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THE UNIVERSITY OF HONG KONG

PRODUCTIVITY LAPTOPS

STAT3613 Marketing Analytics Group Project

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Table of Contents

1. Introduction

1.1. Background and Motivation

Whether it be gaming, content creation, multimedia and design, or education, the use cases for laptops vary and increase providentially in response to ever-changing consumer demands. Such demands typically require a cross-functional device that offers integrated features and fulfils certain computational capabilities. To meet all levels of demand from customers, key manufacturers in the industry in the past decades received substantial investments to deliver multifunctional devices. As such, product innovation efforts coupled with catapulting sales of laptop devices provided a fillip to the market of laptops. However, despite the notable technological advancements in manufacturing multi-purpose and cutting-edge computers as of recent years, a significant majority of users tend to primarily use their laptops for productivity.

In this day and age, although the market in Hong Kong appears to be saturated with productivity laptops, their prices are not always favourable to low-income students and young people. Having experienced this problem ourselves, we are poised to conduct marketing research on productivity laptops in Hong Kong in hopes of finding out whether it is possible to manufacture a low-cost laptop with broadly favourable features and sell it to our target consumer base at a reasonable price.

1.2. Objectives

The ultimate objective of this research is to synthesise comprehensive analysis of the ideal productivity laptop for students. To do so, we aim to identify the exact features in a productivity laptop that our target consumer base wishes to have, and how much emphasis and financial value they place upon each feature. Before we proceed to analysing the data and employing statistical models, we would need to gauge the existing market in search of popular models where those features shall be therein contained. Below are some questions we wish to answer by the end of the research:

- What type of clusters do we get if we segment consumers according to their preference for laptop attributes?
- What attributes do our target consumer base consider when they choose a laptop?
- Which attributes do our target consumer base prefer?

2. Study design

Our study involves collecting first-hand data and conducting statistical analysis on them. The methodology and statistical methods used will be discussed in Section 2.1. We discuss the data collection in Section 2.2 and sampling methods in Section 2.3. Since our study is strongly dependent on existing laptop models in the market, we will discuss them in Section 2.4.

2.1. Methodology and Statistical Methods

Our study involves three stages. In Stage 1, we ask respondents to rate the importance of some selected attributes for laptops. We conduct cluster analysis to quantitatively find clusters of respondents in the laptop market. After grouping the respondents into an appropriate number of clusters, we qualitatively interpret features for each cluster and proceed to Stage 2.

Stage 2 is based on the assumption that the clusters of respondents should represent clusters of consumers in the population, with the same features for each cluster. Motivated by the fact that we could only briefly interpret the clusters of consumers and distinguish difference between clusters in Stage 1, we seek to investigate deeper in each cluster of consumers. For instance, we ask the respondents for each cluster to choose the most preferred laptop model among few possible choices. The given choices vary by which clusters the respondents belong to. Due to anonymity in our survey designs, we cannot predetermine which cluster our respondents belong to. Therefore, we will ask our respondents which cluster they think they belong to before proceeding further. Details of these questions will be given in Section 2.2. After data collection, we conduct conjoint analysis to observe the preference of the respondents.

After Stage 2, we have extracted information about the consumers' preference for important attributes in both clusters. In Stage 3, it remains to consider some minor attributes that are not of particular interests in any clusters of consumers. We ask respondents to choose some combinations of these attributes among some choices and implement a choice model to interpret the result.

2.2. Data Collection

In light of our goal to produce a productivity laptop for students, our **target population** is university students. We conduct surveys to collect first-hand data from university students in all three stages. Surveys are conducted online and anonymously on the Google Form platform. There are three questionnaires in total, one for each stage. The designs of the questionnaire in each stage depend on results from previous stage.

In Stage 1, we asked the respondents to rate the importance of 19 attributes of a laptop in a 5-point scale (1 = least important, …, 5 = most important). The attributes are shown in *Table 1*.

Table 1: Selected Laptop attributes for stage 1

Brand	Price	CPU (Computing Power)
CPU Brand	GPU (Graphics Performance)	GPU Brand
RAM (Memory)	Battery Life	Storage
Number of SSD cards	Touch Screen	360 Rotational Screen
Detachable Screen	Touch Bar	Keyboard
Fingerprint Identification	OS (Operating System)	Screen Size
Weight		

Having identified two main clusters of respondents in stage 1, the questionnaire for stage 2 started with asking interviewees to choose which of the two groups of features they value the most, namely (see section 3.1 for further clarifications):

- Computing Power (CPU, GPU, etc.)
- Other functional features (Touch Screen, Screen Size)

This enabled us to conduct conjoint analysis for each group of respondents. For each group, we identified all important attributes that could affect the preference (factors) and their possible values (levels). *Table 2* summarises the groupings. Since our cluster solution above is easy to interpret, we can simply ask the respondent whether they value "Computer Power" or "Other functional features" the most as the first question, so that we can determine the corresponding questionnaire set for them. Afterwards, a set of stimuli was presented to the respondents according to their answer to the first question, then they were prompted to indicate their preference for each stimulus in a 7-point Likert scale.

