The Impact of Bottle Shape on Consumers

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Abstract
Nowadays as the quality of lifestyle increases, more and more people focus on the aesthetics of the commercial products. And there is a term called "Kansei Engineering" to describe the case that the aesthetics could produce commercial value for the product. In this paper, the author analyzed the influence of bottle shape on its commercial value. The author used a questionnaire to collect the data to investigate this problem. The author analyzed the data to find the relationships between the bottle shape and a few other factors including the market price, physiological expected price, and the popularity of the product. And then analyzed these data by calculating the pairwise Pearson correlation among these factors. Based on the assumption that the psychologically expected price is determined by the bottle shape, we found a strong positive correlation between the bottle shape and the market price as well as the popularity of the product. This phenomenon supports the conclusion that the bottle shape has a positive influence on the commercial value of beverages. Finally, the author modelled several "ideal" shapes for each type of beverage that could contain the highest commercial value by taking the weighted mean of the candidate bottle shapes according to their psychological prices and market prices.

Keywords
Bottle shape; Commercial value; Mathematical modelling; Pearson correlation

Introduction

Nowadays, people are inseparable from shopping for beverages, so there is a huge production of beverages. According to the statistics in 2019, the scale of the domestic soft drink industry was ￥578.6 billion RMB (Snowball, 2020). In addition, the proportion of energy consumption from beverages is extremely high in the UK, especially for babies between age 2 and age 6 who take 68% of their total energy consumption. Though the trend of beverage consumption is declining gradually in the UK (Shu et al, 2011). Besides, in the USA, half of adults and two-thirds of children drink at least a single bottle of beverage each day

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(Bleich et al, 2018).

Therefore, beverages influence our life a lot. According to (Gao, 2018) for Coke (￥3 RMB) the material cost of the beverage bottle is approximately ￥0.45 RMB, and the brand influence is about 8% of the price of the product, the price of the liquid is ￥0.3 RMB. Therefore, an interesting question is where the remainder price goes to? For example, in the Nong Fu Mineral Spring, the price of an ordinary bottle of drinking water is ￥2.5 RMB, but the price of another design bottle is ￥4.5 RMB. Since they are the same brand and the volume of the water is both 500 ml, there is an assumption that the shape of the bottle has a big impact on the price of the beverage.

Thus, it is an interesting research problem to explore the impact of the design of the bottle shape on the commercial value of beverages. In this investigation, I will explore the following topics:
1) The relationship between psychologically expected price and the bottle shape
2) The relationship between the popularity of the product and the bottle shape
3) Construct a model that can be considered "ideal" for commercial values for each type of beverage.

The author will take the following steps to explore the project.
(1) Pick 23 bottles from the market and measure the shapes of these bottles.
(2) Make a questionnaire including the shapes of these 23 bottles and questions about the psychologically expected price and the popularity of the bottles.

(3) Find the relationship between the popularity of the product and the bottle shapes and the relationship between psychologically expected price and the bottle shapes.

(4) Construct a model that can be considered "ideal" for commercial values based on the weighted mean of the difference between the market price and the psychological price of the bottles.

This project discusses how to maximize the commercial value of the beverage by adjusting its bottle shape. According to the data from the questionnaire, this paper will give some suggestions and conclusions on this topic. Furthermore, this paper will also introduce an ideal design that possibly carries the maximum commercial value. This investigation may benefit the beverage industry by introducing the ideal design. Furthermore, the ideal shape may also increase the popularity of the beverages, reducing the potential waste of the beverages.

The Definition of Kansei Engineering

The definition of Kansei engineering from Wikipedia (Wikipedia, 2022) is: "Kansei engineering, emotional or affective engineering, aims at the development or improvement of products and services by translating the customer's psychological needs into the domain of product design."

This theory was firstly presented by Nagamachi, has been applied to improvement of the design that caters to consumers' demands (Nagamachi, 1989). Many designs need to use "Kansei" to improve the aesthetics of their design, And this also could apply to bottle designs (Gislason et al., 2020).

Four Factors According to Previous Research Related to Kansei Engineering

Colour

According to (Gislason et al., 2020), they stated that due to sensory expectation which is generated by cross-modal correspondences, people prefer warm colours to cold colours. Their investigation categorized it into three general colours: warm, cool, and grayscale.

Then they used the questionnaire to seek answers from the participants. The questionnaire included: i) Preference for the appearance of the bottle. ii) Expected quality of beer inside the bottle. iii) The expected price of beer. They concluded colours have a big impact on the evaluation of the product.

In addition, some researchers such as (Sugrue, & Dando, 2017) stated that color has a complicated influence on beverage consumption. They used apple beer as experimental material. Since traditional ideals about the apple are that 1) The more green the apple is, the sourer it tastes 2) The more red apple is, the sweeter it has. Then they asked 109 participants to drink different apple beers which contain in a transparent bottle. After that, participants should write down how the drink tastes. They repeated the experiment with a colour painted red or green, recording the feelings of the participant. Eventually, they concluded that taste of samples could be manipulated by colours.

Figure 1. Gislason's colour research (Gislason et al., 2020))

Bottle Shape

According to research (Gislason et al., 2020), they used two types of bottle shapes: "longneck" and "bomber". After comparing the different bottle shapes, the two types have some differences. They concluded that the "bomber" has been regarded as a "high price", and participants' psychological prices were more than they expected. Another Kansei research paper (Luo et al., 2012) described it more completely. They picked 50 bottles that widely appear in markets. They distributed evaluation questionnaires with a picture of the bottle shape and adjective verbs which describe the picture. The participants need to write down their degree of satisfaction with these words which were linked to the product on the 7 Likert scale. They found that perceived quality could be increased by giving a shape that fits the beverage brand. For instance, bottles of cola and other carbonated drinks often use streamlined shapes. This could leave an impression of "passion", and "energy" to people. Therefore, they have a high quantity of sales among young people. Nevertheless, some researchers do not take data from the realistic bottle. For instance (Mele et al., 2018), used 14 independent parameters with 12 related to geometric shapes in HLCDT. With the aid of KBS, it generated a digital model. After that, they asked some students to describe the model on a Likert scale.

