DBA5103 Group Project

Optimizing Feed Sourcing & Sale Timing for Catfish Producers

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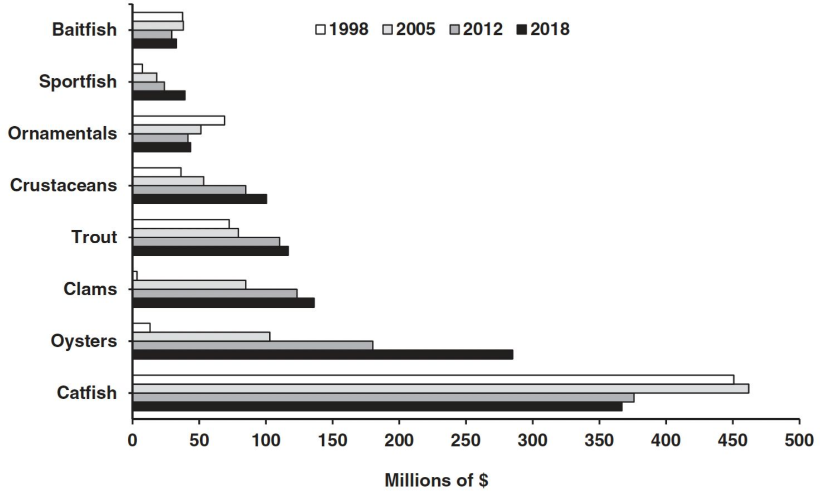
Problem Statement

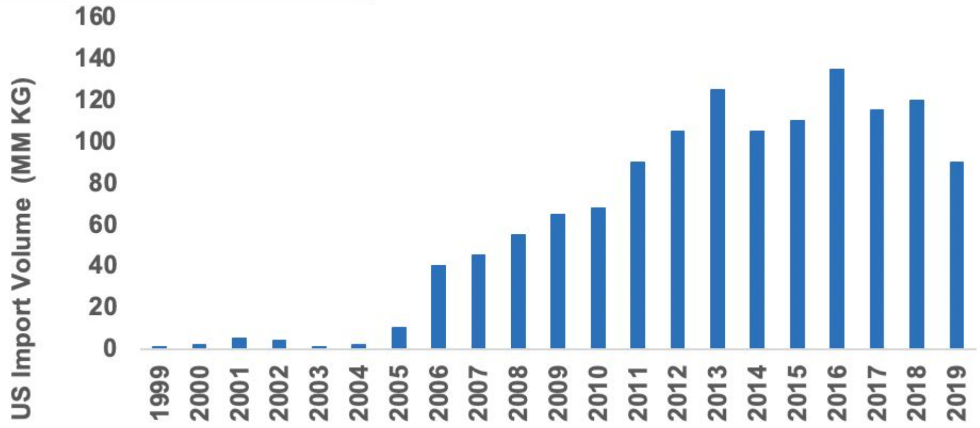
Introduction & Motivation

Global consumption by species group (%)



(Source) https://www.tandfonline.com/doi/full/10.1080/13657305.2021.1896606

US import volume (MM kg)



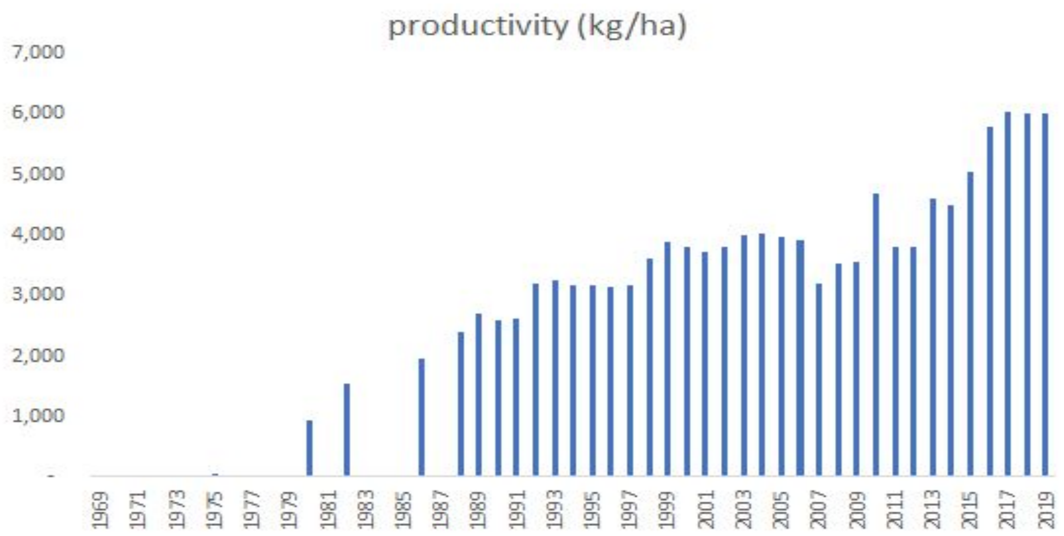
(Source) https://www.tandfonline.com/doi/full/10.1080/13657305.2021.1896606

- Catfish farming is the largest segment of U.S aquaculture - amounting to $365m per annum or 21% of the entire market.
- Similar to agricultural sector, fierce competition and low margins are prevalent.
- Competition has driven producers out of business, especially since foreign procedures enter the market.
- In recent years, U.S catfish producers are trying to fight back and retake their market share.

