A study for portable Bluetooth Speakers was conducted at Humboldt University Berlin using a convenience sample from students and young professionals. The study focuses on portable Bluetooth speakers, which are priced at a lower-medium price range. In this report, I develop a choice-based conjoint model to analyze the preference of respondents and simulate the market performance of different products. Additionally, I segment the respondents based on their preference and analyze which segment to target.

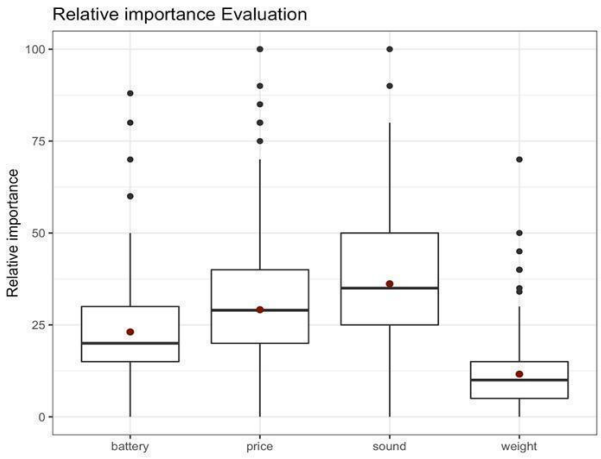
Data description

The sample which contains the socio-demographic information and choice information of 400 respondents is subset from the 697 respondents. There is no missing value in the sample. In the sample of 400 respondents, the participation of male respondents is 50% which is slightly higher than female respondents with 46%. The participants aged 18 to 29 accounted for 82% of the total. 56% of the respondents are students which is followed by employed respondents with 37%. 78% of the respondents have an undergraduate or graduate education background while only 1% was educated less than high school. 49% of the participants have a monthly income below 1000€ and 30% of them earned monthly 1000€ to 3000€, while only 9% have a monthly income more than 3000€. 51% of the respondents reside in Germany, which is the biggest group. In contrast, others live in 39 countries with minor percentages, including France and Turkey. 47% of respondents own a portable Bluetooth speaker and 31% of the total respondents have stated they intend to buy one. 73% of the respondents are aware of 1 to 4 brands out of the present eight, while only 27% know more than 4 brands. The mean value of subjective knowledge is 3.83 on a scale of 7, which indicates a neutral level of knowledge in portable Bluetooth speakers. On average, male respondents have more knowledge in the product than female. The mean value of product involvement is 4.30 on a scale of 7, which means they tend to think portable Bluetooth speakers have importance. On average, young respondents(18-29 years old) think the product is more important than other older age groups.

Figure 1 shows the relative importance evaluation of four attributes of the portable Bluetooth speaker. There are outliers in the four variables. The range of each attribute indicates the heterogeneous preference of the respondents. The box plot of sound is the tallest (interquartile range: about 25% to 50%), which means that respondents hold more different opinions about the importance of sound. On average, sound was evaluated as the most important attribute with 36% and followed by price with 29% and battery(23%). Noticeably, weight has the least importance with a medium percentage of 10%. The figure will be compared with the relative importance from the choice model in the following part.

Figure 2 suggests the distribution pattern of price evaluation among different income groups. The income groups are regrouped from the raw data into five categories for the convenience of illustration. The range of each income group shows the different preference to price within a certain group and the importance of price is the most differently perceived by the respondents in the 2001€ to 3000€ income group(interquartile range: about 10% to 40%). But we can see a decreasing trend of price importance with the increase of the income. The mean importance of price for below 1000€ income group is 32% but only 21% as to the more

than 3000€ income group. There are also other heterogeneous attribute importance evaluation patterns among income groups. The highest mean importance evaluation of sound is from the 2001€ to 3000€ income group at 40% but the below 1000€ income group only evaluated sound importance at 34% . The highest (more than 3000€) income groups value the importance of battery the most compared to others. There is no obvious correlation between income and weight importance from analysis at about 12% among all income groups.



