Controlling Commodity Cost Impacts for Mid-Sized Poultry Processor

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Abstract

Managing cost variability is crucial for every business to ensure sufficient profit margins. This is especially true in sectors such as poultry processing where purchasing primary feed ingredients (i.e., corn and soybean meal commodities) not only impacts a substantial majority of operating costs but also involves significant uncertainty. To manage this risk, many companies hedge grain (corn/soybean) before acquiring commodities to control future costs. To fully take advantage of the price-control opportunities that hedging provides and engage in informed decision-making, it is essential to understand the specific implications of grain costs and their impact on gross profit margins. During a summer internship working for a mid-sized poultry company, I developed a model to analyze various grain costs and their corresponding impact on profitability. This model evaluated the company's gross profit margins across different scenarios and explored strategies to achieve targeted profitability through adjustments in not only input costs, but also in finished product pricing and sales volume.

This paper will highlight the practical use of financial modeling in reducing cost variability and improving decision-making processes to maximize profitability within the poultry industry.

1 Company History

The poultry company, hereinafter referred to as Company X, began operations in the mid-1990s. Since its inception, Company X has expanded production from approximately 2,500 heads per week to 250,000 heads per week. In 2023, the company's revenues from its processing activities surpassed $70 million.[1] Company X sells products to service two niche

[1]Company X also has a subsidiary entity that manages live chicken growout and sells live chickens to various processors. The activities of this subsidiary are excluded from this analysis.

markets: (1) hand-slaughtered Halal poultry for the Muslim market and (2) antibiotic-free, vegetarian-fed, Certified Humane chicken sold under its own label for both retail and food service applications to the “all-natural” market.

Like their Kosher counterparts, Halal poultry products must be slaughtered per religious law. For Halal poultry, Islamic law mandates that chickens be slaughtered by hand, prohibits stunning of the chickens before slaughter, and requires the invocation of Allah’s name during the process. Company X is one of a few USDA-inspected processors in the United States that produces 100% hand-slaughtered Halal poultry. While other entities claim to produce Halal products, only Company X and a select few others meet the “Zabiha” standard, meaning every chicken is hand-slaughtered by Muslims without pre-slaughter stunning.

The true highlight of Company X’s operations is its namesake poultry brand, introduced in 1994, which targets the high-end food service and retail markets in the “all-natural” segment. Since then, the brand has become a staple in regional supermarkets and is offered in many high-end restaurants. Recently, growth in the food service sector has outpaced retail growth, with increasing numbers of institutions committing to “clean” menus and featuring Company X’s chicken as a central element of that commitment.

As consumers become more health-conscious, sensitive to animal treatment, and aware of agri-business practices, demand for natural food products has surged. Company X’s chickens are certified as humanely raised and handled, grown without antibiotics, and fed a vegetarian diet free of animal fats and by-products. Additionally, its artisanal process sets them apart. Unlike the overwhelming majority of processors, Company X maintains a hand-slaughtered process, resulting in a cleaner bleed and superior-tasting product. The dramatic taste difference has positioned Company X’s chicken as a leader in the growing “natural” market.

Due to its exceptional quality and service, Company X’s name and reputation have become well-established in the industry. Company X’s products are featured in various supermarket chains across its sales territory. The company offers a full range of ready-to-cook products for both retail and food service sectors. In addition to whole birds and traditional parts, Company X has emerged as a leader in providing portion-controlled white meat items for food service.

Additionally, because all of Company X’s chickens are both hand-slaughtered Halal and “all-natural” (antibiotic-free, vegetarian-fed, Certified Humane), the company has seen a large expansion in recent years in its food service business with colleges and universities. By serving Company X’s product, schools can offer chicken to their student bodies to simultaneously meet the religious requirements of their Muslim students and satisfy the general student population’s ever-increasing concern for the humane treatment of poultry

2 Preliminary Data

All model data utilized for the analysis were derived from revenue, cost, and production figures for the trailing twelve months (TTM) ending in May 2024. Company X has an arrangement with the subsidiary referred to in Footnote #1 to resell a portion of the live chickens it purchases at an unchanged price. These transactions, referred to as 'live poultry sales,' affect both revenue and costs equally. To ensure accurate analysis, these transactions were excluded from all relevant parameters. The following parameters, used for this analysis, are descriptive, characterizing the business and showing insight into its performance:

- TTM Live Poultry Sales (LPS) = \$4,921,436
- TTM Revenue = \$85,412,164 - LPS = \$80,490,728
- TTM Live Poultry Costs (LPC) = \$41,270,123 - LPS = \$36,348,687

  Note: 45.159% of revenue
- TTM Non-Live Product Costs = \$46,487,491 - LPC = \$5,217,368

  Note: 6.482% of revenue
- TTM Production Labor Costs = \$16,994,670

  Note: 21.114% of revenue
- TTM Packaging Costs = \$4,093,794

  Note: 5.085% of revenue
- TTM Other Costs = \$5,382,756

  Note: 6.687% of revenue
- TTM Pounds Processed = 62,827,649 lbs
- TTM Pounds Sold = 49,037,892 lbs