Due to the large number of possible combinations in each cluster and the technical infeasibility for certain profiles to exist, we had to manually select certain profiles of interest that are also realistic. Therefore, the design of questionnaire for each cluster differed. For example, cluster 1 had 6 x 4 x 2 x 2 = 96 stimuli. Hence, we opted for a full-profile method with a subset of stimuli, selecting 19 profiles as a fractional factorial design.

For cluster 2, however, the total number of stimuli is 2 x 4 x 3 x 2 x 2 x 2 = 192. Therefore, we designed two sets of questions with each set having its own combination of laptop attributes that belong to cluster 2. In reality, *screen size* and *weight* go hand in hand in that an increase in one typically leads to an increase in the other. Thus, we wanted to infer how respondents trade-off *weight* for *screen size* and vice versa. As a result, the first set of questions for cluster 2 included the two factors, *screen size* and *weight*, in a full-profile method design along with *price* that simply serves to illustrate to respondents how the value of a laptop changes if the former two factors change. Respondents evaluated all 8 possible stimuli on a 7-point scale. Note that the *price* was not included in our conjoint analysis for this set. On the other hand, the second set of questions included factors such as *SSD storage*, *fingerprint reader*, *360 screen*, and *touch screen* along with *price* which served the same purpose as in set 1. Respondents evaluated all 24 possible stimuli for this set on a 7-point scale.

In summary, the reason why we divided cluster 2 attributes into 2 sets is firstly to reduce the number of combinations and secondly to facilitate the interpretation of results. For instance, it is relatively more difficult to observe the respondents' trade-off between *screen size* and *weight* if we combine all factors together into one single conjoint analysis. In both sets of questions, *price* was included with each combination of attributes so as to prevent respondents from choosing the best model with all attributes without being aware of its monetary value.

Table 2: Factors and Levels of laptops for stage 2

Cluster	Factor	Levels					
1	**Brand**	Microsoft	DELL	RAZOR	ASUS	HP	Lenovo
	CPU	I5-Gen11	I5-Gen12	I7-Gen11	I7-Gen12		
	Graphics - GPU	Integrated	Dedicated				
	RAW	8GB	16GB				
	Price ($$$ HKD)	< 6	6-8	8-10	10-12.5	12.5-15	15-17
	Screen Size	13.3”	15.6”				
	Weight	< 1.3KG	1.5KG	1.7KG	> 1.7KG		
	SSD Storage	256GB	512GB	1TB			

2	**Fingerprint Reader**	Yes								No							
	360 Screen	Yes								No							
	Touch Screen	Yes								No							
	Price ($$$ HKD)	7	7.5	7.7	8	8.2	8.5	8.7	9	9.2	9.5	9.7	10	10.2	10.5	10.7	11.2

In stage 3, a study of choice of 24 different profiles was conducted. Each profile was described by four attributes – summarised in *table 3.* Out of the 24 distinct combinations, we generated 36 profiles that were segmented into 12 groups. We acknowledge that some profiles may have been repeated between segments, but we ensured that each segment had three unique profiles. Respondents were then asked to select their preferred profile in each segment.

Table 3: Study of choice of different profiles for stage 3

Operating System	Windows		Linux		ChromeOS
Keyboard	Mechanical Keyboard			No Mechanical Keyboard	
Touch Bar	Touch Bar			No Touch Bar	
Detachable Screen	Detachable Screen			No Detachable Screen	

2.3. Sampling Methods

It is practically hard for us to get equal numbers of data from people of different backgrounds (race, nationality, gender, etc.) if we conduct surveys ourselves as our group has only three members. Therefore, in sacrifice of data unbiasedness for time, we use convenient sampling method and obtain responses mainly from the group members' acquittance (who are all university students), so that we can get a considerable amount of first-hand data within a reasonable time.

As for the sample size, the minimum number of samples for the clustering analysis in stage 1 is 30. As the designs of study in later stages depend on the result in Stage 1, we need a relatively higher number of respondents to ensure that our result in Stage 1 is reliable. Due to the length of the surveys in stage 2, we predict that there may be less respondents willing to invest their time to complete the surveys. As a compromise, we do not set a minimum sample size for stage

2. The survey design in Stage 3 is simple and short so we predict that more respondents are willing to complete the questionnaire. Hence, we will set a minimum sample size of 20.

2.4. Existing Laptop Models

Since Hong Kong is a free market with access to countless international brands, we consider only laptops from a subset of popular brands, namely Asus, DELL, HP, Lenovo, Microsoft, Samsung, and Razor. The first six brands have invested in producing productivity or office laptops which are similar products important to our study. The last one is a leading brand in gaming hardware including laptops, so we included it to see if gaming laptops are interesting to students for some potential reasons despite gaming purpose. We did not include other famous laptop brands such as MSI or Acer as they are now more known for gaming laptops instead of laptops for office or productivity work.