Problem Statement

<u>Key Objective</u>: Improve U.S catfish producers' expected return by optimising sourcing and sale timing strategy.

<u>Productivity yield of US catfish from 1969 – 2019</u>



<u>Pounds of feed per pound of live weight</u>

<u>Catfish</u>	Swine	Poultry	Cattle
<u>2 pounds</u>	3.5 pounds	2 pounds	6 pounds

(Source) https://gro-intelligence.com/insights/articles/us-vietnam-catfish-production

Since the lift of trade restrictions, Vietnam catfish producers have dominated the U.S market.

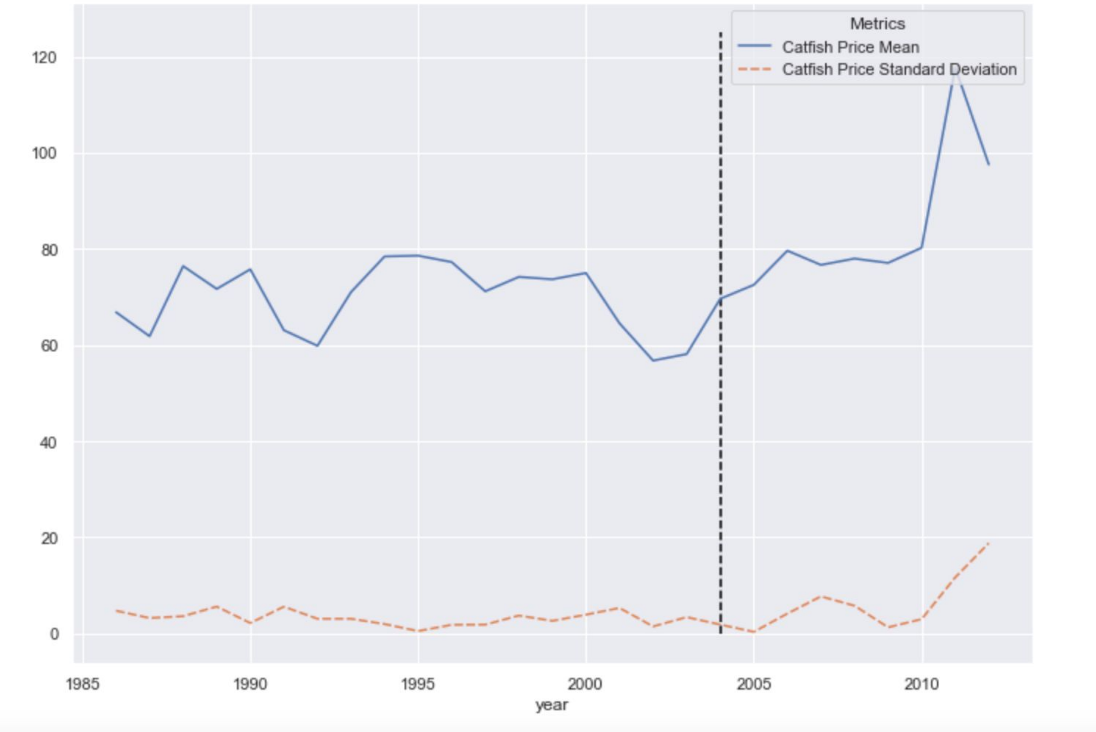
<u>Why focus on sale timing and sourcing?</u>

- Local producers are price takers which face low margins and have little bargaining power.
- Seasonality is evident in the data, adjusting sale timing could counteract the price taking characteristics.
- Feed sourcing is a great opportunity to reduce cost since feed cost is the highest cost in catfish production.

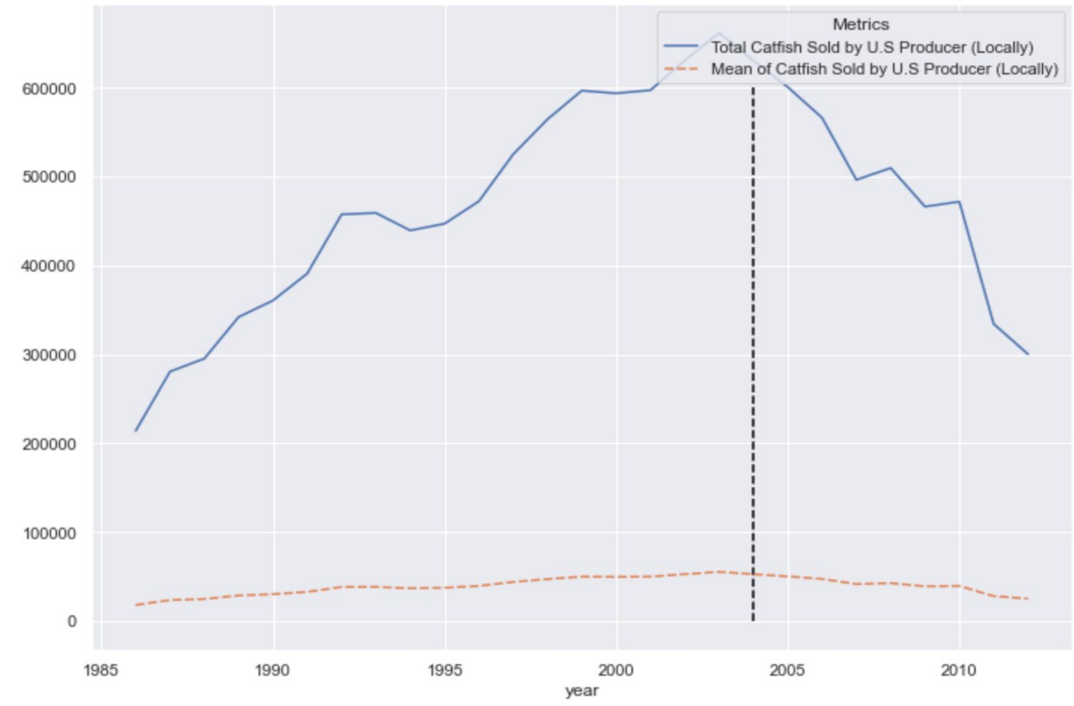
Exploratory Data Analysis (EDA)