3 Calculating Live Chicken Cost

Company X is not a vertically integrated operation and acquires live birds from a partnering hatchery, feed mill, and various family farms [2]. Various factors influence the live bird cost, including the prices of corn and soybean, feed conversion (pounds of feed per pound of

[2] Large poultry processors are organized as vertically integrated operations meaning that they own and control not only the processing plant but hatcheries and feed mills as well. As a medium-sized operator in the industry, Company X is not vertically integrated and the hatchery and feed mill that they work with are independently owned and operated.

chicken raised), chick cost, and utilities, i.e., propane and electricity. It's important to note that there is no real way to predict or hedge chick cost, but it is generally stable, with changes generally fluctuating within a few tenths of a cent. By far, the largest component of live chicken pricing is the feed cost, predominantly composed of corn and soybean meal. The following key considerations regarding corn and soybean meal were utilized:

- A \$0.10/bushel change in the price of corn results in a \$0.0019 change in the cost per pound of live chicken.
- A \$10/ton change in the price of soybean meal results in a \$0.0023 change in the cost per pound of live chicken.

Using Boiler Costs from July 2024, the predicted live chicken cost per pound, L, is given by the equation:

$$L = 0.555 + 0.00023(S - 407) + 0.019(C - 5.51) \tag{1}$$

where S is the soybean meal price (\$ / ton) and C is the corn price (\$ / bushel).

4 Commodity Cost Impact Tool

To help Company X conceptualize the impact of changes in commodity prices on its financial performance, a simulation tool was developed. This device enables the company to input hypothetical adjustments in revenue, additional costs, and targeted gross margins (both in percentage and dollar terms). The tool generates multiple visualizations that assist the company in identifying target ranges for commodity prices and exploring potential solutions if its costs fall outside an acceptable range.

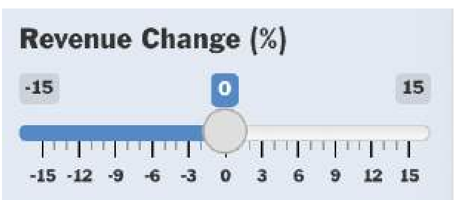
4.1 Input Variables

4.1.1 Time Range

The first variable the company can set is the time range for the simulation. It can choose from annual, quarterly, or monthly intervals. This variable divides the trailing twelve-month (TTM) values according to the selected range: 1 for annual, 4 for quarterly, and 12 for monthly. This setting affects only the total values displayed and is particularly important when the company focuses on achieving its gross margin goal in dollar terms.

4.1.2 Revenue

This tool allows the company to predict the change in revenue for the selected period. All non-live chicken costs will automatically shift with any change in revenue based on the percentages set in the 2. For example, if annual revenue increases by 3%, rising from approximately \$80.49 million to \$82.91 million, production labor costs, which constitute 21.114% of revenue, will also increase, from about \$16.99 million to \$17.50 million. With prices held constant, any revenue increase necessitates volume growth and affects associated costs.

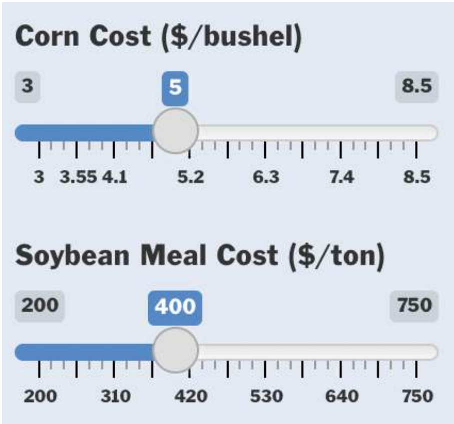


4.1.3 Additional Costs

In addition to cost adjustments correlative to revenue changes, there can be additional cost fluctuations. For example, an increase in wages due to political policies (minimum wage movement) or union collective bargaining agreements will raise production labor costs compared to the TTM percentage, while a boost in cardboard supply could lead to cheaper packaging costs. Company X anticipates a 5% increase in production labor year over year starting in 2025 due to a labor contract executed during Q2 of 2024 and this component of the model will allow this additional cost to be factored into the analysis.

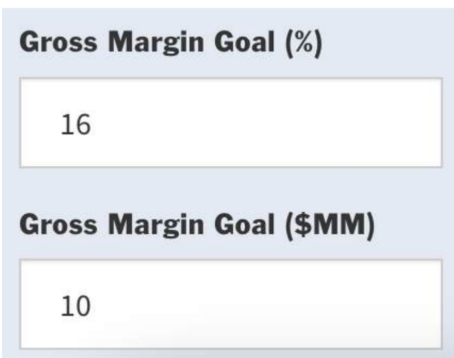
4.1.4 Commodity Costs

After establishing the hypothetical economic environment, the company can adjust corn and soybean prices to evaluate their impact on the bottom line. To predict total live chicken costs for a period, the model applies the inputted commodity prices to (1) and then multiplies the result by the TTM pounds, adjusted for period length.