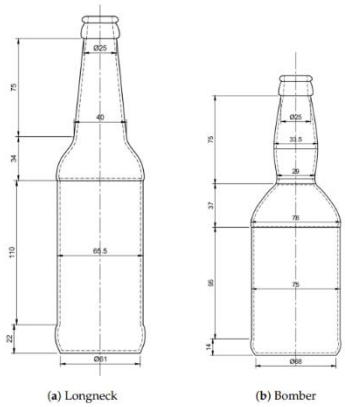


Figure 2. Gislason's bottle shape research (Gislason et al. 2020)

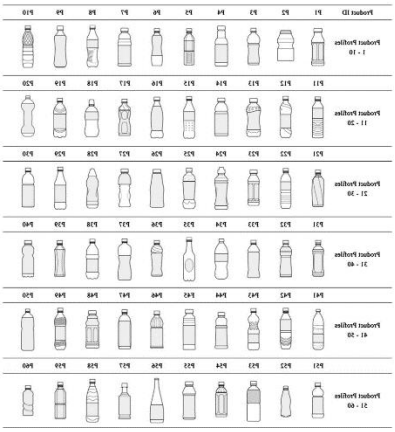


Figure 3. 50 bottle demonstration (Luo et al. 2012)

Brand Shape

According to previous research (Gislason et al., 2020), they divided bottle shapes into three different types: “square”, “round” and “diamond”. According to results from their questionnaire, the level is relatively close or identical, which means the influence of brand shape was not significant.

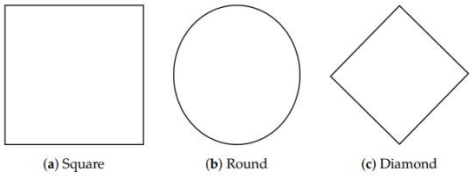


Figure 4. Gislason's brand shapes research (Gislason et al. 2020)

Complexity

According to research (Gislason et al., 2020), they designed different textures by three levels. i) “Low”: little textures on the bottle. ii) “Medium”: a considerable amount of textures on the bottle. iii) “high”: the dense texture of the bottle. The conclusions reflected that the complexity of texture didn’t affect the participant’s evaluations.

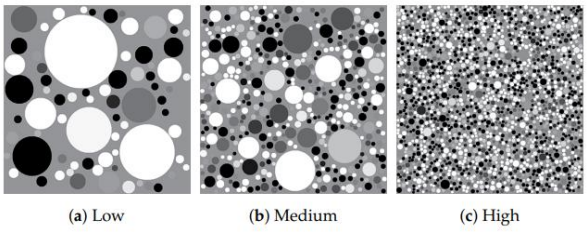


Figure 5. Gislason’s picture by different levels of complexities research (Gislason et al. 2020)

So far what the researchers have done is related to four aspects: colour, bottle shape, brand, and complexity. The majority of the researchers tend to discover the impacts of colour and bottle shape. And they find that colours and bottle shapes have a considerable psychological influence on consumers. Whereas the complexity and brand shape don't have a big impact on consumers' psychological participants' evaluation.

Mathematical Methods Applied to the Bottle Design

Integration (Bottle Volume Calculation)

Integration could be applied to evaluating the volume of bottles (Henderson et al. 2020). It states that the bottle model could be split into different pieces for example one solution which comes from a problem in Dr Hsu ’ s book “ Applied Engineering Analysis” (Hsu, 2018) is that they divided bottles into different sections and categorized them as "cured sections (punt, some part of bottle body, cup bottom) and straight-line section (some part of bottle body) used functions to demonstrate the curved section and straight, for instance, parabolic equations. Elliptic curve, sine function, and cosine function could also be used to demonstrate the curve in the outer shell. Then they measured the length of each part of the section and define the position of each curve. Finally integrate the function with 360 degrees and integrate to measure the volume of the bottle.

The conclusion of the article “ Improving STEM Education by Analyzing the Design of a bottle” (Henderson et al. 2020) states that these mathematical calculations are all correct by using solid work confirmation (solid work creates the exactly accurate bottle model by spine tool and the outcome is as same as the integration outcome which proves that the integration method works)

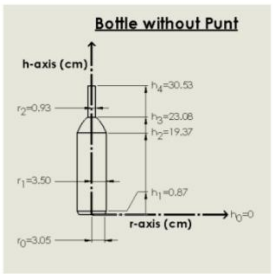


Figure 1. The four curves that were derived to determine the volume of the bottle without the punt.

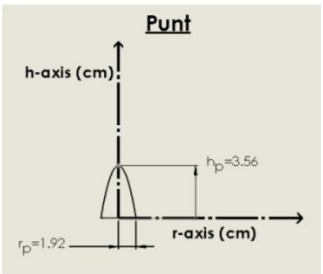


Figure 2. The shape of the punt used to determine the derivation of this curve.

Figure 6. Integration on each part of the bottle (Henderson et al., 2020)

Function Fitting (Bottle Shell Shape Demonstration)

According to Wikipedia, curve fitting is a method to generate a curve or function that fits the data point series. It can be either interpolation or smoothing.

Function Fitting Method (Interpolation)

For interpolation, it needs to fit the data which are required. It could be used to estimate the values or predict unknown values. Based on a discrete set of discrete data points which are known, a new function can be fitted.

This method is commonly applied in the science and engineering field. It can be used to analyse some data from experiments or samples. These data could be represented by a function corresponding to a limited number of independent variables. The independent variable is estimated by the intermediate value of the function.

It could convert a complex function into a simper function by approximation. The results will be simper and close to the original function. However, some data points may produce some errors from interpolation (Wikipedia, 2022).

Function Fitting Method (Smoothing)

Nevertheless, smoothing means approximately fit data to catch essential features in the data. In smoothing, data points that are higher than the adjacent data points will be reduced, and the data points which are lower than the adjacent data points will be increased. This will make the curve smoother. Smoothing could be applied in two aspects (1) extracting more information from the data if smoothing is generated by a reasonable assumption and (2) providing flexible and robust analyses. Smoothing could be applied to many different algorithms (Wikipedia, 2022).

Design

Bottle Design

The bottle design is used by Rhino7. First of all, I picked 5 beverages for each of the types of beverage: 1) carbonated drinks 2) mineral springs 3) tea drinks 4) energy drinks (example: vitamin beverage, juice beverage, and so on). Then, I measured the length of the different parts of the bottles. I recorded the data of 23 bottles and make the scenario of the bottle. I placed the picture of the scenario into Rhino7. Set the unit length as 1 cm. And mark lines based on what I have measured.