- Our datasets contain data from U.S catfish farmers and processors' sales, inventory and stocks from 1986 to 2013.
- Focus on data from 2004 - 2012 (8 years) due to market fluctuation identified during EDA and research.
- The chosen period gives us an opportunity to capture long-term cyclical market conditions.
- We calculated the percentage deviation of each month based on its annual mean to construct the different model scenarios (optimistic and pessimistic) for the producers' catfish prices (cents/lb); this will be adopted in our second model.

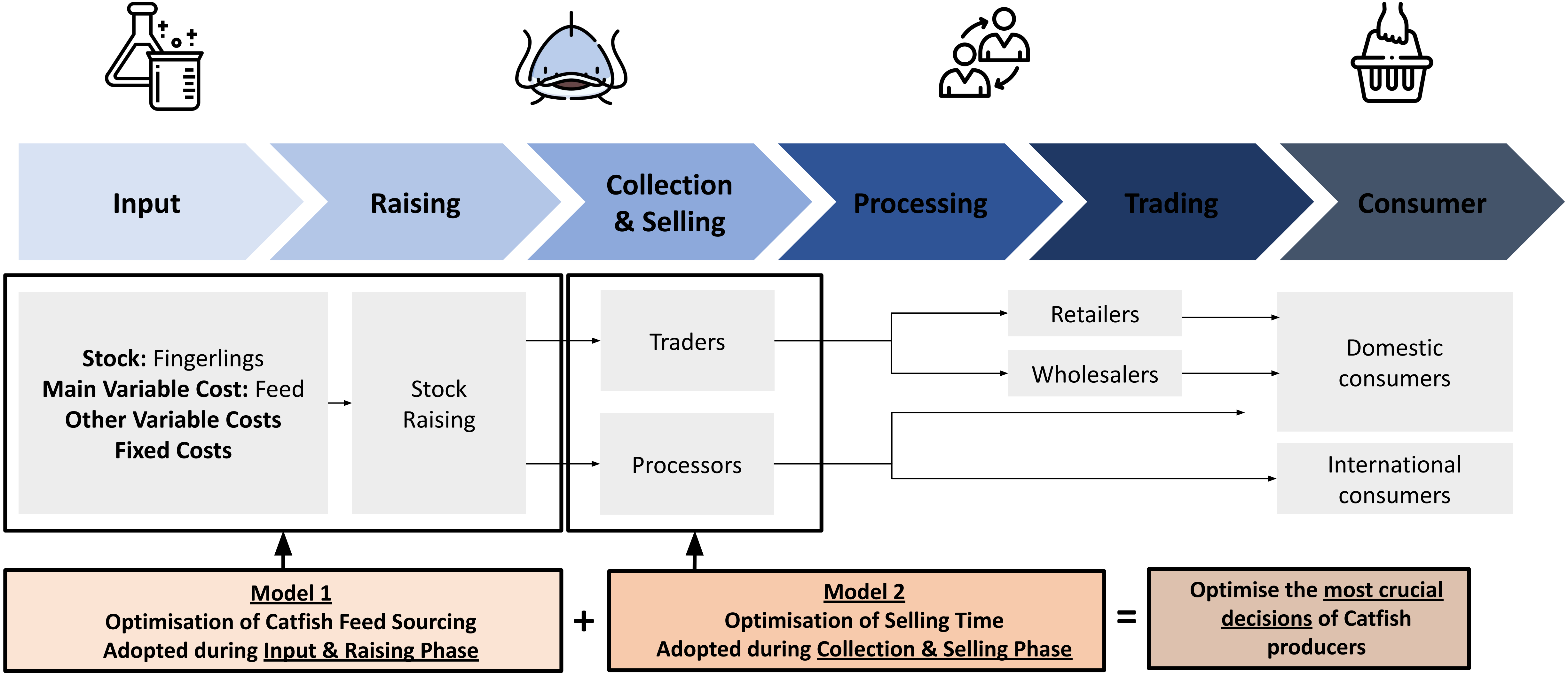
Prices of catfishes



Quantity of catfishes



Catfish Supply Chain



(Source) Food and Agriculture Organization of the United Nations, ISBN: 978-92-5-109466-2

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Methodology

Model Concepts & Assumptions

We adopted 2 models to alleviate the main risks and uncertainties faced by U.S catfish producers.