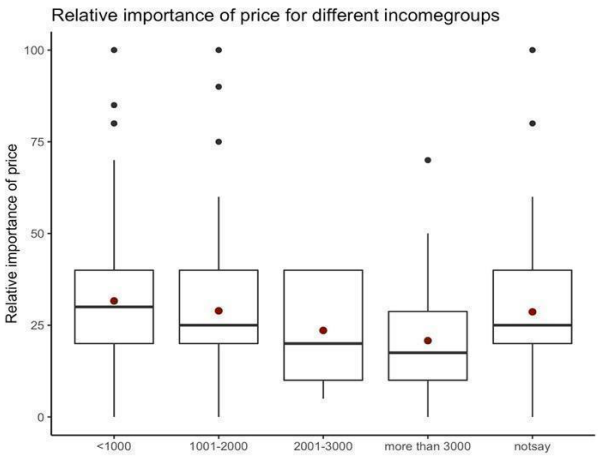


Figure 1: Relative importance evaluated by respondents
Figure 2: Relative importance of price for different income groups

Choice model

Mixed Multinomial Logit Model (MXL) explanation

The choice model which is introduced in the analysis is mixed multinomial logit model(MXL). MXL is a logit model for which the parameters are assumed to vary from one individual to another, therefore it takes the heterogeneity of the population into account. Another advantage of MXL is it breaks the limitation of the Multinomial Logit Model in regards to IIA. In this case study, the portable Bluetooth speakers vary in:

Attributes			Attribute Levels		
Battery life	8 hours	10 hours	12 hours	14 hours	16 hours
Weight	400 grams	500 grams	600 grams	700 grams	
Price	70 €	90€	110€	130€	150€
Sound	3.5 stars	4 stars	4.5 stars	5.0 stars	

Table 1: Attribute levels of portable Bluetooth speaker

Utility function can be written as:

$$U_{ijt} = V_{ijt} + \epsilon_{ijt}$$
$$= ß_i^{none} * D_{ijt}^{none} + ß_{ijt}^{8h} * E_{ijt}^{8h} + ß_{ijt}^{10h} * E_{ijt}^{10h} + ß_{ijt}^{12h} * E_{ijt}^{12h} + ß_{ijt}^{14h} * E_{ijt}^{14h}$$
$$+ ß_{ijt}^{400g} * E_{ijt}^{400g} + ß_{ijt}^{500g} * E_{ijt}^{500g} + ß_{ijt}^{600g} * E_{ijt}^{700g} + ß_{ijt}^{3.5stars} * E_{ijt}^{3.5stars}$$
$$+ ß_{ijt}^{4stars} * E_{ijt}^{4stars} + ß_{ijt}^{4.5stars} * E_{ijt}^{4.5stars} + ß_i^{price} * price_{ijt} + \epsilon_{ijt}$$

where U_{ijt} is the utility that individual i derives from product j in choice task t. D(.) implies dummy coded variable, E(.) implies effects-coded variable, price is linear coded. By using MXL I also make additional assumptions as below:

1. Assuming all preference parameters are normally distributed.
2. Assuming a diagonal covariance matrix of preference estimates, i.e., ignoring potential correlation structure between preference estimates.
3. Assuming the error term (ϵ_{ijt}) follows Type I extreme value distribution.
4. Assuming the respondents take full information into account and under a compensatory decision rule when making choices. Additionally, they have a stable preference among the choice tasks and optimize the utility when making choice decisions.

The number of draws R is also needed to be specified in MXL. Higher R may lead to better precision but comes at a cost of higher estimation time. In this study, I tested R with values of 100, 500 and 1000 separately. The log-likelihood of the null model is -6654. The log-likelihood of MXL with 500 draws is the highest (-3674), so I process with R=500. The estimated result is shown in Table2.

