Portland State University
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ETM 530/630 – Decision Making
Spring 2017

Individual Project Paper

Evaluating the best smart phone in the Market

(Figure 1)

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ABSTRACT

The field of smart phone is one of the most competitive and fastest growing element in today's market. Every year, a new smart phone creates a havoc in the cell phone industry with its new upgraded technology, design specs, exceptional functionalities and user friendly performance. This paper helps evaluate and decide on the best trended smart phone in the current market.

The methodology used in this paper is the Hierarchical Decision Model (HDM) to help evaluate the most preferred cell phone in the market currently. The hierarchical model consists of criteria and sub-criteria which are compared and evaluated by providing weights to the most preferred option. From the overall analysis, the key finding of this report focuses on creating a framework model to evaluate the best smart-phone in the market by defining the appropriate criteria pertaining to the optimized resulted model.

Some of the segments which can be explored more for the future study deals with options of cell phones, the credentials of the experts, and other possible loop holes in model creation which could impact the decision.

INTRODUCTION

Just like people need some necessary key elements to survive, similarly, in the technology arena, the importance and use of cell phones has become one of the most needed tool to communicate. Cellular technology advancement has led to development of smart phone which is becoming a crucial aspect of our lives. [1]

With its expanding ability in its technological ability, smartphones have become one of the most useful medium which helps us stay connected all throughout the world through its internet facility which helps play a major role in our day to day life whether it is used for entertainment, health, communication, business etc.…

Smart phones have gradually reduced the need for computers or laptops. In recent years, the use of the smart phones has been increasing rapidly in our society. Smart phones are a new generation and breakthrough of cellular phones with integrated computer related functions which is capable of performing variety of tasks based on applications. however, selecting a smartphone device which fits the users' requirement is a difficult task considering the competition among many diverse products available in the market. [2]

Today, the use of smart phone is crucial for all age groups. Although the ages teen till mid-twenties most depend on the texting and video chatting facility, the order the age group gets towards a mature age, the use of smart phone also expands in activities which deals with business, health care such as total number of steps the user walked, entertainment in terms of music, videos, eBooks, etc.… Most importantly it is used for capturing memories with the new integrated camera features and other specs. Smart phone is one of the most essential tool needed in today's

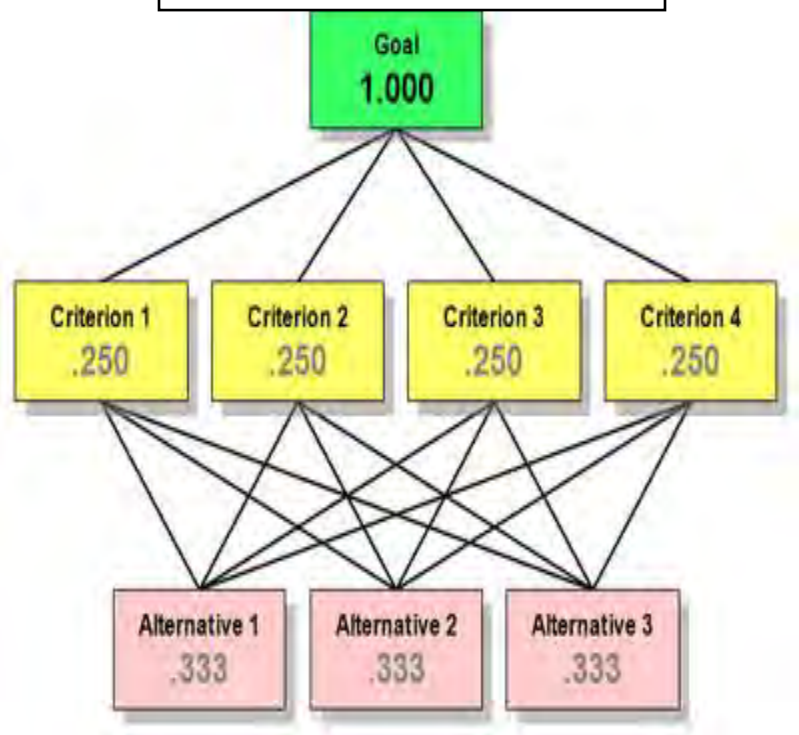
generation to communicate and fulfill our day to day tasks with every facility available making it a user-friendly experience for every consumer.

