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Quarterly Broiler Price Forecasting Models

by

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Introduction

Wide fluctuations in price and net returns are common in the
broiler industry. For example, net returns to broiler production
ranged from 11.6 cents per pound in the third quarter of 1975 to
-5.0 cents per pound in the fourth quarter of 1976. More recently,
net margins varied from -5.2 cents per pound in the second quarter
of 1980 to +5.9 cents per pound in the third quarter of 1980. This
price volatility makes planning future production levels difficult.
Reliable and timely price forecasts should be useful in making
production and marketing decisions.

The objective of this study is to develop price forecasting
models which predict quarterly wholesale Chicago iced broiler prices
one, two, and three quarters in advance. The models are user oriented.
All the data needed to make a prediction are readily accessible and
available from U.S. Department of Agriculture publications early in
each quarter. Data manipulations have been held to a minimum. The

ability of the models to forecast is evaluated using predicted values
of the independent variables.

The Models

The basic broiler price prediction equation assumes price is
determined by per capita sluaghter of broilers, pork, beef, turkey,
and consumer disposable income. For forecasting purposes, per capita
slaughter of the meats and income are predicted based on past prices,
USDA estimates of animals placed, hatched, and on feed. Therefore,
the models are recursive in nature with past prices and biological
growth processes determining current supplies. Figure 1 outlines
the general structure and variables in the three models. Estimated
quantities of commercial slaughter are a function of animal numbers,
current prices of that species and corn, seasonal intercept dummy
variables, and a time trend variable. Disposable income, population,
and the implicit GNP deflator are all functions of their own past
levels and a trend variable. The estimated values of these three
variables are used to determine deflated per capita disposable income.
Estimated commercial slaughter is divided by estimated population to
determine per capita levels. The estimated per capita slaughter
levels, disposable income, and seasonal dummy variables are used
in the broiler price equation to determine the deflated broiler
price forecast. This is multiplied by the estimated implicit GNP
deflator to obtain the actual price forecast.

Broiler price equation

The core of the one-, two-, and three-quarter models is the broiler price equation. In the equation current wholesale broiler prices are determined by current per capita slaughter of broilers, pork, cattle, turkeys, consumer income, and seasonal dummy variables. This formulation assumes that current supplies determine current prices and that current prices will not substantially affect current supplies because these are largely determined by past decisions based on historical prices, costs, and expectations. This assumption may be questioned with respect to broiler slaughter since it takes eight weeks to grow out a broiler chick. However, more careful consideration of the biological processes involved in broiler production indicates that it takes nine months to substantially increase broiler production. The stages of broiler production and the time required for each are shown in Figure 2. The size of the hatchery supply flock determines the quantity of broiler type eggs available for hatching. To increase broiler hatch requires placing more chicks in the hatchery supply flock. From the time chicks are placed in the hatchery supply flock, it takes 176 days to obtain more eggs, 24 days to hatch those eggs, and 52-56 days to produce, slaughter, and ship the broiler; a total time of approximately nine months.

Adjustments in broiler production can be made in several ways. Hatchery flock egg production can be altered by adjusting quality and quantity of feed fed, egg grading standards, length of time birds

remain in the hatchery supply flock, and time at which pullet eggs are regarded as suitable for incubation. From the receipt of the broiler hatching egg through the broiler grow-out stage, few production adjustments are normally made. Production cannot be significantly increased during this stage but can be reduced quickly in response to unfavorable economic conditions. These considerations indicate that current production is a function of decisions made two to nine months earlier; hence, the model assumes current prices do not alter current production. Since a similar argument can be made for hogs, beef, and turkeys, it was deemed appropriate to estimate the price equation via ordinary least squares.

Broiler slaughter per person increased from 30.1 pounds in 1967 to 49.2 pounds in 1980. The main reason for this increase is a drop in the real price of broilers at retail in both an absolute and relative sense compared to hogs and beef. Under the assumption that consumers react to real instead of nominal prices, both the price of broilers and consumer disposable income were deflated by the implicit GNP deflator. Although this increases the data requirements and conversions for users, it is difficult to estimate a broiler price equation with a statistically significant negative relationship between broiler price and quantity unless deflated prices are used.

Previous research has shown a change in demand for broilers during the third and fourth quarters. Zero-one dummy variables were included in the model to account for shifts in demand between

quarters of the year. Quarterly data from 1967 through 1980 were used to estimate the coefficients of the model. Calendar year quarters starting with January were used. The implicit GNP deflator with 1972 as the base was used to deflate prices and income. Per capita slaughter was computed using the U.S. civilian population series. The year 1973 was omitted from the data base because government intervention in the form of price controls and freezes seriously disrupted the normal price determination process. The omission of 1973 should make the equation more representative of the price making forces likely to exist in the 1980s.