4.1.5 Gross Margin Goals

Finally, the model enables the company to set its gross margin goals for the selected time frame, both as a percentage and in absolute dollar terms. All resulting visualizations and solutions are produced utilizing these target metrics.

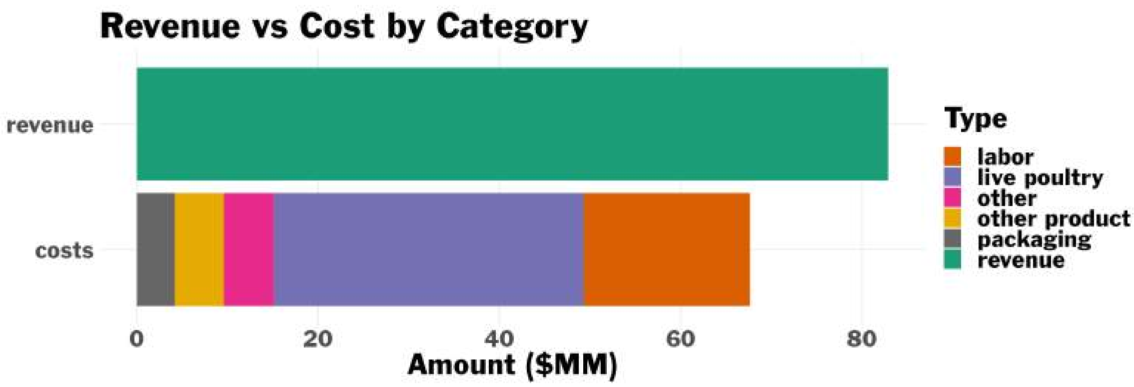


4.2 Simulated Financials

Note: All visualizations are annualized, assuming a 3% rise in revenue (up to $82,905,450) and an additional 5% rise in production labor costs (up to $18,379,736).

4.2.1 Revenue vs. Cost by Category

The first graphic created is a straightforward bar plot that visualizes the revenue and costs over a certain period. This plot updates automatically with changes in inputs, providing the company with a general overview of its finances. The below visualization assumes a corn price of $5 per bushel and a soybean meal price of $400 per ton.



The graphic includes a hover feature that allows the company to see the exact numbers of each category.

4.2.2 Results Table

The resulting table provides a detailed numerical look at the different scenarios facing the company under the given simulation. It also allows the company to fix one commodity price while setting a target for the other. For example, if the company has locked in a corn price of $5.20, the table shows the maximum allowable price for soybean meal to achieve its gross margin percentage goals. The following table uses the same inputs as the previous visualization, with a gross margin percentage goal of 20% and a strict profit target of $ 20 million annually. The following sections will explain how each row of the table was calculated.

Simulated Costs Resulting Costs Based on Inputted Variables

Category	Value
Maximum Live Chicken Cost ($/lb) for 20% Gross Margin	0.5222205
Inputted Corn Price ($/bushel)	5.0000000
Maximum SBM Price for 20% GM (with Corn Price = $5/bushel)	306.6110393
Inputted SBM Price ($/ton)	400.0000000
Maximum Corn Price for 20% GM (with SBM Price = $400/ton)	3.8695021
Inputted Live Chicken Cost ($/lb)	0.5437000
Inputted Gross Margin (%)	18.3722372
Inputted Revenue per Pound Sold	1.6906406
Revenue per Pound Sold Needed for 20% GM	1.7250401
Price Change Needed for 20% GM (%)	2.0347034
Millions of Pounds Sold	49.0378920
Millions Pounds Sold Needed for $20M GM (Annually)	64.3897388
Volume Change (%) Needed for $20M GM (Annually)	31.3060904

4.2.2.1 Row 1: Maximum Live Chicken Cost ($ / lb) for 20% Gross Margin

To find the maximum allowable commodity costs, we first need to calculate the maximum total costs for a given gross margin percentage goal. This can be derived from the gross margin equation:

$$G_0 = \frac{R - O - P_0}{R} \tag{2}$$

where G_0 is the gross margin percentage goal (in decimal form), R is revenue, O is the cost of goods minus live poultry costs, and P_0 is the maximum cost of live poultry to achieve the gross margin percentage goal. Rearranging the equation gives:

$$P_0 = R(1 - G_0) - O \tag{3}$$

where P_0 gives the total amount the company can spend on live poultry over the period. To properly use this in analysis, it must be converted into a per-pound rate. Let M denote the maximum price per pound the company can pay to reach its goal, calculated as:

$$M = \frac{(1 - G_0)R - O}{W} = \frac{P_0}{W} \tag{4}$$

where W is the TTM pounds processed during the period.