Industry Assumptions:

- **Perfect Competition:** producers are homogenous and price takers.
- **Fixed Quantity:** producers face predetermined quantity based on contractual agreements.
- **Profit Maximisation:** producers maximise profit by minimising cost and maximising revenue.
- **Linear Demand:** the demand for the catfish is linear.

Model 1 - Determine feed type (Uncertain Linear Programming)

Objective: Minimise feed cost based on the survival rate (and thus yield) it gives to catfish stock.

This model optimises decision during the producers' **input & raising phase.** We generalise producers' production capacity.

Main Assumptions:

1. U.S Producers' average farm size is 256 acres[1].
2. Producers' source of catfish supply is fingerling.
3. Highest variable costs are fish feed.
4. Catfish fingerlings average survival rate for 256 acres farms are 80%.

Model 2 - Determine optimum selling time (Game Theory)

Objective: Maximise expected gain by optimising selling time based on price fluctuation and producers' risk appetite.

This model optimises decision during the producers' **collection phase.**

Main Assumptions:

1. The market is neutral and is indifferent towards producers.
2. Production patterns of producers will change according to the risk perception of the producers.
3. There are major external factors which are uncontrollable by producers.

Model 1 - Determine Feed Type

Objective: Minimise feed cost based on the survival rate (and thus yield) it gives to catfish stock.

$$\text{Min} \sum_{i=1}^{n} C_i Q_d + 0.105F_1 + 0.115F_2 \quad \text{s.t.}$$

C_i = fixed cost per pound

Q_d = quantity of catfish to be supplied

F_1 = quantity of Feed 1 with associated mean survival rate of 0.8490

F_2 = quantity of Feed 2 with associated mean survival rate of 0.9705

$$0.105F_1 + 0.115F_2 \leq \text{Procurement Budget} \quad \text{(Budget Constraint)}$$

$$0.8490F_1 + 0.9705F_2 - 0.8(F_1 + F_2) \geq 0 \quad \text{(Survival Constraint)}$$

$$F_1 + F_2 \geq F_{total} \quad \text{(Feed Constraint)}$$

$$F_1, F_2 \geq 0$$

Introduce feed survival rate variability (next slide)

Table: Feed

Feed	Cost(per pound)	Survival Rate (Lower)	Survival Rate (Upper)	Mean
Feed 1 (30% Protein)	0.105	83.80%	86.00%	84.90%
Feed 2 (32% Protein)	0.115	96.00%	98.10%	97.05%

- Assumptions on budget are attained from catfish farmer guideline for Alabama and Arkansas (biggest catfish producers in the U.S).
- Fixed costs: equipment, land, construction and miscellaneous costs.
- Variable costs: chemical, repair and maintenance, utilities, seining and hauling, fingerling stock, labour and fish feed costs.
- Feed is the **highest cost in catfish production** thus choosing feed which gives the highest survival rate (and thus, yield) is critical.

Model 1 - Determine Feed Type

$$0.8490F_1 + 0.9705F_2 - 0.8(F_1 + F_2) \geq 0 \quad \text{(Survival Constraint)}$$

Introduce feed survival rate variability into the constraint

$$(0.849 + 0.11Z_1)F_1 + (0.9705 + 0.0105Z_2)F_2 - 0.8(F_1 + F_2) \geq 0$$

$$g(F_1, F_2) = (0.849 - 0.8)F_1 + (0.9705 - 0.8)F_2 + \max(0.011Z_1F_1 + 0.0105Z_2F_2)$$

$$g(F_1, F_2) = 0.049F_1 + 0.1705F_2 + \max(0.011Z_1F_1 + 0.0105Z_2F_2)$$

$$\text{s.t.} \quad |Z_1| \leq 1, |Z_2| \leq 1 \quad Z_1 \geq 0, Z_2 \geq 0$$

$$|Z_1| + |Z_2| \leq 2\alpha \quad 0 \leq \alpha \leq 1$$

Let $|Z_1| = x_1, |Z_2| = x_2$

$$\begin{array}{rl} x_1 + x_2 \leq 2\alpha & p_1 \\ Z_1 - x_1 \leq 0 & p_2 \\ -Z_1 - x_1 \leq 0 & p_3 \\ Z_2 - x_2 \leq 0 & p_4 \\ -Z_2 - x_2 \leq 0 & p_5 \\ x_1 \leq 1 & p_6 \\ x_2 \leq 1 & p_7 \\ x_1 \geq 0, x_2 \geq 0 & \end{array}$$

With duality, we express survival constraint as a minimisation problem:

$$g(F_1, F_2) = 0.049F_1 + 0.1705F_2 + \min\,(2\alpha p_1 + p_6 + p_7)$$

$$\text{s.t.} \quad \begin{array}{l} p_2 - p_3 = 0.011 \\ p_4 - p_5 = 0.0105 \\ p_1 - p_2 - p_3 + p_6 \geq 0 \\ p_1 - P_4 - p_5 + p + 7 \geq 0 \\ p_i \leq 0, i = 1, \ldots 7 \end{array}$$

Model 1 - Determine Feed Type

Final Model:

$$\text{Min} \sum_{i=1}^{n} C_i Q_d + 0.105 F_1 + 0.115 F_2 \quad \text{s.t.}$$

C_i = fixed cost per pound
Q_d = quantity of catfish to be supplied
F_1 = quantity of Feed 1 with associated mean survival rate of 0.8490
F_2 = quantity of Feed 2 with associated mean survival rate of 0.9705

$$0.105 F_1 + 0.115 F_2 \leq \text{Procurement Budget} \quad \text{(Budget Constraint)}$$

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$$p_2 - p_3 = 0.011$$

$$p_4 - p_5 = 0.0105$$

$$p_1 - p_2 - p_3 + p_6 \geq 0$$

$$p_1 - P_4 - p_5 + p + 7 \geq 0$$

$$p_i \leq 0, i = 1, \ldots 7$$

$$F_1, F_2 \geq 0$$

Survival Constraint

Model 2 - Determine Optimum Selling Time

Objective: Maximise* expected gain by optimising selling time based on market price fluctuation and producers’ risk appetite.