I shrunk or enlarged the picture until it fit the marked lines. I added a curve to fit half of the bottle. Request for rotation of 360 degrees then the model finished.

Questionnaire Design

A questionnaire survey is used not only to discover the relationship between bottle shape and psychologically expected price but also to discover the relationship between bottle shape and the popularity of the product. Besides, I have been inspired by the article (Luo et al., 2012). I added some questions about bottle types. I also want to validate if what they have stated is true. By modelling through Rhino7, I got 23 models of different bottles. I divided them into 4 types: (1) carbonated drinks (2) mineral springs (3) tea drinks (4) energy drinks. Each type has 5 bottle models except for mineral spring. Mineral springs have two categories. One is the ordinary form which contains five models. The other form currently appears in the market with a higher market price. I only found three types of beverage bottles that have similar shapes. Therefore, it only has three models. The questionnaire contains three parts

for each model. The first question asked about the psychologically expected price of the bottle. The second question asked for the scale of like of the bottle. The third question asked them to guess the type of beverage.

Participant

The 243 online participants were Chinese citizens.

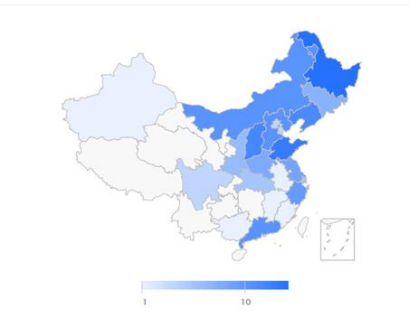


Figure 7. Distribution of participants

The Responses of Participants and Data Category

Among these 243 participants, there were 162 participants' questionnaires that have been fully answered. Among those 162 participants, the majority came from the north of China whereas participants from some provinces such as Zhejiang, and Guangdong also occupied a large percentage.

I have categorized the answers into six parts: beverage type, beverage psychologically expected price, beverage popularity, the type that people think, and the mathematical equation for the bottle design. The beverage psychologically expected price comes from the results of the completion question (estimate bottle model's prices). The beverage's popularity comes from the results of the grade question (satisfaction of bottle model). The type of people think comes from the result of the choice question (estimate the type of beverages from four types of beverages).

In the last part mathematical equation, I chose a certain bottle based on the previous data, measured its length, and picked a point for function fitting. And I finally found the equation of the mathematical function to demonstrate the shape of the bottle. For this part, I gave a specific description later.

The Results of Beverage Psychologically expected Price

I used some methods to mark to deal with this excel table. At the bottom of the left column is the average market price among these 23 bottles. At the bottom of the right column is the average market price among these 23 bottles. According to these means value I have got, mark the data which is below the average of the market price as “yellow”, and mark the data which are above the average of the market price as “green”. If the psychologically expected price is below the average but the market price is higher than the average, I marked “ * ” behind it. If the psychologically expected price is higher than the average but the market price is below average, I marked “*” behind it.

beverage market price(x)	beverage psychological expected price(y)	x-x(mean)	(x-x(mean))^2	y-y(mean)	(y-y(mean))^2	(x-mean)(y-mean)
3	4.72	-1.13043	1.277882798	-0.71435	0.510292817	0.807523629
2.5	4.9	-1.63043	2.658021738	-0.53435	0.285527899	0.871215282
3	5.09	-1.13043	1.277882798	-0.38435	0.147723251	0.434480151
3.8	5	-0.33043	0.109187146	-0.43435	0.188658034	0.143523629
4	5.09	-0.13043	0.017013233	-0.34435	0.118575425	0.044914934
5.4	5.66	1.269565	1.611759841	0.225652	0.050918904	0.286480151
4	5.11	-0.13043	0.017013233	-0.32435	0.105291512	0.042306238
1.8	4.94	-2.33043	5.430626276	-0.49435	0.244379773	1.152045369
4	5.53 *	-0.13043	0.017013233	0.095652	0.009149238	-0.012476371
7.6	5.28 *	3.469565	12.0378828	-0.15435	0.023823251	-0.535819849
4.8	5.1 *	0.669565	0.44821738	-0.33435	0.111788469	-0.223867675
4.2	5.9	0.069565	0.004839319	0.465652	0.216831947	0.032392195
4.5	5.22 *	0.369565	0.13657845	-0.21435	0.045944991	-0.079215501
3	5.54 *	-1.13043	1.277882798	0.105652	0.011162362	-0.119432892
5	5.36 *	0.869565	0.756143667	-0.07435	0.005527899	-0.064650284
4.5	5.9	0.369565	0.13657845	0.465652	0.216831947	0.172088847
3	5.67 *	-1.13043	1.277882798	0.235652	0.055531947	-0.266389414
5	6.08	0.869565	0.756143667	0.645652	0.41686673	0.561436673
2.4	5.96 *	-1.73043	2.994404537	0.525652	0.276310208	-0.909606805
3	5.27	-1.13043	1.277882798	-0.16435	0.027010208	0.185784469
5	6.21	0.869565	0.756143667	0.775652	0.601636295	0.674480151
5.5	5.52	1.369565	1.875708885	0.085652	0.007336295	0.117306238
6	6.08	1.869565	3.495274102	0.645652	0.297736295	1.020132325
4.130434783	5.434347826		Σ(x-x(mean))^2=	39.64869565	Σ(y-y(mean))^2=	3.974765217 Σ(x-mean)(y-mean) 4.334956522
				Pearson correlation coefficient=	0.345314292	

Figure 8. Results from questionnaire

I used data with “*” to reflect the case which contradicts the relevance between market price and psychologically expected price. In the picture, we could see that there are 8 “ * ” among 23 bottle models.

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2 \cdot \sum_{i=1}^{n}(y_i-\bar{y})^2}} = \frac{n\sum_{i=1}^{n}x_i y_i - \sum_{i=1}^{n}x_i \cdot \sum_{i=1}^{n}y_i}{\sqrt{n\sum_{i=1}^{n}x_i^2 - (\sum_{i=1}^{n}x_i)^2} \cdot \sqrt{n\sum_{i=1}^{n}y_i^2 - (\sum_{i=1}^{n}y_i)^2}}$$

Figure 9. Equation of person coefficient

To show the relevance between these two variables in a more precise and professional way. Using the function of the Pearson correlation coefficient, the outcome is 0.345314292.

