The Food and Agricultural Policy Simulator: The Poultry- and Egg-Sector Submodel

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Abstract

The poultry- and egg-sector submodel of USDA's Food and Agricultural Policy Simulator (FAPSIM) endogenously estimates supply, production, ending stocks, retail and wholesale prices, civilian consumption of chicken, turkey, and eggs, the number of layers on farms, the consumer price index for poultry, and cash receipts from marketing of poultry and eggs This article presents the model's structure, parameter estimates, and validation statistics The model predicts that a 200-million-pound increase in broiler meat exports would increase broiler prices by about 2 cents per pound

Keywords

Chickens, econometric model, eggs, simulation, turkeys

Introduction

A variety of econometric models examine the economic forces affecting the poultry and egg sector (*1*, *3*, *4*) [1] Such models recognize interrelationships between the poultry and egg sector and the beef, pork, and feed-grain sectors, but generally treat these other sectors as exogenous The failure to endogenize beef, pork, and feed grains could lead to substantial errors when the effects on the poultry and egg sector of alternative future policies are forecast For example, because poultry is a substitute for red meat, higher poultry prices increase red meat consumption and raise red meat prices Higher red meat prices, in turn, lead to even higher poultry prices Thus, if the beef and pork sectors are assumed to be exogenous, a model will underestimate changes in poultry prices

Recent production, consumption, and price movements indicate a strong interrelationship between poultry and red meat U S per capita consumption of chicken increased from 14 1 pounds per year in 1940 to 27 8 pounds in 1960 and 50 0 pounds in 1980 (*10*, *11*) Lower retail prices for chicken relative to red meat probably contributed significantly to the expansion in chicken consumption Between 1960 and 1980, the retail price of chicken rose 80 percent, while the retail prices of beef and pork rose 193 and 156 percent, respectively During the same period, per capita consumption of chicken rose by 80 percent, compared with a 12-percent increase in per capita beef consumption and a 13-percent increase in per capital pork consumption Future growth in per capital consumption or the price of chicken may be slowed significantly if beef and pork supplies are large enough to limit future price increases in red meat

This article presents the poultry- (chicken and turkey) and egg-sector submodel contained in the U S Department of Agriculture's (USDA's) Food and Agricultural Policy Simulator (FAPSIM) [2] We present the poultry and egg submodel's structure, parameter estimates, historical performance, and linkages to other commodity sectors In addition, we use the model to explore the impacts of

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

[2] FAPSIM is an annual econometric model of the agricultural sector It contains models for beef, pork, dairy, poultry and eggs, corn, grain sorghum, oats, barley, wheat, cotton, and soybeans, which are linked via common variables The model estimates a price-quantity equilibrium solution that is consistent across all commodities For more information, see (7)

changes in broiler exports on U S agriculture and examine the errors generated by failing to allow for feedback from the beef, pork, and feed-grain sectors

Structure of the Poultry- and Egg-Sector Submodel

The submodel explicitly recognizes the linkages between chickens and eggs at the producer level and between chickens and turkeys at the retail level The dual role of chickens and eggs as both food products and as necessary inputs required for egg and chicken production requires that numerous linkages be constructed at both the producer and retail levels Table 1 contains the definitions of the variables included in the submodel, and tables 2, 3, 4, and 5 contain the equations which describe the linkages between these variables

Supply

The structure of the poultry and egg sector changed dramatically during recent decades The trend was toward larger farms and more mechanized production Mechanization plus improvements in disease control and feed conversion helped boost production efficiency Over the past 25 years, output per hour of labor for all poultry and egg production increased nearly sevenfold Poultry and egg producers maintained and sometimes expanded production even during periods of low prices

Poultry and egg producers can adjust output during the year by changing the number of chicks or poults started, by changing the frequency of batches raised, by adjusting market weights, or by culling or recycling layers Year-to-year production response is limited, however, by a variety of economic and biological factors First, the availability of chicks and poults from breeding flocks can constrain production response Second, expansion in housing capacity may be limited due to the high investment costs associated with poultry and egg production Depending on the type of housing, equipment, unit size, and climate, investment costs per bird may be \$4-\$10 per layer, \$2-\$4 per broiler, and \$3-\$8 per turkey (*8*) Third, considerable poultry and egg production is under contract to market firms or is carried out as only one phase within vertically integrated firms High investment costs and the extensive network of linkages between production units and input-supplying and marketing functions limit the extent to which poultry and egg producers respond to year-to-year fluctuations in economic variables