Using the foregoing procedures and assumptions, the estimated broiler price equation is:

$$PBRD = 52.26 - 3.14 \ QBRP - 1.33 \ QPKP - 0.46 \ QBFP$$
$$(5.10) \ (-4.45) \qquad (-6.03) \qquad (-2.74)$$

$$- 4.45 \ QTYP + 0.01 \ DIDP + 2.00 \ D^2 +$$
$$(-2.68) \qquad (3.26) \qquad (2.33)$$

$$+ 15.18 \ D3 + 13.37 \ D4$$
$$(3.05) \qquad (2.57)$$

where variables are defined explicitly in Table 1.

All the estimated coefficients have the theoretically expected signs and are statistically significant at the five percent level. The t-statistic is shown in parentheses for each coefficient. The equation explains 80 percent of the variation in deflated broiler prices. The Durbin-Watson statistic of 1.74 indicates serial correlation is not a problem.

Originally, the equation was estimated with turkey slaughter

Table 1. Variable Definitions

Variable	Unit	Description
POP	million	U.S. civilian population
TREND	-	1967 quarter I = 1,...1980 quarter IV = 52
IGNPD	-	Implicit GNP deflator, 1972 = 100
DI	billion $	U.S. disposable income
QBR	million lbs.	Federally inspected slaughter RTC young chickens
BH	million birds	Broiler type chicks hatched by commercial hatcheries
PBR	¢/lb.	Chicago wholesale price RTC broilers
D2	-	Quarter II = 1, otherwise = 0
D3	-	Quarter III = 1, otherwise = 0
D4	-	Quarter IV = 1, otherwise = 0
QPK	million lbs.	Commercial hog slaughter, carcass weight
PIGC	thou. head	Pig crop in 14 states
PPK	$/cwt.	Barrows and gilts price, 7 markets
PC	$/bu.	Chicago corn price, U.S. No. 2
QBF	million lbs.	Commercial cattle slaughter, carcass weight
S711	thou. head	Number steers 700 to 1100 + lbs. on feed, 23 states
S56	thou. head	Number of steers 500-699 lbs. on feed, 23 states
S05	thou. head	Number of steers less than 500 lbs. on feed, 23 states
H59	thou. head.	Number heifers 500 to 900 + lbs. on feed, 23 states

Table 1 (Continued)

Variable	Unit	Description
H59	thou. head	Number heifers 500 to 900 lbs. on feed, 23 states
H06	thou. head	Number of heifers less than 699 lbs. on feed, 23 states
H05	thou. head	Number of heifers less than 500 lbs. on feed, 23 states
HSB5	thou. head	Number of heifers, steers, & bulls less than 500 lbs. outside feedlots
PBF	$/cwt.	Omaha choice steer price, 900-1100 lbs.
PCF	$/cwt.	Good and choice Kansas City feeder steer calf price
QTY	million lbs.	Federally inspected slaughter RTC young turkeys
TH	thou. birds	Poults hatched, total all breeds
PTY	¢/lb.	Chicago wholesale price RTC frozen turkeys
QTS	million lbs.	Total turkey cold storage holdings
HSF2	thou. birds	Hatchery supply flock. Sum of domestic broiler chicks placed in hatchery supply flocks in quarters t-2 through t-6
HSF3	thou. head	Hatchery supply flock. Sum of domestic broiler chicks placed in hatchery supply flocks in quarters t-3 through t-6

included each quarter. The estimated coefficient had the expected
sign but was not statistically significant. The model was reesti-
mated with turkey slaughter included only in the III and IV quarters,
resulting in the equation given above.

Interpretation of the dummy variables for quarters III and IV
must be made in conjunction with the turkey slaughter variable.
Average turkey slaughter for quarters III and IV was 2.98 and 3.09
pounds per capita, respectively. This indicates turkey supplies
would, on the average, reduce the broiler price by 13.26 (-4.45 x
2.98) cents per pound in the third quarter and by 13.75 (-4.45 x
3.09) cents per pound in the fourth quarter. If the seasonal dummies
are interpreted by themselves, the price of broilers would increase
15.18 cents in quarter III and 13.37 cents in quarter IV. However,
turkey supplies have reduced the price of broilers in the third
and fourth quarters so that the overall change is a 1.92 (15.18 -
13.26) cent increase in quarter III and -0.38 (13.37 - 13.75) cent
decrease in quarter IV.

Based on mean prices and quantities over the period 1967 to
1980, the computed price flexibilities with respect to each meat
and consumer disposable income are: broilers = -1.02, pork =
-0.72, beef = -0.41, turkey = -0.45, and income = +1.34. These
estimates are similar to those obtained by others such as Heien, and
George and King. The "income flexibility" indicates that deflated
broiler prices increase by 1.34 percent when real consumer disposable
income increases by one percent. However, it should not be

interpreted as an income elasticity since it does not measure the increase in broiler consumption with rising incomes.

