**Interpretations of the charts**

**1. Utilities Chart (`utilities.png`):** A bar chart showing the utilities (coefficients) of the features from the conditional logit model.

**2. Feature Importance Chart (`feature\_importance.png`):** A bar chart showing the relative importance of `Size\_Performance`, `Advanced\_Feature`, and `Price`.

**3. Price Elasticity Chart (`price\_elasticity.png`):** A line plot showing average price elasticity versus price.

**4. Profile Shares Line Plot (`profile\_shares\_line.png`):** A line plot with profiles on the x-axis, shares (choice probabilities) on the y-axis, and four lines for the price scenarios (Baseline, 10% Increase, 10% Decrease, Custom).

**1. Utilities Chart (`utilities.png`)**

# Description

- Generated By: `plot\_utilities` method.

- Type: Bar chart.

- X-Axis: Features (e.g., `Price`, `Size\_Perf\_High`, `Adv\_Feat\_ElecLife`, etc.).

- Y-Axis: Utility values (coefficients from the conditional logit model).

- Purpose: Shows the estimated utility (preference weight) for each feature in the model, excluding the constant term.

# Expected Output

- The chart should have 9 bars (based on `X\_cols` in `fit\_model`):

- `Price`

- `Size\_Perf\_High`

- `Adv\_Feat\_ElecLife`

- `Adv\_Feat\_Health`

- `Adv\_Feat\_ModbusBasic`

- `Adv\_Feat\_Current`

- `Adv\_Feat\_ModbusEth`

- `Adv\_Feat\_Safety`

- `Adv\_Feat\_TempMon`

- Each bar represents the coefficient of the feature in the logit model, indicating its impact on choice probability.

- The `const` term is dropped (`utilities.drop('const', errors='ignore')`), so it’s not shown.

# Interpretation

**- Sign of Coefficients:**

**- Positive Coefficients:** Features with positive utilities (e.g., `Adv\_Feat\_Health`) increase the likelihood of a profile being chosen. For example, if `Adv\_Feat\_Health` (Visible Health Indication) has a positive value, respondents prefer profiles with this feature.

**- Negative Coefficients:** Features with negative utilities (e.g., `Price`) decrease the likelihood of choice. Since `Price` typically has a negative coefficient in choice models, a higher price reduces the probability of a profile being selected.

**- Magnitude:**

- Larger absolute values indicate stronger effects. If `Adv\_Feat\_Safety` has a larger positive value than `Adv\_Feat\_ElecLife`, the Operator Safety feature has a greater impact on choice than Higher Electrical Life.

- For `Price`, a more negative value (e.g., -2.5 vs. -0.5) indicates higher price sensitivity; a small price increase significantly reduces choice probability.

**- Relative Comparison:**

- Compare the utilities of dummy variables (e.g., `Adv\_Feat\_...`) to understand which advanced features are most valued. For instance, if `Adv\_Feat\_ModbusEth` (Modbus Ethernet) has a higher utility than `Adv\_Feat\_ModbusBasic` (Basic Modbus), respondents prefer the more advanced connectivity option.

- `Size\_Perf\_High` (High Performance Ics=Icu=Icw 66kA) is relative to the dropped level (likely Compact Frame Size). A positive value means High Performance is preferred over Compact Frame Size.

- Practical Insight:

- Features with the highest positive utilities are key drivers of preference. Focus on these (e.g., `Adv\_Feat\_Safety` or `Adv\_Feat\_Health`) when designing or marketing profiles.

- The negative `Price` coefficient quantifies trade-offs. For example, if `Price` = -1.0 and `Adv\_Feat\_Safety` = 0.5, a $500 increase in price (0.5 in model units, since prices are in thousands) offsets the utility gain from adding the Safety feature.

# Potential Observations

- If `Price` has a large negative value (e.g., -2.0), respondents are highly price-sensitive.

- If advanced features like `Adv\_Feat\_ModbusEth` or `Adv\_Feat\_TempMon` have high positive utilities, connectivity and monitoring features are critical to respondents.

- If `Size\_Perf\_High` is near zero, respondents may not strongly prefer High Performance over Compact Frame Size.

**2. Feature Importance Chart (`feature\_importance.png`)**

# Description

- Generated By: `plot\_feature\_importance` method.

- Type: Horizontal bar chart (via `sns.barplot`).

- X-Axis: Importance (normalized, 0 to 1).

- Y-Axis: Feature groups (`Size\_Performance`, `Advanced\_Feature`, `Price`).

- Purpose: Shows the relative importance of feature categories in driving choices.

# Expected Output

- The chart should have 3 bars:

- `Size\_Performance`: Based on the range of utilities for `Size\_Perf\_...` (only `Size\_Perf\_High` in this case).