The production cycle for broilers and turkeys is short, and producers can alter production within a year in response to current economic signals However, as noted earlier, various biological and economic forces tend to constrain the level of year-to-year change Given these constraints, we express young chicken (CHISPYO) and turkey (TURAP) production as functions of their respective (current and lagged) wholesale price deflated by the cost of feed, lagged production, and time—a proxy for technological change (table 2) [3] Total chicken production consists of slaughter of young (broilers) and other chickens (hens, surplus cockerels, and fowl from egg-producing flocks) Production of other chickens largely reflects producers' decisions to reduce or expand egg production If producers reduce the size of the layer flock in response to lower egg prices, there will be fewer hens, reducing other chicken production Therefore, we express production (slaughter) of other chicken (CHIAPOT) as a function of the number of layers on farms The number of layers (CHISVLA) is, in turn, a function of the lagged number of layers on farms and the ratio of egg prices to feeding costs Total supplies of chicken (CHIASYO), turkey (TURAS), and other chicken (CHIASOT) depend on production plus beginning stocks

We determine total egg production (EGGAP) by multiplying the number of layers and egg produc-

[3] A number of alternative equation specifications were estimated to test the relationship between poultry and egg production and current and lagged poultry and egg prices and feeding costs Equations specifying production as a function of the sum of current and lagged ratios of price-to-feeding costs were selected for inclusion in the model because these equations generally possessed lower mean square errors and other desirable properties, such as more significant coefficients with appropriate signs than alternative specifications

We estimated the parameters of the poultry and egg submodel by using ordinary least squares Annual data for three time periods (1950 79, 1955-79, 1960 79) were selected for estimation The set of equations selected for the model represents the best set based on hypothesized parameter signs, significance of parameters, and the standard error of regression

Table 1—Variable definitions for poultry and egg submodel

Variable	Definition
Endogenous	
CHISPYO	Production of young chicken, million pounds
CHIASYO	Supply of young chicken, million pounds
CHIHTYO1	Ending stocks of young chicken, million pounds
CHICCYO	Civilian disappearance of young chicken, million pounds
CHIAPOT	Production of other chicken, million pounds
CHIASOT	Supply of other chicken, million pounds
CHIHTOT1	Ending stocks of other chicken, million pounds
CHICCOT	Civilian disappearance of other chicken, million pounds
CHIIRFR	Retail price index of frying chicken, 1967 = 1 0
CHIPR	Retail price of chicken, cents per pound
CHIPWBR9C	Wholesale price of broilers, nine-city, cents per pound
CHIPWXB	Wholesale price of nonbroilers, cents per pound
CHISVLA	Number of layers on farms, million head
EGGAA	Egg production per layer
EGGBB	Eggs used for hatching, million dozen
EGGAP	Production of eggs, million dozen
EGGAS	Supply of eggs, million dozen
EGGCC	Civilian disappearance of eggs, million dozen
EGGHT	Ending stocks of eggs, million dozen
EGGIR 67	Consumer price index of eggs, 1967 = 1 0
EGGPRAL	Retail price of eggs, large grade A, cents per dozen
EGGPF	Average price received by farmers for eggs, cents per dozen
TURAP	Production of turkey, million pounds
TURAS	Supply of turkey, million pounds
TURHT1	Ending stocks of turkey, million pounds
TURCC	Civilian disappearance of turkey, million pounds
TURPR	Retail price of turkey, cents per pound
TURPF	Average price received by farmers for turkey, cents per pound
PCPOU	Consumer price index for poultry, 1967 = 1 0
POUFC	Cash receipts from marketings of poultry and eggs, million dollars
Exogenous	
CORPF*	Average price received by farmers for corn, October-September, dollars per bushel
SORPF*	Average price received by farmers for grain sorghum, October-September, dollars per bushel
BARPF*	Average price received by farmers for barley, June-May, dollars per bushel
OATPF*	Average price received by farmers for oats, June-May, dollars per bushel
WHEPF*	Average price received by farmers for wheat, June-May, dollars per bushel
SOMPF*	Price of soybean meal, Decatur, dollars per hundredweight
PORIR 67*	Consumer price index for pork, 1967 = 1 0
BEEIR*	Consumer price index for beef and veal, 1967 = 1 0
PC*	Consumer price index for all items, 1967 = 100
YPD$	U S personal disposable income, billion dollars
NPC	Total U S population, millions
WRHPP	Poultry processing industry wage rate, dollars per hour
GASIR	Consumer price index for regular and premium gasoline, 1967 = 1 0
DUMij	Dummy variable, 19ij
DUMijkl	Dummy variable, 19ij - 19kl
CHICMYO	Military consumption of young chicken, million pounds
CHIMXYO	Exports of young chicken, million pounds
CHICMOT	Military consumption of other chicken, million pounds
CHIMXOT	Exports of other chicken, million pounds
EGGCM	Military consumption of eggs, million dozen
EGGMI	Imports of eggs, million dozen
EGGMX	Exports of eggs, million dozen
FDC	Feed cost index, chickens
FDE	Feed cost index, eggs
FDT	Feed cost index, turkeys
TURCM	Military consumption of turkey, million pounds
TURMX	Exports of turkey, million pounds
TIME	Time trend 1950 = 50, 1951 = 51, and so forth