The objective of this project helps evaluate and examine determining factors for smartphone brand selection decision. The criteria and sub-criteria for evaluating the best smart phone is determined through literature reviews of scholarly articles on smartphones and the official sites of the phone options. The alternative is also based on the articles on the latest trends which is currently the most used device in the market.

METHODOLOGY

The methodology used in this paper is the hierarchical decision model which is multi-criteria based method used for complex decision analysis. The hierarchical decision model concept uses pairwise comparison scale and judgement quantification techniques. This HDM model is used from the Portland State University generated tool.

Figure 2: HDM model example



The HDM model consist of different hierarchical levels starting with the main goal. The hierarchy levels depend on the simplicity or complexity of decision problem. The hierarchy is displayed into various levels with different numbers of decision elements residing on each level. Each level consists of decision elements which are further connected to other decision elements on the level above or below them.

HDM method breakdown consist of a step by step process. First, the problem is manifested into a hierarchy which is easy to comprehend independent problems analyzing. The independent problems or elements are explored into sub-problems based on their relevance. Once each element cannot be explored further, that level connects to the alternatives used for the decision-making purposes. The hierarchical structure of the model represents a simple yet

an effective way for decision makers to compare tangibles as well as intangibles side by side by aggregating large data at different scales and by converting judgement into normalized data for quantitative decision making.

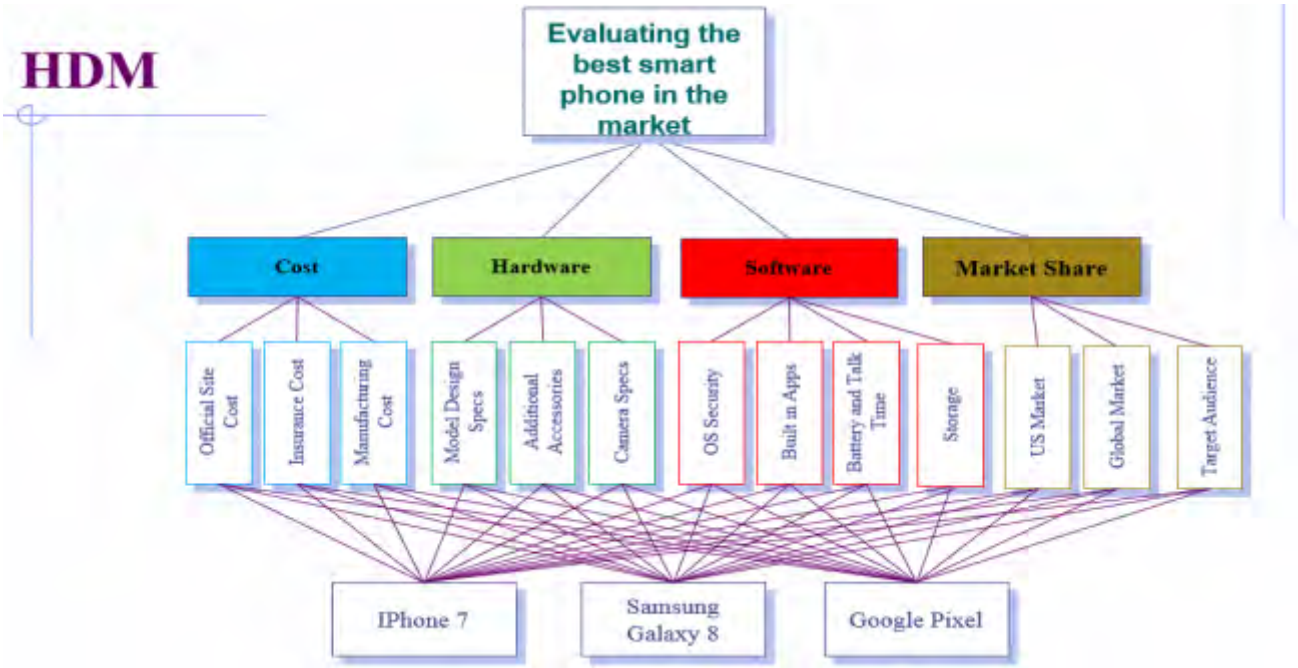
The hierarchical decision model uses varies techniques which help analyze the inputs and outputs in the evaluation process. Some of the techniques used for this model include: Judgment Quantification, Pairwise Comparisons, Inconsistency, and Disagreement.

