# Parts or Whole? Efficient Broiler Production Responses to Consumer-Driven Markets

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Adoption of consumer-market-oriented production on broiler profit-maximizing modeling generates results that differ from those traditionally used in profit maximization for broiler production. This model shows that the adoption of step-pricing and marketing options (examples of consumer-market-oriented decisions) modify the optimal levels and types of broiler production to generate maximum profitability. Thus optimal protein levels in the feed formulated exceed currently recommended levels and alternative protein sources are also allocated. The adoption of step-pricing to respond to consumer-market-oriented decisions shows that higher profits can be obtained for targeted weights only if premium prices for output are allocated.

Integration in the broiler industry vertical chains of production makes determining profit-enhancing decisions perplexing. Ascertaining profits in broiler production is a complex matter because the production and processing involve many steps, ranging from hatchery to production to processing in the plants to distribution and onwards. The efficient allocation of resources will produce not necessarily the heaviest but the most profitable chickens. On the other hand, the retail market is consumer driven, and it is important for processors to know they most profitably are meeting the specific characteristics desired by consumers for product size and quality.

The retail market demands specific finished products that are not always the most efficient results of production processes. For example, fast food restaurants only want breast meat that falls into the weight that will fit in their sandwich bread. But this smaller-weight bird may not be as profitable to a broiler integrator as birds fed for longer periods or fed a low-cost ration that will not give the desired weight or fat content. Further, the retail market pays a premium price for the specifications of the products they expect from broiler integrators. Using the specifications for desired weight and the premium price paid, a profit maximization model must show efficient ways of meeting such distinctive products that result in profitability for the firm. Modeling consumer market-driven broiler production to obtain maximum profits requires the adoption of marketing requirements that affect efficient production. This study analyzes the effects of adoption of step-pricing, marketing options, and protein variability (sources and levels) on efficient/profitable broiler production.

Higher prices are paid for processed parts that meet specifications of the retail market; this concept is called *step-pricing*. Such specifications can be used for selling chicken parts that fit in a weight range that the consumer prefers, for example. The concept of *marketing options* is based on the fact that broiler integrators must decide at what processing level they want to sell their products; i.e., whether to process chickens into whole carcasses or to further process them to sell as cut-up parts, seasonally adjusting to the market. The prices paid differ according to the level of processing; the production process is also influenced by the marketing-decision process. After the step-pricing and marketing options are chosen, this information must be integrated into the model to determine the specific feed to be formulated.

The proper feed ration is formulated according to prior information on step-pricing and marketing options but will also be affected by the prices and availability of nutrient sources (mainly protein sources). Other factors such as the gender percentage of the chicks, and the temperature and size of the house also influence the optimal production that generates maximum profit.

The profit-maximizing analysis for consumer-market-driven broiler production and processing decisions presented in this study comprises of three

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objectives. First, estimated response functions are computed to determine the production functions to be used in the profit-maximization model. Second, results obtained from the optimization scenarios are used for profitability analysis of the competing protein sources in the model and for two marketing options: selling broilers processed as whole carcass versus selling broilers processed as cut-up parts. Finally, a step-pricing analysis of outputs from the two marketing options determines premium prices that are profitable for the target weights determined by the demand generated by industry and retailers that deal with consumers.

## Related Literature

### *Profit-Maximization and Cost-Minimization Broiler Production Models*

Interest in feed formulation was renewed in the 1950s with the wide-spread adoption of mathematical programming. For decades, the major objective to be attained in optimal broiler production was minimizing the cost of feed, and little consideration was allocated to other determinants of maximum profit. Least-cost rations minimize the cost of diets, given a certain set of ingredients and their nutritional content. An important assumption of least-cost-formulated diets is that every unit of a least-cost-formulated ration has the same productivity regardless of ingredient sources (Allison and Baird).

The adoption of simple cost minimization does not account for differentials in productivity among input sources; e.g., in experimental trials the performance of broilers fed peanut-meal protein has been shown to differ significantly from those fed SBM protein (Costa *et al.*, 1998). On the other hand, the adoption of profit-maximization techniques later in the 1990s has taken into consideration the productivity aspect of economically efficient broiler production. Few models have been developed, and they differ in their approaches to the problem.