Figure 3 contains actual and estimated broiler prices from the price equation. The equation catches turning points well, missing only eight in 52 quarters. The average absolute error is 1.4 cents with a range from -5.7 to +4.4. Seventy-four percent of the estimates are within two cents of the actual price. The Theil U_2 coefficient is .48, indicating the equation does substantially better than assuming a naive no change model. The RMSE is 1.82 cents per pound. These statistics indicate the broiler price equation can estimate broiler prices reasonably well when actual levels of the independent variables are known. The important question is how well can the equation forecast when estimated values of the independent variables are used.

Independent Variable Prediction Models

Three models were designed to predict per capita broiler, pork, beef, turkey slaughter and income levels one, two, and three quarters in advance. These models only use information known at the time the predictions are made. The feeding periods for the four types of animals are from 8 weeks to 7 months long. Hence, the number of animals on feed by weight groups, pig crops and sow farrowing intentions, number of birds hatched, and number of birds in the hatchery supply flock largely determine future supplies. Some adjustment in production in response to output and input prices is possible through

changing the length of feeding periods and selling weights. The flexibility available to producers increases with the length of the forecast period. As a result, prices should have a greater impact on slaughter in the two-quarter and three-quarter models. Given these two considerations, the inventory level and economic conditions, each meat quantity prediction equation contains a variable(s) indicating: (1) the number of animals on feed, hatched, etc., (2) current prices of that meat type and the price of corn, (3) seasonal dummy variables, and (4) trend. All prices are deflated by the implicit GNP deflator. The equations predict total meat slaughter which is divided by predicted population to determine per capita slaughter.

Population, disposable income, and the implicit GNP deflator are predicted using their lagged values and time trend. Simple trend models were tried but they consistently over or underestimated for long periods of time. The definitions of all the variables used in predicting the values of the independent variables are contained in Table 1. Price variable names with a D at the end indicate they have been deflated.

Table 2 indicates the months in which forecasts are made and the quarter being forecast for the one-, two-, and three-quarter models. During the forecast month, the user must wait for the release of the Cattle on Feed report before a forecast can be made. Hence, the forecasts are made about the third week of each forecast month. The Hogs and Pigs report information released prior to the forecast

Table 2. Time Relationship Between Forecast Month and Quarter being
Forecast

Forecast month	Length of Forecast		
	One quarter	Two quarter	Three quarter
	Quarter being forecast is:		
January	I	II	III
April	II	III	IV
July	III	IV	I
October	IV	I	II

month is used for each forecast period. Even though forecasts are

not made until the third week of the quarter, the prices during the

first three weeks are not used.

The quarter

Table 3 contains the estimated equations used to predict, one

quarter in advance, the values of the independent variables in the

broiler price equation. The numbers in parentheses under the esti-

mated coefficients are t-statistics. Population, the implicit GNP

deflator, and disposable income are each predicted as a function

of trend and the previous quarter's level for the respective vari-

able. Each equation has an R^2 of .99.

Broiler slaughter (QBR) is largely determined by broiler hatch

(BH) in the previous quarter. The price of broilers and corn were

tried in this equation but were not statistically significant and

Table 3. Estimated Equations Used to Predict Values of Independent Variables in One Quarter Forecast Model

$POP_t = 15.77 + 0.92\ POP_{t-1} + 0.05\ TREND_t$
$\quad\quad (1.77)(13.21)\quad\quad\quad (1.13)$

$\quad R^2 = .99\quad C.V. = 0.31\quad D.W. = 1.89$

$IGNPD_t = 4.55 + 0.94\ IGNPD_{t-1} + 0.16\ TREND_t$
$\quad\quad\quad (1.87)(25.69)\quad\quad\quad (2.45)$

$\quad R^2 = .99\quad C.V. = 1.21\quad D.W. = 1.76$

$DI_t = 9.79 + 0.9837\ DI_{t-1} + 1.1474\ TREND_t$
$\quad\quad (0.87)(34.11)\quad\quad\quad (1.69)$

$\quad R^2 = .99\quad C.V. = 1.71\quad D.W. = 2.25$

$QBR_t = 160.61 + 1.8525\ BH_{t-1} + 12.64\ TREND_t + 54.5\ D2_t - 76.9\ D3_t - 65.7\ D4_t$
$\quad\quad\quad (2.36)\ (16.65)\quad\quad (16.23)\quad\quad (3.1)\quad (-3.6)\quad (-4.0)$

$\quad R^2 = .99\quad C.V. = 1.92\quad D.W. = 1.57$

$QPK_t = 230.13 + 0.0841\ PIGC_{t-2} + 0.0564\ PIGC_{t-3} + 12.06\ TREND_t - 7.71\ PPKD_{t-1} + 10.65\ PCD_{t-1} +$
$\quad\quad\quad (0.34)\ (5.59)\quad\quad (3.65)\quad\quad (8.94)\quad\quad (-0.98)\quad\quad (0.20)$