Judgement quantification process is used to gain subjective data when the objective data are not available while deciding. The hierarchical decision model uses constant-sum method of assigning total 100 points between two elements in the decision model. Therefore, distributing of the points between two elements help compare the importance of the two elements in respect to the upper level element which is linked.

Pairwise comparison technique is used for the quantification process for all decision elements. In mathematical terms, the number of pairwise comparisons (N) for (n) is [N= n(n-1)/2]. The number of comparisons increase and decrease based on the number of elements in a group.

Inconsistency is evaluated when the pairwise comparisons provide different results. Inconsistency in the hierarchical decision model is a measure which displays expert's response to the judgement quantification process and how valid the judgements can be considered. The inconsistency measure of a value of 10% or less is acceptable inconsistency.

Disagreement concept is used with the HDM to describe and evaluate the synchronicity and harmony between experts' inputs. The inputs can be evaluated based on large number of experts with diverse knowledge and experience resulting in different opinions and judgements. [3]



The basic breakdown of the HDM model for this paper starts with the goal to find the best smart phone leading to some influencing criteria. The criteria and sub-criteria are determined through literature review. The criteria basic criteria to evaluate the goal are: Cost, Hardware, Software and Market Share. These four main criteria are further broken down into sub criteria such as: Cost from Official site, Insurance Cost, Manufacturing Cost, Model Design Specs, Additional Accessories, Camera Specs, OS security, Built in Apps, Battery/Talk time, Storage, US market share, Global market share, and Target Audience. The understanding and opinions of these sub criteria leads to weighing the three best alternatives in the smart phones: IPhone 7, Samsung Galaxy 8, and Google Pixel.

DATA AND DATA SOURCE(S)

In terms of evaluating the data for this model, there are two different data sources. The **first data source** is the literature review based on scholarly articles on evaluating smart phones, understanding the HDM model, and quantitative data to analyze and formulate the criteria. This data source helps evaluate and determine the criteria and sub criteria of the model. Criteria of this model defines four elements: Cost, Hardware, Software, and Market Share.

Cost is one of the biggest element in determining the best product for the consumer. Consumers are known to make sacrifice to buy other things in terms of monetary and non-monetary cost. Non-monetary cost includes time, cost, search cost and psychic cost when it comes to making decision to purchase a best smart phone. Therefore, cost is one of the influencing factors to evaluate the best possible alternative. [4] The cost consists of three sub-criteria: cost from official site, insurance cost and manufacturing cost. *Cost from the official site* gives users biggest decision making context to purchase the phone based on their financial budget. Also with such a fast-paced life, users may get clumsy and drop or break the phone. If the user does not have an insurance coverage, they may have to purchase a whole new phone which builds into additional expense, thus, in such situation *insurance cost* coverage is one of the beneficial option to be considered during the decision-making process. The last sub-criteria under cost is the *manufacturing cost*. Although it is not a demanded element in evaluation, however, it helps user understand how the brand influence their revenue by selling the manufactured smartphones with higher prices.