Gonzalez-Alcorta *et al.* (1994) developed a profit-maximization model that uses nonlinear programming and separable linear programming to determine the precise energy and protein levels in the feed that maximize profit. Their model is distinguished by the assumption that body weight is not fixed at a predetermined level. Feed cost is not determined by least-cost feed formulation. Rather, it is determined as a variable of the profit-maximization model in a way similar to that described in Pesti *et al.* (1986). Gonzalez-Alcorta *et al.* (1994) conclude that the mathematical programming functions applied in their model show that set energy and protein levels that vary with output and input prices can raise profits compared to fixed levels of energy and protein based on previous nutritional guidelines.

Costa *et al.* (2000) developed a two-step profit-maximization model that minimizes feed cost and maximizes profit in broiler production. The model shows the optimum average feed consumed, feed cost, live and processed body weight of chickens, the optimal length of time that the broilers must stay in the house, and other factors for given temperature, size of the house, and cost of inputs and outputs and for certain pre-determined protein level, source, and processing decisions. They conclude that peanut meal can be more profitable than SBM for growing birds to be processed and sold as whole carcasses.

The analysis conducted in our study differs from Costa *et. al.* (2000) by developing a model that allows for a single procedure that is determined by the consumer market-oriented decisions. The model selects the optimum protein level and source in the formulated ration to be fed to the chickens. This model not only generates processing alternatives for selling whole carcass and cut-up parts but also determines the most profitable marketing option. The solutions also allow for adjustment given targeted weights and premium prices. An important feature of this model is that the processing decision takes place only after prices of inputs and outputs are determined. Output prices are determined by the consumer market of broiler processed products.

### *Studies on Cottonseed Meal as a Protein Source for Poultry*

Peanut, canola, and sunflower meal are some of the many protein meals cited as potential substitutes for soybean meal (SBM) in poultry production in previous studies. The interest expressed on cottonseed meal (CSM) is greater than others. This is because CSM availability decreases shortage risks assumed when using an alternative protein source, and CSM ensures a higher quality level than the other sources.

Studies developed by Watkins *et al.* (1993), Watkins *et al.* (1994), and Watkins and Waldroup (1995) show promising results for the use of CSM as a complement for SBM in poultry diets, if not as a substitute. This may be because it is believed that higher levels of CSM may not be as efficient as levels used in past studies. Our study uses data obtained by an experiment conducted at the University of Georgia[1] which uses full substitution of protein sources; *i.e.*, experiments are conducted with diets that contain either SBM or CSM for the collection of information on live body weight, feed consumption, and weight of processed parts. This data set, which contains productivity information on each source (SBM and CSM) is used to estimate the production functions that are used in the profit-maximization model of this study.

Profitable use of CSM requires that its price must be lower than the price of SBM, and either CSM-fed broilers must be as productive as SBM-fed broilers or the price for CSM must be such that it compensates for a lower physical productivity of the CSM-fed broilers. The price difference of protein sources is important because protein sources in the diets account for approximately 30% of the total diet for high-protein-level feeds. Historical data on prices show that SBM price has always been higher than the price of CSM for several markets (Feedstuffs).

## Model Description

A brief description of the model follows.[2] The objective function to be optimized is