As a price taker, catfish producers can hedge against the uncertainties of the market prices by adopting different game strategies. Different producers’ behaviours are captured through six game theory models with the following linear programming model*:

$$a_{ij} = \text{price per lb matrix, i = years and j = months}$$
$$p_j = \text{proportion of sales in each month}$$
$$Z = \text{Expected gains}$$

$$\text{Max Z}^*$$

s.t.

$$Z \le \sum_{i=1,j=1}^{m,n} a_{ij} p'_j \;^*$$

$$\sum_{j=1}^{n} p_j = 1$$

$$p_j \ge 0$$

*The objective function for the Savage’s minimum regret is Min Z and $Z \ge \sum_{i=1,j=1}^{m,n} a_{ij} p'_j$

Model 2 - Determine Optimum Selling Time

Chosen Models Strategy Breakdown

Game Strategy	Producers Characteristics	Explanation
Wald (Maximin)	Pessimistic	Producer believes that market conditions will deteriorate, averts risks and seek certainty.
Laplace	Cautious	The producer believes that there are equal probabilities between best and worst outcomes.
Regrets	Minimise regrets	The producer minimize the probable regrets.
Benefit	Relatively optimistic	Production and marketing conditions will improve and the producer takes some risk.
Hurwicz	Between optimistic and pessimistic	The producer is indecisive on being optimistic or pessimistic.
Wald (Maximax)	Optimistic	Production and marketing conditions will improve and the producer takes risk.

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Preliminary Results

Preliminary Results & Analysis

Model 2 Results

Price improvement after adopting model						
	Wald (Pessimistic)	**Laplace**	**Hurwicz**	**Benefit**	**Minimum Regret**	**Optimistic**
Average Price (cents/lb)	70.665	78.52	84.41	84.56	85.358	89.01
Improvement against base (Wald Pessimistic)	-	10.01%	16.29%	16.43%	17.21%	20.61%

Unsurprisingly, the model which gives the highest increase in average price is the optimistic model, as producers under this model are willing to take more risks - presuming that market conditions are optimistic.

Based on our understanding on the catfish market, it is like that producers' risk appetite fall within range of Laplace and Hurwicz model as the producers are in a competitive market. As such, we will pay more attention to the results given by these models in our report. On average, these models give an improvement of 13.99% as compared to the pessimistic model - which is reflective of the current producers' strategy,

Preliminary Results & Analysis

Model 2 Results

Quantity sold allocation per month (in %)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pessimistic					100							
Laplace		23	77									
Min Regret				83		17						
Hurwicz			100									
Benefit	2		98									
Optimistic			100									

- All of our models suggests that U.S catfish producers should sell within one or two different months
- We can conclude that first half of the year(i.e: before July) would give higher prices to producers. This corresponds to seasonality in the catfish market also discovered in our data.
- Further, comparison between reported optimal monthly selling strategies and optimal months for the processors will be performed.

Next Steps

<u>Model 1 Result</u>
Determine a robust feed source that minimise cost and have reliable survival rate