	None	Price	Battery 8h	Battery 10h	Battery 12h	Battery 14h
ß	-8.03***	-0.05***	-1.27***	-0.33***	0.21***	0.63***
σ	3.29***	0.03***	0.74***	0.19	0	0.10
	Weight 400g	Weight 500g	Weight 600g	Sound 3.5s	Sound 4s	Sound 4.5s
ß	0.62***	0.29***	-0.17***	-2.32***	-0.48***	0.92***
σ	0.61***	0.31***	0.01	1.31***	0.54***	0.25*

Note of p-value: ∗(0.01, 0.05]; ∗∗ (0.001, 0.01]; ∗∗∗ [0, 0.001]
Table 2: MXL model estimates with R=500

The result shows the coefficients, standard deviation and significant level of each attribute from the model. The left-out attribute levels are: Battery 16h, weight 700g and sound 5.0 stars. From the significance of coefficients perspective, every attribute is statistically significant. The coefficient of price is negative (-0.05) from Table 2. Although there is heterogeneity in price with a standard deviation of 0.03, the coefficient of price is still in the negative domain. That corresponds to our expectation and perception. Although there is also variation in battery preference, especially the preference to 8h battery, the average preference is towards longer battery time, i.e., they prefer 16h over 14h, 14h over 12h, 12h over 10h, 10h over 8h. On average, the respondents prefer lighter weight and better sound quality portable Bluetooth speakers. However, there is also heterogeneity within attribute preference, especially the variations within preference to weight 400g, weight 500g, sound 3.5 stars and sound 4 stars are extremely high.

Relative attribute importance and willingness-to-pay(WTP) estimates

Relative importance of attributes and willingness-to-pay as scale-independent measures can better interpret the model. Relative Importance reveals which attributes of a product are more or less important when making a choice decision and is calculated based on the relative range

of the partworth utilities. The positive coefficient of price means that the respondents prefer higher price, which is unrealistic and contrary to perception. The close to 0 price coefficient will lead to outliers and skew the result. Therefore, after testing I set the threshold of price coefficient as -0.015 for analysis and exclude 39 observations whose price coefficient is above the threshold.

Table 3 shows the mean relative attribute importance from three perspectives: self-evaluation in the survey, individual-level estimates and population-level estimates. The individual-level and population-level estimate results are quite similar, suggesting price and sound are most important attributes and account for more than 30%. The respondents evaluated sound quality as the most important attribute(36%) and followed by price(29%) in the self-evaluation survey. Similarly, weight is the least important attribute from three perspectives when making a choice decision.

	battery	price	sound	weight
Self-evaluation	23%	29%	36%	12%
Individual-level	18%	37%	34%	11%
Population-level	17%	35%	35%	13%

Table 3: Mean relative attribute importance based on three perspectives

The Figure3 and Figure 4 show the distribution of the relative attribute importance and different evaluation patterns based on individual-level and population-level. There are outliers in both figures. The two figures show a quite similar pattern and heterogeneity within each attribute. It is obvious that the box plot of price and sound is taller than the other two, because individuals or the population held more different opinions about the relative importance of price and sound. There are four different relative attribute importance patterns in both two graphs. There is one pattern that values price the most but regards battery and weight as unimportant attributes in both figures. And one pattern values the most in weight and the third pattern thinks sound quality is much more important than other attributes. The fourth pattern values weight more or as important as price.