(1) $Max\ \Pi = [(DP_{BW} * BW) - (P_{FC} * FC) * I]/t$

Subject to

(2) $P_{FC} = P_F + DEL$

(3) $P_F = \sum_{t=1}^{n} P_i + * X_i$

(4) $BW = f(FC, FC^2, PR, PR^2, FE)$

(5) $FC = f(t, t^2, PR, PR^2, FE)$

(6) $w_1 = f(BW, PR, PR^2, FE)$

(7) If $\mathbf{w}_1 = \mathbf{TW}_1$ then

$$ADP_k = \frac{\sum_l (w_l * (\mathbf{TP}_l - PRO_l - CAT_l)}{BW}$$

(8) otherwise

$$ADP_k = \frac{\sum_l (w_l * (\mathbf{P}_l - PRO_l - CAT_l)}{BW}$$

In the objective function (Equation 1), maximum profit per bird per day ((), is defined as a function of derived price at farm ($DP_{BW}$), live body weight ($BW$), cost of feed consumed ($P_{FC}$), feed consumed ($FC$), interest cost ($I$), and feeding time ($t$). Because of the objectives' specification, the constraint set includes a number of equations that are not mentioned in this article. However, the most relevant constraints that allow for a direct comparison between the two marketing options and step-pricing analyses are described next. Cost of feed consumed includes feed-delivery cost ($DEL$) and the least-cost feed ($P_F$, Equation 2). The least-cost-feed function ($P_F$) minimizes the cost of feed for pre-determined ingredients ($X_i$) and their prices ($P_i$) and is determined by the optimization process (Equation 3). Live-chicken body weight ($BW$) is determined by feed consumed ($FC$), feed consumed squared ($FC^2$), protein level ($PR$), protein level squared ($PR^2$), and an intercept shifter for female chickens ($FE$) (Equation 4). The coefficients of the $BW$ function are determined by ordinary least squares (OLS) on experimental data, and their values depend on whether SBM or CSM is chosen as the protein source. Further, coefficients in Equations 5 and 6 are also estimated separately for SBM and for CSM using the experimental data. Feed consumed ($FC$) is determined by feeding time ($t$), feeding time squared ($t^2$), protein level ($PR$), protein level squared ($PR^2$), and an intercept shifter for female chickens ($FE$, Equation 5).

Equation 6 is estimated as processed weight,

[1] Feed-composition and feeding-level experiment was conducted by the Poultry Science Department at the University of Georgia. The experiment consisted of using four levels of protein (17%, 20%, 23%, and 26%) and two sources of protein (SBM *vs.* CSM) to feed broiler chickens until 42 days old and collecting body weight, feed consumed, and weight of processed parts. For more detailed information, contact the authors.

[2] The objective of this manuscript is to discuss not the description and functionality of the proposed model but the application of the same to consumer-market-oriented profitable decisions. For a more detailed description, contact the authors.

$w_l$, of each part $l$ derived from a live bird ($l = WC$ for whole carcass and $BR$ for skinless boneless breast weight, $TE$ for tenderloin, $LQ$ for leg quarters, $WI$ for wings, $FP$ for fat pad, and $RC$ for rest of chicken for the cut-up parts processed broiler). The sum of all processed parts must equal the live weight of the bird (plus offal and giblets). Each equation is estimated as a function of live-bird weight ($BW$), protein level ($PR$), protein level squared ($PR^2$), and gender of birds ($FE$). The estimated coefficients are obtained by OLS on experimental data and their values also depend on whether SBM or CSM is chosen as protein source.

The modification in the model for the adoption of the step-pricing constraint is accomplished by setting an extra constraint on the targeted weight for the processed part to be produced. Equations 7 and 8 show the constraint that is added to the model. The target weight of part $l$, $TW_l$, is determined by the consumer market and must be met by the integrator by contract with buyers of such weight-targeted processed parts. If the model finds the target weight as optimal answer it uses the premium price, $TP_l$, as a step-price in the model; otherwise, it uses the lower price, $P_l$.

## Estimated Production Functions

Production Equations 4–6 are estimated by OLS and presented in Tables 1 and 2. Table 1 shows the estimated coefficients of Equations 4, 5 and 6 (in 6, for estimation of carcass weight only) for both CSM- and SBM-fed broilers. Live bird weight ($BW$) increases at a decreasing rate with respect to feed consumed ($FC$) and protein level ($PR$), while feed consumed increases at an increasing rate with respect to feeding time ($t$) and increases at a decreasing rate with respect to protein level ($PR$). Weight of whole carcass ($W_{WC}$) increases at a decreasing rate with respect to protein level ($PR$).

Estimated coefficients of Equation 6 (for skinless boneless breast, tenderloin, leg quarters, and wings) are shown in Table 2 for CSM- and SBM-fed broilers. For CSM-fed broilers, weights of skinless boneless breast, tenderloin, and wings ($W_{BR}$, $W_{TE}$, and $W_{WI}$, respectively) increase at decreasing rates with respect to $PR$. Weight of leg quarters ($W_{LQ}$) decreases at an increasing rate with respect to $PR$. For SBM-fed broilers, weights of skinless boneless breast, tenderloin, leg quarters, and wings increase at increasing rates with respect to $PR$. These results concur with those of Pesti and Smith (1984) and indicate that production responses of broilers to dietary energy and protein levels show diminishing marginal returns.