Second criteria influencing the decision is the **Hardware** of the smart phone. Importance of hardware is not only evaluated externally through its design, but also internally with its

processors, chips etc.… to determine the best smart phone. The hardware is further broken down into sub-categories which includes: model design specifications, additional accessories, and camera specifications. *Design specification* includes features defining the model in terms of its length, width, weight, color and overall feel of the model along with the display. Display is one of the most important component in the smartphone as it serves as the only interface. Thus, customers focus highly on the resolution such as IPS-LCD, OLED and Super LCD. Next sub-category is the *Additional Accessories* provided with the smartphones. Current trend in the phones designing turbo charge and headphone less model. However, new integration of accessories or removing them also plays a role in evaluating in the purchasing of the phone. The last sub-category in the hardware arena is the *Camera*. Camera is one of the most utilized component in the phone and an incredibly complex piece of equipment. The evaluation of camera is done based on many features. The first feature is the megapixels which helps determine the resolution of photos and ability to zoom in to view more detail. Another feature is the video resolution. The higher resolution results in better outcome. Many modern phones consist of 1080p which is a minimum quantity to record from the phone. Last but certainly not the least is the feature of slow motion and image stabilization. Although it is integrated with the phone's software, it is one of the most important aspect in evaluating the best smart phone based on the user's requirements. [5]

Third criteria are the **Software** of the smart phones. Software is one of the most integral part of the phone which defines if the phone is user friendly for all age groups. If the phone is not easy to navigate, it creates confusions thus, smart phone should be embedded with software which helps navigate through options and explore features easiest way possible. The criteria are

explored further into sub-criteria which consist of: Operating System Security, Built in Apps, Battery/Talk Time and Storage. *OS Security* is one of the important factors in determining smartphones. Smart phones are used to store contact list, social network which contains passwords, bank details etc.… Losing a phone and being infected by malicious software are two main risk factors in terms of security. To protect personal data from malware attacks, the smart phone users are required to regularly download software updates ad backup data to another device to be safe from any security concern. [2] Therefore, users need to understand and evaluate which OS security is best for them in-order to be safe from malicious activities. The second sub criteria are the *Built-in Apps*. Whether the phone is iOS or Android based, they both consist of some built in apps which are similar as well as different in terms of their uniqueness. Some of the built-in apps are trying to serve a purpose for making phone more user friendly, however with every software upgrade, the built-in apps also take up lot of memory. In such situations, some smartphones give users an ability to remove such apps, however others do not. Thus, built in apps also plan an important role in smart phone analysis. The third sub-criteria deal with the *Battery and Talk Time*. In terms of assessing the power in smart phones, it is normal to recharge smartphone batteries at least once or more times a day. However, due to some technical errors the battery also tend to drain over night when smartphone is partially or fully idle. However, modern smart phones can use more than one data network and have certain features and modes that claim to save power consumption resulting in battery usage hours. Therefore, it is very important in evaluating the battery life and consistency in evaluating the alternative. [6] The last sub-criteria under this segment deals with the *Storage*. Storage performance for the smart-phones affect the performance of many common applications such

as Web browsing, maps, application install, email, Facebook etc.…. Studies show that for several Android smartphones, just by varying the underlying flash storage, performance over Wi-Fi can typically vary between 100% to 300% across applications and can jump to maximum 3000%. Therefore, application performance is highly dependent on the storage. Thus, it is very crucial to evaluate the software of the phone based on the available storage based on the built-in applications as well as cloud or SD card features. [7]

The last criteria in determining the phone based model is the **Market Share**. Understanding the market share of the most valued smart phone is also a beneficial alternative to evaluate the best phone. Market share demographics provides many breakdown and insight on different categories. The first sub-criteria identified is the *US Market*. The U.S. smartphone market consists of all firms throughout the word that manufacture and sell smartphones to U.S. consumers. Smart phone market is changing rapidly with constant product introductions which is quickly evolving technology and designs, product life cycles, pricing, technological advancements and price sensitive consumers. Some of the factors influencing the decision in US Market is the existence of patents, high fixed costs and economies of regulation as well as brand loyalty [8]. The second sub-criteria are the *Global Market*. Global Market provides word wide analysis of the preference of the best possible smart phone in the market. These criteria provide broad understanding based on contextual factors, cognitive beliefs, previous experience and everyday use [9]. The final sub criteria for this element is the *Target Audience*. Personal demographic plays potential role in the selection decision such as consumer's age, gender, and other personal experience traits. Some of the personal experience traits include factors such as consumer's background, usage ability, and most valued and significant factor in evaluating the

decision process. [2] Another element is understanding the buyer's goal and deciding on a strategy for engaging with them based on their budget, profile and their functionality requirements from the phone.