Figure 10. Graph related to the relationship between market price and psychological price

The Results of Beverage Type

beverage name	beverage type	the type people think(for majority)	
1:Sprite	carbonated drinks	carbonated drinks(48.77%)	
2:NongFu Spring	mineral spring	mineral spring(45.06%)	
3:Ganten	mineral spring(version2)	mineral spring(46.3%)	
4:Fanta	carbonated drinks	carbonated drinks(35.80%)	
5:Evian Spring	mineral spring	mineral spring(43.21%)	
6:Alien electrolyte spring	energy drinks	mineral spring(37.04%)	
7:Pomelo Tea	tea drinks	mineral spring(36.42%)	
8:Ceston Spring	mineral spring	mineral spring(38.89%)	
9:NongFu fruit and vegetable	energy drinks	energy drinks(27.78%)	
10:Burning Tea	tea drinks	mineral spring(43.21%)	
11:NongFu Spring(New year sprica	mineral spring(version2)	mineral spring(50.62%)	
12:Vitamin water	energy drinks	energy drinks(32.72%)	
13:ALKAQUA	mineral spring	mineral spring(44.44%)	
14:Ice black tea	tea drinks	mineral spring(35.80%)	
15:Pocari sweat	energy drinks	mineral spring(35.19%)	
16:NongFu Spring(New Version)	mineral spring(version2)	mineral spring(38.27%)	
17:Mirinda	carbonated drinks	mineral spring(35.8%)	
18:Kunlun Mountian	mineral spring	mineral spring(40.74%)	
19:green tea	tea drinks	mineral spring(29.63%)	
20:Coca-cola	carbonated drinks	carbonated drinks(31.48%)	
21:Classmate XiaoMing	tea drinks	mineral spring(35.80%)	
22:Yuanqi Forest	carbonated drinks	mineral spring(30.86%)	
23:Aquamore	energy drinks	mineral spring(35.80%)	
	outcome(all)=	(13/23) percentage of option occupation-->	mineral spring=78.26%(18/23)
	outcome(mineral spring)=	(8/8)	carbonated drinks=13.04%(3/23)
	outcome(carbonated drinks)=	(3/5)	energy drinks=8.70%(2/23)
	outcome(tea drinks)=	(0/5)	
	outcome(energy drinks)=	(0/5)	

Figure 11. Graph comparison between beverage type and type that people think of

I marked the case in which the participants answer beverage type correctly as "green". The outcome turns out that the participants' accuracy is 13/23.

In addition, I categorized the result depending on the four bottle types. It reflected that majority of people could recognize all mineral spring samples correctly. And most people could recognize the plenty of carbonated drinks correctly. Nevertheless, the accuracy of the other two types of beverages is poor.

beverage name	beverage type	beverage market price	beverage psychological expected price
1:Sprite	carbonated drinks	3	4.72
2:NongFu Spring	mineral spring	2.5	4.9
3:Ganten	mineral spring(version2)	3	5.05
4:Fanta	carbonated drinks	3.8	5
5:Evian Spring	mineral spring	4	5.09
6:Alien electrolyte spring	energy drinks	5.4	5.66
7:Pomelo Tea	tea drinks	4	5.11
8:Ceston Spring	mineral spring	1.8	4.94
9:NongFu fruit and vegetable	energy drinks	4	5.53
10:Burning Tea	tea drinks	7.6	5.28
11:NongFu Spring(New year sprical	mineral spring(version2)	4.8	5.1
12:Vitamin water	energy drinks	4.2	5.9
13:ALKAQUA	mineral spring	4.5	5.22
14:Ice black tea	tea drinks	3	5.54
15:Pocari sweat	energy drinks	5	5.36
16:NongFu Spring(New Version)	mineral spring(version2)	4.5	5.9
17:Mirinda	carbonated drinks	3	5.67
18:Kunlun Mountian	mineral spring	5	6.08
19:green tea	tea drinks	2.4	5.96
20:Coca-cola	carbonated drinks	3	5.27
21:Classmate XiaoMing	tea drinks	5	6.21
22:Yuanqi Forest	carbonated drinks	5.5	5.52
23:Aquamore	energy drinks	6	5.98
	average=		
		market price average	beverage psychological expected price average
	total=	4.130434783	5.434347826
	mineral spring=	3.56	5.246
	carbonated drinks=	3.66	5.236
	tea drinks=	4.4	5.62
	energy drinks=	4.92	5.686
	mineral spring(version2)=	4.1	5.35

Figure 12. Data type influences beverage market price and beverage psychologically expected price

By dividing it into five parts, I have calculated the mean of each type of beverage. It reflected that the type which has a higher market price will receive a higher psychologically expected price.

By arranging the rank ordered we can see the rank is close. In market price the sequence is energy drinks (4.92)>tea drinks (4.4) >mineral spring (version2) (4.1)>carbonated drinks (3.66)>mineral spring (3.56). While in the psychologically expected price we can see that energy drinks (5.686)>tea drinks (5.62)>mineral spring (version2) (5.35)>mineral spring (5.246)>carbonated drinks (5.236).

Hence, we can find orders are similar. It means that the market price is fair in people's minds. Besides, by looking at the mineral spring, the market price of version 2 has a significant increase compared to version1 while the psychologically expected price of version 2 also has a considerable rise compared two version1. The mineral spring bottle shape of the version is recently come up in the Chinese market. An example of it is what I have told in the introduction part, the bottle with ￥2.5 RMB is a bottle shape in version 1 whereas the bottle with ￥4.5 RMB is a bottle shape in version2. By just looking at the mineral spring parts, these enterprises get a successful market design.