Prices of inputs and outputs are collected for the profit-maximization analysis. The price data include prices of ingredients available for the ration formulation including major feedstuffs and synthetic amino acids that supplement the deficiencies of major sources such as CSM and prices received in Georgia (or the Southeast) for the outputs and other costsconsidered in the analysis. Other inputs to the model include average temperature and size of the broiler house.

## Model Interactions, Marketing Options and Step-pricing Analyses

This model estimates the profitability of base scenarios where broilers are produced and sold using either SBM or CSM as the protein source. Broilers are sold either after being processed into whole carcasses or cut-up parts. Thus a total of four base scenarios are analyzed for the collected data on prices of inputs and outputs. Initially, comparisons are made directly between SBM and CSM results for each selling alternative. Prices of inputs (SBM and CSM) are then varied for price-sensitivity analysis. Lastly, targeted weights are applied to the model to measure premium prices and their profitabilities. The optimal answers report broiler weight, feed consumption, feeding time, and feed composition that maximize profit under certain production-function estimation, market option, and input/output prices. All optimal formulated rations meet all nutrient requirements from the National Research Council (NRC, 1994) for the nutrient requirements for poultry production. The results obtained from the interaction of the program formulate an optimal grow-out feeding ration. Each optimized ration is fed to broilers for an optimal number of days to obtain a target weight to be processed and sold to a specific market given the prices of outputs and ingredients and other costs integrated in the model, as illustrated by the case scenario in Figure 1.

Assume in Figure 1 that the current price of SBM has increased considerably. Assume also that whole-carcass prices are higher at this same time

**Table 1. Estimated Body Weight, Feed Consumed and Carcass Weight for CSM- and SBM-Fed Broilers.**

| | Body Weight | | Feed Consumed | | Carcass Weight | |
|---|---|---|---|---|---|---|
| Variable | CSM | SBM | CSM | SBM | CSM | SBM |
| Intercept | -1.192** | -1.698** | -1.900** | -1.107 | -318.362** | -409.280** |
| | *(0.394)* | *(0.542)* | *(0.947)* | *(0.854)* | *(147.302)* | *(179.164)* |
| *FC* | 0.634** | 0.692** | —— | —— | —— | —— |
| | *(0.023)* | *(0.034)* | | | | |
| $FC^2$ | -0.035** | -0.043** | —— | —— | —— | —— |
| | *(0.005)* | *(0.007)* | | | | |
| *t* | —— | —— | 0.015 | 0.004 | —— | —— |
| | | | *(0.019)* | *(0.017)* | | |
| $t^2$ | —— | —— | 0.002** | 0.002** | —— | —— |
| | | | *(0.001)* | *(0.001)* | | |
| *BW* | —— | —— | —— | —— | 0.720** | 0.753** |
| | | | | | *(0.010)* | *(0.013)* |
| *PR* | 0.117** | 0.158** | 0.140* | 0.086 | 20.815 | 25.523 |
| | *(0.036)* | *(0.050)* | *(0.079)* | *(0.071)* | *(14.085)* | *(17.158)* |
| $PR^2$ | -0.002** | -0.003** | -0.003* | -0.002 | -0.436 | -0.546 |
| | *(0.001)* | *(0.001)* | *(0.002)* | *(0.002)* | *(0.326)* | *(0.397)* |
| *FE* | -0.082** | -0.061** | -0.337** | -0.240** | 6.391 | 7.760 |
| | *(0.013)* | *(0.017)* | *(0.027)* | *(0.024)* | *(6.726)* | *(7.890)* |
| $R^2$ | 0.9945 | 0.9899 | 0.9939 | 0.9946 | 0.9820 | 0.9703 |
| N | 72 | 72 | 72 | 72 | 144 | 144 |

Standard errors are in parentheses.
* parameter estimate is statistically significant at the 0.10 level.
** parameter estimate is statistically significant at the 0.05 level.
Body-Weight and Feed-Consumption functions are estimated in kg. Carcass-Weight function is estimated in grams.

