CATFISH REVENUE MANAGEMENT STRATEGY

For local catfish market in Nigeria

Abstract

Seafood safety and environment sustainability certification was implemented by WorldFish in Nigeria where fish is an important part of household diet and the majority of the fish is consumed domestically (WorldFish, 2021). This project is based on preceding study on local catfish market in Nigeria. The objective is to conduct revenue optimisation and pricing analysis on Nigeria's catfish market, which is focused on 8 catfish products under 3 attributes, particularly certification attribute. Firstly, willingness to pay matrices are constructed and non-parametric analysis is applied to identify demand/price relationship. Secondly, price differencing method is used to achieve revenue optimisation by distinguishing fish attributes. Next, multinomial logit demand model is used to obtain attraction values associated with prices and Markov Chain Choice model is applied in joint pricing & assortment optimisation. To implement markdown pricing strategy, a 5-day fish selling scenario is simulated.

Group 12 Revenue Management Consultig Report

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1 Project Overview and Objective

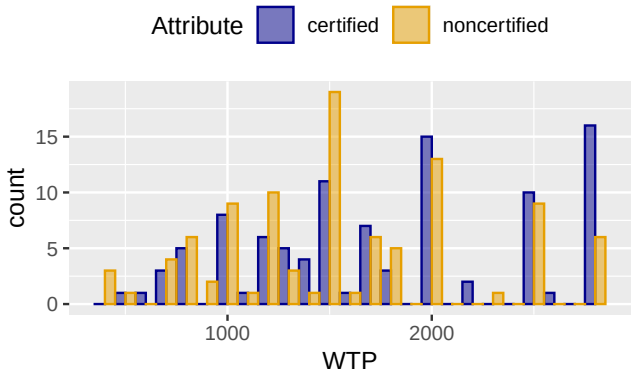
This project's aim is to explore the possibility of revenue optimisation in the local catfish market of Nigeria according to latest-released seafood safety certification policy. As Nigeria is a developing country in Africa, the project is to examine consumers' willingness to pay (WTP) for safety and environment sustainability certified catfish and boost local catfish market in Nigeria. The data are from a previous fish consumption study on the catfish consumption in Nigeria, collected by Kelvin et al. (2020), supporting concrete strategies and practices in different levels of revenue management and pricing in Nigeria catfish market.

2 Data Exploration

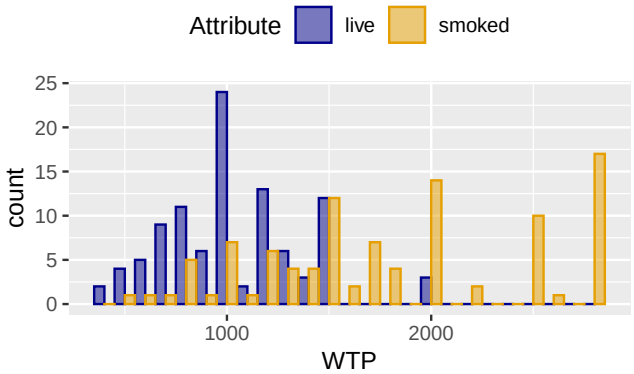
The original survey data were made by WorldFish Center to assess consumers' demand for seafood safety certification. From WTP-recording sheets in the original survey, consumers are expected to fill the survey by choosing from a range of prices that each fish price (in Naira: ₦) is selected from ₦0 to ₦2,850 by an increment of ₦50. Consumers' WTPs are extracted from the data to explore revenue management and pricing on catfish consumption behaviour and knowledge about food safety. The original dataset consists of 100 survey respondents' WTPs. Data are examined to exclude any missing value, where no missing value exists. The `consumer_id`, `fish_product`, and `price` represent numbers assigned to each consumer, types of catfish product and consumer's maximum WTP (the highest price that a consumer is willing to pay for certain catfish product). The survey involves 8 catfish products, where products vary in three attributes, namely **certification status** (certified vs non-certified labeled), **size** (250g vs 500g for smoked fish; and 500g vs 1,000g for live fish), and **form** (live and smoked). Specifically, the 8 fish products are classified as follows: (1) Non-certified, live, large, (2) Certified, smoked, large, (3) Certified, live, large, (4) Non-certified, live, medium, (5) Non-certified, smoked, large, (6) Certified, live, medium, (7) Non-certified, smoked, medium, and (8) Certified, smoked, medium.