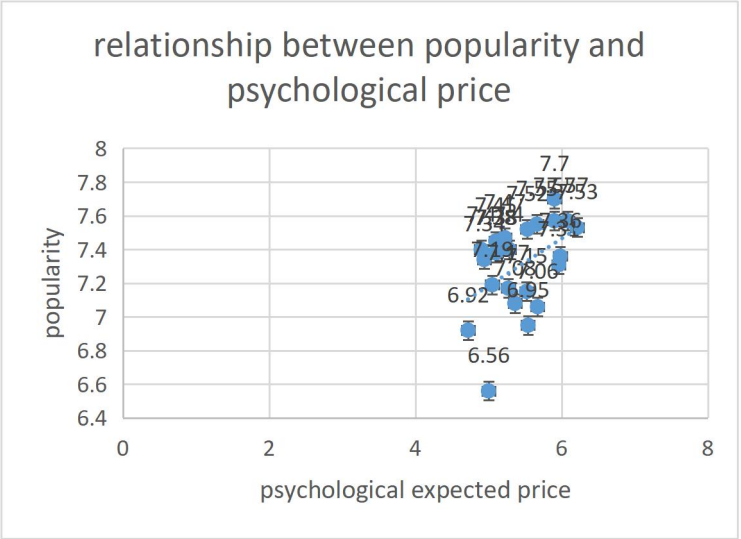


Figure 14. The graph between popularity and psychological price and its best fit line

The Results of the Popularity of the Questionnaire

beverage name	beverage type	beverage market price	beverage psychological expected price	popularity	mean=
2:NongFu Spring	mineral spring	2.5	4.9	7.4	5.246
5:Evian Spring	mineral spring	4	5.09	7.38	
8:Ceston Spring	mineral spring	1.8	4.94	7.34	
13:ALKAQUA	mineral spring	4.5	5.22	7.47	
18:Kunlun Mountian	mineral spring	5	6.08	7.57	
3:Ganten	mineral spring(version2)	3	5.05	7.19	7.403333
11:NongFu Spring(New	mineral spring(version2)	4.8	5.1	7.45	
16:NongFu Spring(New	mineral spring(version2)	4.5	5.9	7.57	
1:Sprite	carbontad drinks	3	4.72	6.92	6.972
4:Fanta	carbontad drinks	3.8	5	6.56	
17:Mirinda	carbontad drinks	3	5.67	7.06	
20:Coca-cola	carbontad drinks	3	5.27	7.17	
22:Yuanqi Forest	carbontad drinks	5.5	5.52	7.15	
7:Pomelo Tea	tea drinks	4	5.11	7.38	7.353333
10:Burning Tea	tea drinks	7.6	5.28	7.4	
14:Ice black tea	tea drinks	3	5.54	6.95	
19:green tea	tea drinks	2.4	5.96	7.31	
21:Classmate XiaoMing	tea drinks	5	6.21	7.53	
6:Alien electrolyte spring	energy drinks	5.4	5.66	7.55	7.442
9:NongFu fruit and vege	energy drinks	4	5.53	7.52	
12:Vitamin water	energy drinks	4.2	5.9	7.7	
15:Pocari sweat	energy drinks	5	5.36	7.08	
23:Aquamore	energy drinks	6	5.98	7.36	

Figure 13. Popularity result

Using the previous method to analyze the popularity results. First of all, I tried to find the relationship between the beverage type and popularity. Therefore, I reordered the sequence of the beverage depending on the type of beverage I also analyzed the mean popularity of each type. It reflected the sequence: energy drinks>mineral spring (version 2)>tea drinks>carbonated drinks>mineral spring. Since the mineral spring is at the bottom of the rank and energy drinks are at the top of the rank. The trend is quite similar to the previous two.

Using the Pearson correlation coefficient, we can find the correlation is 0.453240289. It reflected that the relationship between psychological price and popularity is a positive correlation with medium relevance. I have already shown it at the top of the picture. I have plotted all the points on a graph. The x-axis is the psychologically expected price and the y-axis is the popularity. And we could see the point is gathering around the best fit line.

Create the "Ideal Model" Weighted Means

So far, the data I have been fully collected. How to use it is a problem I need to solve. In my view, the psychologically expected price is within the customer's acceptance range. For example, the Nong Fu Mineral Spring has a psychologically expected price of ￥4.9 RMB. So, when customers see the price of the goods on shelves, they might think the price is reasonable. In this case, the price doesn't have a negative influence on the amount of selling. And popularity has a positive relationship with the number of sales. The more popular the product is, the larger number of selling it will be. So the (psychologically expected price – market price)* popularity should be the profit. Since the feature of the bottle shape of different bottle

types is different, therefore I regard the one beverage type as a group. In each group, the total weighted is one. The weight of every bottle in the group is the percentage of its profit dividing the total profit. After I measured the weight of every bottle, I picked some points of each bottle and record the position of these points. Hence, I calculated the mean weighted of the position. And the position of this new point is the ideal bottle point. Then I will use function fitting to plot the curve of the bottle shape.

beverage name	beverage type	beverage market price	beverage psychological expected price	popularity	(market price-psychological expected price)*popularity
2:NongFu Spring	mineral spring	2.5	4.9	7.4	17.76
5:Evian Spring	mineral spring	4	5.09	7.38	8.0442
8:Ceston Spring	mineral spring	1.8	4.94	7.34	23.0476
13:ALKAQUA	mineral spring	4.5	5.22	7.47	5.3784
18:Kunlun Mountian	mineral spring	5	6.08	7.57	8.1756
3:Ganten	mineral spring(version2)	3	5.05	7.19	14.7395
11:NongFu Spring(New	mineral spring(version2)	4.8	5.1	7.45	2.235
16:NongFu Spring(New	mineral spring(version2)	4.5	5.9	7.57	10.598
1:Sprite	carbontad drinks	3	4.72	6.92	11.9024
4:Fanta	carbontad drinks	3.8	5	6.56	7.872
17:Mirinda	carbontad drinks	3	5.67	7.06	18.8502
20:Coca-cola	carbontad drinks	3	5.27	7.17	16.2759
22:Yuanqi Forest	carbontad drinks	5.5	5.52	7.15	0.143
7:Pomelo Tea	tea drinks	4	5.11	7.38	8.1918
10:Burning Tea	tea drinks	7.6	5.28	7.4	-17.168
14:Ice black tea	tea drinks	3	5.54	6.95	17.653
19:green tea	tea drinks	2.4	5.96	7.31	26.0236
21:Classmate XiaoMing	tea drinks	5	6.21	7.53	9.1113
6:Alien electrolyte spring	energy drinks	5.4	5.66	7.55	1.963
9:NongFu fruit and vege	energy drinks	4	5.53	7.52	11.5056
12:Vitamin water	energy drinks	4.2	5.9	7.7	13.09
15:Pocari sweat	energy drinks	5	5.36	7.08	2.5488
23:Aquamore	energy drinks	6	5.98	7.36	-0.1472

