

In the third scenario, both beef and pork prices are reduced by 1 percent per year, whereas chicken prices are increased by 1 percent per year for 10 years This alternative is a variation of the previous scenario, as the prices of both red meats (beef and pork) are postulated to be affected by the change in consumer demand in favor of white meat Simulated data for this alternative are not shown in tabular form, as this scenario is a variation of scenario 2

Under scenario 3, beef prices are reduced a little more by the 10th year (by 14 percent, as compared with 11 percent) compared with those under scenario 2, and pork prices fall by 12 percent at the end of the period However, because of the interaction of red meat prices on chicken prices, the price of chicken decreases by 5 percent at the end of the period, compared with a 1-percent increase in chicken prices at the end of the period under scenario 2 The CPI for

all food declines moderately, to 3 percent by the end of the period

Again, the price-corn ratios are in the intermediate range, so that inventories are changed much less than prices Therefore, per capita beef consumption fell by 4 pounds at the end of the period, and pork was down by 3 pounds Chicken consumption increased by only 1 pound by the 10th year because of the price decline induced by falling prices of red meat Consumption of all three meats fell 6 pounds by the 10th year

Net farm income fell slightly more than under scenario 2 because hog prices also declined The implications of scenario 3 are similar to those of scenarios 1 and 2 However, the decline in both red meat and chicken prices reinforces the implication of the previous scenario, indicating that prices of red meats affect chicken prices far more than chicken prices affect red meat prices

Scenario 4: Consumer Preference for Beef Increases

In the fourth scenario, the retail beef price is increased by 1 percent per year for 10 years This scenario, which represents a return to growth in demand similar to that in the sixties and early seventies, portrays a complete turnaround in price and production statistics The retail beef price index increases by 14 percent at the end of the 10th year, it also raises retail prices of pork and chicken 5 and 10 percent, respectively (table 3) The CPI index for all foods increases by 2 percent at the end of the period

Primary market prices also increase more, caused by changes in both the percentage base calculation and the likely narrowing of the price spread Thus, Choice steer prices increase by over 30 percent in the 10th year, and hog and broiler prices increase by 15 percent or more Because of the stronger demand for feed grains (that is, corn feeding increases by 2 percent), corn prices on farm increase by 11 percent by the 10th year

Price-production ratios tended to remain near the upper levels of the indeterminate range for signal ing production change, although the beef-corn ratio

Table 3—Scenario 4 Retail price of beef increased by 1 percent per year

Variable	1982	1986	1991
	Percentage change		
Retail price indexes			
Beef	+1	+7	+14
Pork	+1	+2	+5
Chicken	+1	+5	+10
CPI food	+[1]	+1	+2
Primary market prices			
Choice steers	+2	+10	+31
Barrows and gilts	+1	+5	+18
Broilers	+1	+7	+14
Corn (farm)	0	+4	+11[2]
Inventories			
Beef cows, Jan 1	0	+1 1	+4 4
Hogs (breeding), Dec 1	0	+	+
Corn fed	+1	+2	+2[2]
Net farm income	+3	+14	+25[2]
	Pounds		
Per capita consumption			
Beef	+ 1	+ 8	+2 7
Pork	0	+ 6	+ 9
Chicken	0	+ 4	+ 5
Total	+ 1	+1 8	+4 1
	Ratios		
Performance indicators			
Beef corn ratio	27	28	24
Hog-corn ratio	22	20	18
Broiler corn ratio	19	16	14
	Percent		
Portion of beef fed	74	78	74

[1]Sign indicates direction of change, but value is less than 1 percent
[2]Data for 1990

(which is particularly high in the early years of the simulation) induced an expansion in beef cattle numbers by about 4 percent

Because of improved prices and profitability of livestock production, per capita consumption of the three types of meats increased by slightly more than 4 pounds, with about 75 percent of that increase for beef The portion of beef fed was the highest under any scenario, generally exceeding 75 percent of beef production

Higher prices obviously increased net farm income by as much as 25 percent at the end of the period, with both livestock and grain producers sharing the increased profits

Under this scenario, primary producers of livestock and poultry would enjoy better incomes, with consumers facing higher prices for minimal quantity increases The increase in feed prices again reflects the positive effects of domestic livestock on the total demand for corn, and the carryover effects of increasing beef prices on the hog and broiler markets reemphasize the dominant effect of beef in the meat price structure

Implications

The major conclusion of these experiments is that there is considerable inertia in the supply response of the total system Although the simulated prices changed rather rapidly in response to changing market conditions, change in livestock production was slow mainly because of small changes in relative profitability, as feed prices also fell It was surprising that corn production adjusted minimally, even after a substantial change in the corn price This finding probably reflects a production structure in which producers have limited alternatives for land use, so they maintain production to bolster cash receipts as long as they can cover variable costs Furthermore, the existing price support program (target prices) tends to maintain grain production

Beef prices drive the total livestock production system and dominate the pricing structure, even when the beef price (pricing structure) is reduced and the chicken price is increased Because of the slow change in supply response, consumers would not suffer from lack of product availability nearly so much as they would from having to pay more for the small changes in the quantity of product available

Given expected future increases in population after the simulation period (1990 and beyond), population numbers will probably put pressure on the production system Thus, a slight shift in demand from beef to white meat might help maintain price stability and product availability

If the scenarios depicting a decline in consumer preference for either all meat or for only red meat do develop, many livestock and poultry producers could probably remain in business, but profitability would be reduced to minimal levels—just high enough to keep resources in livestock production If export demand for grains increased to offset declines in feed use, higher grain prices would lower meat production at a faster rate than indicated in these simulations

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