The model consists of three different alternatives as a chosen option for the best phone in the market which includes: IPhone 7, Samsung Galaxy 8, and Google Pixel. These three phones are currently the biggest breakthrough in the market with its new technological features capabilities.

IPhone 7 is the newest model in the IPhone series which consists of improved aspects of iPhone experience with new advanced camera system and best performance and battery life in an iPhone. The display is bright and colorful with immersive stereo speakers with sound two times louder than iPhone 6s. Some of the hardware accessories are Ear Pods with lightning connector and Air Pods. It consists of some built-in elegant apps which include photos, maps, messages, news, health, and more. The Siri iOS 10 has proactive suggestions, predictive typing, and Siri makes everything easier, quicker, and easy to operate. [10]

Samsung Galaxy 8 is the newest model in the Samsung series which has revamped its design specs all together. In terms of the design, the boundaries are removed thus, the infinity display has an incredible end-to-end screen which spills over the phone's side making it smooth without bumps and angles. The phone consists of camera's facility which provides accurate and fast result with its 12MP rear camera. In terms of security, the Galaxy S8 has unlocking pattern through iris scanning and face recognition. Irises have pattern which is unique to each individual and difficult to replicate. [11]

Google Pixel is the phone built by google which is the first device consisting of Google Assistant built in. It is one of the highest-rated smartphone camera with Pixel taking brilliant photos in bright light, low light, and any light. The best possible feature for this phone is its unlimited storage capacity for all the photos and videos. [12]

The **second data source** is the expert panel to evaluate the model with its pair-wise comparisons. There are eight experts chosen to evaluate and weigh the model. The experts are chosen on basis of their background understanding of the different smart phone in the market and their experience with the different phones. All the eight experts are friends and family from diverse age groups. However, due to not many evaluations of the model from the needed customers results in less diversity based on ethnicity.

Expert 1: Currently a graduate student gaining MS degree at Portland State University

Age: 32; Ethnicity: Indian; Gender: Female

Expert 2: Currently a bachelor student obtaining Computer Science degree at Portland State

Age: 20; Ethnicity: Indian; Gender: Male

Expert 3: Currently a retiree located in India

Age: 72; Ethnicity: Indian; Gender: Male

Expert 4: Currently an employee working as a call center representative in Boston

Age: 29; Ethnicity: White; Gender: Female

Expert 5: Currently working as a government employee as a Developer

Age: 26; Ethnicity: White; Gender: Male

Expert 6: Currently working in the childcare field by handling and baby siting children

Age: 52; Ethnicity: Indian; Gender: Female

Expert 7: Currently a student in high school located in India

Age: 16; Ethnicity: Indian; Gender: Female

Expert 8: Currently a systems analyst at Intel

Age: 24; Ethnicity: Indian; Gender: Female

The experts are mainly from similar ethnicity which can be improved further in the future research. However, one advantage of this survey denotes a huge range of experts from different age thus giving us a broader outlook in evaluating in that sense. Apart from the variations in age, current backgrounds for each expert is vastly different which also gives a positive advantage in evaluating the hierarchical decision model.

ANALYSIS AND KEY FINDINGS

Based on the hierarchical decision model, the best alternative on evaluating smart phone is IPhone 7 with the highest weight of mean 0.35. Refer to Appendix A below which helps understand the weights per experts for the three alternatives and their inconsistency based on their answers.