$\quad\quad 311.4\ D2_t + 350.3\ D3_t + 292.32\ D4_t$
$\quad\quad (3.4)\quad\quad (3.5)\quad\quad (2.0)$

$\quad R^2 = .90\quad C.V. = 4.01\quad D.W.\ 1.48$

Table 3 (Continued)

$$QBF_t = 4870.0 + 0.0987 \ S711_t + 0.3065 \ H59_t - 39.03 \ PBFD_{t-1} + 549.54 \ PCD_{t-1} - 17.61 \ PCFD_{t-4} +$$
$$(10.7) \ (1.31) \qquad\qquad (1.85) \qquad\qquad (-5.16) \qquad\qquad (6.14) \qquad\qquad (-4.34)$$

$$8.90 \ TREND_t + -7.90 \ D2_t + 188.2 \ D3_t + 269.1 \ D4_t$$
$$(2.67) \qquad\quad (-0.1) \qquad (2.7) \qquad\quad (3.7)$$

$$R^2 = .89 \quad C.V. = 2.76 \quad D.W. = 1.45$$

$$QTY_t = -150.43 + 0.010 \ TH_{t-2} + 0.94 \ TREND_t + 1.54 \ PTYD_{t-1} - 13.72 \ PCD_{t-1} + 196.7 \ D2_t +$$
$$(-2.52) \ (8.02) \qquad\qquad (1.97) \qquad\qquad (1.22) \qquad\qquad (-1.12) \qquad\qquad (11.2)$$

$$292.33 \ D3_t + 121.20 \ D4_t$$
$$(11.1) \qquad\quad (2.54)$$

$$R^2 = .98 \quad C.V. \ 8.15 \quad D.W. = 2.09$$

subsequently dropped. This is not surprising since integrators have very little flexibility in adjusting production once birds have been placed in broiler houses. Trend and seasonality are important variables in this equation. The equation misses only three turning points in 52 quarters.

Pork slaughter (QPK) is determined by the pig crop two and three quarters earlier, hog and corn prices, and seasonal dummies. All the variables are highly significant except pork and corn prices. The negative sign on pork price suggests that as current prices increase, producers hold back more gilts and sows and feed to heavier weights, hence, reducing slaughter. The positive sign on corn prices indicates that as prices increase reducing profitability, producers sell breeding stock adding to the slaughter. These variables were retained because they give the model user some idea of the impact of changing prices on hog slaughter. If they were omitted, the user would not have any basis for evaluating the impact of changing prices on slaughter. The equation misses only six turning points in 52 quarters. The largest turning point error is less than eight percent of actual pork slaughter.

Cattle slaughter (QBF) is determined by number of steers over 700 pounds and heifers over 500 pounds in feedlots at the beginning of the quarter plus the prices of finished cattle, feeder calves, and corn. The number of animals on feed have the anticipated positive sign, but they are not statistically significant at the five percent level. The highly significant price variables probably explain why

numbers on feed are not significant. Cattle feeders have a lot of flexibility in determining the ration, the length of the feeding period, and the finished weight. As fed cattle prices increase (PBFD), they feed longer and to heavier weights, hence reducing current slaughter. As corn prices increase, feeding profitability declines, and cattle are sold at lighter weights increasing current slaughter. The price of feeder calves (PCFD) four quarters earlier is included to pick up changes in cow slaughter. This variable indicates that as calf prices increase, cow-calf operators cull less cows reducing cattle slaughter. It missed 11 turning points in 52 quarters. The largest turning point error was five percent of actual cattle slaughter.

Turkey slaughter (QTY) is largely determined by hatch six months earlier and the seasonal dummy variables. This leaves little of the variation in turkey slaughter to be explained by prices. It is not surprising, therefore, that deflated turkey and corn prices are statistically insignificant. The signs on the turkey and corn prices are reversed from those in the pork and cattle equations. The necessity of having turkeys slaughtered before Thanksgiving and Christmas may limit lengthening the feeding period in response to higher turkey prices, hence, giving the positive sign. It misses only three turning points in 52 quarters with the largest turning point error being less than 1 percent of actual turkey slaughter.

Quarter two and three

Table 4 contains the estimated equations used to predict two quarters in advance. In general, the equations are similar to those in the one quarter forecast model except quantities and prices are lagged two quarters instead of one. All the two-quarter equations predict as well as the one quarter equations except beef which is slightly lower. In terms of turning point errors, the equations have the same number of misses as the one quarter except hogs which misses one more. The magnitude of turning point errors are similar between the two models.