- `Advanced\_Feature`: Based on the range of utilities for `Adv\_Feat\_...` (7 features).

- `Price`: Based on the price coefficient scaled by the price range in the data.

- Importance values are normalized to sum to 1, so each value represents a proportion (e.g., `Price: 0.5`, `Advanced\_Feature: 0.4`, `Size\_Performance: 0.1`).

**# Interpretation**

**- Dominant Feature:**

- The feature group with the highest importance drives choices the most. If `Price` has the highest importance (e.g., 0.6), price is the primary factor in respondents’ decisions.

- If `Advanced\_Feature` is highest (e.g., 0.5), advanced features (connectivity, safety, etc.) collectively have the largest impact.

**- Relative Importance:**

- Compare the bars to see trade-offs. For example, if `Price` = 0.6 and `Advanced\_Feature` = 0.3, price is twice as important as advanced features in influencing choices.

- A low `Size\_Performance` value (e.g., 0.1) suggests that the difference between High Performance and Compact Frame Size is not a major driver of choice.

**- Practical Insight:**

- If `Price` dominates, focus on competitive pricing to influence market share. For instance, a small price reduction could significantly boost a profile’s share.

- If `Advanced\_Feature` is significant, prioritize adding or highlighting features like Operator Safety or Modbus Ethernet in marketing or product design.

- If `Size\_Performance` is low, respondents may be indifferent to breaker size/performance differences, so resources might be better spent elsewhere.

**# Potential Observations**

- If `Price` importance is high (e.g., 0.7), the market is price-sensitive, and small price changes will have a large impact on shares (as seen in the profile shares plot).

- If `Advanced\_Feature` importance is high, look at the utilities chart to identify which specific features (e.g., `Adv\_Feat\_Safety`) are driving this.

- A balanced importance (e.g., 0.4, 0.3, 0.3) suggests respondents value a mix of price, features, and performance, requiring a balanced strategy.

**3. Price Elasticity Chart (`price\_elasticity.png`)**

# Description

- Generated By: `plot\_price\_elasticity` method.

- Type: Line plot with markers.

- X-Axis: Original price (in original units, after multiplying model `Price` by 1000).

- Y-Axis: Average own-price elasticity (\( E\_{ii} \)).

- Purpose: Shows how sensitive choice probabilities are to price changes at different price levels.

# Expected Output

- The x-axis should show the unique price levels in `profiles['Price']` (e.g., 1000, 1500, 2000, etc., after converting back from thousands).

- The y-axis shows elasticity values, typically negative (since higher prices reduce choice probability).

- A single line with markers connects the average elasticity at each price level.

# Interpretation

- Elasticity Values:

- Elasticity (\( E\_{ii} \)) measures the percentage change in a profile’s choice probability for a 1% change in its price.

- Negative values are expected: a higher price reduces share. For example, an elasticity of -2 means a 1% price increase leads to a 2% decrease in choice probability.

- Elastic (> |1|): If elasticity is less than -1 (e.g., -2.5), demand is elastic; price changes have a large impact on share.

- Inelastic (< |1|): If elasticity is between 0 and -1 (e.g., -0.5), demand is inelastic; price changes have a smaller impact.

- Trend Across Prices部分: Trend:

- If elasticity decreases (becomes more negative) as price increases, respondents become more price-sensitive at higher price levels.

- If elasticity increases (less negative) at higher prices, sensitivity decreases, possibly because only less price-sensitive respondents choose expensive profiles.

- Practical Insight:

- At price levels with high elasticity (e.g., -3.0), small price reductions can significantly increase market share, while price increases will hurt share substantially.

- At price levels with low elasticity (e.g., -0.8), you have more pricing flexibility; a price increase won’t drastically reduce share, which could improve revenue.

# Potential Observations

- If elasticity is consistently high (e.g., -2.5 to -3.0 across prices), the market is very price-sensitive, aligning with a high `Price` importance in the feature importance chart.

- If elasticity varies significantly (e.g., -1.5 at low prices, -3.0 at high prices), consider segmenting the market: lower prices for price-sensitive respondents, higher prices for less sensitive ones.

- If the line is relatively flat, price sensitivity is stable across price levels, simplifying pricing strategies.

**4. Profile Shares Line Plot (`profile\_shares\_line.png`)**

# Description

- Generated By: `evaluate\_price\_scenario` method (as updated in your last request).

- Type: Line plot with markers.

- X-Axis: Profiles (labeled with `profile\_labels`, e.g., `High perf... + Current M...`).

- Y-Axis: Choice probability (share, in %).

- Lines: Four lines, one for each price scenario (`Baseline`, `10% Increase`, `10% Decrease`, `Custom`).

- Purpose: Shows how profile shares change across different price scenarios.