In the design of survey for Stage 2, we consider laptops with different hardware components such as CPU and graphics cards. As we lack the domain knowledge in the price of these components, the combinations presented in the survey of Stage 2 are real existing laptop models, which are listed in the *Appendix A.*

3. Results

3.1. Cluster Analysis on Importance for Laptop Components

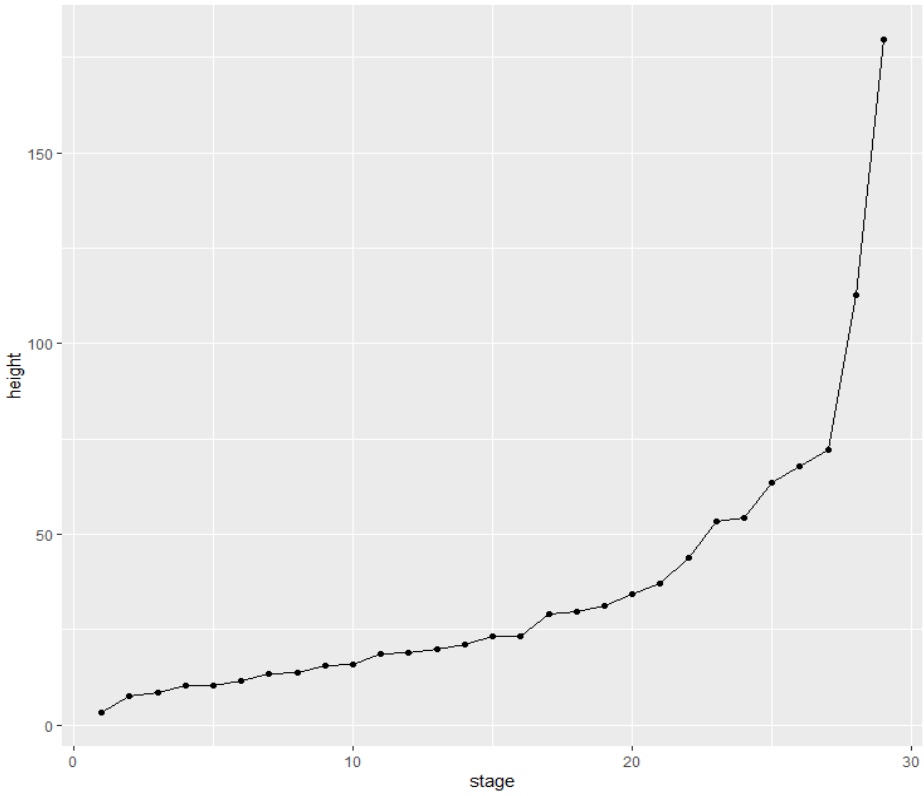

Figure 1: Plot of distances at each stage

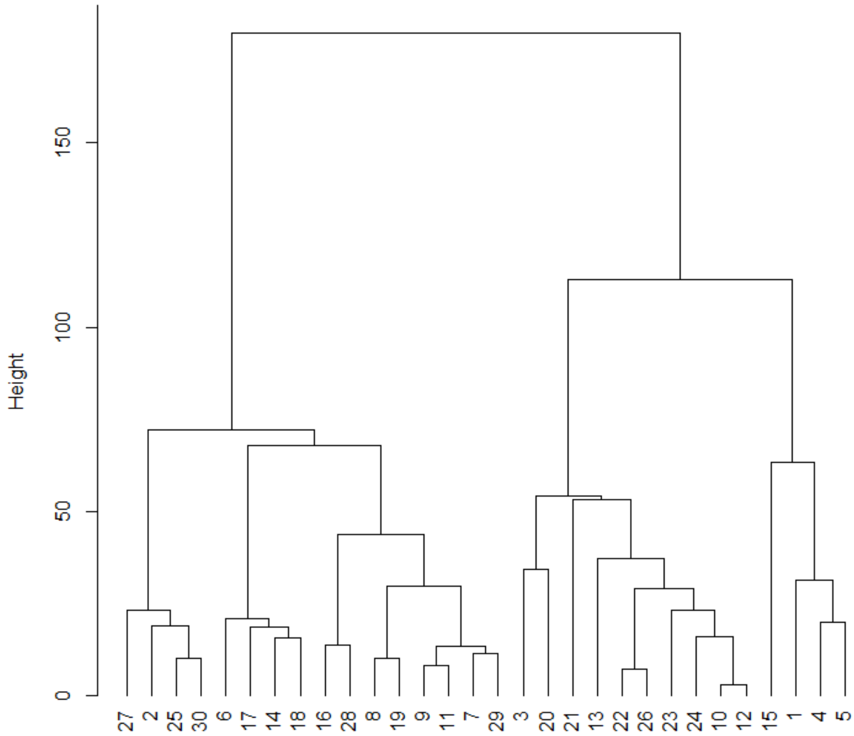

Figure 2: Dendrogram

From *figure 1*, there is a jump from 3-cluster solution to 2-cluster solution, suggesting 3 clusters. This is supported by the observations in *figure 2*. However, from the distribution of respondents into the three clusters in *table 4,* we noticed that the first cluster has a very small market. Besides, the profile of mean values in the 3-cluster case did not provide a clear and consistent segmentation for that cluster. Therefore, we decided to re-do cluster analysis assuming a two-cluster solution. This time, we had a roughly even market for each cluster with interpretable preferences. See *figure 3*.