Inserting simulated inputs, let R = \$82,905,450, O = \$33,514,471, G_0 = 0.20, W = 62,827,649 lbs, resulting in,

$$\begin{aligned} M &= \frac{(1 - 0.20)\$82,905,450 - 5}{62,827,649 \text{ lbs}} \\ &= \frac{\$32,809,889}{62,827,649 \text{ lbs}} \\ &\approx \$0.5222 \text{ / lb} \end{aligned}$$

where M is the maximum price per pound of live poultry that meets the gross margin goal.

4.2.2.2 Row 2: Inputted Corn Price (\$/bushel)

The corn price inputted into the model.

4.2.2.3 Row 3: Maximum SBM Price for 20% GM (with Corn Price = \$5 / bushel)

Rearranging (1), the cost of soybean meal (\$ / ton), S, can be using the following equation:

$$S = \frac{0.555 - L + 0.019(C - 5.51) - (407 \times 0.00023)}{-0.00023} \tag{5}$$

where L is a given live chicken price per pound and C is the corn price. Substituting M, the maximum price per pound the company can pay to maintain its gross margin goal (found in equation (4)), for L, and using C as given in section `4.2.2.2`, we get:

$$
\begin{aligned}
S &= \frac{0.555 - M + 0.019(C - 5.51) - (407 \times 0.00023)}{-0.00023} \\
&= \frac{0.555 - 0.5222205 + 0.019(5 - 5.51) - (407 \times 0.00023)}{-0.00023} \\
&\approx \$306.611 \ / \ \text{ton}
\end{aligned}
$$

where M is the previously calculated maximum price per pound of live chicken, and C is the corn price used in the calculation.

4.2.2.4 Row 4: Inputted SBM Price ($ / ton)

The soybean meal price inputted into the model.

4.2.2.5 Row 5: Maximum Corn Price for 20% GM (with SBM Price = $400 / bushel)

Rearranging (1), the cost of soybean meal ($ / ton) S can be found by the equation

$$
C = \frac{0.555 - L + 0.00023(S - 407) - (5.51 \times 0.019)}{-0.019} \tag{6}
$$

where L is a given live chicken price per pound and S is the soybean meal price. Substituting M, the maximum price per pound the company can pay to maintain its gross margin goal (found in equation (4)), for L, and using S as given in section `4.2.2.4`, we get:

$$
\begin{aligned}
C &= \frac{0.555 - M + 0.00023(S - 407) - (5.51 \times 0.019)}{-0.019} \\
&= \frac{0.555 - 0.5222205 + 0.00023(S - 407) - (5.51 \times 0.019)}{-0.019} \\
&\approx \$3.8695 \ / \ \text{bushel}
\end{aligned}
$$

where M is the previously calculated maximum price per pound of live chicken, and S is the soybean meal price used in the calculation.

4.2.2.6 Row 6: Inputted Live Chicken Cost ($ / lb)

Inserting commodity prices as inputted (in this simulation, corn = $5 per bushel and soybean meal = $400 per ton), into (1), use:

$$\begin{aligned}L &= 0.555 + 0.00023(S - 407) + 0.019(C - 5.51) \\ &= 0.555 + 0.00023(400 - 407) + 0.019(5 - 5.51) \\ &\approx \$0.5437 \ / \ \text{lb}\end{aligned}$$

where S is the price of soybean meal and C is the corn price. The resulting live chicken rate is $0.5437 per pound.

4.2.2.7 Row 7: Inputted Gross Margin (%)

To determine the current cost of live poultry, P, for the current simulation, we multiply the live chicken rate, L, by the pounds processed over the period, W. The formula is:

$$P = LW$$

Inserting simulated inputs, where $L = 0.5437$ (as found in `4.2.2.6`), $W = 62{,}827{,}649$ lbs,

$$\begin{aligned}P &= \$0.5437 \ / \ \text{lb} \times 62,827,649 \text{ lbs} \\ &= \$34,159,393\end{aligned}$$

where P is the current cost of live poultry. Next, we calculate the gross margin percentage, G, using the following revised version of (2):

$$G = \frac{R - O - P}{R}$$

where revenue, $R = \$82{,}905{,}450$ and other costs of goods, $O = \$33{,}514{,}471$. Substituting the values, as well as P as just found:

$$
\begin{aligned}
G &= \frac{R - O - P}{R} \\
G &= \frac{\$82,905,450 - \$33,514,471 - \$0.5437\ /\ \text{lb} \times 62,827,649\ \text{lbs}}{\$82,905,450} \\
&\approx 0.1837
\end{aligned}
$$

calculate the Inserting simulated inputs, where R = \$82,905,450, O = \$33,514,471, into (1),

Multiplying by 100 to convert G into percentage:

$$\textbf{Gross Margin Percentage} = 0.1837 \times 100 = 18.37\%$$

This is below the target gross margin of 20%.