Figure 15. Graph of weighted mean

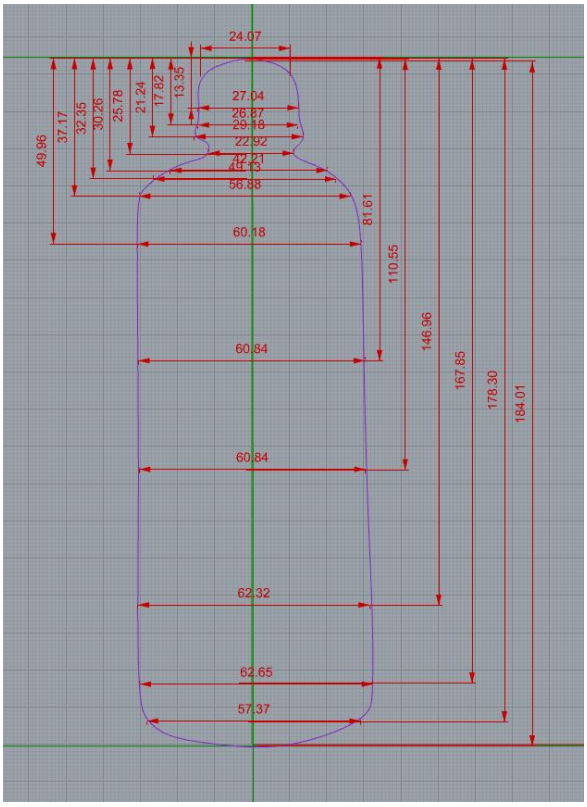


Figure 16. Picking point from a bottle

	7:Pomelo Tea	14:Ice black tea	19:green tea	21:Classmate XiaoMing	
weighted	0.1343365	0.2894898	0.42675841	0.1494153	part1:
AX1	23.12	15.48	13.83	14.27	15.621387
AY1	14.29	14.19	13.29	38.5	17.451637
					part2:
BX1	23.12	15.48	13.83	14.27	15.621387
BX2	27.23	26.74	21.81	25.8	24.5614555
BX3	29.75	28.41	24.21	27.95	26.7288946
BY1	14.29	14.29	13.29	38.5	17.4805859
BY2	15.21	12.06	12.38	16.44	13.2741617
BY3	12.02	11.49	11.83	15.54	12.3114282
					part3:
CX1	29.75	28.41	24.21	27.95	26.7288946
CX2	35.8	35.09	26.47	36.42	31.7054437
CX3	38.86	38.78	30.64	41.64	35.7442612
CX4	41.51	45.92	33.67	44.15	39.8353204
CX5	46.05	51.54	41.68	48.02	46.0687128
CX6	50.42	57.32	48.59	52.03	51.8770702
CY1	12.02	11.49	11.83	15.54	12.3114282
CY2	14.54	16.59	14.22	18.36	15.5676578
CY3	15.58	19.54	17.53	16.86	17.74981
CY4	19.5	24.51	20.3	16.28	20.8106333
CY5	24.86	27.58	27.12	15.84	25.2641602
CY6	28.66	30.83	29.31	16.28	27.7158244
					part4:
DX1	50.42	57.32	48.59	52.03	51.8770702
DX2	56.64	71.95	58.24	61.84	62.5318616
DX3	70.25	86.58	66.25	74.92	73.9681039
DX4	81.01	108.52	74.44	84.58	86.7034737
DX5	99.5	116	93.73	93.8	100.962518
DX6	126.89	122.47	111.57	105.99	115.949737
DX7	144.71	134.37	142.33	125.17	137.781416
DY1	28.66	30.83	29.31	16.28	27.7158244
DY2	30.84	29.88	30.58	18.58	28.6193011
DY3	30.51	29.4	30.03	23.19	28.8901023
DY4	30	25.95	28.67	26.98	27.8087435
DY5	28.74	25.38	28.12	29.73	27.6506453
DY6	27.73	25.28	28.03	30.1	27.5028918
DY7	27.57	26.28	26.94	29.96	27.2848029
					part5:
EX1	144.71	134.37	142.33	125.17	137.781416
EX2	159.83	149	158.34	149.99	154.588709
EX3	175.65	159.89	174.99	176.51	170.934478
EX4	188.18	172.84	189.2	189.02	184.300029
EX5	200.38	186.93	199.99	197.71	195.920988
EX6	211.94	202.92	213.22	204.35	208.740991
EY1	27.57	26.28	26.94	29.96	27.2848029
EY2	28.15	28.79	28.12	29.21	28.4808509
EY3	28.41	27.98	31.31	29.73	29.720347
EY4	28.32	28.24	31.85	28.69	29.8585817
EY5	24.88	28.15	30.12	24.16	27.9552667
EY6	24.88	25.35	30.12	24.16	27.1446953

Figure 17. Collection of points from one group of bottles

The Function Curving of Bottle Shape

I divided the bottle point into five parts. The first part is the bottle cap. Since the shape of the bottleneck is complicated. Therefore, I split the points into two parts. One part starts from the bottle cap to the lowest of the bottleneck. The other point starts from the lowest point to the end of a bottleneck.

The fourth part is the main body of the bottle. The final part is the bottle bottom. To a precise curve, the fitting function needs more data to input. Therefore, for every function, I input two groups of data. Usually, the bottle cup doesn't contain a curve. So I regard it as a constant function. The main fitting object is the remaining parts. So I used MATLAB to fit the function. For function fitting, normally I tried every function model it has. Then I remove the failure case. I use R^2 as the fitting degree and pick the model with the highest fitting degree as the final model.

After having a curve of every part of the beverage bottles. I combined each part as a two-dimensional piece-wise function. And I plotted it as the cross-section of the bottle.