Table 4: Cluster sizes and total proportions

Cluster	Respondents	Proportion
1	4	0.133333
2	16	0.533333
3	10	0.333333

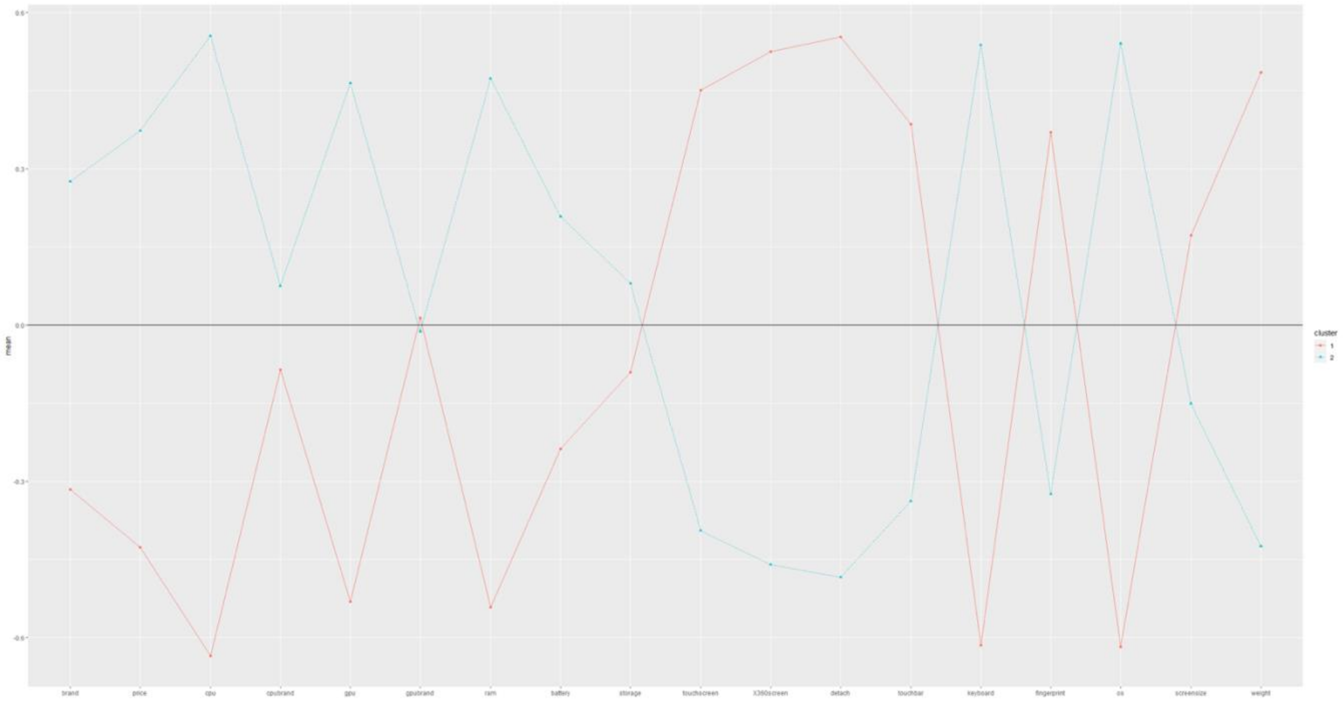

Figure 1: Profile of mean values for a 2-cluster solution

From *figure 3*, we can highlight all the attributes that are high at one of the two clusters and low at the other. Results are presented in *table 5*. Note that cluster 1 is characterised by consumers who prefer computing power, whereas cluster consumers prefer `gimmicky` features. Note that respondents in both clusters had no strong preference for CPU brand or GPU brand.

Table 5: Interpretation of 2-cluster solution

	Cluster 1	Cluster 2
1	Brand	Screen Size
2	Price	Weight
3	CPU	Touch Bar
4	GPU	SSD Storage
5	RAM	Fingerprint Reader
6	OS	360 Screen
7	Keyboard	Touch Screen
8	Battery Life	Detachable Screen

3.2. Conjoint Analysis on Preference for Laptop Components

After we have grouped the consumer base into two clusters based on result from Stage 1, we conduct a survey for each cluster to have a closer look on their preference regarding computer attributes that are important to them.

3.2.1. Cluster 1 (Computing Power)

There are 16 respondents who responded that they value computing power the most. One respondent has rated *1* for all options. We decide to drop this data as we cannot draw any useful information from this respondent. We have 15 valid responses in total for our analysis in cluster 1. After collecting their rating of preference regarding the 19 combinations of attributes, we perform ANOVA for each respondent to estimate the part-worth of each level and relative importance of each factor.

The part-worth of the brand levels for the 15 respondents are shown in *table 6* where significantly positive part-worth are labelled green and significantly negative part-worth are labelled as red. We observe that *Lenovo* laptops are generally more preferred. From our knowledge, we know that *Lenovo* laptops are well-known for its budget laptops which are popular among consumers who value budget. It suggests that budget, or equivalently *price*, is an important factor for students. It also suggests that a further study on the marketing strategy used by *Lenovo* may provide potentially useful information for the marketing of our laptops.