There are only two substantial differences between the one-quarter and two-quarter model equations. First, in the broiler slaughter equation, the number of birds in the broiler hatchery supply flock (HSF) has replaced broiler hatch (BH). The HSF variable is highly significant since it determines the number of broiler type eggs available for hatch. Since integrators have some control of the length of time pullets stay in the hatchery supply flock and the grading of eggs produced by the flock, the broiler and corn price variables are now highly significant. They indicate broiler slaughter increases as broiler prices increase and decreases as corn prices increase.

The second major difference between the one-quarter and two-quarter models is in the cattle slaughter equation. The model for a two-quarter forecast includes the lighter weight steers (S56) and

Table 4. Estimated Equations Used to Predict Values of Independent Variables in Two Quarter Forecast Model

$POP_t = 32.054 + 0.8379\ POP_{t-2} + 0.099\ TREND_t$
$\qquad\quad (1.61)\quad (8.08)\qquad\qquad (1.79)$

$\qquad R^2 = .99\quad C.V. = 0.44\quad D.W. = 0.90$

$IGNPD_t = 9.38 + 0.8701\ IGNPD_{t-2} + 0.332\ TREND_t$
$\qquad\qquad (2.76)\ (16.79)\qquad\qquad\quad (3.56)$

$\qquad R^2 = .99\quad C.V. = 1.71\quad D.W. = 0.77$

$DI_t = 18.645 + 0.9668\ DI_{t-2} + 2.28\ TREND_t$
$\qquad\quad (1.29)\ \ (25.18)\qquad\qquad (2.57)$

$\qquad R^2 = .99\quad C.V. = 2.20\quad D.W. = 1.17$

$QBR_t = 548.059 + 0.0137\ HSF2_t + 9.09\ PBRD_{t-2} - 130.52\ PCD_{t-2} + 26.63\ TREND_t + 192.97\ D2_t +$
$\qquad\quad (2.98)\ \ (5.94)\qquad\quad (2.55)\qquad (-5.20)\qquad\qquad (41.27)\qquad\qquad (8.02)$

$\qquad 155.69\ D3_t - 29.30\ D4_t$
$\qquad (7.08)\qquad\quad (-1.32)$

$\qquad R^2 = .99\quad C.V. = 2.47\quad D.W. = 1.29$

Table 4 (Continued)

$$QPK_t = -923.55 + 0.0967 \ PIGC_{t-2} + 0.0799 \ PIGC_{t-3} + 11.10 \ TREND_t + 9.486 \ PPKD_{t-2}$$
$$(-1.67) \ (7.76) \qquad\qquad (5.39) \qquad\qquad (8.43) \qquad (1.55)$$

$$-48.75 \ PCD_t + 445.05 \ D2_t + 552.70 \ D3_t + 423.92 \ D4_t$$
$$(-0.92) \qquad (4.31) \qquad (5.07) \qquad (2.64)$$

$$R^2 = .91 \quad C.V. = 3.92 \quad D.W. = 1.61$$

$$QBF_t = 6776.64 + 0.4003 \ S56_{t-1} + 0.5167 \ HO6_{t-1} + 24.79 \ TREND_t - 0.34 \ QBF_{t-4} - 20.64 \ PCFD_{t-4}$$
$$(7.39) \ (2.74) \qquad (2.55) \qquad (5.72) \qquad (-2.11) \qquad (-4.89)$$

$$-44.26 \ PBFD_{t-2} + 621.47 \ PCD_{t-2} - 661.95 \ D2_t - 509.09 \ D3_t + 205.11 \ D4_t$$
$$(-4.45) \qquad (6.51) \qquad (-4.63) \qquad (-4.04) \qquad (2.91)$$

$$R^2 = .88 \quad C.V. \ 2.93 \quad D.W. = 1.19$$

$$QTY_t = -89.37 + 0.0101 \ TH_{t-2} + 1.15 \ TREND_t + 0.26 \ PTYD_{t-2} - 18.76 \ PCD_{t-2} + 194.67 \ D2_t +$$
$$(-1.53) \ (7.61) \qquad (2.54) \qquad (0.20) \qquad (-1.53) \qquad (10.87)$$

$$287.13 \ D3_t + 115.79 \ D4_t$$
$$(10.55) \qquad (2.26)$$

$$R^2 = .98 \quad C.V. = 8.18 \quad D.W. \ 2.15$$

heifers (H06) on feed and a four-quarter lag of beef slaughter. All three variables are statistically significant at the five percent level. The price variables remain highly significant and the signs unchanged from the previous model.

Table 5 contains the estimated equations for the three-quarter forecast model. The population, implicit GNP deflator, and disposable income equations still predict well, but the Durbin-Watson statistic indicates positive serial correlation in the residuals. This statistical problem was not corrected. Correcting for autocorrelation would complicate the model for users and only marginally increase predictive capability.