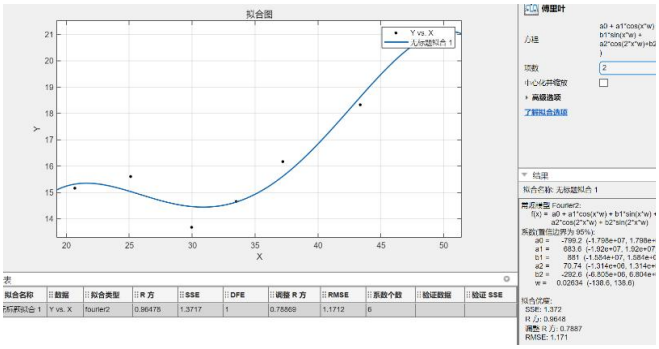


Figure 18. Function curving for a part of the bottle

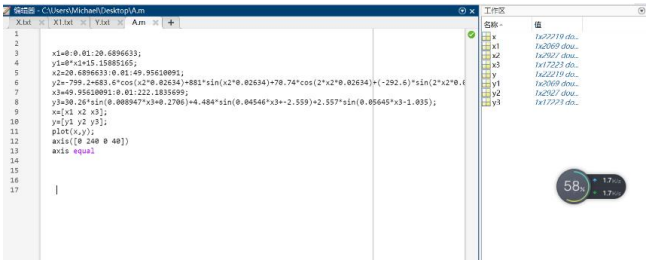


Figure 19. Combines the functions and plots the cross-section

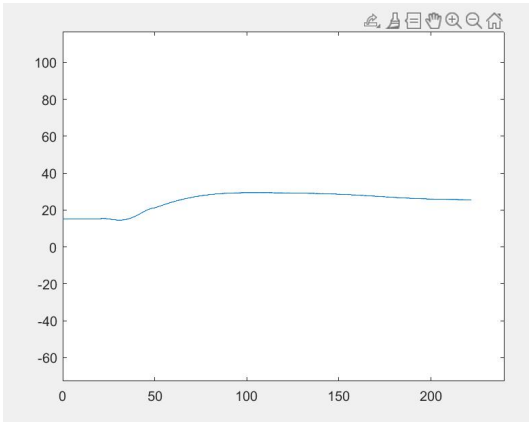
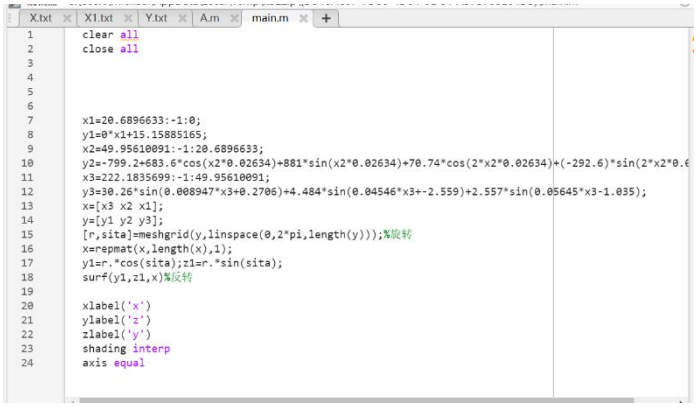


Figure 20. Cross-section of beverage

The Ideal Case Beverage Model

In the previous graph, the bottle cup is near the y axis. If I don't do anything, the bottle cup will be at the bottom. So, I need to reverse the value of x value, same for y value. Then according to the value of x and y, I rotate it by the x-axis. After that, I create the grid of each axis. Finally, I draw it and made it value of each axis equal.



```
clear all
close all


x1=20.6896633:-1:0;
y1=0*x1+15.15885165;
x2=49.95610091:-1:20.6896633;
y2=-799.2+683.6*cos(x2*0.02634)+881*sin(x2*0.02634)+70.74*cos(2*x2*0.02634)+(-292.6)*sin(2*x2*0.6
x3=222.1835699:-1:49.95610091;
y3=30.26*sin(0.008947*x3+0.2706)+4.484*sin(0.04546*x3+-2.559)+2.557*sin(0.05645*x3-1.035);
x=[x3 x2 x1];
y=[y1 y2 y3];
[r,sita]=meshgrid(y,linspace(0,2*pi,length(y)));%旋转
x=repmat(x,length(x),1);
y1=r.*cos(sita);z1=r.*sin(sita);
surf(y1,z1,x)%反转

xlabel('x')
ylabel('z')
zlabel('y')
shading interp
axis equal
```

Figure 21.Program of the beverage

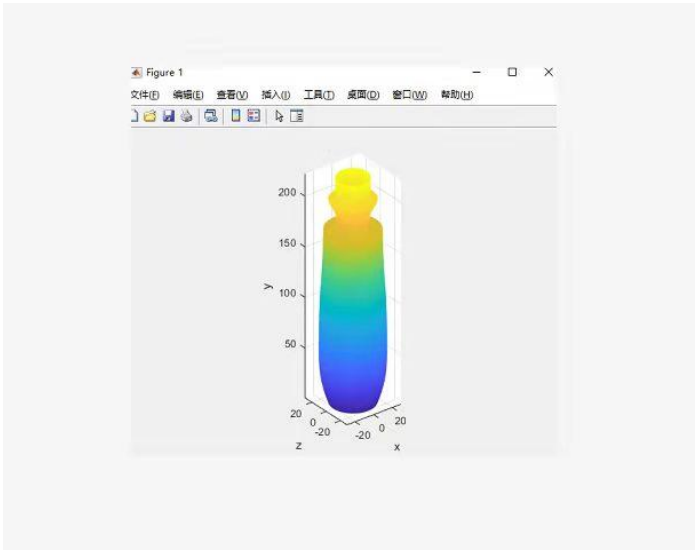


Figure 22. Results one ideal bottle for one bottle type

Analysis of Psychologically expected Price

Pearson correlation coefficient is 0.345314292. Because the value of the Pearson correlation coefficient is between 0.2 and 0.4 therefore, the relationship between psychologically expected price and market price has a weak linear relationship. Since the value is positive, it means the greater the market price is the higher the psychological price the customer will consider. And this outcome also is proved by its best fit line.

The Hypothesis from the Inconsistent between Psychological Price and Market Price

From Figure 7, we can see that some bottles with extremely low market prices have a considerable high psychologically expected price in the questionnaire. For instance, the 19th sample has only a market price of ￥2.4 RMB

but the psychological price is 5.96RMB.

In addition, it is also interesting that some bottles with a ￥7.6 RMB market price but only have a ￥5.28 RMB psychological price. From my perspective, one rational hypothesis is that carbonated beverage bottle is often cheap but the bottle design of this kind of bottle is often complicated with streamlining. It will bring an illusion to the participants that this kind of beverage is expensive. On the other hand, some tea drinks or energy drinks need high-quality gradients such as juice or tea, so the company is not so focused on a fancy design. Therefore, the bottle shape of these groups of the design is made of a straight line. So due to its simple structure, the customer will give a low psychological price on their bottle models.