**Table 2. Effects of Live Weight, Protein Level, and Sex of Bird on Weights of Cut-up Parts of CSM- and SBM-Fed Broilers.**

| | Breast | | Tenderloin | | Leg Quarters | | Wings | |
|---|---|---|---|---|---|---|---|---|
| Variable | CSM | SBM | CSM | SBM | CSM | SBM | CSM | SBM |
| Intercept | -196.509* | -221.257* | -61.380** | -80.876** | -34.145 | -29.088 | -28.607 | -50.023 |
| | *(110.377)* | *(118.450)* | *(30.716)* | *(26.624)* | *(113.019)* | *(136.867)* | *(48.000)* | *(44.314)* |
| *BW* | 0.160** | 0.184** | 0.035** | 0.044** | 0.353** | 0.079** | 0.083** | |
| | *(0.007)* | *(0.008)* | *(0.002)* | *(0.002)* | *(0.007)* | *(0.010)* | *(0.003)* | *(0.003)* |
| *PR* | 13.479 | 12.058 | 4.136 | 4.530* | -1.661 | -0.264 | 2.939 | 4.384 |
| | *(10.551)* | *(11.385)* | *(2.936)* | *(2.560)* | *(10.804)* | *(13.155)* | *(4.588)* | *(4.259)* |
| $PR^2$ | -0.285 | -0.234 | -0.080 | -0.083 | 0.001 | -0.008 | -0.068 | -0.100 |
| | *(0.244)* | *(0.263)* | *(0.070)* | *(0.059)* | *(0.250)* | *(0.304)* | *(0.106)* | *(0.098)* |
| *FE* | 7.096 | 13.237** | 4.749** | 6.119** | -6.754 | -17.239** | 3.883* | 0.835 |
| | *(5.051)* | *(5.216)* | *(1.406)* | *(1.172)* | *(5.172)* | *(6.027)* | *(2.197)* | *(1.951)* |
| $R^2$ | 0.8403 | 0.8212 | 0.7533 | 0.8412 | 0.9604 | 0.9268 | 0.8608 | 0.8738 |
| N | 144 | 144 | 144 | 144 | 144 | 144 | 144 | 144 |

Standard errors are in parentheses.
* parameter estimate is statistically significant at the 0.10 level.
** parameter estimate is statistically significant at the 0.05 level.
All functions are estimated in grams.