Note Asterisk (*) denotes variables that are exogenous to the poultry- and egg sector submodel, but are endogenously predicted by other FAPSIM submodels

Table 2—Supply relationships

Variable	Equation
CHISPYO	− 13852 6 + 211 806 TIME + 0 570838 CHISPYO(−1) + 94 6545 (CHIPWBR9C(−1)/FDC(−1) + CHIPWBR9C/FDC) (−3 33) (3 17) (3 22) (2 91)
	R^2 = 0 982
CHIASYO	CHISPYO + CHIHTYO1(−1)
CHIAPOT	74 6666 + 2 26567 CHISVLA (0 47) (4 25)
	R^2 = 0 532
CHIASOT	CHIAPOT + CHIHTOT1(−1)
TURAP	− 2594 40 + 0 210301 TURAP(−1) + 49 6344 TIME + 24 2195 (TURPF(−1)/FDT(−1) + TURPF/FDT) (−3 43) (0 88) (4 13) (1 97)
	R^2 = 0 876
TURAS	TURAP + TURHT1(−1)
CHISVLA	93 9849 + 13 0996 DUM67 + 0 588864 (EGGPF(−1)/FDE(−1) + EGGPF/FDE) + 0 604911 CHISVLA(−1) (3 46) (2 84) (2 83) (5 58)
	R^2 = 0 881
EGGAA	51 2774 + 0 552840 EGGAA(−1) + 0 709783 TIME (1 86) (2 43) (2 05)
	R^2 = 0 954
EGGAP	(CHISVLA)(EGGAA)/12 0
EGGAS	EGGAP + EGGHT(−1) + EGGMI

Note Numbers in parentheses are Student-t values

tion per layer Egg production per layer has been steadily increasing, paralleling improvements in disease control and layer quality We do not attempt to predict improvements in disease control and layer quality over time and express egg production per layer (EGGAA) simply as a function of lagged egg production per layer and a time trend The total supply of eggs (EGGAS) equals the sum of egg production, beginning stocks, and imports Imports are treated as exogenous

The feed cost variables (FDE, FDC, FDT) are weighted sums of the prices of corn, oats, grain sorghum, wheat, barley, and soybean meal (table 3) The weights reflect the average relative importance of wheat, soybean meal, and feed grains in broiler and layer rations Since crop prices are exogenous to the poultry- and egg-sector submodel, the feed cost variables are also These feed cost variables link the poultry and egg submodel with the wheat, soybean, and individual feed-grain submodels contained in FAPSIM

Consumption and Stocks

We calculate civilian consumption of chicken (young and other) (CHICCYO) and turkey (TURCC) by subtracting exports, ending stocks, and military consumption from total supply (table 4) Military consumption and exports are treated as exogenous A similar identity, which adjusts downward the available supply of eggs by the number of eggs used for hatching, is used to estimate civilian consumption of eggs (EGGCC) The quantity of eggs used for hatching (EGGBB) is directly related to the number of layers on farms and young chicken production An expansion in young chicken production is associated with an increase in eggs used for hatching and a reduction in the quantity of eggs available for consumption

Table 3—Exogenous feed cost indexes

Variable	Equation
FDE	0 4838 CORPF(-1) + 0 0852 SORPF(-1) + 0 0227 WHEPF(-1) + 0 2500 SOMPF(-1) + 0 1263 OATPF(-1) + 0 0320 BARPF(-1)
FDC	0 6081 CORPF(-1) + 0 0513 SORPF(-1) + 0 0173 OATPF(-1) + 0 0044 BARPF(-1) + 0 0031 WHEPF(-1) + 0 3157 SOMPF(-1)
FDT	0 5091 CORPF(-1) + 0 1341 SORPF(-1) + 0 0471 OATPF(-1) + 0 0119 BARPF(-1) + 0 0085 WHEPF(-1) + 0 2893 SOMPF(-1)