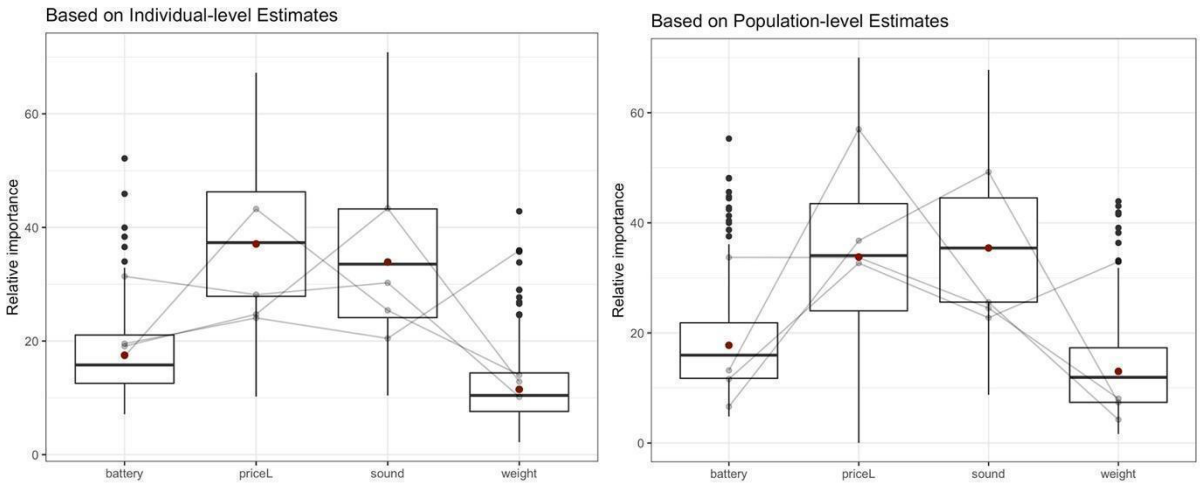


Figure 3: Relative attribute importance based on individual-level estimates

Figure 4: Relative attribute importance based on population-level estimates

Willingness to pay (WTP) is the maximum price at or below which a consumer will definitely buy one unit of a product and is calculated by comparing to a reference level. In this study, I set the attributes: Battery 16h, Weight 700g, Sound 5 stars as reference(left-out) levels.

Table 4 shows the mean WTP of the attributes compared to the reference level based on individual level. Noticeably, on average people are willing to pay more 91.70€ for a portable Bluetooth speaker with 5 star sound quality compared with 3.5 star. On average, people are willing to pay less 42.90€ for a portable Bluetooth speaker with 8h battery compared with 16h battery and willing to pay more 29.40 € for a portable Bluetooth speaker with 400g in weight compared with 700g in weight.

	Battery 8h	Battery 10h	Battery 12h	Battery 14h	Sound 3.5s	Sound 4s	Sound 4.5s	Weight 400g	Weight 500g	Weight 600g
Mean	-42.90	-23.10	-11.90	-3.05	-91.70	-51.60	-22.10	29.40	22.40	12.60

Table 4: Mean WTP of attributes based on individual-level

For visual illustration of distribution and the purpose of saving space, I take the distribution plot of weight as an instance, which is shown in Figure 5. There are some outliers in the data in Figure 5. Taking the weight of 700g as reference, the WTP of weight 400g, 500g and 600g are mainly distributed in the positive domain. This means that most of the respondents are willing to pay more for a lighter portable Bluetooth speaker compared with 700g in weight. Few are even willing to pay more than 50€ for a 400g product compared with 700g.

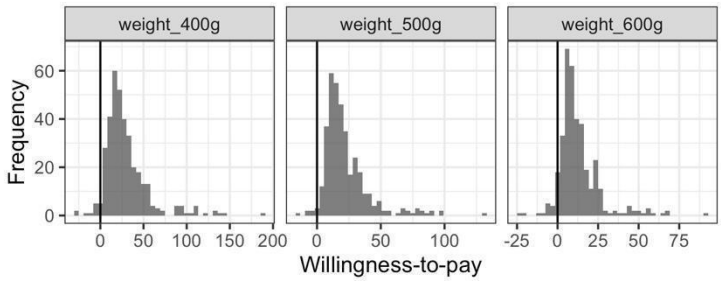


Figure 5: WTP of attribute weight

Cluster analysis

Deciding on variables

In order to identify distinct segments, cluster analysis is introduced in this part. In this study, I set the relative attribute importance estimate based on individual-level as the basis. Because relative attribute importance is a scale-independent measure of preference and can reveal the heterogeneity among groups. The social demographic variables (own, intent to buy, brand awareness, subjective knowledge, product category involvement, age, education level, occupation, gender, income level and residence) can be introduced as descriptors, because they can describe the groups specifically. For the convenience of analysis, I collapse income