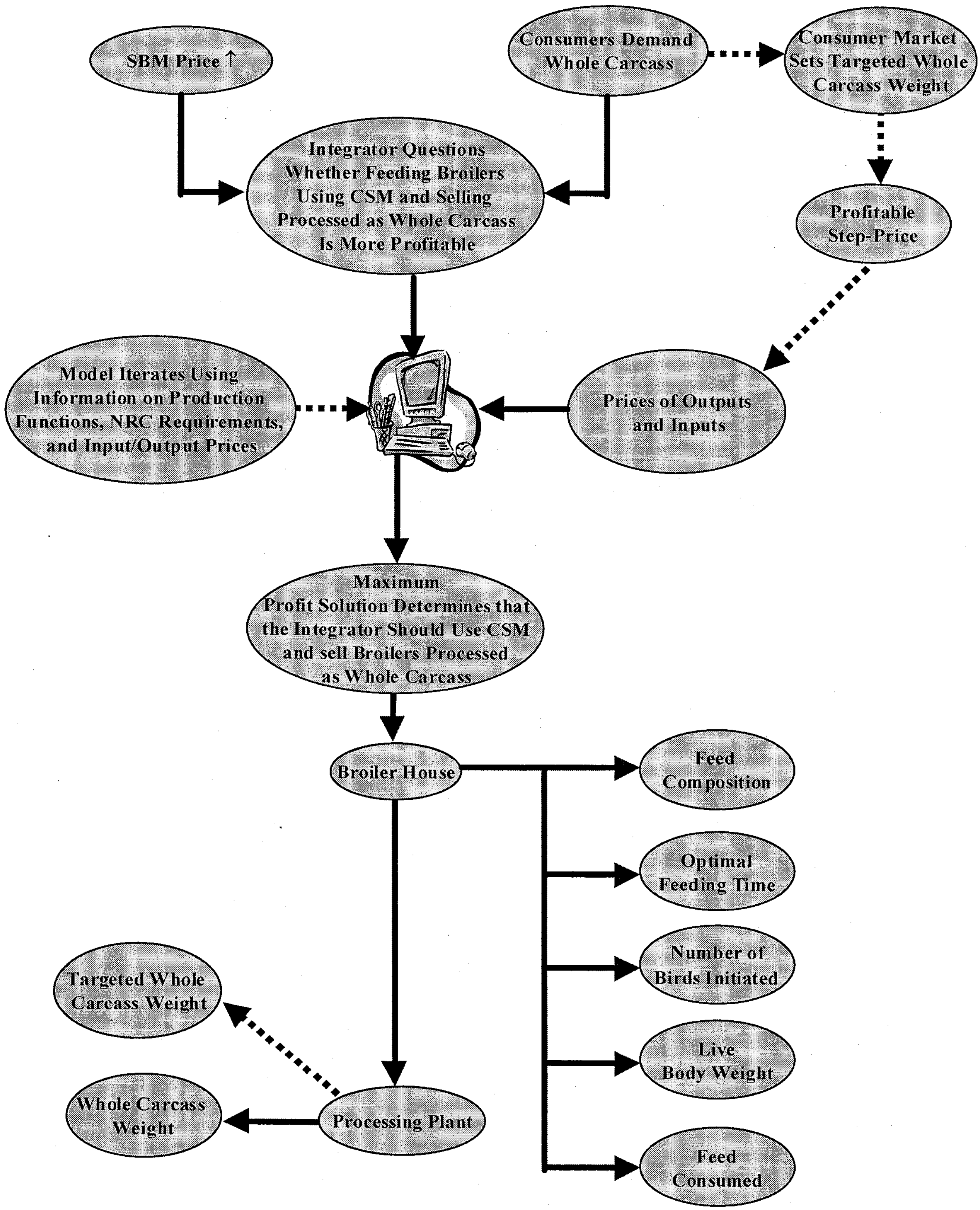


**Figure 1. Example of Production and Processing-Decision Schematic for Integrated Broiler-Profit Maximization.**

of the year because consumers are demanding more whole-carcass meat. The model faces these two aspects of the input and output markets and after running its procedure it recommends that the integrator grow broilers fed CSM and processed into cut-up parts. Prices of outputs and inputs are then entered into the model, which uses previously entered information and relationships on production and returns to carcass-weight fed CSM, nutrient requirements determined by the NRC (1994), size of the house information, temperature, chicks gender, and other production costs. The optimal solution set generated by the model goes first to decisions in the broiler house, where optimal feed composition—with CSM as protein source—and optimal feeding time are set to deliver the target live body weight of birds. The body weight produced in the broiler house is transmitted to the processing plant, where the outcome is. a profit-maximizing breast weight

A second output generated by this model is represented in Figure 1 by the dotted lines. The dotted lines represent the option of setting a targeted weight that is rewarded by a step-price. As consumers increase demand for whole carcass, the consumer market sets targeted whole-carcass weights that are conformable to the weights they sell in their markets. As a reward for requiring such weight for the output they provide a step-price to the poultry integrator who redefines his process of production to attain such target weight. The redefinition involves using a different time of production as well as a different combination of inputs to attain the desired targeted weight efficiently.

*Selling Broilers According to Marketing Options*

The first analysis compares selling broilers that are processed into whole carcass or cut-up parts. Results, presented in Table 3, indicate that CSM and SBM are more profitable for the production of broilers processed and sold as whole carcass and cut-up parts, respectively. These results are derived under the prices of inputs and outputs observed for the time period chosen. Results will differ for different price circumstances. The NRC (1994) recommends that the protein level in the diets used for broilers in the grower phase (from 3 to 6 weeks) should be 20 percent. However, the formulated feeds in this model present protein levels above the expected average. Comparative results also indicate that more feeding time and more feed con-