4.2.2.8 Row 8: Inputted Revenue per Pound Sold

To determine the revenue per pound sold, U, divide the current revenue, R, by the TTM pounds sold, V. For this simulation:

- Current revenue, R = \$82,905,450
- TTM pounds sold, V = 49,037,892 lbs (annualized)

$$
\begin{aligned}
U &= \frac{R}{V} \\
&= \frac{\$82,905,450}{49,037,892\ \text{lbs}} \\
&\approx \$1.6906\ /\ \text{lb}
\end{aligned}
\tag{7}
$$

4.2.2.9 Row 9: Revenue per Pound Needed for 20% GM

The solution to achieving a 20% gross margin percentage goal comes from a price increase, which will result in higher revenue while keeping volume and costs unchanged. The goal revenue, R_0, can be found by substituting R_0 for R in the gross margin formula (2):

$$G_0 = \frac{R_0 - O - P}{R_0}$$

where G_0 is the target gross margin percentage, R_0 is the goal revenue, O is the non-live poultry cost of goods, and P is the current live poultry cost. Rearranging and inserting simulated inputs, we calculate the goal revenue, R_0 as follows:

$$\begin{aligned} R_0 &= \frac{O+P}{1-G_0} \\ &= \frac{\$33,514,471 + \$34,159,393}{1-0.20} \\ &= \$84,592,330 \end{aligned} \tag{8}$$

To determine the goal revenue per pound sold, U_0, divide the goal revenue R_0, by the TTM pounds sold, V, which is annualized at 49,037,892 lbs).

$$\begin{aligned} U_0 &= \frac{R_0}{V} \\ &= \frac{\$84,592,330 \text{ / lb}}{49,037,892 \text{ lbs}} \\ &\approx \$1.7250 \text{ / lb} \end{aligned} \tag{9}$$

4.2.2.10 Row 10: Price Change Needed for 20% GM (%)

To determine the percentage change in price needed, denoted as Z, first calculate the added revenue necessary by subtracting the current revenue R from the goal revenue R_0. Then, divide this difference by the current revenue, R, and multiply by 100 to express Z as a percentage. It's important to note that Z can be negative; if the company is already reaching its goal in the current simulation, it could actually **decrease** prices and still reach its target. The calculation is as follows:

$$\begin{aligned} Z &= 100 \times \frac{R_0 - R}{R} \\ &= 100 \times \frac{\$84,592,330 \text{ / lb} - \$82,905,450}{\$82,905,450} \\ &\approx \$2.0347\% \end{aligned} \tag{10}$$

4.2.2.11 Row 11: Millions of Pounds Sold

The TTM pounds sold over the chosen period, V, expressed in millions. For an annual time range, $V \approx 49.04$ million pounds.

4.2.2.12 Row 12: Millions of Pounds Sold Needed for $20M GM (Annually)

The solution for achieving the $20-million gross margin dollar goal involves increasing the volume, which will lead to both higher revenue and costs but keep prices unchanged.

First, we need to determine the current gross margin in dollars, N, to find the current profit per pound sold, Y. This can be found easily, using:

$$N = R - O - P \tag{11}$$

where R is the current revenue, O is the current non-live cost of goods, and P is the current live poultry cost (as determined in `4.2.2.7`). Substituting the simulated inputs, we find:

$$\begin{aligned} N &= \frac{\$82,905,450 - \$33,514,471 - \$34,159,393}{49,037,892 \text{ lbs}} \\ &= \$15,231,586 \end{aligned}$$

where N is the current gross margin in dollars.

Next, we calculate the current gross margin profit per pound sold, Y, using:

$$Y = \frac{N}{V} \tag{12}$$

where V is the current volume (as found in `4.2.2.11`). Inserting simulated inputs:

$$\begin{aligned} Y &= \frac{\$15,231,586}{49,037,892 \text{ lbs}} \\ &\approx \$0.3106 \text{ / lb} \end{aligned}$$

With prices staying constant, Y will also stay the same. To find the necessary volume, V_0, needed to achieve the $20 million gross margin goal

$$
\begin{aligned}
V_0 &= \frac{N_0}{Y} \\
&= \frac{\$20,000,000}{\$0.3106\ /\ \text{lb}} \\
&= 64,389,739 \text{ lbs}
\end{aligned} \tag{13}
$$

where N_0 is the goal gross margin dollars ($20 million) and Y is the profit per pound sold.