- Find the best feed source
- Calculate **cost saving** from acquired strategy

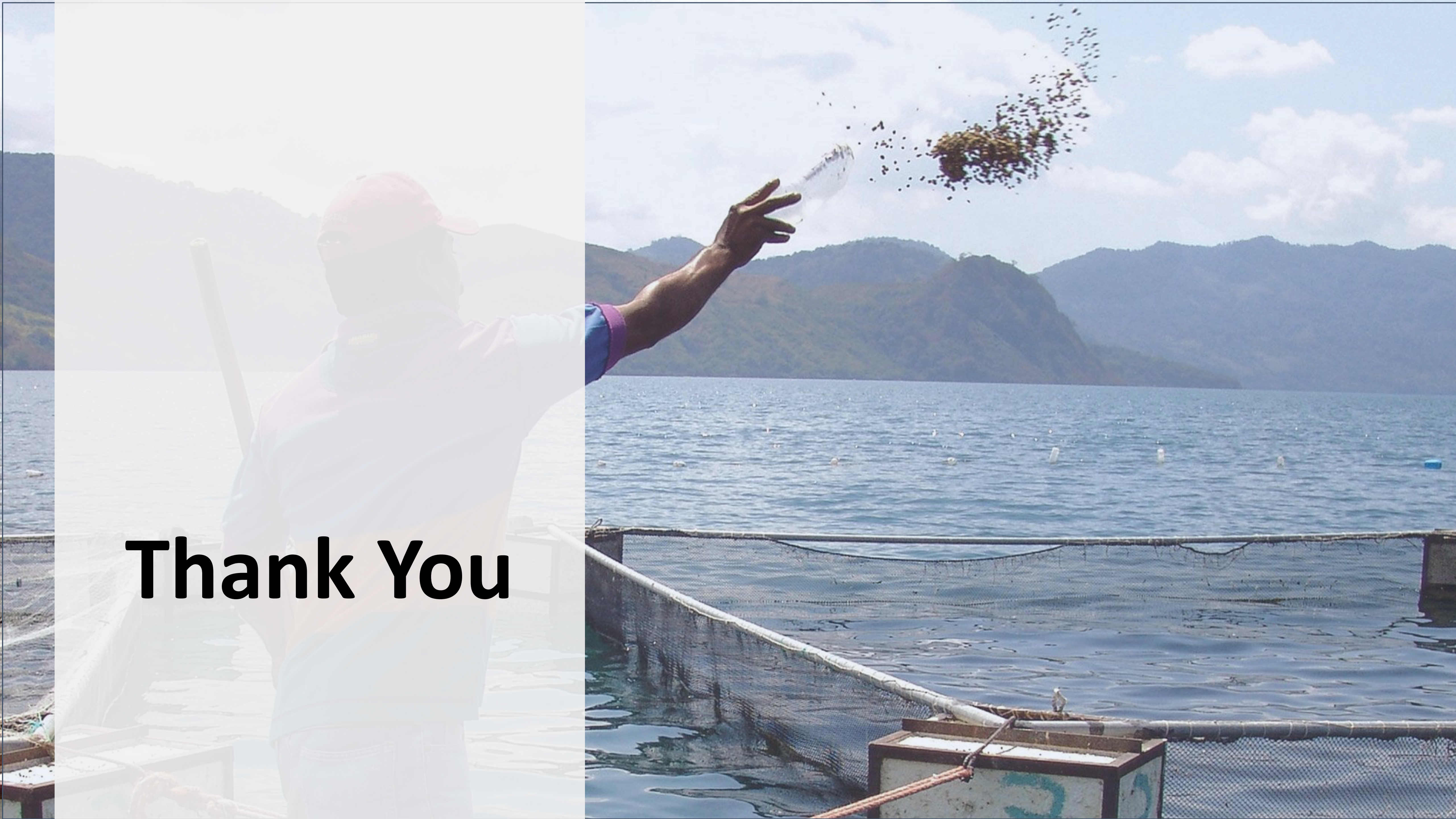
+

<u>Model 2 Result</u>
Determine the optimum selling time strategy

- Provide more bargaining power to the producers via the a better understanding of the optimal selling month so that the producers can negotiate with the intermediaries (eg. processors)
- With less uncertainty, it will enable the producers to strive for **higher revenue**

<u>Final Result & Comparison</u>
Cost reduction (Model 1) +
increased revenue (Model 2)
= Improvement in U.S Producers' Annual Profit

- Deduce most plausible strategy for producers



Thank You

Appendix

Model 2 – Wald's Maximin Criterion

Our equations

a_{ij} = price per lb matrix, i = years and j = months

p_j = proportion of sales in each month

Z = Expected gains

$$\text{Max } Z \quad \text{s.t.} \quad \begin{array}{ll} Z \leq \sum_{i=1,j=1}^{m,n} a_{ij} p'_j & p_j \geq 0 \\ & \text{i=1,2...,m} \\ \sum_{j=1}^{n} p_j = 1 & \text{j = 1,2,...,n} \end{array}$$

Wald's Maximin Criterion

The Wald's maximin criterion is a pessimistic approach where the producers have minimum risk appetite and receives only the minimum payouts. This criterion appeals to producers who are cautious and seek assurance that in the event of an unfavourable outcome, there is a least known minimum payoff.

<u>**Catfish prices ($/pound) used in Wald's Maximum Criterion**</u>

Year	January	February	March	April	May	June	July	August	September	October	November	December
2004	52.8384	59.90731	66.03441	70.57332	70.66521	65.96884	58.93655	55.87227	55.52219	57.21015	58.05823	57.97094
2005	57.34707	62.29337	66.94775	70.2825	70.8615	69.0327	62.47965	59.22624	58.85515	59.59733	61.00748	60.99551
2006	57.50527	62.12294	68.04376	76.09898	78.12432	77.26684	70.17078	66.34321	67.63465	68.81681	70.52937	70.40528
2007	66.2062	71.41155	76.53781	81.5277	82.44275	78.2243	65.84992	59.79887	56.66028	56.14003	56.12014	54.6103
2008	52.04741	58.62906	67.86109	73.38462	76.1614	76.02214	70.68929	67.65208	67.22819	67.91133	69.34967	68.97701
2009	64.07052	65.61682	70.6011	73.96627	74.78735	73.05402	66.62768	62.90743	62.75715	63.21927	64.46233	64.1041
2010	60.43195	65.19074	71.69711	77.94087	78.12432	75.25618	68.09677	64.62532	66.33398	68.48754	70.86643	72.33765
2011	73.64155	85.4723	98.18394	110.6101	114.7328	117.863	108.1944	104.464	103.6468	103.8838	105.9205	105.1038
2012	98.71606	104.7313	109.692	113.1306	101.8757	89.42655	72.84972	65.27975	64.46427	66.10036	69.2654	69.73316

Model 2 – Laplace's Criterion

Our equations

a_{ij} = price per lb matrix, i = years and j = months

p_j = proportion of sales in each month

Z = Expected gains

$$\text{Max } Z \quad \text{s.t.} \quad Z \le \sum_{i=1,j=1}^{m,n} a_{ij} p'_j \qquad p_j \ge 0$$

$$i = 1,2\ldots,m$$

$$\sum_{j=1}^{n} p_j = 1 \qquad j = 1,2,\ldots,n$$

Laplace's Criterion

The Laplace's criterion assume that there are equal probabilities for both outcomes. This is based on Jakob Bernoulli's Principle of Insufficient Reason where "in the absence of any prior knowledge", we should assume that the scenarios have the same probability". The scenarios are mutually exclusive and collectively exhaustive.