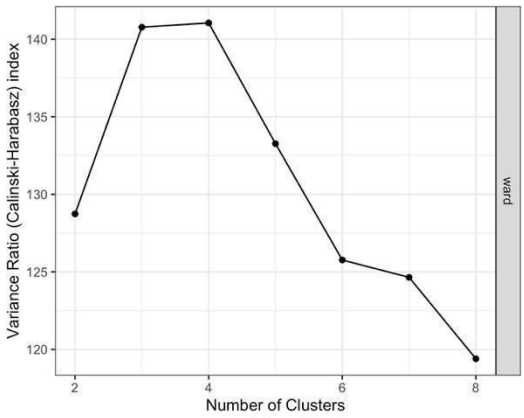
groups into 4 and regroup residence into Germany and other, and then dummy code the variables(gender, income, occupation and residence).

Selecting proximity measure and appropriate algorithm

The relative attribute importance is a metric variable, and thus Euclidean distance as a commonly used proximity measure is suitable for analysis. I standardize the input variables so that they are all on the same scale and more comparable for computing distance-based measures. The single linkage, complete linkage, and average linkage methods are sensitive to outliers. As we can see from Figure 3, outliers exist in attributes such as 'weight' and 'battery'. Therefore, they are not suitable for study. The centroid linkage and median linkage method are affected by the noise in the data and give out uneven size of segments. Ward's method and K-means are proper for analysis and both suggest almost identical results. Ward's method, which is less susceptible to outliers and noise in the data, is a sound approach for segmentation in this context.

Determining the number of clusters

The Calinski-Harabasz index, known as the Variance Ratio Criterion, is the ratio of the sum of between-clusters dispersion and of inter-cluster dispersion for all clusters. Higher value of CH index means the clusters are dense and well separated. Figure 6 shows that the 3-cluster or 4-cluster solutions are high in value and there is an elbow point on the 4-cluster solution. Given the size of each segment, there is a segment in fairly small size in 4-cluster solution, i.e., 6% in Ward's solution. Therefore, I adopt a 3-cluster solution in this study. Meanwhile, the Figure 7 also illustrates that a 3-cluster solution can give a reasonable separation among clusters although it explains 76.36% of the point variability.



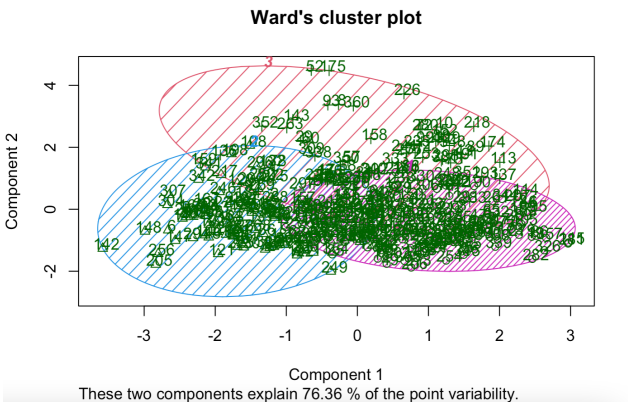


Figure 6: VRC plot based on Ward's Method
Figure 7: 3-cluster plot: Ward's Method

Cluster Descriptions

After conducting 3-cluster analysis based on Ward's method, I got 3 clusters which varied in attributes. Table 5 summarizes the main attributes which make them different. As for other

omitted variables, such as education and residence, they are not obviously heterogeneous among groups. That is to say, for all three clusters the members are on average undergraduate and half are resident in Germany. Furthermore, the values are color coded. Orange means that the value of attributes surpass the mean obviously, green on the contrary.