4.2.2.13 Row 13: Volume Change (%) Needed for $20M GM (Annually)

To determine the percentage change in volume needed, denoted as S, first, calculate the added volume necessary by subtracting the current volume V from the goal volume V_0. Then, divide this difference by the current volume, V and multiply by 100 to express S as a percentage. It's important to note that S can be negative; if the company is already reaching its goal in the current simulation, it could actually **decrease** volume and still reach its target. The calculation is as follows:

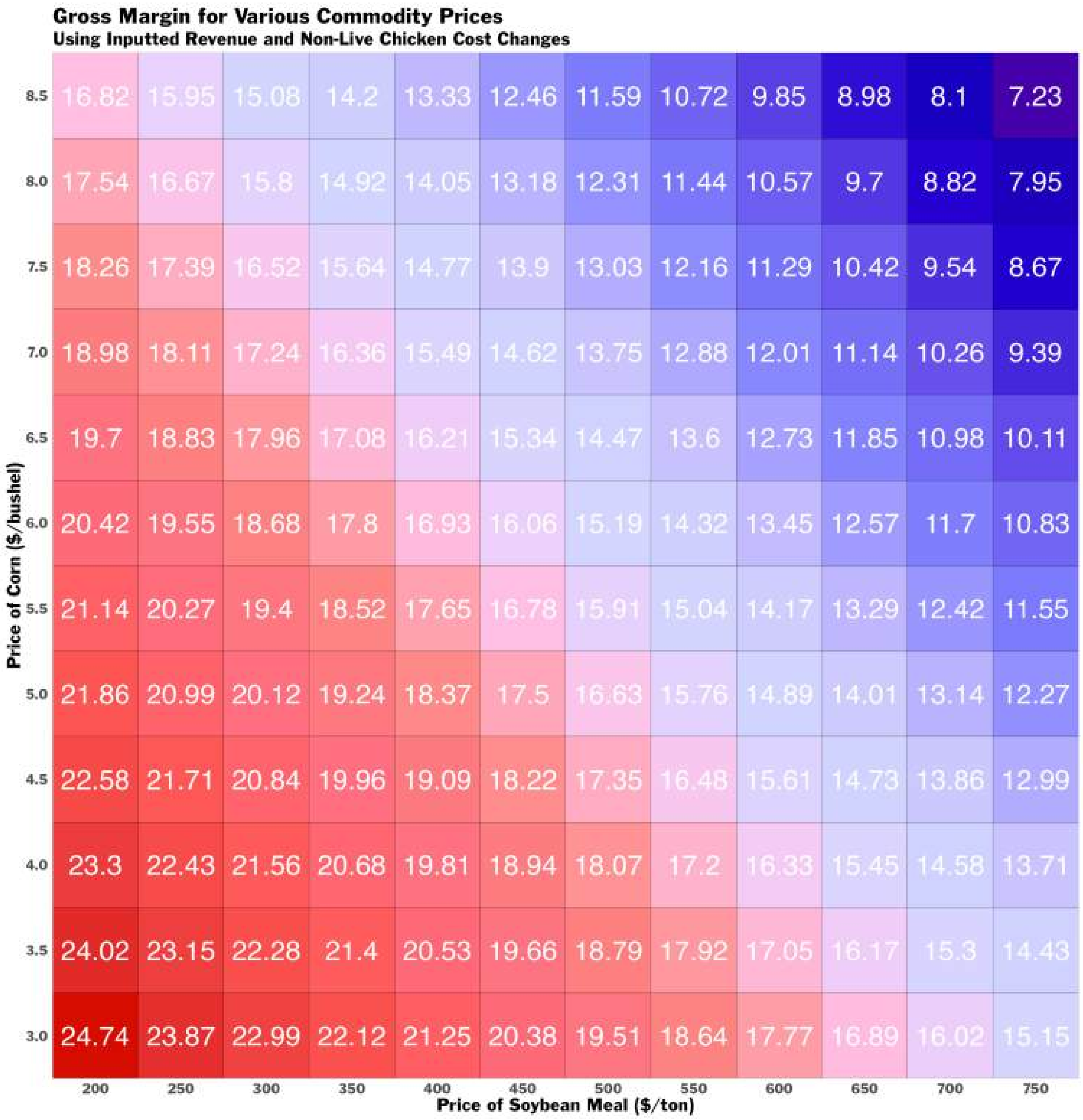
$$
\begin{aligned}
S &= 100 \times \frac{V_0 - V}{V} \\
&= 100 \times \frac{64,389,739 \text{ lbs} - 49,037,892 \text{ lbs}}{49,037,892 \text{ lbs}} \\
&\approx 31.306\%
\end{aligned} \tag{14}
$$

4.3 Range Visualizations

Three visualizations produced by the tool contextualize scenarios involving different price ranges for corn and soybean under the given financial simulation.

4.3.1 Feed Cost Matrix

Following the methodology outlined in `4.2.2.7`, various soybean and corn prices are inputted into the formula to determine the gross margin percentage under different scenarios. The tool then provides Company X with ranges for its gross margin based on these price variations.



