JMP® ACADEMIC CASE STUDY

JMP043: Pricing Musical Instrument

Conjoint Analysis/Choice Model

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STATISTICAL DISCOVERY FROM SAS

Pricing a Musical Instrument
Conjoint Analysis/Choice Model

Key ideas:

This case study requires the use of regression and concepts related to choice modeling (also called conjoint analysis) to understand and analyze the importance of the product attributes and their levels influencing the preferences.

Background

Joseph runs a musical instrument shop. Of the many products he manufactures and sells, flutes are the leading musical instrument. The perceived quality of the flute depends on the method (how it was made): by hand, by machine or by a combination of the two (hybrid). The material can be bamboo, plastic, or metal. Joseph then chooses three price levels that he thinks are affordable for his customers.



The Task

Joseph wants to find out which of the combinations are most preferred by customers. He also wants to understand the perceived utility and importance of the three attributes so that he can plan further for mass production. Joseph wants to know the type of instrument to be produced and its assigned price.

Each of the product attributes, namely material, method and price have three levels each, resulting in a total of 27 profiles or combinations. This is considered as full factorial design. Due to lack of resources, Joseph decides to go for a fraction of the factorial design and chooses only nine combinations (based on his experience and knowledge) out of 27. He begins by conducting a survey. Each profile is given an ID and the description of the of the profiles is shown in Exhibit 1.

Exhibit 1 Profile Descriptions

Profile ID	Material	Method	Price in USD
BH50	Bamboo	Hand	50
BM100	Bamboo	Machine	100
BC150	Bamboo	Hybrid	150
PH100	Plastic	Hand	100
PM150	Plastic	Machine	150
PC50	Plastic	Hybrid	50
MH150	Metal	Hand	150
MM50	Metal	Machine	50
MC100	Metal	Hybrid	100

The Data Instrument Preference.jmp

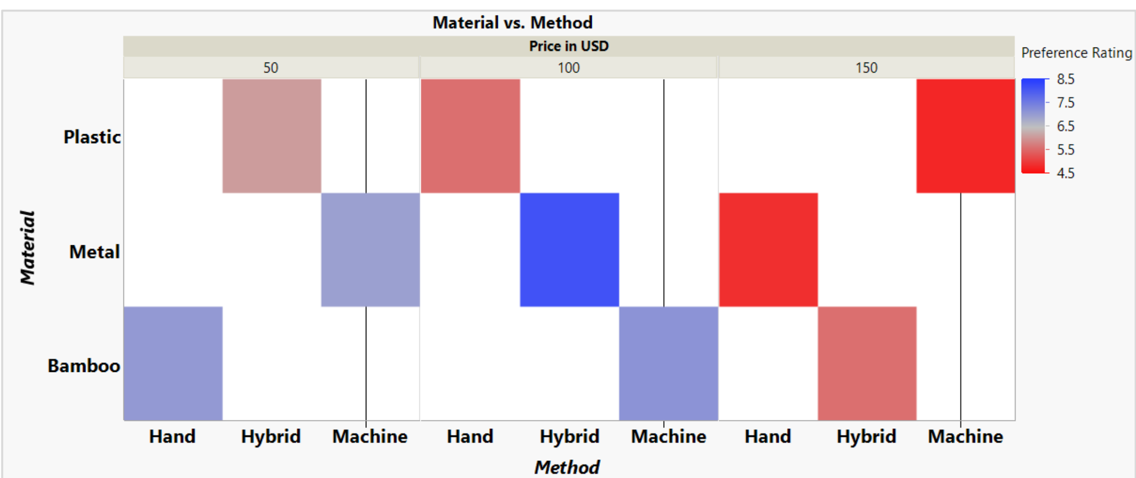
The nine profiles were presented to 10 musicians. Their preferences were collected on a rating scale of 1 to 10 (1 being the least preferred and 10 being the most). This exercise generated 90 observations. The variables in the data set are:

Respondent ID	ID of the 10 respondents
Profile ID	ID of the profile
Material	Material involved in making (three levels)
Method	Process of making (three levels)
Price in USD	Planned price of the flute (three levels)
Preference Rating	Rating provided by the respondent for each profile ID

Visualization

Let us visualize the data using Graph Builder, JMP's powerful exploratory data analysis platform that helps explore data visually.