The Analysis of Results of Beverage Type

Since the correctness of the answer was over half whereas the probability of random choice the 25%. It could prove that the opinion (Luo et al., 2012) is correct. People can distinguish the different types of bottles by looking at the bottle shape.

The Assumption According to the Data

Based on the facts that people choose the option of mineral spring and carbonated drinks is over 90% whereas there is a low correct rate in tea drinks and energy drinks. I assumed that most people have drunk mineral springs, and some teenagers often drink carbonated drinks. For two other types of beverages, people don't often drink. Therefore, people have a strong impression of mineral springs and carbonated but have no preference for tea drinks and energy drinks.

Analysis of the Data Relationship among Three Factors

Previously, I found some samples contradict the relevance between psychologically expected price and market price. However, according to the trend, I found that tea drinks and energy drinks have higher market prices and psychological prices. When I arranged the average value of different beverage types from high to low, the rank of market price and the order of psychologically expected price is very similar.

Contradiction between Two Results and Reasonable Explanation

We can see that the conclusions have contradictions as we take the beverage type as a factor. Without considering the beverage type, the market price and psychologically expected price have a low positive correlation, and there are plenty of occasions that have a negative correlation. And I stated the assumption to explain it. But when taking the beverage type into consideration, we could see the trends of the two factors were almost the same. Therefore, the relationship between market price and psychologically expected price is considerable. And some tea and energy drinks have higher market prices and psychologically expected prices. It contradicted my assumption. There was one reasonable explanation. Before taking beverage type into an account, plenty of negative occasions were enlarged as I use the mean value of every beverage to judge. After taking beverage type as a factor, I use the several mean values of the different types of beverages to judge. So the accuracy has risen, and conclusions have changed. Besides, the Pearson correlation efficiency only shows a positive linear relationship. It can't show the non-linear case. Therefore, the relationship has been under estimated.

The Analysis of the Results of the Popularity

The Analysis of the Relationship between Popularity and Psychologically expected Price

From the Pearson correlation coefficient, we could see that its value of it is higher than the previous relationship which means this relationship is more linear than the previous one. The best-fit line in this graph also has a higher gradient than the previous one. So it has a stronger relationship than the previous one. In

my view, both the data of popularity and the psychologically expected price came from the customers. In contrast, the market price came from the sellers or the beverage industry. So the market price has more factors that need to consider whereas the popularity and psychologically expected price have the same source.

Some Potential Problems during Function Fitting

The problem of Weighted Mean

Although the bottle I pick all have a positive contribution to the profit, some bottles' contributions are not as high as the highest bottle. Therefore, the result of the "ideal case model" might not be as high as the highest weighted model.

The problem of Function Curving

Some functions especially polynomials have a high fitting degree while it has too many waves because of the high index. Although the fitting degree is high, the curve isn't similar to the bottle.

On certain occasions, the function I pick is the one with a high fitting degree and normal shape instead of the highest fitting degree.

Conclusion

In this investigation, I have learned some factors which influence the bottle commercial values of beverages such as bottle shape, bottle color, the complexity of bottle texture, and the shape of the bottle label. I focused on the bottle shape study. And I found some previous research on this topic. Furthermore, I applied some of their conclusions to my questionnaire design. I also learned some mathematical knowledge such as finding volume by integration, demonstrating bottle shape by function fitting, and so on. Then I learned some technical skills in model design and function curving. And I applied on questionnaire and model design. I have proved the research (Luo et al. 2012) on bottle type have a big impact on bottle shape design by sending questionnaires. Based on the result of the questionnaire I found that the bottle shape has a positive impact on the commercial value and the popularity of the beverage. Besides, I also found a strong relationship between popularity and psychologically expected price. Although the distribution of data is too difficult for me to find an equation to demonstrate the relationship, I created the "ideal model" based on the weighted mean of the bottle shapes.

Conflict of Interests: the author has claimed that no conflict of interests exists.

References

1. Snowball, (2020). China's beverage industry market share, the latest authoritative statistics, https://xueqiu.com/3624290485/157401495
2. Ng, S., Ni Mhurchu, C., Jebb, S., & Popkin, B. (2012). Patterns and trends of beverage consumption among children and adults in Great Britain, 1986–2009. British Journal of Nutrition, 108(3), 536-551. doi:10.1017/S0007114511006465
3. Bleich, S. N., Vercammen, K. A., Koma, J. W., & Li, Z. (2018). Trends in beverage consumption among children and adults, 2003-2014. Obesity, 26(2), 432-441.
4. Gao, (2018). https://www.zhihu.com/question/53618210
5. Wikipedia,(2022)https://en.wikipedia.org/wiki/Kansei_engineering
6. Nagamachi, M. (1989). Kansei Engineering'Kaibundo Publisher.
7. Gislason, S., Bruhn, S., Christensen, A. M., Christensen, M. T., Hansen, M. G., Kha, T. T., & Giacalone, D. (2020). The influence of bottle design on the perceived quality of beer: A conjoint analytic study. Beverages, 6(4), 64.
8. Luo, S. J., Fu, Y. T., & Korvenmaa, P. (2012). A preliminary study of perceptual matching for the evaluation of beverage bottle design. International Journal of Industrial Ergonomics, 42(2), 219-232.
9. Mele, M., & Campana, G. (2018). Prediction of Kansei engineering features for bottle design by a Knowledge-Based System. International Journal on Interactive Design and Manufacturing (IJIDeM), 12(4),

1201-1210.
10. Henderson, A., & Garcia, A. (2020, June), Improving STEM Education by Analyzing the Design of a Bottle Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual Online. 10.18260/1-2—34794
11. Hsu, T.-R. (2018). Applied Engineering Analysis (1st Ed.). Wiley. Retrieved from https://www.perlego.com/book/991494/applied-engineering-analysis-pdf (Original work published 2018)
12. Wikipedia,2022.https://en.wikipedia.org/wiki/Curve_fitting, https://en.wikipedia.org/wiki/Interpolation, https://en.wikipedia.org/wiki/Smoothing