Table 4—Consumption and stock relationships

Variable	Equation
CHICCYO	CHIASYO - CHIHTYO1 - CHICMYO - CHIMXYO
CHIHTYO1	62 7349 + 19 9557 DUM6667 - 26 9081 CHIIRFR/CHIIRFR(-1) (3 62) (3 27) (-1 62) R^2 = 0 417
CHICCOT	CHIASOT - CHIHTOT1 - CHIMXOT - CHICMOT
CHIHTOT1	93 5894 + 0 0354460 CHIAPOT - 20 1003 CHIIRFR/CHIIRFR(-1) - 28 7933 DUM6869 (10 92) (0 37) (-0 54) (-2 25) R^2 = 0 143
TURCC	TURAS - TURHT1 - TURCM - TURMX
TURHT1	341 184 + 0 225232 TURHT1(-1) + 127 497 DUM67 + 115 976 DUM73 - 167 787 TURPR/TURPR(-1) (2 72) (1 38) (3 32) (2 24) (-1 46) R^2 = 0 490
EGGCC	EGGAS - EGGHT - EGGBB - EGGCM - EGGMX
EGGHT	- 28 7092 + 0 693292 EGGHT(-1) + 0 0184625 EGGAS - 61 3829 EGGIR 67/EGGIR 67(-1) (-0 38) (3 81) (1 44) (-3 42) R^2 = 0 515
EGGBB	435 293 - 8 74153 TIME + 0 374997 CHISVLA + 0 0596407 CHISPYO (2 64) (-3 51) (1 73) (7 62) R^2 = 0 978

Note Numbers in parentheses are Student t values

The demand for stock holdings consists of two components (1) speculative and (2) transactions (*6*) The speculative component refers to the holding of stocks as a means of benefiting from price fluctuations The transactions component refers to stocks used to conduct day-to-day business operations

The transactions component is normally expressed as a function of sales, whereas the speculative component is normally expressed as a function of expected price Therefore, we express commercial stock levels as a function of total supply and the ratio of current to lagged retail price The regression results suggest that commercial stocks of young chicken (CHIHTYO1), other chicken (CHIHTOT1), and turkey (TURHT1) are not greatly influenced by beginning stock levels, production, or retail prices (table 4) However, ending stocks of eggs (EGGHT) were significantly related to both the level of beginning stocks and the retail price of eggs

Prices

We estimated equilibrium retail prices of chicken (CHIPR), turkey (TURPR), and eggs (EGGPRAL) by inverting retail demand equations which express consumption of each commodity as a function of per capita disposable income, own real retail price, and the real retail prices of substitute commodities We hypothesize that turkey and chicken are competing products at the retail level and that both compete with beef, pork, and fish for the consumer's food dollar

The regression results indicate that the real retail prices of frying chicken and turkey are positively related (table 5) Increases in the retail prices of pork and beef also positively influence the retail prices of chicken (CHIIRFR) and turkey (TURPR) But, the retail prices of turkey and chicken were not significantly related to the retail price of fish For this reason, the retail price of fish was not included in the equations for these variables The retail price of eggs (EGGIR 67) is not significantly affected by changes in the retail prices of other foods or in per capita disposable income We include a time trend in the retail egg price equation to account for the effects of increased consumer awareness of cholestrol intake These retail price equations directly link poultry to the beef and pork submodels contained in FAPSIM

We express the level of market (farm) prices for (young) chicken (CHIPWBR9C), turkey (TURPF), and eggs (EGGPF) as functions of their corresponding retail price and variables which reflect meat processing and marketing costs The wage rate in each livestock processing industry and a general fuel price index are assumed to reflect changes in meat processing and marketing costs

The regression results indicate that changes in marketing costs affect farm prices of chickens (CHIPWBR9C) However, marketing cost variables appear not to significantly affect farm-level egg prices (EGGPF) This merely reflects the limited processing that eggs undergo between the farm gate and the grocery shelf

We express the wholesale market price of nonbroilers (spent hens) (CHIPWXB) as a function of the market price of broilers and the relative proportion of total chicken consumption accounted for by nonbroilers Holding all other factors constant, we expect that the increase in other chicken consumption brought about by an increase in other chicken production places downward pressure on the price of nonbroilers (CHIPWXB)

Four auxiliary equations close out the poultry and egg submodel The first equation links the consumer price index (CPI) for poultry (PCPOU) to the retail index for frying chicken and the retail price of turkey The CPI for poultry in turn is used by another sector of FAPSIM to compute the CPIs for food and all items The second equation predicts farm cash receipts from marketings of poultry and eggs (POUFC) In turn, FAPSIM uses this latter equation to estimate net farm income The final two equations express the retail prices of chicken (CHIPR) and eggs (EGGPRAL) as functions of their corresponding retail indices

Validation Procedures

The equations contained in the poultry and egg sector submodel appear to contain parameters of appropriate sign and magnitude However, such characteristics do not ensure that the entire system of equations will accurately predict events We use model predictions for historical periods to examine the model's predictive ability