<u>**Catfish prices ($/pound) used in Laplace Criterion**</u>

Year	January	February	March	April	May	June	July	August	September	October	November	December
2004	69.14929	74.23797	77.52377	78.83233	75.50511	69.70013	65.74117	64.98758	64.75451	65.86463	65.82066	66.32502
2005	75.04975	77.19482	78.59602	78.50747	75.71485	72.93729	69.69335	68.88874	68.64168	68.61294	69.16423	69.78545
2006	75.25679	76.98361	79.88272	85.00464	83.4751	81.63716	78.27248	77.1668	78.88105	79.2271	79.9592	80.55125
2007	86.64364	88.49419	89.85465	91.06867	88.0893	82.64877	73.45274	69.55479	66.08184	64.63263	63.62345	62.48009
2008	68.11412	72.65394	79.66827	81.97263	81.37773	80.32206	78.85085	78.68921	78.407	78.18464	78.62177	78.91716
2009	83.84869	81.31328	82.88502	82.62235	79.90958	77.18606	74.3203	73.1705	73.19251	72.78279	73.08099	73.34201
2010	79.08691	80.78527	84.17172	87.06208	83.4751	79.51277	75.95901	75.16865	77.3641	78.84802	80.34133	82.76208
2011	96.37423	105.9185	115.267	123.5545	122.5909	124.5295	120.6861	121.5068	120.8814	119.5988	120.0821	120.2501
2012	129.1891	129.7844	128.7774	126.37	108.8532	94.48464	81.26071	75.92985	75.1835	76.09971	78.52624	79.78227

Model 2 – Savage's Regret Criterion

Our equations

a_{ij} = price per lb regrets matrix, i = years and j = months

p_j = proportion of sales in each month

Z = Expected regrets

$$\text{Min } Z \quad \text{s.t.} \quad Z \geq \sum_{i=1,j=1} a_{ij} p_j' \qquad p_j \geq 0$$

$$\sum_{j=1}^{n} p_j = 1, \qquad i=1,2\ldots,m \qquad j = 1,2,\ldots,n$$

Savage's Regret Criterion

The Savage's Regret criterion examines the regret, opportunity cost or loss resulting when a particular situation occurs and the payoff of the selected alternative is smaller than the payoff that could have been attained with that particular situation. The producer looks at the maximum regret of each situation and select the smallest value. This approach appeals to cautious producers.

Catfish prices ($/pound) used in Savage's Regret Criterion

Year	January	February	March	April	May	June	July	August	September	October	November	December
2004	6	2.5	0.5	0	0.8	3.9	4.6	4.5	4.5	3.3	3.9	3.8
2005	0.8	0.2	0	0.8	1.1	1.2	1	0.9	0.9	0.9	0.9	0.7
2006	11.1	10.9	9.3	5.3	4.2	3.1	2.6	2.7	0.6	0.2	0.1	0
2007	0.4	0.3	0.3	0	0.1	2.4	7.9	11	14.4	15.9	17.5	19.1
2008	16.9	13.9	8.4	7	5.1	3.3	0.9	0	0	0.2	0.4	0.6
2009	0	4	3.7	4.7	4.8	4.7	3.9	4.1	3.8	4.2	4.5	4.7
2010	9.7	9.6	7.6	5.7	6.5	7.5	7.3	7.1	4.5	2.9	2	0
2011	34.6	27.4	20.2	13.6	10.8	4.6	2.5	0	0.2	1.5	2	2.6
2012	0	1.9	4.7	8.1	21	31.4	40.5	45	45.5	44.5	42.6	41.8

Model 2 – Benefit Criterion

Our equations

a_{ij} = price per lb matrix, i = years and j = months

p_j = proportion of sales in each month

Z = Expected gains

$$\text{Max } Z \quad \text{s.t.} \quad Z \le \sum_{i=1,j=1}^{m,n} a_{ij} p_j' \qquad p_j \ge 0$$

$$\sum_{j=1}^{n} p_j = 1 \qquad i=1,2\ldots,m \qquad j = 1,2,\ldots,n$$

Benefit Criterion

The Benefit criterion is a relatively optimistic where the producers are willing to take some degree of risk. Given that the payoff will be lower than those from the Wald's Maximax Criterion.