The broiler slaughter equation is formulated exactly like the two-quarter model except the hatchery supply flock variable (HSF3) now contains chick placements into the flock from quarters t-3 to t-7. The coefficients are similar to those in the two-quarter model, and the equation misses only four turning points during 45 quarters.

The pork slaughter equation is similar to the two-quarter model except that sow farrowing intentions (SFI) two quarters earlier have been added. Since farrowings intentions data have only been collected since 1970, this equation was estimated using 38 observations. The remaining price variables, trend, and seasonal dummies are all statistically significant and have the anticipated signs. The equation misses eight turning points in 38 quarters. The largest error is 12.5 percent of actual hog slaughter.

The three quarter beef slaughter (QBF) equation is quite different

Table 5. Estimated Equations Used to Predict Values of Independent Variables in Three Quarter Forecast Model

$POP_t = 49.600 + 0.7483\ POP_{t-3} + 0.15\ TREND_t$
$\quad\quad\ \ (1.92)\quad (5.55)\quad\quad\quad\quad\ (2.14)$

$\quad R^2 = .98\quad C.V. = 0.53\quad D.W. = 0.58$

$IGNPD_t = 14.22 + 0.798\ IGNPD_{t-3} + 0.50\ TREND_t$
$\quad\quad\quad\ (3.42)\ (12.54)\quad\quad\quad\quad\ (4.44)$

$\quad R^2 = .99\quad C.V. = 2.08\quad D.W.\ 0.44$

$DI_t = 27.444 + 0.9468\ DI_{t-3} + 3.45\ TREND_t$
$\quad\quad\ \ (1.66)\ (20.85)\quad\quad\quad\ (3.34)$

$\quad R^2 = .99\quad C.V. = 2.51\quad D.W. = 0.84$

$QBR_t = 419.55 + 0.0138\ HSF3_t + 12.78\ PBRD_{t-3} - 140.95\ PCD_{t-3} + 27.22\ TREND_t + 191.82\ D2_t +$
$\quad\quad\ \ (2.08)\quad (5.52)\quad\quad\quad\ (3.23)\quad\quad\quad\ (-5.22)\quad\quad\quad\ (38.80)\quad\quad\quad\quad (7.92)$

$\quad\quad\ \ 186.14\ D3_t - 2.46\ D4_t$
$\quad\quad\ \ (7.10)\quad\quad (-0.10)$

$\quad R^2 = .98\quad C.V. = 2.64\quad D.W. = 1.10$

Table 5 (Continued)

$$QPK_t = -116.96 + 0.0880\ PIGC_{t-3} + 0.4780\ SFI_{t-2} + 11.19\ PPKD_{t-3} - 200.78\ PCD_{t-3} + 7.50\ TREND_t$$
$$(-0.18)\quad (3.94)\qquad (3.23)\qquad (1.53)\qquad\quad (-2.63)\qquad (2.84)$$

$$+\ 392.35\ D2_t + 345.85\ D3_t + 581.82\ D4_t$$
$$(3.11)\qquad (2.70)\qquad (2.47)$$

$$R^2 = .86 \quad C.V. = 5.20 \quad D.W. = 1.34$$

$$QBF_t = 2405.12 + 0.3359\ QBR_{t-4} + 0.0488\ HSB5_{t-2} - 9.81\ PCFD_{t-4} + 250.29\ D3 + 288.23\ D4$$
$$(4.89)\qquad (3.94)\qquad\quad (5.50)\qquad (-2.83)\qquad (3.10)\qquad (3.49)$$

$$R^2 = .79 \quad C.V. = 3.67 \quad D.W. = 1.15$$

$$QTY_t = 114.28 + 0.8013\ QTY_{t-4} - 0.2694\ QTS_{t-3} - 0.44\ PTYD_{t-3} - 25.77\ PCD_{t-3} + 1.62\ TREND_t$$
$$(1.71)\qquad (6.49)\qquad\quad (-1.87)\qquad (-0.31)\qquad (-1.80)\qquad (2.65)$$

$$27.67\ D2_t + 136.00\ D3_t + 88.78\ D4_t$$
$$(1.43)\qquad (2.67)\qquad (1.53)$$

$$R^2 = .98 \quad C.V. = 7.89 \quad D.W. = 1.15$$

from the one- and two-quarter equations. Animal numbers in the lightest weight groups two quarters earlier had the wrong sign and were not significant. This was not unexpected since the light weight groups make up a small percentage of total cattle on feed in any quarter. Similarly, the prices of corn and beef, trend and the quarter II seasonal dummy were all highly insignificant (t-statistics less than .5). Hence, these variables were dropped. The level of cattle slaughter was predicted using cattle slaughter lagged one year and the number of heifers, steers, and bulls under 500 pounds outside feedlots. Both these variables were positively correlated with cattle numbers and statistically significant. Calf prices lagged one year remained significant and the seasonal shift variables in the third and fourth quarters were significant. The equation missed 13 turning points in 48 quarters. The largest error was 11.9 percent of actual cattle slaughter.