Evaluating the best smart-phone in the market	IPhone 7	Samsung Galaxy 8	Google Pixel	Inconsistency
Expert 1	0.28	0.27	0.45	0.01
Expert 2	0.48	0.27	0.25	0.01
Expert 3	0.25	0.41	0.34	0
Expert 4	0.3	0.3	0.4	0
Expert 5	0.26	0.48	0.26	0.01
Expert 6	0.23	0.32	0.45	0
Expert 7	0.46	0.27	0.27	0
Expert 8	0.53	0.22	0.25	0.01
Mean	**0.35**	**0.32**	**0.33**	
Minimum	**0.23**	**0.22**	**0.25**	
Maximum	**0.53**	**0.48**	**0.45**	
Std. Deviation	**0.11**	**0.08**	**0.08**	
Disagreement				**0.09**

Appendix A: Final Data

Analyzing the data for the three alternatives, all the three phones have data which are in the same ranges with the most to least preferred such as 0.35 for IPhone 7, 0.33 for Google Pixel, and 0.32 for Samsung Galaxy 8. The reason the numbers are closely related because all the experts are students who have similar experiences with different phones defined in the alternatives.

Apart from the experts' expertise, some of the factors which influence the results are the ranking of criteria and sub criteria. Evaluating the table level by level, the first level consists of the four

main criteria: Cost, Hardware, Software and Market Share. Therefore, the data from all the eight experts for each criterion is evaluated and average was taken to identify the top most influencing criteria of the decision. The table below shows the breakdown of level 1 criteria with experts.

Level 1	Evaluating the best smart-phone in the market								Average
Experts:	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	
Cost	0.3	0.56	0.36	0.31	0.38	0.45	0.37	0.48	**0.40**
Hardware	0.22	0.15	0.25	0.24	0.21	0.17	0.25	0.15	0.21
Software	0.31	0.2	0.24	0.24	0.26	0.23	0.23	0.28	0.25
Market Share	0.17	0.09	0.15	0.2	0.15	0.16	0.15	0.09	0.15
								Total	1.00

Looking at the overall of average of each criteria, the **Cost** is one of the highest influencing contributor in Level 1. Followed by the Cost, Phone Software, Phone Hardware and Market Share are ranked respectively.

Moving forward to evaluating the Level 2 which is the sub criteria of each criteria. There are total of 13 sub-criteria for the 4 criteria defined in Level 1. Therefore, the same process is used in evaluating the Level 2. The data from all the experts for the level 2 pairwise comparison is identified and the average of each sub-criteria is evaluated. Below is an example of Experts aggregated data.

Experts	Expert 1				Expert 2				Expert 3				Expert 4			
Level-2	Cost	Hardware	Software	Market Share	Cost	Hardware	Software	Market Share	Cost	Hardware	Software	Market Share	Cost	Hardware	Software	Market Share
Cost from official site	0.45	0	0	0	0.45	0	0	0	0.52	0	0	0	0.5	0	0	0
Manufacturing Cost	0.24	0	0	0	0.23	0	0	0	0.19	0	0	0	0.23	0	0	0
Insurance Cost	0.31	0	0	0	0.33	0	0	0	0.29	0	0	0	0.27	0	0	0
Model Design Specs	0	0.41	0	0	0	0.49	0	0	0	0.41	0	0	0	0.41	0	0
Additional Accessories	0	0.24	0	0	0	0.1	0	0	0	0.21	0	0	0	0.22	0	0
Camera Specs	0	0.36	0	0	0	0.41	0	0	0	0.38	0	0	0	0.36	0	0
OS Security	0	0	0.26	0	0	0	0.4	0	0	0	0.27	0	0	0	0.3	0
Built in Apps	0	0	0.18	0	0	0	0.15	0	0	0	0.26	0	0	0	0.22	0
Battery and Talk Time	0	0	0.3	0	0	0	0.29	0	0	0	0.21	0	0	0	0.31	0
Storage	0	0	0.25	0	0	0	0.15	0	0	0	0.25	0	0	0	0.27	0
US Market	0	0	0	0.35	0	0	0	0.33	0	0	0	0.37	0	0	0	0.39
Global Market	0	0	0	0.32	0	0	0	0.33	0	0	0	0.3	0	0	0	0.28
Target Audience	0	0	0	0.33	0	0	0	0.33	0	0	0	0.33	0	0	0	0.33

The aggregated data identified above for each expert is then summarized and normalized for each sub criteria representing the main criteria. For example, the data for Cost criteria and official site for expert 1 is summed with other 7 experts and finally averaged. Performing the same process for all the elements provides the average table for Level 2 as mentioned below.