WTP matrix is constructed and transformed from original survey dataset, in which rows represent 100 consumers and columns are maximum WTPs. We plot histograms to visualise

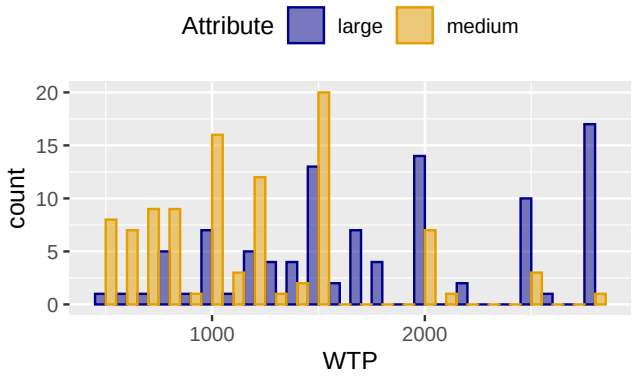
the distributions of WTPs as shown in Figure 1. In plot (a), the distribution of non-certified fish is more symmetric, centred at approximately ₦1,500; certified fish shows a skew to right, centred at around ₦2,000. Certified fish has the greatest consumer count with WTP close to ₦2,850, while non-certified fish reaches its highest point with WTP around ₦1,500. In plot (b), distributions present a huge mean difference. Live fish is in a left-skewed shape, where the mid-point is ₦1,000, while smoked fish is much more right-skewed, where the mid-point is around ₦2,000. The highest point of live fish is at ₦1,000 while that of smoked fish is at ₦2,850. Plot (c) has left-skewed distribution of large fish and right-skewed distribution of medium fish. Large fish is centred at around ₦1,000 with highest point at ₦1,500, while medium fish is centred at ₦2,000 with greatest count at ₦2,850. In conclusion, consumers' sensitivity to different prices is affected the most by live/smoked attribute. Nevertheless, the least mean difference of consumers' WTPs can be found in certification attribute which is essential to make strategies and improve revenue.



(a) For certified and noncertified



(b) For smoked and live

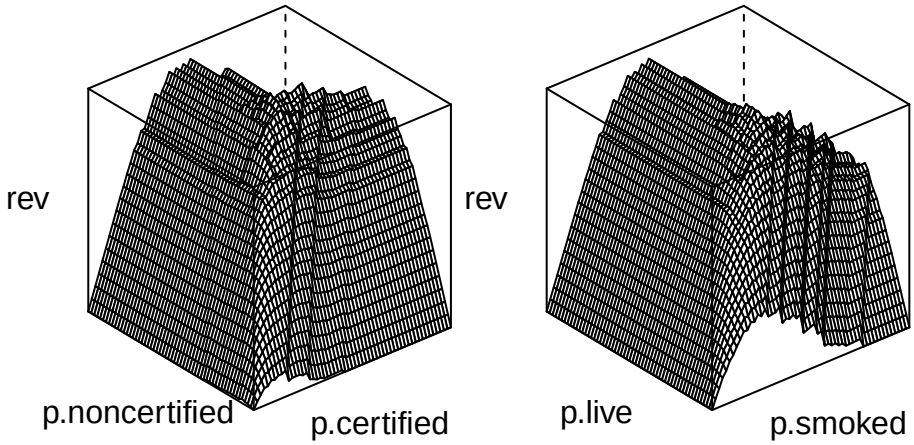


(c) For large and medium

Figure 1: The comparison of WTP distributions across three catfish attributes.

3 Price Differencing by Fish Attributes

WTPs are directly used to estimate demand without making assumptions on the distributions, and non-parametric analysis is applied to identify demand/price relationship. Each attribute differentiates two prices. Taking certified fish as an example, we search prices from ₦50 to ₦2,850 with increment of ₦50, and demands are found for each combination. Specifically, a consumer buys certified fish when surplus for certified is greater than that for non-certified and greater than 0 as well. In total, 57 price points for certified and 57 for non-certified are recorded, and the same process is repeated for the other two catfish attributes.



(a) For different certification status **(b)** For different forms

Figure 2: Price searching processes for two attributes.