**Table 3. Scenarios Used to Determine Efficient Production of Broilers Under Consumer-Market-Determined Marketing Conditions to Obtain Maximum Profitability in Broiler Production.**

| | | Whole Carcass | Cut-up Parts |
|---|---|---|---|
| Variable | Unit | CSM | SBM |
| Protein Level | % | 23.92 | 23.92 |
| Feeding Time | days | 34.94 | 40.07 |
| Bird Weight | lb | 4.24 | 5.10 |
| Feed Cost | cents/lb | 7.51 | 7.61 |
| Feed Consumed | lb/bird | 6.32 | 8.04 |
| Feed Conversion Ratio | lb/lb | 1.58 | 1.58 |
| **Profit (Π)** | **cents/bird/day** | **2.08** | **2.59** |
| Derived Price | cents/lb | 29.19 | 33.29 |
| Broiler-House Revenue | $/house/period | 12,778 | 19,622 |
| Carcass Weight | lb | 2.90 | — |
| Skinless Boneless Breast Weight | lb | — | 0.790 |
| Tenderloin Weight | lb | — | 0.178 |
| Leg Quarters Weight | lb | — | 1.625 |
| Wings Weight | lb | — | 0.420 |

sumed produce a heavier bird for the cut-up-parts marketing option than for the whole-carcass marketing option. This is because cut-up parts have an aggregate value higher than the value of whole carcass. Therefore, more feeding time and more feed consumed can be used to find a higher point of maximum profit.

*Step-Pricing Analysis for Targeted Weight of Whole Carcass and Cut-up Parts*

This section analyzes the effects on profitability of targeting optimal weights as determined by the consumer market. A new constraint is added to the model that sets carcass or cut-up-parts weights equal to a desired level (as indicated in Equations 7 and 8 and Figure 1). This desired level is determined by the retailers who learn from their own consumption studies what processed weights of carcass or cut-up parts their consumers prefer. Thus a poultry integrator must meet certain weight levels to guarantee a premium price paid by the retailers. As an example, fast food restaurants require that the weight of chicken breasts fall within a certain range that can fit in the sandwich bread, and they will pay a premium price to an integrator who sells a processed bird with such a weight level.

Sample data on carcass and skinless boneless breast weights are collected from a food retailer; the average weight for each processed part is assumed to be the target weight to be met. All averaged weights reported by the food retailer are higher than the optimal levels indicated in previous analyses conducted with baseline prices and no target weights set as constraints. Despite those differences, the next analyses show target weights and step-prices that become as profitable as the baseline solutions for the marketing options.

*Step-Pricing Analysis on Whole Carcass*

This analysis sets a carcass target weight of 3.99 lbs. against baseline levels of 2.90 lbs. for CSM-fed broilers. In the first column of Table 4 the target-weight constraint is applied to broilers using the same price as the result presented in Table 3, analysis for whole carcass. Profit levels decline for that targeted weight, showing that if no step-price is applied the target weight generates inefficiency. Protein level, feeding time, live weight, feed cost, and feed-conversion ratio increase when the target weight is considered. For a profit level that equals the baseline profit level reported in Table 3 there must be an increase in the price of whole carcass on the order of 2.44 percent and for the same targeted weight of 3.99 pounds.

*Step-Pricing Analysis on Cut-up Broiler Parts*

The step-price analysis for targeted weights is next applied to cut-up processed parts: skinless boneless breast, tenderloin, leg quarters, and wings. Their targeted weight are 1, 0.196, 1.93, and 0.406 lbs., respectively. The sampled average weights from the food retailer are higher than the baseline optimal solutions for the SBM-fed birds, with the exception of the weight of wings which is lower than the baseline solution. In other words, the optimal solution obtained in the model interaction for SBM-fed broilers at current prices indicate that the weight of skinless boneless breast, tenderloin, and leg quarters are lower (and for wings, higher) than the average weights reported by the food retailer.

Columns 3–10 of Table 4 report the premium price analyses of targeted skinless boneless breast, tenderloin, leg quarters, and wings weights for SBM-fed broilers. The targeted weights drive profitability down for all processed parts when compared to the baseline solution. In order to attain the same profitable level of production as reported before, increases in the prices of cut-up parts are necessary. The prices of skinless boneless breast, tenderloin, leg quarters, and wings should increase by 7.03 percent, 2.42 percent, 8.77 percent, and 0.64 percent, respectively, to match profitability levels recorded in the baseline solution. The protein level, feeding time, and live-bird weight are higher and wings weight is lower for the targeted weights of processed parts than the baseline solution. This is again because more inputs are allocated, since there is an extra reward as a step-price to the efficient production of broilers.