# Expected Output

- X-axis: 16 profiles (0 to 15), with labels like `High perf... + Current M...`.

- Y-axis: Shares (e.g., 0% to 10%, since there are 16 profiles).

- Four lines with distinct colors and markers:

- `Baseline`: Original prices.

- `10% Increase`: Prices increased by 10%.

- `10% Decrease`: Prices decreased by 10%.

- `Custom`: All profiles at the mean price.

- Legend: Identifies the four scenarios.

# Interpretation

- Scenario Comparison:

- Baseline: Reflects the current market shares based on original prices. Profiles with higher shares are currently preferred.

- 10% Increase: If a profile’s share decreases compared to Baseline, it’s price-sensitive. Larger drops indicate higher sensitivity.

- 10% Decrease: If a profile’s share increases, a price reduction boosts its appeal. Larger increases suggest higher price elasticity.

- Custom: Since all profiles have the same price (mean price), differences in shares reflect preferences for non-price attributes (`SP`, `AF`). Profiles with higher shares in this scenario are preferred for their features, not price.

- Profile Preferences:

- Profiles with consistently high shares across scenarios (e.g., Profile 5 at 8% in all scenarios) are strongly preferred, likely due to valuable features (check utilities chart).

- Profiles with low shares in `Custom` (e.g., 4%) have less desirable features when price is equalized.

- Price Sensitivity:

- Profiles with large share changes between `10% Increase` and `10% Decrease` (e.g., 4% to 8%) are highly price-sensitive, consistent with the price elasticity chart.

- Profiles with small changes (e.g., 6% to 6.5%) are less affected by price, possibly due to strong feature preferences.

- Practical Insight:

- To maximize overall share, focus on profiles with high shares in `Custom` (strong feature preference) and consider price reductions for price-sensitive profiles (large share increase in `10% Decrease`).

- For profiles with low shares in all scenarios, consider improving features (e.g., adding `Adv\_Feat\_Safety` if it has high utility) rather than price adjustments.

- The `Custom` scenario highlights feature-driven preferences: use this to guide product design or marketing (e.g., emphasize Operator Safety if its utility is high).

# Potential Observations

- If shares are equal in `Custom` (e.g., ~6.25% for all 16 profiles), non-price attributes (`SP`, `AF`) have similar appeal, and price is the main differentiator.

- If one profile dominates in `Baseline` (e.g., Profile 3 at 10%) but drops sharply in `10% Increase` (e.g., to 5%), its current share relies on a competitive price, and raising its price would hurt its position.

- If a profile’s share increases significantly in `10% Decrease` (e.g., from 5% to 9%), a price cut could be a strategic move to capture more market share.

**Synthesis of Insights**

- Price Sensitivity: The price elasticity chart and profile shares plot both indicate how price changes affect choices. If `Price` has high importance (feature importance chart) and elasticity is high (e.g., -2.5), small price adjustments can significantly shift shares, as seen in the `10% Increase` and `10% Decrease` scenarios.

- Feature Preferences: The utilities chart identifies which features drive choices (e.g., `Adv\_Feat\_Safety` or `Adv\_Feat\_ModbusEth`). The `Custom` scenario in the profile shares plot confirms which profiles are preferred when price is equalized, aligning with high-utility features.

- Strategic Implications:

- Pricing: For price-sensitive profiles (large share changes in `10% Increase/Decrease`), consider targeted price reductions to boost share, especially if elasticity is high.

- Product Design: Enhance profiles with low shares in `Custom` by adding high-utility features (e.g., Operator Safety if `Adv\_Feat\_Safety` has a large positive coefficient).

- Marketing: Highlight features with high utilities (utilities chart) in campaigns, especially for profiles with strong feature-driven shares (`Custom` scenario).

- Trade-Offs: The utilities chart (e.g., `Price` = -1.5, `Adv\_Feat\_Safety` = 0.75) quantifies trade-offs. A $500 price increase (0.5 in model units) offsets the utility of adding Safety, helping you balance price and feature improvements.

**Next Steps**

1. Review Specific Values:

- If you can share specific values or trends from the charts (e.g., "Price utility is -2.0, Adv\_Feat\_Safety is 1.0", or "Profile 3 drops from 10% to 5% in 10% Increase"), I can provide more detailed interpretations.

2. Unexpected Behavior:

- If any chart shows unexpected results (e.g., positive price elasticity, no change in shares across scenarios), let me know, and I can debug the code or data.

3. Further Analysis:

- If you want to segment respondents by group (e.g., `Group A` vs. `Group B`) and compare their charts, I can help modify the code to split the analysis.

- If you want to focus on a subset of profiles (e.g., top 5 by share), I can adjust the profile shares plot.