4.3.2 Price Change Matrix

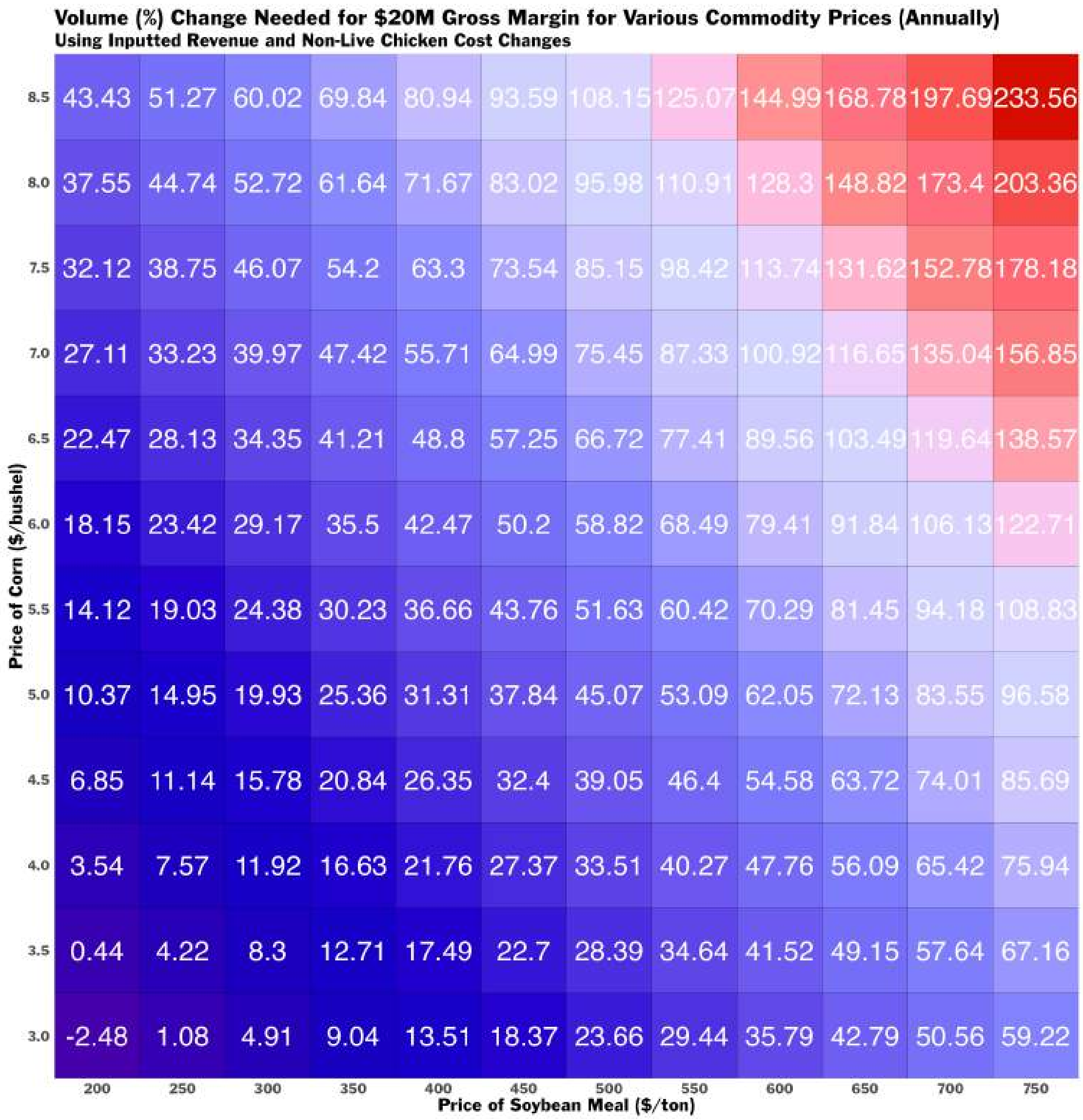
Following the methodology outlined in `4.2.2.10`, various soybean and corn prices are inputted into the formula to determine the percentage change in price under different scenarios.

Price (%) Change Needed for 20% GM for Various Commodity Prices
Using Inputted Revenue and Non-Live Chicken Cost Changes

Price of Corn ($/bushel) \ Price of Soybean Meal ($/ton)	200	250	300	350	400	450	500	550	600	650	700	750
8.5	3.98	5.07	6.16	7.24	8.33	9.42	10.51	11.6	12.69	13.78	14.87	15.96
8.0	3.08	4.17	5.26	6.34	7.43	8.52	9.61	10.7	11.79	12.88	13.97	15.06
7.5	2.18	3.27	4.36	5.44	6.53	7.62	8.71	9.8	10.89	11.98	13.07	14.16
7.0	1.28	2.37	3.46	4.54	5.63	6.72	7.81	8.9	9.99	11.08	12.17	13.26
6.5	0.38	1.47	2.56	3.65	4.73	5.82	6.91	8	9.09	10.18	11.27	12.36
6.0	-0.52	0.57	1.66	2.75	3.83	4.92	6.01	7.1	8.19	9.28	10.37	11.46
5.5	-1.42	-0.33	0.76	1.85	2.93	4.02	5.11	6.2	7.29	8.38	9.47	10.56
5.0	-2.32	-1.23	-0.14	0.95	2.03	3.12	4.21	5.3	6.39	7.48	8.57	9.66
4.5	-3.22	-2.13	-1.04	0.05	1.13	2.22	3.31	4.4	5.49	6.58	7.67	8.76
4.0	-4.12	-3.03	-1.94	-0.85	0.23	1.32	2.41	3.5	4.59	5.68	6.77	7.86
3.5	-5.02	-3.93	-2.84	-1.75	-0.67	0.42	1.51	2.6	3.69	4.78	5.87	6.96
3.0	-5.92	-4.83	-3.74	-2.65	-1.56	-0.48	0.61	1.7	2.79	3.88	4.97	6.06

4.3.3 Volume Change Matrix

Following the methodology outlined in `4.2.2.13`, various soybean and corn prices are inputted into the formula to determine the percentage change in price under different scenarios.