**Conclusions**

The profit-maximization model interactively generates optimal solutions for the marketing options that process and sell broilers in the carcass and cut-up parts markets using either CSM- or SBM-fed broilers. The feed formulated for all optimal solu-

**Table 4. Step-Pricing Analysis of Carcass, Skinless Boneless Breast, Tenderloin, Leg Quarters, and Wings Prices on Targeted Weights Determined by the Consumer Market for Maximum Profitability of Broiler Production.**

| | | Carcass | | Skinless Boneless Breast | | Tenderloin | | Leg Quarters | | Wings | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Unit | CSM | | SBM | | SBM | | SBM | | SBM | |
| Step-Price Increase | % from base | 0 | 2.44 | 0 | 7.03 | 0 | 2.42 | 0 | 8.77 | 0 | 0.64 |
| Protein Level | % | 23.67 | 23.70 | 24.16 | 24.18 | 24.01 | 24.02 | 24.49 | 24.49 | 23.96 | 23.96 |
| Feeding Time ($t$) | days | 44.11 | 44.11 | 48.04 | 48.03 | 42.62 | 42.62 | 45.96 | 45.96 | 39.12 | 39.12 |
| Bird Weight ($BW$) | lb | 5.72 | 5.72 | 6.26 | 6.26 | 5.50 | 5.50 | 6.00 | 6.00 | 4.93 | 4.93 |
| Feed Cost ($P_F$) | cents/lb | 7.49 | 7.50 | 7.66 | 7.66 | 7.64 | 7.64 | 7.70 | 7.70 | 7.63 | 7.63 |
| Feed Consumed ($FC$) | lb/bird | 10.38 | 10.37 | 11.83 | 11.83 | 9.18 | 9.17 | 10.75 | 10.75 | 7.62 | 7.62 |
| Feed-Conversion Ratio | lb/lb | 1.81 | 1.81 | 1.89 | 1.89 | 1.67 | 1.67 | 1.79 | 1.79 | 1.55 | 1.55 |
| Birds Initiated | bird | 22,700 | 22,700 | 21,609 | 21,610 | 23,101 | 23,102 | 22,162 | 22,162 | 24,000 | 24,000 |
| **Profit ($\Pi$)** | **cents/bird/day** | **1.95** | **2.08** | **2.41** | **2.59** | **2.57** | **2.59** | **2.49** | **2.59** | **2.58** | **2.59** |
| Derived Price | cents/lb | 29.62 | 30.64 | 34.00 | 35.42 | 33.56 | 33.70 | 33.87 | 34.66 | 33.15 | 33.19 |
| Broiler-House Revenue | $/house/period | 13,833 | 15,102 | 19,206 | 21,036 | 19,326 | 19,497 | 19,463 | 20,465 | 18,243 | 18,289 |
| Output Price | $/lb | 0.615 | 0.630 | 1.28 | 1.37 | 1.65 | 1.69 | 0.28 | 0.31 | 0.78 | 0.79 |
| Output Target Weight | lb | 3.97 | 3.97 | 1.00 | 1.00 | 0.196 | 0.196 | 1.93 | 1.93 | 0.406 | 0.406 |

tions meets all NRC requirements for nutrient composition of feed rations. Protein levels indicated by the model are above the average levels reported in the industry and range from 23 to almost 25 percent. Results indicated that profits are higher with CSM-fed broilers for the whole-carcass marketing option, while profits are higher with SBM-fed broilers for the cut-up-parts marketing option. CSM-fed birds are fed for less time than are SBM-fed broilers in all directly compared scenarios. Average live body weight and feed consumed are lower for CSM-fed broilers than for SBM-fed broilers. Adoption of targeted weights initially represents a decline in profits if no step-price is applied to the targeted weight. Then, as step-prices are employed, profits increase for both marketing options.

The results indicate that negotiation must take place between retailers and integrators when deciding what step-price should be adopted for different marketing options. Poultry integrators must incorporate all steps of their production process and agree on terms that represent efficient allocation of their inputs. On the other hand, retailers must recognize that step-prices must be paid when special requests for targeted weights are set. This manuscript does not determine what should be the terms of negotiation, but the model used in this model, as well as the results generated may serve as a reasonable start.

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