	RI(battery)	RI(price)	RI(sound)	RI(weight)	own	Intent to buy	Brand awareness
1	15.1	45.97	29.09	9.84	0.44	0.25	3.08
2	16.19	24.37	48.99	10.44	0.54	0.36	3.68
3	25.14	34.08	23.86	16.92	0.36	0.37	3.05
	Subjective Knowledge (mean)	product involvement (mean)	Employed	Student	male	Income<1000€	Income>2500 €
1	3.79	4.18	0.34	0.59	0.43	0.51	0.04
2	3.94	4.67	0.39	0.56	0.62	0.49	0.15
3	3.58	3.91	0.41	0.48	0.45	0.41	0.15

Table 5: Mean value of selected variables across clusters

Segment1: This is the largest segment(50%). These people pay less attention to battery and weight of a portable Bluetooth speaker but prefer cheaper products. Their intent to buy products are lowest among three segments. They are mainly 25-29 years old students and only 34% of them are employed. Meanwhile, their income is also on average the lowest among three clusters. More than half of them have a monthly income below 1000€ and only 4% earned more than 2500€ monthly.

Segment2: This is the second largest segment(30%). These people value the sound quality most but focus less on price than other groups. More than half of them have owned one portable Bluetooth speaker already and 36% of them intend to buy one, which is high. The average brand awareness, subjective knowledge and involvement are also the highest among three clusters. They are on average around 30 years old. More than 60% of them are male and 15% of them have more than 2500€ monthly income.

Segment3: This is the smallest cluster with a share of 20%. They think battery and weight are more important than other groups. Although only 36% of them have owned a portable Bluetooth speaker and know less about the portable Bluetooth speaker, the intent to buy(37%) is highest among the three segments. They are on average more than 30 years old employers or students. They have the best income status among three clusters. That is to say, 47% of them earn more than 1000€ monthly.

Market attractiveness of segment and target approach

Considering the attractiveness of the segments, the factors, i.e., the size of clusters, intent to buy, product involvement, relative importance of price and income play an important role. The size of clusters has an impact on the sales performance and market share as a whole. Intent to buy and product involvement imply the possibility to make a purchase, which is important to producers. Income is closely related to the ability of the segment to purchase the

products. Relative importance of price hints the potential profit margin for the producer. That is to say, if the segment perceives price less important, the producer will have the possibility to gain more. Therefore, these five variables are mainly taken into account in this context. Due to the lack of information about the producer, I assume a producer can introduce different products to target each segment.

Segment1: It seems that targeting this cluster would be beneficial for producers, because it is the largest segment(50%) and they tend to think portable Bluetooth speakers are important. However, from the other three perspectives, this segment has the lowest income level and only 25% of them intend to buy. They also think the importance of price is high. This implies they prefer a cheap product and have not enough financial ability to afford an expensive but good performance product. This makes it low on the market attractiveness. On a scale of 1- 7, 4 is a reasonable score for this cluster. The producer can engage this segment by introducing cheap portable Bluetooth speakers and compromise the attributes like weight and battery, because they regard battery and weight as unimportant factors.

Segment2: This is the most attractive segment to target among all clusters because they have a high income level and perceive price relatively less important compared with other 2 clusters. Moreover, this segment has a high percentage of intent to buy and think portable Bluetooth products more significant. This means they are open to buy a product and have the ability to afford a satisfying portable Bluetooth speaker. And the share of the segment is also reasonable. Therefore, a producer has a high chance to make profit from targeting this segment and 6 is reasonable for this segment. The producer can target this segment by introducing high sound quality products and compromise a bit on other three attributes. According to the segment description, they are mainly young students or employees, and thus the producers can advertise by distributing leaflets in universities and sponsoring job hunting events. The male percentage is also high, so producers can advertise in sport events or computer games.

Segment3: This segment seems like an attractive segment to target because of their high intent to buy and income level. However, the share is the smallest and the importance perception is also low, which will negatively affect the market share. Overall, 3 is reasonable for attractiveness rating. The producer can target this segment by introducing a practical portable Bluetooth speaker which has good performance with a reasonable price.