Catfish prices ($/pound) used in Benefit Criterion

Year	January	February	March	April	May	June	July	August	September	October	November	December
2004	0	3.5	5.5	6	5.2	2.1	1.4	1.5	1.5	2.7	2.1	2.2
2005	0.4	1	1.2	0.4	0.1	0	0.2	0.3	0.3	0.3	0.3	0.5
2006	0	0.2	1.8	5.8	6.9	8	8.5	8.4	10.5	10.9	11	11.1
2007	18.7	18.8	18.8	19.1	19	16.7	11.2	8.1	4.7	3.2	1.6	0
2008	0	3	8.5	9.9	11.8	13.6	16	16.9	16.9	16.7	16.5	16.3
2009	4.8	0.8	1.1	0.1	0	0.1	0.9	0.7	1	0.6	0.3	0.1
2010	0	0.1	2.1	4	3.2	2.2	2.4	2.6	5.2	6.8	7.7	9.7
2011	0	7.2	14.4	21	23.8	30	32.1	34.6	34.4	33.1	32.6	32
2012	45.5	43.6	40.8	37.4	24.5	14.1	5	0.5	0	1	2.9	3.7

Model 2 – Hurwicz's Criterion

Our equations

a_{ij} = price per lb matrix, i = years and j = months
p_j = proportion of sales in each month
Z = Expected gains

$$\text{Max } Z \quad \text{s.t.} \quad Z \le \sum_{i=1,j=1}^{m,n} a_{ij} p'_j \qquad p_j \ge 0, \quad i=1,2\ldots,m, \quad j=1,2,\ldots,n$$
$$\sum_{j=1}^{n} p_j = 1$$

Hurwicz's Criterion

The Hurwicz's criterion attempts to strike a balance with the maximax and maximin criteria. It suggest that the minimum and maximum of each scenario should be averaged using an α and (1- α) as weights. α represents the index of optimism. In our model, we have assumed that the α is 0.8 because the USA government has imposed tariff to protect its agricultural industry.

Catfish prices ($/pound) used in Wald criterion: Pessimistic producers

Year	January	February	March	April	May	June	July	August	September	October	November	December
2004	78.93582	82.83637	84.41738	83.78773	78.40905	71.9389	69.82394	70.45677	70.2939	71.05732	70.47812	71.33746
2005	85.67136	86.13568	85.58498	83.44246	78.62686	75.28004	74.02157	74.68623	74.5136	74.0223	74.05829	75.05942
2006	85.9077	85.90002	86.9861	90.34804	86.68556	84.25935	83.13349	83.66096	85.62888	85.47327	85.61711	86.63883
2007	98.90611	98.74378	97.84476	96.79325	91.47723	85.30346	78.01444	75.40834	71.73477	69.72819	68.12544	67.20196
2008	77.75415	81.06888	86.75258	87.12543	84.50754	82.90201	83.74778	85.31149	85.11429	84.34862	84.18504	84.88124
2009	95.71559	90.73116	90.25537	87.81599	82.98291	79.66528	78.93587	79.32833	79.45372	78.5209	78.25219	78.88476
2010	90.27989	90.14199	91.65649	92.53481	86.68556	82.06673	80.67635	81.49465	83.98217	85.06431	86.02627	89.01675
2011	110.0138	118.1862	125.5168	131.3212	127.3058	128.5294	128.1812	131.7325	131.2221	129.0278	128.5791	129.3379
2012	147.4729	144.8164	140.2286	134.3136	113.0397	97.5195	86.30731	82.31991	81.61503	82.09932	84.08275	85.81173

Model 2 (Wald's Maximax Criterion)

Our equations

a_{ij} = price per lb matrix, i = years and j = months

p_j = proportion of sales in each month

Z = Expected gains

$$\text{Max } Z \quad \text{s.t.} \quad Z \leq \sum_{i=1,j=1}^{m,n} a_{ij} p'_j \qquad p_j \geq 0$$

$$\text{i=1,2...,m}$$

$$\sum_{j=1}^{n} p_j = 1 \qquad \text{j = 1,2,...,n}$$

Wald's Maximax Criterion

The Wald's maximax criterion is an optimistic approach where the producers is willing to take maximum risk and receives maximum payouts. This criterion appeals to producers who are risk takers that in the event of a favourable outcome, there is a maximum payoff.

Catfish prices ($/pound) used in Wald's Maximum Criterion

Year	January	February	March	April	May	June	July	August	September	October	November	December
2004	85.46017	88.56863	89.01312	87.09134	80.34501	73.43142	72.54579	74.10289	73.98683	74.51912	73.58309	74.67909
2005	92.75243	92.09626	90.24428	86.73244	80.56819	76.84187	76.90705	78.55123	78.42821	77.62855	77.32099	78.57539
2006	93.0083	91.84428	91.72168	93.9103	88.82588	86.00748	86.37417	87.9904	90.12744	89.63738	89.38904	90.69722
2007	107.0811	105.5768	103.1715	100.6096	93.73585	87.07325	81.05557	79.31071	75.5034	73.12523	71.12676	70.34987
2008	84.18083	86.67883	91.47545	90.56064	86.59407	84.62198	87.0124	89.72634	89.58581	88.45794	87.89388	88.8573
2009	103.6269	97.00974	95.16894	91.27842	85.03181	81.3181	82.01291	83.43356	83.62787	82.3463	81.69966	82.57993
2010	97.74188	96.37981	96.64634	96.18329	88.82588	83.76937	83.82124	85.71198	88.39422	89.2085	89.81623	93.18652
2011	119.1069	126.3646	132.3501	136.4989	130.4491	131.196	133.1779	138.5496	138.116	135.3138	134.2438	135.3964
2012	159.6621	154.8376	147.8627	139.6093	115.8307	99.54273	89.67171	86.57995	85.90272	86.09907	87.78709	89.83137