The most widely used validation statistics include the mean absolute relative error, Theil's U, U_1, and U_2 statistics, and turning point error (*9*) The definitions of these statistics along with a discussion of their properties may be found in (*5*)

The poultry and egg submodel was validated over the 1966-80 period For each year, the model was solved by use of a Gauss-Seidel solution algorithm (*2*) We used historical values for all nonpoultry- and egg-sector variables contained in FAPSIM, and we allowed the poultry and egg submodel to generate values for all lagged endogenous variables in the poultry and egg submodel Thus, errors in model predictions over the validation period reflect the model's failure to predict economic events

Table 5—Price relationships

Variable	Equation
CHIIRFR	0 350530 BEEIR + 0 227790 PORIR 67 + 0 00659730 TURPR + 0 00428652 PC (3 37) (2 50) (2 49) (2 99) - 0 000207805 [(CHICCYO + CHICCOT)(PC)/ NPC] + 0 160750 YPD$/ NPC (-4 40) (2 11) - 0 0979468 DUM72 - 0 0869418 DUM74 (-2 91) (-2 43) R^2 = 0 999
CHIPR	2 100 + 36 5252 CHIIRFR (2 87) (62 45) R^2 = 0 995
CHIPWBR9C	- 2 87217 - 1 17604 WRHPP - 1 45386 GASIR + 0 834765 CHIPR (-3 96) (-2 57) (-3 21) (28 93) R^2 = 0 995
CHIPWXB	17 7720 - 3 19743 (TIME-59)**0 5 - 2 89117 DUM75 + 0 326075 CHIPWBR9C (2 32) (-2 83) (-2 40) (6 89) -82 2282 CHICCOT/(CHICCOT + CHICCYO) (-1 91) R^2 = 0 744
TURPR	0 621100 YPD$/ NPC + 3 0084 PORIR 67 + 17 1236 BEEIR + 22 0145 CHIIRFR (0 25) (0 43) (3 75) (2 37) -0 0383407 [(TURCC)(PC)/ NPC] - 6 62700 DUM75 - 4 60619 DUM6869 + 0 348050 PC (-2 91) (-3 30) (-4 02) (3 31) R^2 = 0 999
TURPF	- 7 97843 - 6 4993 DUM74 + 5 27449 DUM78 - 1 09233 WRHPP - 3 11445 GASIR + 0 693958 TURPR (-3 05) (-3 43) (2 61) (-0 72) (-1 96) (7 81) R^2 = 0 955
EGGIR 67	0 0614617 PC - 0 000799868 [(EGGCC)(PC)/ NPC] + 0 271316 DUM7374 - 0 000449893 (TIME)(PC) (6 28) (-3 44) (4 18) (-1 41) R^2 = 0 997
EGGPRAL	2 9118 + 47 0872 EGGIR 67 (3 11) (65 34) R^2 = 0 995
EGGPF	- 9 77410 - 0 259020 WRHPP - 0 398191 GASIR + 0 821078 EGGPRAL (-7 85) (-0 39) (-0 55) (26 79) R^2 = 0 999
PCPOU	0 030092 + 0 896133 CHIIRFR + 0 001477 TURPF (3 85) (41 44) (3 21) R^2 = 0 999
POUFC	- 201 215 + 0 00810359 (CHISPYO)(CHIPWBR9C) + 0 00330590 (CHIAPOT)(CHIPWXB) (-2 14) (9 56) (1 47) + 0 00959384 (EGGAP) (EGGPF) + 0 0227709 (TURAP) (TURPF) - 6 08587 (TIME-49) (17 13) (7 38) (-1 03) R^2 = 0 999

Note Numbers in parentheses are Student t values occurring in the poultry and egg sector in any particular year as well as prior ones.

Table 6 presents the validation statistics for the poultry and egg submodel. The equations predict reasonably well over the validation period. The MARE statistics indicate that production of young (CHISPYO) and other chickens (CHIAPOT), eggs (EGGAP), and turkey (TURAP) were predicted within an average error of 4 percent. For all the above variables, Theil's U_2 statistic was below 1.0 and the TPE was below 0.4. Thus, the model performed better than a simple no change from the previous year's forecast model, and the model adequately predicted turning points.

The largest predictive errors occurred for ending stocks of young (CHIHTYO1) and other chickens (CHIHTOT1), eggs (EGGHT), and turkeys (TURHT1). Total stocks of these commodities tend to be small relative to their total demand. Therefore, fairly substantial errors in predicting their levels need not adversely affect the model's overall performance. The MAREs for ending stocks of eggs, young and other chicken, and turkey exceeded 10 percent, but the Theil's U_2 statistics were below 1. Thus, for these variables the model outperformed a no change from the previous year's forecast model.