The turkey slaughter (QTY) equation includes turkey slaughter lagged one year and turkey cold storage stocks. Lagged slaughter is very significant because of the seasonality in turkey slaughter. Turkey storage stocks have the anticipated negative coefficient indicating that producers feed and slaughter less turkeys when stock levels increase. The price of turkeys and corn are not significant. The trend and seasonal dummy variables have the anticipated signs and relative magnitudes. The equation misses only three turning points in 48 quarters.

Broiler Price Forecasts

The predictive ability of these models was evaluated over the period 1975 to 1980. This period was selected since it corresponds to the period of time USDA has been making broiler price forecasts in the Poultry and Egg Situation. According to a USDA official, these price estimates are a concensus of informed judgment by professional economists and others. USDA makes forecasts one and two quarters ahead in most issues of the Poultry and Egg Situation. One-quarter forecasts were made in the first month of the current quarter or the last month of the previous quarter. Two-quarter forecasts were made in the first month of the previous quarter or the last month of two quarters earlier.

The price estimates from the broiler equation were also compared to futures market price estimates. The futures market price estimates were calculated by averaging the closing prices during the first five business days of each quarter for all futures contracts maturing one, two, and three quarters into the future. For example, the January forecast for quarter II would be obtained by averaging the closing prices of the April, May, and June contracts during the first five business days in January.

The one-quarter forecasts are in Table 6. Using the criteria given at the bottom of Table 6, the futures market is the best predictor, the price equation is second, and USDA is third. The futures market makes fewer large errors and misses less turning points. Both

Table 6. Comparison of One Quarter Forecasts by the Futures Market, USDA, and Price Equation 1975I to 1980IV

Year & quarter	Price Forecast				Error		
	Futures market	USDA	Price equation	Actual price	Futures market	USDA	Price equation
1975 I	40.10	42.0	39.37	41.3	1.20	-0.7	1.93
II	39.97	45.0	39.78	43.0	3.03	2.0	3.22
III	44.07	44.0	46.39	50.0	5.93	6.0	3.61
IV	44.01	41.0	43.35	44.8	0.79	3.8	1.44
1976 I	39.99	43.0	43.89	41.9	1.91	-1.1	-1.99
II	40.50	43.0	42.03	41.5	1.00	-1.5	-.53
III	41.76	43.0	40.90	41.5	-0.26	-1.5	0.60
IV	35.60	38.0	37.82	35.4	-0.20	-2.7	-2.42
1977 I	37.68	37.0	40.35	40.7	3.02	3.7	0.35
II	42.64	37.0	39.69	41.9	-0.74	5.9	2.21
III	41.99	43.0	40.90	42.1	0.11	-0.9	1.20
IV	37.12	39.0	40.29	37.2	0.08	-1.8	-3.09
1978 I	38.68	38.0	42.46	41.5	2.82	3.5	-0.96
II	45.26	39.0	42.09	47.3	2.04	8.3	5.21
III	48.70	48.0	42.14	45.8	-2.90	-2.2	3.66
IV	42.40	41.0	42.76	41.7	-0.70	0.7	-1.06
1979 I	45.30	44.0	45.44	47.0	1.70	3.0	1.56
II	49.64	48.0	44.44	47.1	-2.54	-0.9	2.66
III	42.41	48.0	41.08	39.9	-2.51	-8.1	-1.18
IV	37.66	36.0	39.52	41.1	3.44	5.1	1.58
1980 I	44.39	43.0	45.44	42.5	-1.89	-0.5	-2.94
II	41.18	44.0	45.05	40.5	-0.68	-3.5	-4.55
III	47.53	51.0	43.56	53.0	5.47	2.0	9.44
IV	50.69	48.0	46.03	49.4	-1.29	1.4	3.37
Average absolute error					1.93	3.14	2.53
Range in errors					8.83	16.40	13.99
% errors ≤ 2¢/lb.					54	50	46
RMSE					2.46	3.69	3.17
Turning point errors					6/23	8/23	9/23

USDA and the price equation make eight and nine cents per pound errors, while the large error made by the futures market was 5.9 cents per pound.

Analysis of the two largest forecast errors by the price equation may help locate potential problems. The largest error was made in the third quarter of 1980 when actual broiler price was 53 cents and the equation predicted 43.56 cents. The price equation using the actual values of the independent variables predicts a price of 52.27 cents, hence, the problem is not the broiler price equation. The independent variable prediction model substantially over-estimated broiler, pork, and turkey slaughter and consequently predicted a lower price. Extremely hot weather in the summer of 1980 killed broilers and turkeys and slowed down weight gains of hogs. Since temperature is not a variable in the model, these equations overestimated supplies. In practice the user would adjust the model for this situation as it developed, hence, reducing the error.