We also observe considerably significant part-worth of *Razor* for respondent 9, 10 and 11 while having highly negative part-worth for respondents 3-7. Since *Razor* produces gaming laptops, we conclude that students who play games will opt for gaming laptops over other laptops regardless of price, while non-gamers strongly do not prefer gaming laptops, possibly due to significantly higher price of gaming laptops compared to office laptops. Although our aim is to produce a productivity laptop, this information may be useful for future marketing study.

Table 6: Part-worth of brands

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
ASUS	0.05	0.43	0.08	1.05	0.67	-0.6	1.27	0.03	-0.1	0.05	-0.4	-0.3	0.15	-1.1	0.9
DELL	-0	-0	0.72	0.65	0.83	0.45	0.49	-0.1	-1.2	-0	-0.3	0.57	0.6	-0.4	0.34
HP	-0.1	0.3	-0.3	0.87	0.79	0.46	-0.6	-0.2	-0.9	-1.1	-1.6	-0.3	-0.4	0.83	-1.3
Lenovo	1.05	0.93	1.58	-0.5	-0.3	1.92	0.77	0.03	0.43	1.05	-1.4	0.75	0.15	0.88	1.9
Microsoft	0.16	-0.4	0.44	0.22	-0.4	0.37	-0.9	1.25	0.74	-0.8	-1.2	-1.2	-0.3	-0.1	-0.9
Razor	-0.4	-0.2	-2.7	-4.2	-3.6	-1.6	-1.5	-0.8	2.18	2.18	5.09	0.21	-0.1	-0.2	-0.2
Samsung	-0.8	-1	0.19	1.88	2.1	-1	0.48	-0.2	-1.2	-1.4	-0.2	0.23	-0.1	0.12	-0.7

Table 7 shows the part-worth of different *CPU* levels. We observe that our respondents mainly prefer Intel Core i7 CPUs, especially the 11th Generation ones.

Table 7: Part-worth of CPUs

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
i5-gen11	-0.4	-0.6	-0.9	-0.3	0.11	-0.7	-0.7	-0.2	0.48	-0.6	0.43	-0.2	-0.1	0.36	-1.1
i5-gen12	0.27	-0.4	-1	-1.4	-1	-0.5	-0.1	-0.3	0.57	0.44	-0.1	-0.3	-1.2	0.71	-0.7
i7-gen11	0.15	1.55	2.14	2.77	1.63	1.54	0.44	0.55	-1.6	-0.4	-0.6	-0.3	1.21	-0.9	1.71
i7-gen12	-0	-0.5	-0.3	-1	-0.7	-0.3	0.37	-0	0.59	0.52	0.25	0.86	0.03	-0.2	0.15

Table 8 shows the part-worth of different *GPU* and *RAM* levels. We cannot observe any obvious preference in *GPU*. As expected, respondents 9-11 (who prefers *Razor* gaming laptops) prefer *dedicated* graphics card as it provides more powerful graphics computing power than *integrated* graphics card. Meanwhile, we also observe that some presumably non-gamers still prefer *dedicated* graphics card. We suspect that students who are involved in media processing (such as 3D graphics or video editing) may prefer dedicated graphics card, while other students generally prefer *integrated* graphics card for a cheaper price. Therefore, we suggest that we should include both options in our product.

As for *RAM*, it seems that the part-worth are relatively insignificant. Since 16 GB *RAM* is a more common configuration in the market, we will select 16 GB here. Let us proceed to their relative importance.

Table 8: Part-worth of GPUs and RAM

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
dedicated	0.47	0.28	-0.7	-0.9	-0.7	0.52	-0.6	-0.1	0.94	0.47	0.32	-0.6	-0.3	-0.1	-0.3
integrated	-0.5	-0.3	0.68	0.95	0.67	-0.5	0.64	0.08	-0.9	-0.5	-0.3	0.59	0.27	0.14	0.28
16GB	0.11	0.13	0.21	-0.2	-0.3	0.43	-0.2	0.06	0.48	0.35	-0	-0.2	0.34	-0.2	0.11
8GB	-0.1	-0.1	-0.2	0.2	0.32	-0.4	0.19	-0.1	-0.5	-0.4	0.02	0.16	-0.3	0.19	-0.1

Table 9 shows the relative importance of a factor for each respondent. In general, *brand* and *CPU* are more important to our respondents compared to *GPU* and *RAM*. It suggests that we should study the marketing strategies of other brands and production managers may pay more attention to selecting the CPU model for our laptop.