The retail prices of both chicken (CHIPR) and turkey (TURPR) had MAREs below 4 percent. However, the MARE for the retail price of eggs (EGGPRAL) exceeded 7 percent, even though the total supply of eggs (EGGAS) was generally estimated to within 2 percent. Although the equa-

Table 6—Validation statistics, 1966-80

Variable	Mean absolute relative error	Theil's U statistic	Theil's U_1 statistic	Theil's U_2 statistic	Turning point error[1]
	Percent				
CHISPYO	3.09	0.018	0.302	0.608	0.067
CHIASYO	3.06	.018	.300	.607	.067
CHIHTYO1	24.36	.116	.367	.644	.400
CHICCYO	3.20	.019	.324	.665	.200
CHIAPOT	3.33	.020	.369	.644	.333
CHIASOT	3.37	.021	.364	.612	.267
CHIHTOT1	12.76	.081	.341	.591	.267
CHICCOT	3.96	.023	.369	.607	.467
CHIIRFR	3.50	.021	.210	.396	.400
CHIPR	2.86	.017	.168	.315	.467
CHIPWBR9C	4.77	.027	.225	.415	.467
CHIPWXB	8.36	.054	.265	.437	.267
CHISVLA	1.99	.011	.483	1.022	.267
EGGAA	0.70	.005	.404	.849	.400
EGGBB	3.82	.023	.424	.878	.200
EGGAP	1.77	.011	.474	.864	.200
EGGAS	1.76	.010	.478	.890	.200
EGGCC	1.81	.011	.524	1.045	.267
EGGHT	37.99	.168	.441	.816	.333
EGGIR 67	6.93	.042	.353	.653	.400
EGGPRAL	7.04	.040	.336	.620	.333
EGGPF	9.17	.054	.366	.684	.400
TURAP	3.82	.022	.321	.595	.333
TURAS	3.39	.023	.405	.733	.267
TURHT	12.37	.069	.304	.553	.400
TURCC	3.45	.025	.438	.847	.267
TURPR	3.08	.017	.187	.359	.067
TURPF	7.08	.037	.205	.385	.267
PCPOU	2.88	.015	.167	.314	.467
POUFC	5.05	.024	.175	.331	.333

[1] The number of turning point errors divided by 15, the total number of possible turning point errors.

tion for the retail price of eggs fit the historical data reasonably well, it missed numerous turning points and significantly underestimated price during the late sixties and early seventies These changes in the retail price of eggs were not related to the retail prices of other livestock products or disposable income Many of the errors in predicting the retail price of eggs might be due to using a time trend to control for consumer concerns related to cholesterol intake

The CPI for poultry (PCPOU) and cash receipts from farm marketings of poultry and eggs (POUFC) were estimated with little error The MARE for the poultry CPI was below 3 percent, and the MARE for cash receipts from farm marketings of poultry and eggs was below 6 percent

An additional validation test is to compare model predictions with actual data for periods not used to estimate the model's equations Therefore, we performed a 1-year simulation for 1981 Again, the results were encouraging The only substantial error occurred in the estimate of egg prices However, the error was below 7 percent

Analysis of Expansion in Broiler Exports

Between 1975 and 1980, exports of broiler meat increased from 254 million pounds to 722 million pounds This increase put upward pressure on domestic broiler prices, and, because of the substitution possibilities between chicken, beef, and pork, it also probably put upward pressure on beef and pork prices Future increases in broiler meat exports are likely because of increased demand for poultry meat by the Middle East, the Far East, the Soviet Union, the Caribbean, and the European Community (*12*)

In the remainder of this article, we utilize FAPSIM's poultry- and egg-sector model and its other livestock and crop models to analyze the impacts of an expansion in broiler exports on the agricultural sector We evaluated these impacts by comparing FAPSIM model forecasts under two alternative assumptions of broiler meat export levels for 1982-86 The base solution assumed that broiler exports would remain at their 1981 level during the period The alternative solution assumed that broiler exports would increase by 200 million pounds per year Thus, broiler meat exports in 1986 were assumed to exceed their 1981 level by 1 billion pounds

Table 7 presents the changes from the baseline projections resulting from the assumed expansion in broiler meat exports FAPSIM estimates that the retail price of chicken (CHIPR) would increase 2 3 cents per pound in 1982 if broiler exports expanded 200 million pounds The retail price of turkey (TURPR) would increase 1 4 cents per pound because of the increase in the price of chicken and the resulting increase in the consumer demand for turkey Civilian consumption of young chicken (CHICCYO) declines by 164 million pounds whereas young chicken production increases by 34 7 million pounds in 1982 Cash receipts to poultry and egg producers increase by $256 0 million The adjustments predicted for 1982 seem relatively minor, which is probably reasonable as a 200-million-pound increase in broiler exports represents only about a 2-percent increase in demand for broiler meat