5 Accuracy Tests

To test the accuracy of the model, **real** pounds processed and **real** non-live cost of goods were used for a month-by-month comparison. Real pounds were used in favor of the TTM average because monthly revenue reflects the actual pounds processed. Without aligning costs with the same volume scale, the error metrics would not accurately represent the model's performance.

Company X employs hedging strategies to lock in prices for corn and soybean meal. To account for these maneuvers, the simulated live chicken price for past months was adjusted by subtracting the estimated per-pound gain or loss on live chicken from hedging investments. For example, if Company X paid $0.55 per pound for live chicken but savings from corn hedging reduced costs by $0.02 per pound, then the adjusted real live chicken price would be $0.53 per pound.

Comparing the model's estimate to the real cost each month since June 2022 (when the partner last updated its formula), found:

- Average effective live error = $-0.0031
- Average (monthly) gross margin dollars error: $13,637.08
- Average gross margin percentage error: -0.2304%

Significantly greater error was observed in November as compared to other months, primarily due to the increased turkey sales during Thanksgiving. Since turkeys are purchased from a third party processor and are not raised by Company X's grower, the model consistently underestimated costs and overestimated gross margin during the month. After excluding November, the errors were:

- Average effective live error = $-0.0031
- Resulting average (monthly) gross margin dollars error = $45,528.39
- Resulting average gross margin percentage error: -0.6895%

It's important to note that live poultry sales are excluded from revenue and cost of goods before analysis. Including these sales would slightly lower the real gross margin (on average, the simulated gross margin is about 0.33% higher than the real gross margin).

6 Discussion

6.1 Potential Errors

The model is expected to remain reliable as long as there are no significant shifts in the industry's economic conditions (e.g., global inflation or major changes in Company X's operations). The differences observed in Section 5 may be attributed to several potential sources of error, some of which were touched on earlier. These include:

- **Live chicken cost variables**
  The model assumes a **fixed** price for various feed mill variables. While most utilities remain relatively stable month-to-month, chick prices can fluctuate. Since there is no mechanism for Company X to hedge against chick prices, it is at the mercy of the industry. However, since changes in chick prices are generally minimal—often just a cent or less—the impact on model accuracy, as noted in Section 5, is relatively minor.

- **General industry changes in November**
  November sees a significant increase in turkey orders due to Thanksgiving, which is not accounted for in the model. The model, based on annual averages and chicken prices, is less effective for predicting November's financial outcomes. A more accurate model could incorporate turkey revenue to address this seasonal anomaly.

- **Removal of live poultry sales**
  The analysis excludes live poultry sales from both revenue and cost of goods. Although this exclusion is relatively minor, it affects the output. On average, as discussed earlier, the simulated gross margin percentage is about 0.33% higher than the actual gross margin percentage. While this isn't a substantial discrepancy, it is important for Company X to consider.

6.2 Practical Uses

In the future, this model can be utilized to contextualize different commodity pricing scenarios for Company X and their impact on profitability. While some economic outcomes are obvious (e.g., paying less for corn is always advantageous), the quantitative effects of various scenarios are less clear. This tool helps Company X understand the reality awaiting them under different market conditions. Additionally, since hedging strategies allow Company X to lock in prices months in advance, this tool can help them proactively address higher-than-expected costs, whether through adjusting prices or altering volume, thereby avoiding last-minute financial pressures.

6.3 Future Steps

With more time, I would have explored incorporating corn and soybean price prediction models into the tool. Such models could offer the company tailored recommendations based on current and anticipated market conditions as well as its financials. A model that suggests hedging strategies aligned with the current market snapshot would be invaluable. It could advise the company on whether to lock in prices to achieve its gross margin goals or to wait for better market conditions, balancing the risk of falling short of targets against the opportunity to maximize its gross margin.

7 Acknowledgements

This internship was an incredibly rewarding experience, and I am grateful to my employer for the opportunity to expand my horizons and deepen my knowledge of both the industry and data science.

The following R libraries were utilized in my making of the graphics:

- caret
- dplyr
- extrafont
- flexdashboard
- ggplot2
- ggpubr
- ggsci
- gt
- knitr
- plotly
- RColorBrewer
- sf
- shiny
- terra
- tidyverse