The second largest forecast error occurred in the second quarter of 1978. The price equation predicted a price of 41.63 cents when the actual price was 47.3 cents. Using the actual values of the independent variables, the price equation predicted 44.7 cents, missing the actual price by 2.6 cents. Therefore, about half the forecast error was directly associated with the inability of the broiler price equation to forecast the actual price. The remaining forecast error was largely associated with a one-pound overestimate

of per capita slaughter of pork and a half pound overestimate of per capita beef slaughter.

Overall, using predicted instead of actual values of the independent variables during 1975-1980 had the following impacts. The average absolute error increased from 1.83 to 2.53 cents, the range in errors increased from 9.28 to 13.99 cents, the percentage of errors under two cents decreased from 54 to 46 percent, the RMSE increased from 2.28 to 3.17 cents, and the number of turning points missed increased from four to nine. The reduction in forecasting ability emphasizes the difference between forecasting with actual values of the independent variables and estimated values. Model users should be careful in formulating expectations about the accuracy of models that have not been tested using predicted values of the independent variables.

The price equation predictions appear to be biased downward over the 1975-1980 evaluation period. The model underestimates 15 times with an average error of 2.8 cents and overestimates nine times with an average error of 2.1 cents. A large number of these underestimates occur in 1975, 1978, and 1979 when beef prices increased substantially. The price equation appears to underestimate the increase in demand for broilers relative to beef and pork. An attempt was made to include this phenomenon in the broiler price equation, but it was unsuccessful.

The forecast evaluation statistics for the two-quarter and three-

quarter ahead models are summarized in Table 7. The price equation
forecasts are superior in both quarters in all areas evaluated.
The improvement of the broiler equation forecasts relative to the
others is largely a result of deterioration in the forecasting
accuracy of the futures market and USDA.

The forecast evaluation indicates that the two-quarter model
does as well as the one-quarter model. The model overestimates
price 15 times with an average error of 1.98 cents. The average
underestimate of price is 3.55 cents which occurs nine times. Hence,
the model has an overall tendency to underestimate price. The futures
market underestimated price 15 times, with an average underestimate
of 4.4 cents. In contrast, USDA consistently overestimated price 10
out of 14 times with an average error of two cents. USDA's four
underestimate errors were large--11.0, 4.9, 10.3, and 6.9 cents for
an average of 8.3 cents.

The three-quarter ahead forecasts from the equation are superior
to those of the futures market, but the performance of the price
equation drops substantially compared to the two-quarter model. The
number of forecasts within two cents of the actual price drops to
38 percent compared to 54 percent in the two-quarter model. The
tendency to underestimate actual price continues in the three-quarter
model and the futures market. Although the futures market has an
equal number of under and overestimates, the average underestimate
is 4.45 cents while the average overestimate is 2.01 cents.

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Table 7. Summary Statistics for the Two- and Three-Quarter Forecasts
by the Futures Market, USDA, and Price Equation 1975I to
1980IV

Measure	Futures market	USDA	Price equation
Two-quarter model			
Average absolute error, ¢/lb.	3.45	3.67	2.57
Range in errors, ¢/lb.	15.91	16.00	11.87
% errors ≤ 2¢/lb.	38	50	54
RMSE	4.16	5.04	3.18
Turning point errors	10/23	-	8/23
Three-quarter model			
Average absolute error, ¢/lb.	3.60	-[a]	2.99
Range in errors ¢/lb.	16.49	-	15.07
% errors ≤ 2¢/lb.	38	-	38
RMSE	4.40	-	3.68
Turning point errors	-[b]	-	9/23

[a] USDA published only two three-quarter forecasts during 1975-80.

[b] Missing observations prohibited evaluation of turning point errors.

Conclusions

The broiler price equation forecasts based on estimated values of the independent variables are superior to USDA's forecasts and the futures market when forecasting two and three quarters in advance. The futures market markes better forecasts than the price equation when forecasting one quarter ahead. On the average, the price equation forecasts are within three cents per pound of the actual price. The one, two and three quarter models make 46, 54, and 38 percent, respectively, of their forecasts within two cents of the actual price. The three models estimate correctly 60 to 65 percent of the turning points during 1975 to 1980. The relatively poor quality of the USDA forecasts would indicate that their forecasting procedure might be improved by incorporation of a price forecasting equation. The combination of experience and informed judgment along with an equation could improve their forecasting accuracy.

All the forecasting methods analyzed tended to underestimate price during 1975-80. This underestimation is probably related to the growth in demand for broilers associated with declining real prices at retail and the decline at the retail level in broiler prices relative to beef and pork prices. The price equation model could be improved if a relatively simple method could be found for incorporating this phenomenon into the model.

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