By 1986, some dramatic adjustments occur in the poultry and egg sector The expansion in broiler meat exports of 1 0 billion pounds above the baseline pushes the retail prices of chicken (CHIPR) and turkey (TURPR) up by 9 8 and 5 6 cents per pound, respectively Civilian consumption of young chicken (CHICCYO) falls by 630 million pounds while civilian consumption of turkey (TURCC) increases slightly (26 9 million pounds) Egg production (EGGAP) falls moderately as feed-grain and soybean meal prices increase in response to higher poultry and livestock prices, thereby increasing egg producers' feeding costs The farm price of eggs (EGGPF) increases by 1 4 cents per dozen, and cash receipts to poultry and egg producers (POUFC) increase by $1 4 billion

FAPSIM enables one to examine the impacts of the expansion in broiler meat exports on the entire agricultural sector Such an expansion puts upward pressure on pork and beef prices, which in turn results in adjustments in livestock production and in the demand for feed There may be sizable effects on the feed-grain, beef, and pork sectors FAPSIM predicts that the price of slaughter steers will increase by $2 18 per hundredweight and the

Table 7—Impact of increasing broiler meat exports by 200 million pounds per year, 1982-86

Variable[2]	1982	1983	1984	1985	1986
CHISPYO	[1]34 67	112 66	196 41	281 34	370 29
CHIASYO	34 67	111 79	195 75	280 72	369 64
CHIHTYO1	- 87	- 66	- 62	- 65	- 64
CHICCYO	-164 46	-287 54	-403 64	-518 63	-629 73
CHIAPOT	- 07	- 19	- 31	- 50	- 69
CHIASOT	- 07	- 83	- 79	- 95	-1 18
CHIHTOT1	- 64	- 48	- 45	- 49	- 49
CHICCOT	58	- 36	- 34	- 46	- 69
CHIIRFR	06	11	16	21	27
CHIPR	2 26	3 95	5 75	7 72	9 78
CHIPWBR9C	1 89	3 30	4 80	6 44	8 17
CHIPWXB	54	97	1 42	1 93	2 46
CHISVLA	- 03	- 08	- 14	- 22	- 30
EGGAA	00	00	00	00	00
EGGBB	2 03	6 82	11 94	16 70	21 83
EGGAP	- 60	-1 68	-2 83	-4 55	-6 32
EGGAS	- 60	-1 80	-3 15	-5 07	-7 04
EGGCC	-2 51	-8 30	-14 56	-21 06	-27 95
EGGHT	- 11	- 32	- 52	- 72	- 92
EGGIR 67	01	01	02	03	04
EGGPRAL	15	46	82	1 22	1 68
EGGPF	13	38	67	1 00	1 38
TURAP	4 15	12 18	18 08	22 18	27 00
TURAS	4 15	9 75	15 81	19 97	24 78
TURHT	-2 42	-2 27	-2 20	-2 22	-2 16
TURCC	6 57	12 02	18 01	22 20	26 94
TURPR	1 39	2 32	3 39	4 51	5 61
TURPF	96	1 61	2 35	3 13	3 89
PCPOU	06	10	15	20	25
POUFC	256 00	500 00	776 00	1075 00	1403 00

[1] Change from baseline projection after increasing broiler meat exports by 200 million pounds per year beginning in 1982
[2] See table 1 for units of measure

price of barrows and gilts will increase by $2 78 per hundredweight in 1986 Higher meat prices induce beef and pork producers to expand production This expansion in pork and beef production coupled with the expansion in young chicken and turkey production increases the demand for feed By crop year 1985, FAPSIM predicts that the price of corn, wheat, and soybeans will increase by 5 9, 2 3, and 7 1 cents per bushel, respectively Although cash receipts to poultry and egg producers will increase by $1 4 billion, crop, beef, and pork producers will also benefit from the expansion in broiler exports, causing total farm receipts to increase by $4 1 billion in 1986

These results suggest that treating and evaluating impacts on the poultry and egg sector without examining the potential feedback effects on other agricultural sectors can lead to misleading statements regarding the total impact on the agricultural sectors To evaluate the magnitude of error caused by failing to allow for feedback between the poultry and egg sector and other agricultural sectors, we performed an additional simulation This simulation assumed the same expansion in broiler exports and also assumed that non-poultry- and egg-sector variables would not be affected by the expansion in broiler exports Table 8 reports the percentage errors in estimates resulting from assuming no feedback between the poultry and egg sector and the beef, pork, and crops sectors