Level-2 Average from Experts	Cost	Hardware	Software	Market Share
Cost from official site	0.49625	0	0	0
Manufacturing Cost	0.2175	0	0	0
Insurance Cost	0.28375	0	0	0
Model Design Specs	0	0.45875	0	0
Additional Accessories	0	0.19625	0	0
Camera Specs	0	0.345	0	0
OS Security	0	0	0.35875	0
Built in Apps	0	0	0.20625	0
Battery and Talk Time	0	0	0.23	0
Storage	0	0	0.20375	0
US Market	0	0	0	0.3525
Global Market	0	0	0	0.3175
Target Audience	0	0	0	0.32625

The next influencing factors for the derived results are the top three indicators in the sub factors level 2. The way the top three indicators are identified is by multiplying the average of Level 1 criteria: Cost, Hardware, Software and Market Share with the average data for Level 2 sub criteria with their represented criteria. For example, the value for Cost from official site is determined by multiplying the average on Level 2 Cost from official site with the average of Cost determined in Level 1 (Ex: 0.49625 L2 X 0.40 L1). Similarly, the same method is applied while evaluating each sub criteria by multiplying with its respective criteria. The table below shows the top three indicator evaluated for Level 2 based on the method described.

Level-2 Average from Experts	Cost	Hardware	Software	Market Share		Value
Cost from official site	0.49625	0	0	0		0.20
Manufacturing Cost	0.2175	0	0	0		0.08
Insurance Cost	0.28375	0	0	0		0.12
Model Design Specs	0	0.45875	0	0		0.09
Additional Accessories	0	0.19625	0	0		0.04
Camera Specs	0	0.345	0	0		0.07
OS Security	0	0	0.35875	0		0.09
Built in Apps	0	0	0.20625	0		0.05
Battery and Talk Time	0	0	0.23	0		0.06
Storage	0	0	0.20375	0		0.05
US Market	0	0	0	0.3525		0.05
Global Market	0	0	0	0.3175		0.05
Target Audience	0	0	0	0.32625		0.05
					Total:	1.00

Based on the value identification to evaluate the top three key factors, the image shows there are four sub criteria identified with two criteria with similar result of value of 0.09. The highest indicating factor is the Cost from official site with the 0.20 value, followed by the Insurance Cost with 0.12 value and finally the Model Design Specs and OS Security with 0.09 value.

Analyzing the top three indicators, the reason Cost from the official site is one of the highest factor is because it is one of the highest factor to purchase the best possible smart phone based on the budget requirement. The reasonable cost of a device encourages and attracts the customer to purchase it. The second highest factor is the insurance cost which goes hand in hand with the original purchase. With fast paced life, it is likely to come across scenarios where the user may lose the phone or break the phone. In such cases, lack of insurance adds an additional cost of new purchase for the customer. Thus, opting in for the insurance cost is the best approach in the phone purchase decision. Finally, the third deciding factor is the model design specs and the OS security. These two criteria also go hand in hand which helps identify the phone hardware

and software functionality and features. Both criteria are important as well as crucial elements when deciding on the best smart phone alternative.