Exhibit 2 Heat Map of the Preference Rating of the Attributes



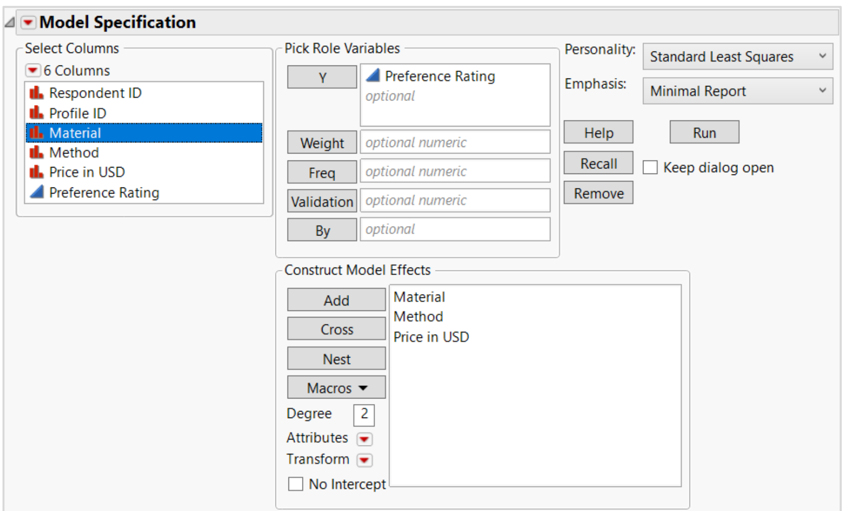
To create, Graph>Graph Builder>Drop Method to the X axis; Material to the Y axis; Price to the Group by X; Preference Rating to the Color. Choose the Heat Map from the top graph lists. To inverse the colors for the preference rating, right-click on the color gradient, choose Gradient and select Reverse Colors.

From Exhibit 2, one can observe that the metal flutes made by machine and hand priced at $100 are the most preferred. The heat map also suggests that plastic flutes made by hand priced at $150 are the least preferred.

Regression analysis

To find out the utility of the each of the attributes, we will be applying regression technique to derive part-worths. When multiple attributes are used to describe the total worth of the product, the utility values for the individual parts of the product (assigned to the multiple attributes) are known as part-worths. Part-worths are generally estimated using OLS (ordinary least squares regression) and can be understood as utilities for each of the attributes’ levels.

Exhibit 3 Regression Window



To create, Analyze>Fit Model>Y = Preference Rating; Material, Method and Price as Model Effects. Choose Minimal Report as Emphasis. Click Run to produce Minimal Report. Using the red triangle drop-down for Response Preference Rating, choose Estimates and select Expanded Estimates.

Exhibit 4 Estimates of All Factors at All Levels

Expanded Estimates

Nominal factors expanded to all levels

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	6.2777778	0.12042	52.13	<.0001*
Material[Bamboo]	0.3555556	0.1703	2.09	0.0399*
Material[Metal]	0.4222222	0.1703	2.48	0.0152*
Material[Plastic]	-0.777778	0.1703	-4.57	<.0001*
Method[Hand]	-0.411111	0.1703	-2.41	0.0180*
Method[Hybrid]	0.3555556	0.1703	2.09	0.0399*
Method[Machine]	0.0555556	0.1703	0.33	0.7451
Price in USD[50]	0.4555556	0.1703	2.68	0.0090*
Price in USD[100]	0.7222222	0.1703	4.24	<.0001*
Price in USD[150]	-1.177778	0.1703	-6.92	<.0001*

The expanded OLS estimates based on effects coding of the qualitative factors are shown in Exhibit 4 as part-worths. Please note that the utilities in the expanded estimates sum to zero for each attribute.

To know the relative importance of the attributes, one needs to calculate the range of the part-worths. The range of part-worths is defined as the difference between the highest part-worth and the lowest.

Let us consider the attribute material. The highest part-worth is 0.42 (metal) and lowest part-worth is -0.77 (plastic). The difference {(0.42 – (-0.77)} is 1.19. This is called range of the part-worth. Similarly, the range of part-worths for other attributes are calculated and populated in Exhibit 5.