Table 9: Relative Importance of Brand, CPUs, GPUs and RAM

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
Brand	0.5	0.4	0.47	0.49	0.55	0.46	0.5	0.64	0.4	0.56	0.8	0.42	0.22	0.47	0.47
CPU	0.18	0.43	0.34	0.33	0.26	0.29	0.2	0.27	0.26	0.17	0.12	0.26	0.52	0.37	0.42
GPU	0.26	0.11	0.15	0.15	0.13	0.14	0.23	0.05	0.22	0.15	0.08	0.25	0.12	0.07	0.08
RAM	0.06	0.05	0.05	0.03	0.06	0.11	0.07	0.04	0.11	0.11	0	0.07	0.15	0.09	0.03

3.2.2. Cluster 2 (Other functional features)

We received 10 valid responses from Cluster 2. Similar to previous analysis, we perform ANOVA for two question sets in Cluster 2 and estimate the part-worth and relative importance.

Table 10 shows the part-worth of the levels of *screen size* (row1-2) and *weight* (row3-6). We can observe a slight inclination towards a smaller screen size. Meanwhile, for the weight, respondents 1 and 2 prefer a lighter laptop while 6, 7, 8 prefers a heavier laptop. This is understandable as we use price as the control factor (which is included in the questionnaire but not shown here). We estimated the increase in price with respect to a larger screen and smaller weight by referring to some existing laptop models, so conservative respondents tend to give up on either screen size or weight.

Table 10: Part-worth of Screen Sizes and Weights

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
13.3	0.25	0.5	-0.5	0.25	-0.625	-0.625	1.375	-0.625	0.125	-0.25
15.6	-0.25	-0.5	0.5	-0.25	0.625	0.625	-1.375	0.625	-0.125	0.25
<1.3	-0.25	1.25	1.5	-0.75	-0.125	0.375	-1.125	-1.125	-0.375	-1.75
>1.7	0.25	-0.75	-1.5	0.75	-0.625	0.875	0.875	1.875	-0.875	0.25
1.3-1.5	-0.25	0.25	0.5	-0.25	0.375	-0.625	-0.125	-0.625	0.625	-0.25
1.5-1.7	0.25	-0.75	-0.5	0.25	0.375	-0.625	0.375	-0.125	0.625	1.75

Table 11 shows the relative importance of screen size and weight for each respondent. We can see that respondents care more about weight than screen size. Together with the above information, we will consider and a 1.7+ KG laptop (while adjusting the price). As for the screen size, since a heavier laptop often binds to a larger screen, and there is no particular reluctance towards it, we will consider a 15.6-inch screen.

Table 11: Relative Importance of Screen Sizes and Weights

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
screensize	0.5	0.3333	0.25	0.25	0.5556	0.4545	0.5789	0.2941	0.1429	0.125
weight	0.5	0.6667	0.75	0.75	0.4444	0.5455	0.4211	0.7059	0.8571	0.875

Proceeding, we let respondents rate different combinations of storage, existence of fingerprint, 360 screen, and touch screen features. *Table* 12 shows a strong preference for 1024 GB SSD (storage) despite the price. This could be due to a need for storing lecture materials, videos, games which account for several gigabytes easily. For fingerprint and touch screen, no particular preference can be seen, while respondents 8 and 10 clearly do not favour a trade-off between having a 360 screen and a high price. Therefore, we will exclude all these three features to cut down the price of the laptop.

Table 12: Part-worth of Storage (SSD), Fingerprint, 360 Screen, Touch Screen

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
256	-0.83	-0.5	-1.1667	-1.208	-0.458	-0.125	-1.292	-0.833	0.292	-0.25
512	0.417	0.25	0.0833	0.5417	0.542	0.375	0.3333	0.1667	0.417	0.125
1024	0.417	0.25	1.0833	0.6667	-0.083	-0.25	0.9583	0.6667	-0.708	0.125
0	-0.13	0.833	-0.3333	0.2083	-0.583	-0.25	-0.125	-0.083	0.292	-0.625

1	0.125	-0.833	0.3333	-0.208	0.583	0.25	0.125	0.0833	-0.292	0.625	(**fingerprint**)
0	-0.04	0.0833	-0.0833	0.375	0.167	-0.25	-0.208	0.8333	0.125	1.2917	
1	0.042	-0.0833	0.0833	-0.375	-0.167	0.25	0.2083	-0.833	-0.125	-1.292	(**360 screen**)
0	-0.46	0	-0.5	-0.208	-0.75	0.0833	-0.458	-0.167	-0.375	-0.458	
1	0.458	0	0.5	0.2083	0.75	-0.083	0.4583	0.1667	0.375	0.4583	(**touch screen**)

3.3. Choice Model on the Remaining Components

To propose a complete laptop product, the final step is to determine the remaining components that are not considered in stage 2. In our analysis, we employed a multinomial logit model since respondents were promoted to choose from 3 available stimuli the one that maximises their utility. In reference to *table 3*, the contrasts associated with each factor are shown in *table 13*.

Table 13: Summary of Contrasts

	Linux	*Windows*
ChromeOS	0	0
Linux	1	0
Windows	0	1

	Mechanical Keyboard
No Mechanical Keyboard	0
Mechanical Keyboard	1

	Touch Bar
No Touch Bar	0
Touch Bar	1

	Detachable Screen
No Detachable Screen	0
Detachable Screen	1

Table 14 shows the coefficient estimations (or part-worth), p-value, range, and importance of some variables of the full model by the maximum likelihood method. The estimates for all variables are positive indicating high part-worth.