Using `lattice` package, Figure 2 shows price searching process for 2 attributes (certification and form). Revenue changes are visualised as a function of certified/non-certified prices or smoked/live prices. Similar pattern is found that revenue increases first and then decreases as two prices grow. Table 1 shows the optimal prices and expected revenues for each price differencing process. Optimal prices differentiated by attributes are found by solving non-linear optimisation in `nloptr` package. Maximum expected revenue is achieved when adopting **certification** as price differencing attribute, with a total revenue of ₦118,194, where certified fish (₦1,808) is ₦44 higher than non-certified (₦1,764). To conclude, as a novel attribute compared to fish size and form, **certification**-based pricing demonstrates that consumers have weak sensitivity to high-priced certified fish. Due to relatively small WTP difference between certified/non-certified fish, consumers potentially have strong purchase intention for

certified fish, making certification attribute a key to improve revenue.

Table 1: Two optimal prices and total revenue (in Naira) across all the products are obtained for each price searching process.

	Attribute 1: certification	Attribute 2: size	Attribute 3: form
Optimal price 1	certified = 1808	large = 1724	smoked = 1725
Optimal price 2	noncertified = 1764	medium = 1586	live = 1515
Expected revenue	118194	111942	111729

4 Joint Pricing and Assortment Optimisation

Multinomial logit demand model (MNL) also helps to identify the relationship between demand/price. Shape parameter μ is estimated by calculating the average variance of WTPs ($\mu = \frac{\sqrt{6*var}}{\pi}$). Gross utilities are obtained by computing mean WTPs across 8 products. Attraction values associated with prices are then calculated via $attraction = exp\left(\frac{util-price}{\mu}\right)$. Markov Chain Choice model is applied to conduct joint pricing assortment optimisation. The attraction values are first normalised to be summed up to 1 (including no purchase). Two parameters for the choice model, probabilities of first choice (a_j) and transition matrix (b_{ij}), are then obtained. Linear programming is constructed to find optimal assortment. Across all the 8 products, WTP medians and ₦100 price difference are used to set 3 price alternatives for each product, which is regarded as a subset, resulting in 24 alternatives in total. Price alternatives are denoted as $p_{j.i}$ ($j = 1, ..., 8; i = 1, 2, 3$). For example, $p_{j.2}$ represents WTP medians for all 8 products, namely $p_{1.2} = 900$, $p_{2.2} = 1,700$, $p_{3.2} = 1,000$, $p_{4.2} = 500$, $p_{5.2} = 1,500$, $p_{6.2} = 500$, $p_{7.2} = 1,000$ and $p_{8.2} = 950$. The other two prices within one subset are $p_{j.1} = p_{j.2} - 100$ and $p_{j.3} = p_{j.2} + 100$. To achieve joint pricing via assortment optimisation, an assumption is made that **at most** one alternative is chosen from one subset (product j). Two applications and associated results are indicated as below:

- Assortment 1: all the 8 products must be chosen. As a result, the optimal expected revenue is ₦27,284.6. In this assortment, the chosen alternatives are $p_{1.1} = 800$, $p_{2.1} = 1,600$, $p_{3.1} = 900$, $p_{4.3} = 600$, $p_{5.1} = 1,400$, $p_{6.3} = 600$, $p_{7.1} = 900$ and $p_{8.1} = 850$.
- Assortment 2: the assortment size is not constrained (i.e. no Cardinality constraint).

Therefore, the assortment that has the optimal revenue is obtained as a size of 2, in which 2 products are **certified, smoked, large fish** and **non-certified, smoked, large fish**. The associated prices are $p_{2.1} = 1,600$ and $p_{5.2} = 1,500$. As a result, the expected revenue is ₦113,550.30.

In short, the expected revenue increases greatly by assortment optimisation. However, the optimisation is subjected to limitations. Smoked fish probably costs higher than live, and large fish can be short in supply. Hence, other data should be collected to improve the analysis and refine solutions, such as intentory levels and the cost of unit product that can help with profit maximisation.