After calculating the range of part-worth for all the attributes, calculate the total sum and percentage for each attribute range part-worth. The relative importance is computed using the following formula:

$$Relative\ importance = \frac{Range\ of\ the\ part\text{-}worth\ of\ that\ attribute}{Sum\ of\ all\ the\ ranges\ of\ part\text{-}worths\ of\ all\ the\ attributes}$$

The calculations for the other attributes and their relative importance are summarized in Exhibit 5.

Exhibit 5 Calculation of Range Part-Worths and Relative Importance

Attribute	**Highest Part-Worth**	**Lowest Part-Worth**	**Range of Part-Worth (Highest to Lowest)**	**% Relative Importance**
Material	0.42 (Metal)	- 0.77 (Plastic)	0.42 – (-0.77) = 1.19	1.19 / 3.84 = 0.31 = 31%
Method	0.35 (Hybrid)	- 0.41 (Handmade)	0.35 – (-0.41) = 0.76	0.76 /3.84 = 0.20 = 20%
Price	0.72 ($100)	- 1.17 ($150)	0.72 – (-1.17) = 1.89	1.89 / 3.84 = 0.49 = 49%
Sum of ranges of part-worths total = 1.19 + 0.76 + 1.89 = 3.84				

Total utility (highest and lowest) using the Prediction Profiler

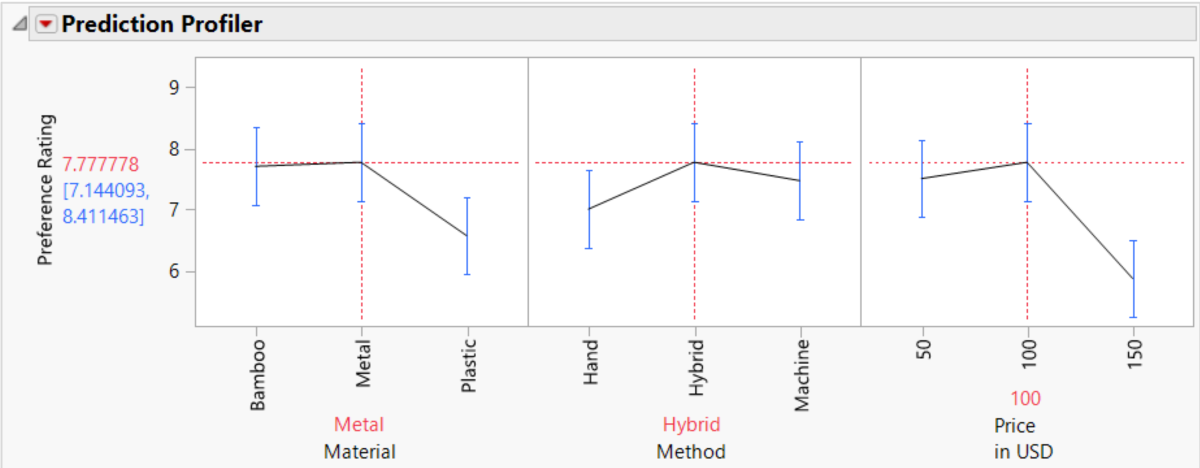
The part-worths can also be used to determine the total highest utility. Of the nine possible combinations, the best product configuration is the one identified by the maximum part-worth for each attribute. Exhibit 5 shows these part-worths as 0.42, 0.35, and 0.72. The intercept is 6.27. Adding all these would result in 7.76, which is the total utility for a metal flute made with the hybrid method and priced at $100. Similarly, one can calculate the lowest total utility (6.27 – 0.77 – 0.41 – 1.17 = 3.92), which is a plastic flute, handmade and priced at $150.