The results presented in table 8 suggest that treating the poultry and egg sector in isolation may cause sizable errors FAPSIM predicts that the adjustment in the retail price of chicken due to a 200-million-pound annual increase in broiler meat exports would be underestimated by about 19 percent

Table 8—Percentage errors in estimates resulting from assuming no feedback between the crops, beef, pork, and poultry and egg sectors, 1982-86

Variable	1982	1983	1984	1985	1986
			Percent		
CHISPYO	[1]-7 02	-5 35	-2 90	0 14	2 31
CHIASYO	-7 02	-5 23	-2 86	18	2 34
CHIHTYO1	-20 54	-15 47	-19 93	-20 26	-18 33
CHICCYO	1 56	2 12	1 47	- 07	-1 35
CHIAPOT	-132 84	-159 89	-181 09	-186 60	-194 35
CHIASOT	-132 84	-52 29	-82 34	-109 59	-124 83
CHIHTOT1	-21 00	-17 47	-23 83	-26 34	-27 20
CHICCOT	-7 99	-99 10	-160 04	-196 98	-194 47
CHIIRFR	-20 13	-18 27	-19 03	-19 61	-19 72
CHIPR	-20 04	-18 25	-18 94	-19 55	-19 59
CHIPWBR9C	-20 17	-18 34	-18 97	-19 54	-19 61
CHIPWXB	-23 06	-20 87	-21 29	-21 61	-21 47
CHISVLA	-136 67	-162 50	-180 00	-186 82	-196 00
EGGAA	00	00	00	00	00
EGGBB	-6 32	-4 64	-2 13	1 06	3 33
EGGAP	-135 05	-160 10	-181 08	-186 86	-194 32
EGGAS	-137 35	-153 48	-168 55	-173 89	-181 69
EGGCC	-34 83	-34 94	-35 92	-38 63	-40 56
EGGHT	-57 89	-55 84	-61 27	-70 53	-78 66
EGGIR 67	-48 55	-42 00	-41 18	-42 31	-44 44
EGGPRAL	-49 26	-42 61	-41 95	-43 44	-44 40
EGGPF	-48 80	-42 44	-41 64	-43 19	-44 30
TURAP	-18 36	-17 92	-15 97	-11 72	-8 93
TURAS	-18 36	-12 92	-12 90	-8 22	-5 83
TURHT	-38 01	-37 36	-43 47	-43 46	-39 46
TURCC	-25 78	-17 54	-16 64	-11 75	-8 53
TURPR	-37 38	-37 45	-39 78	-40 81	-40 59
TURPF	-37 42	-37 47	-39 79	-40 81	-40 55
PCPOU	-20 69	-19 00	-19 86	-20 41	-21 16
POUFC	-23 44	-21 40	-21 65	-21 86	-21 60

[1] Percentage errors in estimates resulting from assuming the crops, pork, and beef sectors are not affected by the 200-million-pound annual increase in broiler exports during the 1982-86 period

This underestimate occurs because treating the poultry and egg sector in isolation fails to recognize that an increase in the retail price of chicken puts upward pressure on pork and beef prices Higher pork and beef prices in turn lead to even higher chicken prices

The adjustment in egg and turkey prices are also underestimated when no feedback is allowed between the crops, beef, pork, and poultry and egg sectors Adjustments in both prices are underestimated by about 40 percent The adjustment in cash receipts from marketings of poultry and eggs is underestimated by about 22 percent

Conclusions

The poultry and egg industry has radically changed since 1950 Changes include production on fewer and larger farms, expanding output, and integration of production with input-supplying and marketing functions Poultry and egg production expanded despite declining real prices because of mechanization and improvements in feeding efficiency and disease control

These structural changes in the poultry and egg industry have important implications for the pork and beef industries Because consumer demands for pork and beef are affected by the price of poultry, expansion in poultry production puts downward pressure on red meat prices

The poultry- and egg-sector model described here explicitly recognizes the complexity of the poultry and egg sector and potential feedback effects on the pork and beef industries The model has also been integrated into FAPSIM This makes it possible to estimate impacts of changes in poultry- and egg-sector variables on both crop and livestock producers while allowing for feedback among the different sectors of the model

We have shown that the failure to allow for feedback among the crops, beef, pork, and poultry and egg sectors results in an underestimate of the price adjustment that would occur as a result of an expansion in broiler meat exports Because the magnitude of error is sizable, it appears that using a partial equilibrium framework to analyze the poultry and egg sectors may lead to serious prediction errors

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