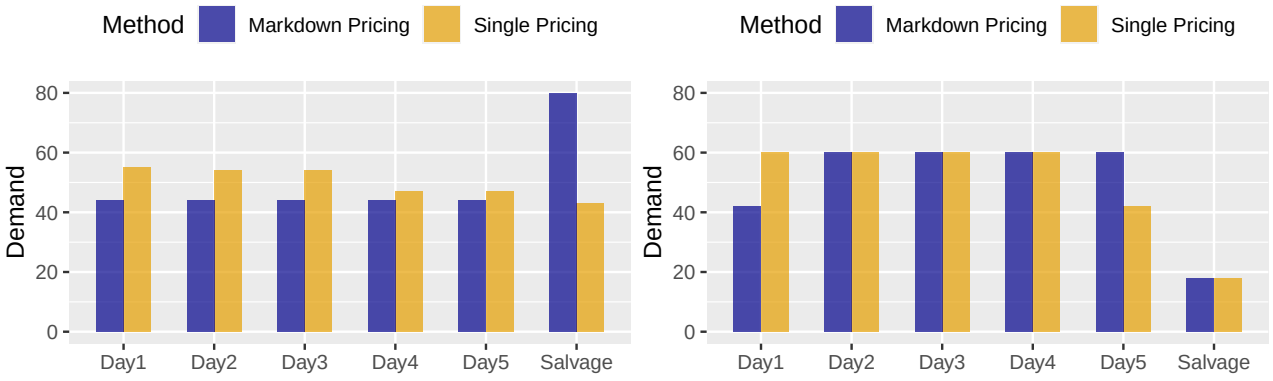
5 Markdown Pricing Strategy

Considering time-based price differencing, markdown pricing strategy is implemented to improve revenue. Two products found in the previous assortment optimisation are used, which are certified, smoked, large fish (CSL) and non-certified, smoked, large fish (NCSL). The assumptions are: (1) Selling time is 5 days. (2) Both inventory levels are 300. (3) WTPs from survey data are used for day 1. (4) Due to lack of WTPs along the time, a ₦50 decrease is applied by days throughout the whole horizon. (5) Based on the minimum WTP on the last day, salvage prices for CSL and NCSL are ₦300 and ₦200.

For markdown pricing, a modelling framework based on deterministic demand/price relationship is used via `nloptr` package. Daily demands are estimated based on consumers' surpluses. To compare single-price and markdown pricing strategies, two scenarios are as below:

- Scenario 1: single price for each product is set separately throughout the time horizon. As a result, the optimal prices are ₦1,599 for CSL and ₦1,349 for NCSL, and the expected revenue is ₦807,861.
- Scenario 2: markdown pricing strategy is performed. As a result, the optimal CSL fish prices from day 1 to day 5 are ₦1,951, ₦1,874, ₦1,845, ₦1,811 and ₦1,775, while the optimal NCSL fish prices are ₦1,500, ₦1,396, ₦1,393, ₦1,350 and ₦1,298. The maximum total revenue is ₦847,484.

It is evident that total revenue increases by 4.9%. Further, daily demands under single and markdown pricing methods are compared in Figure 3. By single-price method, demand decreases across 5 days, while demand is stable under markdown pricing method. Therefore, markdown pricing strategy is effective to improve revenue. However, salvage demand for CSL is high probably because this application is based on simulated inventory levels and WTP changes across time, which should be collected via surveys.



(a) Product1: Certified, smoked, large **(b)** Product2: Non-certified, smoked, large

Figure 3: Daily demands for two products using different pricing strategies.

6 Conclusions and Recommendations

Conclusions with recommendations are made as follows: (1) By using two-price differencing method and non-linear programming, certification attribute is identified to be essential for improving revenue. Comparing with conventional attributes (fish size and form), consumers show tendency to purchase certified fish with higher prices, making certification a potential attribute to boost revenue. (2) With application of joint pricing and assortment optimisation, large revenue increase is found in the optimal two-product assortment, where certified/non-certified, smoked, large catfish products are highly recommended. (3) Using markdown pricing method, revenue is improved effectively. Local catfish market should advocate markdown-pricing strategy to facilitate product selling and maximise total revenue. Although the analysis is partly based on real-world data from original survey, yet more data are needed, such as the cost of unit product for profit optimization, inventory levels, local catfish market size, consumers' WTPs across the time horizon, etc.

7 References

Kelvin M. S., Nhuong T., Lauren P., Vivian H., Carl J. L., Shehu L. A., Kafayat A. F., (2020), "Demand for seafood safety and environmental sustainability certification standards in sub-Saharan Africa: the case of Nigeria", https://doi.org/10.7910/DVN/SXQKZ0, Harvard Dataverse, V2.

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