Market simulation

Market simulation scenario1

There are two alternatives and a none option in the first market scenario and the market size is 400. Knowing that the constant marginal cost of firm 1 is 75€ and firm 2 is 70€, I assume the price range of each firm is from the marginal cost to 150€. In a dynamic competition context, I assume an initial price for firm 1, which is 75€. And then the firm 2 will react by setting a profit-maximizing price(99€) to achieve more profit. Similarly firm 1 will also react to set a

new profit-maximizing price(114€). Both firms will continue reacting until both get to a point where changing the price does not make sense. This is called Nash equilibrium, which means each firm is assumed to know the equilibrium strategies of the other firms, and no firm has anything to gain by changing only their own strategy.

In this context, I set the threshold of changing in price as 5€ to achieve convergence, which means no firm will change more than 5€ to gain more profit. Table 6 suggests that the profit-maximizing price, market share and profit of each firm at this point. The profit-maximizing price for firm 1 and firm 2 is 119€ and 103€ respectively. The market share of firm 1(48.25%) is higher than firm 2(39.75%) and the profit of firm 1(8492€) is also higher than firm 2(5247€) in this scenario.

	Price	Cost	Profit per unit	Market share	Profit
Firm1 (5 stars sound, 600g, 12h battery)	119€	75€	44€	48.25%	8492€
Firm2 (4 stars sound, 400g, 16h battery)	103€	70€	33€	39.75%	5247€
None	0€	0€	0€	12%	0€

Table 6: Market simulation scenario1 result

Market simulation scenario2

Based on the market scenario 1, firm 1 introduces a new model(Alternative 3). Therefore, there are three alternatives and a none option in the second market scenario with a market size of 400. Knowing the constant marginal cost of each product, I assume the price range of each product is from the marginal cost to 150€. Given the price of alternative 1 and alternative 2 is 119€ and 103€ respectively based on market scenario 1, the alternative 3 will be introduced at a profit-maximizing price(113€) to achieve more profit. In a dynamic competition context, the alternative 1 and alternative 2 will also react accordingly. Three alternatives will continue reacting until all of them get to a point where changing the price does not make sense.

In this context, I set the threshold of changing in price as 2€ to achieve convergence, which means no firm will change more than 2€ to gain more profit. Table 7 suggests the profit-maximizing price, market share and profit of each alternative at this point. Alternative 3 has the highest profit-maximizing price (87€), market share(55%) and profit(2640€). In contrast, alternative 1 has the lowest profit-maximizing price (82€) and profit(707€) because of the introduction of alternative 3. This is presumably because the alternative 3 has better battery life (16 hours) compared to alternative 1, with all other attributes and cost being equal. This makes alternative 3 more competitive and thus poses a threat to alternative 1 and alternative 2. Compared with market scenario 1, the market share and profit of alternative 1 and alternative 2 decrease dramatically.

	Price	Cost	Profit per unit	Market share	Profit
Alternative 1 (5 stars sound, 600g, 12h battery)	82€	75€	7€	25.25%	707€
Alternative 2 (4 stars sound, 400g, 16h battery)	85€	70€	15€	16%	960€
Alternative 3 (5 stars sound, 600g, 16h battery)	87€	75€	12€	55%	2640€
None	0€	0€	0€	3.75%	0€

Table 7: Market simulation scenario2 result

The profit of firm 1 at a profit-maximizing price in the first market scenario is 8492€. If firm 1 can benefit from introducing the new product, then the profit generated from alternative 1 and alternative 3 in market scenario 2 should be higher than 8492€. Table 7 shows the total profit of alternative 1 and alternative 3 at profit-maximizing price is 3347€. Therefore, firm 1 cannot benefit from the introduction of the new product.

This means that the new product not only makes customers from competitor firm 2 switch, but also attract customers who originally choose alternative 1 in the first market scenario. Additionally, the cost of a new product has the same cost as the alternative 1. This makes alternative 1 in market scenario 2 even less attractive and cannot achieve a high profit. Therefore, although alternative 3 has the highest market share and profit in market scenario 2 among these three alternatives, firm 1 cannot benefit from the introduction of the new product at these profit-maximizing prices.