Table 14: Statistics of the Full Model

Factor	Level	Part-worth	p-value	Range	Importance
OS	ChromeOS	0		0.938908	35.49%
	Linux	0.045725	0.7903		
	Windows	0.938908	3.406e-09		

Touch Bar	No Touch Bar	0		0.219009	8.28%
	Touch Bar	0.219009	0.2748		
Mechanical Keyboard	No Mechanical Keyboard	0		0.677839	25.62%
	Mechanical Keyboard	0.677839	5.289e-05		
Detachable Screen	No Detachable Screen	0		0.809721	30.61%
	Detachable Screen	0.809721	1.660e-06		
			Total	**2.645477**	

Operating system is the most important factor (35.49%), followed by Detachable Screen (30.61%), and Mechanical Keyboard (25.62%). Touch Bar is the least important factor (8.28%). Therefore, we should not add touch bar in order to reduce the cost of our laptop. From the estimated part-worth, we should use Windows as the operating system for our laptop to maximize market share. Mechanical keyboards should be strongly considered to be implemented with our laptop if the production cost is reasonable. However, detachable screen may not be a reasonable choice if we do not include touch screen as a feature for our laptop. *Table 15* shows the market share of 3 profiles.

Table 15: Market Share of the Selected Profiles

Profile	OS	Mechanical Keyboard	Touch Bar	Detachable Screen	ALT	SID	Choice	Share
1	ChromeOS	Yes	Yes	No	1	99	1	16.92%
2	Linux	Yes	Yes	Yes	2	99	1	39.81%
3	Windows	Yes	Yes	No	3	99	1	43.27%

3.4. Final combination of attributes

To conclude our findings from the three stages, we list out the following combination of attributes to produce our laptop (the price is set with reference to existing laptop models):

Table 16: Final components of the desired productivity laptop

Components	Attribute	
OS	Windows 11 Home	
CPU	11th Generation Intel Core i7 Processor	
GPU	Integrated (Intel Iris Xe Graphics)	Dedicated (GeForce GTX 1660 Ti)
RAM	16 GB	
Storage (SSD)	1 TB	
Screen Size	15.6"	
Weight	1.7 KG	
Other Features	Mechanical keyboard *	
Price	$ 7,999	$ 10,499

It is important to note that laptops with mechanical keyboard are extremely scarce on the current market. We suspect that the R&D cost for implementing a mechanical keyboard may be high. Therefore, the decision on implementing mechanical keyboard in our laptop depends heavily on the estimated R&D cost, which is beyond the scope of this marketing research.

4. Stage Interpretations

Given that a laptop is composed of various components, and each is designated for distinct functionalities (e.g. CPU for computing and GPU for graphics, but we almost never use CPU for massive rendering), customers in this market may differ in terms of preference in laptop functions. As such, to determine an ideal productivity laptop, we need to progressively narrow down customer preferences, starting from the general combinations of components they value (stage 1), followed by a specific model of each of the components (stage 2 & 3). Inevitably, it will be a complex process to reach the final product. Nevertheless, we notice that we can indeed draw insights out of individual stages and these insights might be useful for respective management levels in depicting future business plans. This will be elaborated in the coming sub-sections.

4.1. Cluster Analysis on Importance of Laptop Components

In this stage, we performed cluster analysis on general preferences of laptop components, and the responses show that one cluster puts more emphasis on computing power (CPU, GPU, etc.) and another cluster on additional features (touch screen, fingerprint, etc.). Also, the first cluster has a larger size and thus a potentially larger market. This result can serve as references for some top-level decisions, i.e. production managers can focus on either cluster to specify the requirements designated to that group of customers for their new laptop model.

4.2. Conjoint Analysis on Preference of Laptop Components

In this stage, we divide our respondents into two groups, and with respect to the cluster they belong to, they are asked to rate specific model combinations of the components they value. We perform conjoint analysis on their rating and conclude that cluster 1 are in favour of computing power (CPU, GPU, etc.), and cluster 2 are in favour of other functional features (screen sizes and weights, touch screen, etc.). Technical employees in the production sector can then base on these results to determine specific models according to the requirements given by their manager.

4.3. Choice Model on Remaining Components

In this stage, we combine the respondents back into one group and ask for their preferences for the remaining components. This stage is to complete the laptop model, so it is also left for the technical employees to determine specific models base on model results.

4.4. Interpretation Summary

As a result to the above interpretations, despite the complicated processes to determine the laptop model, ideas can be extracted from each stage and presented to corresponding management levels for hierarchical business decisions. Below is a table to summarize how the three stages can assist in the laptop design process.

Stage	Interpretation
1	Top-level decisions for managers to determine the direction (focus on computation power / additional features) to produce a new laptop model
2	Specific consumer preferences for employees in the production sector to determine the CPU & GPU model, arrangement of RAM, SSD, etc.
3	

5. Limitations

Our study contains several limitations with some discussed in Section 2. Convenient sampling in our data collection methods may cause biases, thus generating inaccurate clustering result. Our sample sizes are also relatively small which suggest that the data may not represent our target population (university students) well. However, these problems are easy to address and improved by repeating the study with larger budget, longer time and possibly more manpower.