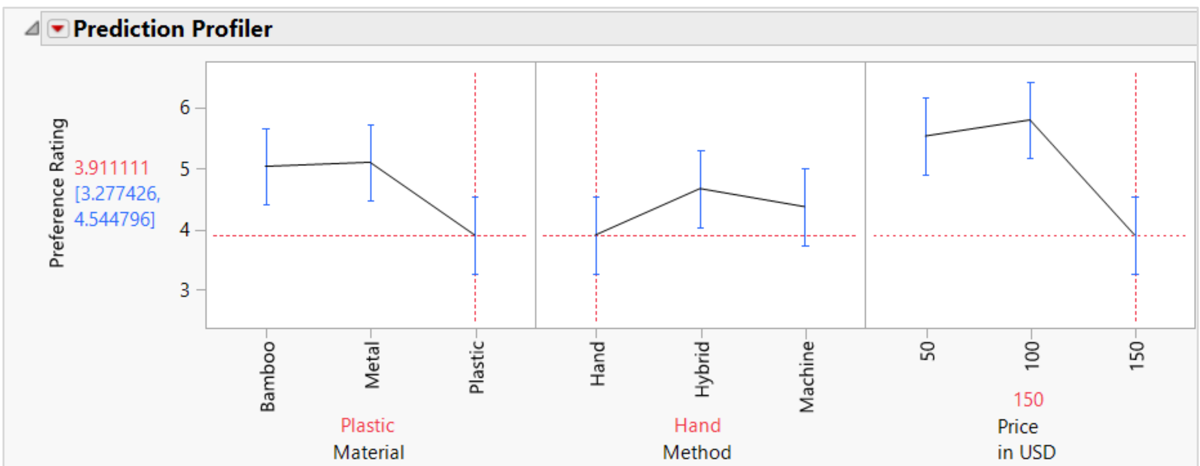
The same can be visually observed using the Prediction Profiler, which can be found under the red triangle next to Response Preference Rating. Choose the option Factor Profiling>Profiler.

The Prediction Profiler is interactive, with vertical red lines corresponding to the current value of the attributes. Click and drag the vertical red lines to change the current levels of the attributes. The corresponding utility or the total part-worth will be reflected in the performance rating on the Y axis.

By setting all the attributes to their highest or lowest levels of part-worth, one can observe the value on the performance rating. The highest total worth has a value of 7.77 and the lowest is 3.91, as shown in Exhibit 6.

Exhibit 6 Highest and Lowest Part-Worths in the Prediction Profiler





Summary

Statistical insights

Conjoint analysis (or choice modeling) is a powerful analytical method used to estimate the probability of individuals making a particular choice from the presented alternatives. A choice experiment studies customer preference for a set of product or process (in the case of services) attributes. Respondents are presented sets of product attributes, called profiles. Each respondent is shown a small set or a complete set of profiles, called a choice set, and asked to select the preference or give a preference score to the combination most preferred.

OLS regression, along with the expanded estimates, provides part-worth utility estimates. The relative attribute importance of the attributes is the key to understanding the perceived utility of the attributes by the customers.

Implications

Since customers vary in how they value attributes, many market researchers view market segmentation as an important step in analyzing preferences and choices. It also helps when designing products or processes so that they are aligned with the preferences of market segments.

The above analysis shows that customers perceive a high level of utility from price attribute (since the relative importance is close to 49%) followed by material and method. The best combination as perceived by the customers is a metal flute made with the hybrid method and priced at $100. Since the customers are highly sensitive to the change in price, it is advisable to keep the price below $100. Joseph can completely avoid stocking plastic flutes as they are least preferred.

JMP features and hints

This case used Graph Builder to visualize the preferences in the form of a heat map. It also leveraged Fit Model to apply simple linear regression to calculate the parameter estimates.

Basic arithmetic operations on the estimates resulted in deriving part-worths and relative importance. The Prediction Profiler helped visualize the impact of changing attributes on the preference scores.

Exercise

Joseph is also planning to understand the preferences and perceptions of another rhythm instrument that has four attributes, each with three levels. Instead of full factorial, he applied fraction of factorial method and created profile sets and conducted the survey. He collected the preference rating for each of the profile sets from five potential customers; the data is presented in Rhythm_pref.jmp. Perform the analysis:

- Visualize the data using Graph Builder.
- Ascertain the highest and lowest part-worths for each of the attributes.
- Calculate the relative importance of attributes.
- Calculate the highest and lowest utility using the Prediction Profiler.