In addition to limitation in our sampling method, we have received feedback from some of the respondents that the questions in the Stage 2 questionnaire may be hard to interpret, thus requiring longer time to complete. Feeling overwhelmed by the number of features and profiles, they may resort to simplification strategies and their answers in the survey may not align with their actual actions when buying a laptop. This is indeed an issue which we have predicted before conducting the survey. However, we think the selected features are all important to study and designing a conjoint analysis is complicated, so we do not take risk to oversimplify the questionnaire. One possible remedy is to increase incentive for respondents to complete the surveys. This method is commonly used in academic research in psychology.

Another area of concern is the assumption of a 2-cluster solution instead of a 3-cluster solution in section 3.1. To reiterate, although the graphs pointed at a 3-cluster solution we chose to proceed with a 2-cluster solution due to the small market share of one of the three clusters relative to the other two and difficulty in interpreting the results. As a result of this choice, we may have neglected the preference of an entire group of respondents even though it was underrepresented. This in turn could have affected subsequent steps. For instance, it could have led to a different division of laptop features in stage 2. A possible remedy to this problem is to attempt to increase the representation of that particular cluster. This could be done by increasing the sample size as mentioned previously.

6. Conclusion

In this marketing research, we set out to find the most important features to include in designing a productivity laptop from the perspective of low-income students. Through a series of surveys and questionnaires coupled with statistical analysis described in the above sections, we assembled the components of a productivity laptop as highlighted in *table 16.*

In stage one, we managed to segment respondents into two clusters – one that prefers computing features and the other prefers miscellaneous and ‘gimmicky’ features. In stage two, we sought out the exact levels of the features within each cluster by asking respondents to indicate their preferences in a point scale. Finally, in stage three, we conducted a study of choice model to determine the remaining features that were excluded in stage 2. After all three stages, we base on all model results to determine a suitable laptop for production.

7. Appendix

7.1. A: Existing Laptop Models

Name	Brand	CPU	GPU	RAM	Price	CPU model	GPU model
Surface Laptop 5 i5 8GB RAM 13.5"	Microsoft	i5-gen12	integrated	8GB	9988	i5-1235U	Iris Xe Graphics
Surface Laptop 5 i5 16GB RAM 13.5"	Microsoft	i5-gen12	integrated	16GB	11988	i5-1235U	Iris Xe Graphics
Surface Laptop 5 i7 16GB RAM 13.5"	Microsoft	i7-gen12	integrated	16GB	13988	i7-1255U	Iris Xe Graphics
Surface Laptop Studio i7	Microsoft	i7-gen11	dedicated	16GB	15488	i7-11370H	RTX 3050 Ti
Vostro 3510	DELL	i5-gen11	integrated	16GB	5799	i5-1135G7	Iris Xe Graphics
Inspiron 16 i5	DELL	i5-gen12	integrated	16GB	8299	i5-1240P	Iris Xe Graphics

Name	**Brand**	**CPU**	**GPU**	**RAM**	**Price**	**CPU model**	**GPU model**
Inspiron 16 i7	DELL	i7-gen12	dedicated	16GB	10399	i7-1260P	MX570
Razer Book	Razor	i7-gen11	integrated	16GB	12999	i7-1165G7	Iris Xe Graphics
Razer Blade Stealth 13	Razor	i7-gen11	dedicated	16GB	15499	i7-1165G7	GTX 1650 Ti Max-Q
VivoBook S15 S533	ASUS	i5-gen11	integrated	8GB	4225	Core i5-1135G7	Iris Xe Graphics
VivoBook S14 OLED	ASUS	i5-gen12	integrated	8GB	6999	Core i5-12500H	Iris Xe Graphics
Galaxy Book2	Samsung	i5-gen12	integrated	16GB	7380	Core i5-1235U	Iris Xe Graphics

Name	Brand	CPU	GPU	RAM	Price	CPU model	GPU model
Galaxy Book2	Samsung	i7-gen12	integrated	16GB	8280	Core i7-1255U	Iris Xe Graphics
Galaxy Book2	Samsung	i7-gen12	dedicated	16GB	9780	Core i7-1260P	ARC Graphics
HP ProBook 440 G8 Nnotebook	HP	i5-gen11	integrated	8GB	5399	Core i5-1135G7	UHD Graphics
HP ProBook 430 G8 Nnotebook	HP	i5-gen11	integrated	16GB	5599	Core i5-1135G7	UHD Graphics
Spectre 14-ef0023TU x360 convertible	HP	i7-gen12	integrated	16GB	13999	Core i7-1255U	Iris Xe Graphics
IdeaPad L3i Gen 6	Lenovo	i5-gen11	integrated	8GB	4499	Core i5-1135G7	Iris Xe Graphics
IdeaPad 3i	Lenovo	i5-gen12	integrated	8GB	6499	Core i5-1235U	Iris Xe Graphics