Level-3	Cost from official site	Manufacturing Cost	Insurance Cost	Model Design Specs	Additional Accessories	Camera Specs	OS Security	Built in Apps	Battery and Talk Time	Storage	US Market	Global Market	Target Audience	
IPhone 7	0.25	0.33	0.25	0.21	0.26	0.28	0.4	0.3	0.26	0.25	0.27	0.33	0.31	
Samsung Galaxy 8	0.23	0.33	0.26	0.17	0.31	0.28	0.24	0.3	0.26	0.33	0.27	0.33	0.29	
Google Pixel	0.52	0.33	0.49	0.62	0.43	0.44	0.36	0.4	0.48	0.43	0.46	0.33	0.4	Expert 1
	Cost from official site	Manufacturing Cost	Insurance Cost	Model Design Specs	Additional Accessories	Camera Specs	OS Security	Built in Apps	Battery and Talk Time	Storage	US Market	Global Market	Target Audience	
IPhone 7	0.51	0.46	0.33	0.59	0.27	0.53	0.73	0.44	0.37	0.33	0.5	0.54	0.62	
Samsung Galaxy 8	0.29	0.32	0.33	0.27	0.42	0.18	0.09	0.24	0.2	0.25	0.27	0.28	0.22	
Google Pixel	0.2	0.22	0.33	0.14	0.31	0.28	0.18	0.31	0.43	0.42	0.23	0.18	0.16	Expert 2
	Cost from official site	Manufacturing Cost	Insurance Cost	Model Design Specs	Additional Accessories	Camera Specs	OS Security	Built in Apps	Battery and Talk Time	Storage	US Market	Global Market	Target Audience	
IPhone 7	0.18	0.33	0.24	0.26	0.19	0.29	0.31	0.22	0.25	0.19	0.29	0.33	0.33	
Samsung Galaxy 8	0.47	0.33	0.43	0.42	0.42	0.36	0.35	0.47	0.41	0.44	0.41	0.33	0.33	
Google Pixel	0.35	0.33	0.33	0.31	0.39	0.35	0.34	0.31	0.34	0.37	0.3	0.33	0.33	Expert 3

Moving forward in evaluating and analyzing the model data. The next analysis is performed at level 3 with the pair wise comparison of the three smart phones alternatives: IPhone 7, Samsung Galaxy 8 and Google Pixel with the Level 2 Sub Criteria which consist of 13 elements. An example on the aggregated expert data for this comparison is provided on the left side.

After gathering the aggregated data of this comparison, the data was then evaluated to be normalized by calculating the average of each phone per experts based on each sub criteria specification. Thus, the average result based on the level 2 and 3 comparison results with the image below.

Level-3 Average	Cost from official site	Manufacturing Cost	Insurance Cost	Model Design Specs	Additional Accessories	Camera Specs	OS Security	Built in Apps	Battery and Talk Time	Storage	US Market	Global Market	Target Audience
IPhone 7	0.3575	0.38625	0.32	0.33625	0.23125	0.3425	0.47375	0.34	0.29625	0.25125	0.335	0.33375	0.375
Samsung Galaxy 8	0.295	0.32125	0.335	0.3525	0.38875	0.3	0.235	0.31125	0.315	0.34	0.32125	0.3475	0.3225
Google Pixel	0.34625	0.2875	0.3425	0.30875	0.3775	0.35625	0.29	0.34625	0.3875	0.40875	0.3425	0.3125	0.30125

Looking at the normalized data for level 3 based on pairwise comparisons on the phone alternatives and sub criteria, the result indicates the average weights for each criterion. Based on the analysis of value indication for each phone, **IPhone 7** has been weighted highest for its OS

Security. The Samsung Galaxy 8 has been weighted highest for its additional accessories and Google Pixel is weighted highest with its unlimited google storage facility. Therefore, OS Security has been one of the determining factor with the highest weight allocation of 0.47 compared two different phones and sub criteria thus of 0.39 and 0.41 respectively. This indicates that the weights are very closely ranked for the highest sub criteria thus the results are also closely aligned giving IPhone 7 a bit of a higher edge resulting it to be the best alternative in the final decision making process.

Finally, the last segment of data analysis deals with evaluating the data of the result per each expert. This segment compares the main goal with the three defined criteria. Therefore, in terms of evaluating the data, the aggregated data was first combined from all the eight experts. An example of the aggregated data is shown in the image to the left.

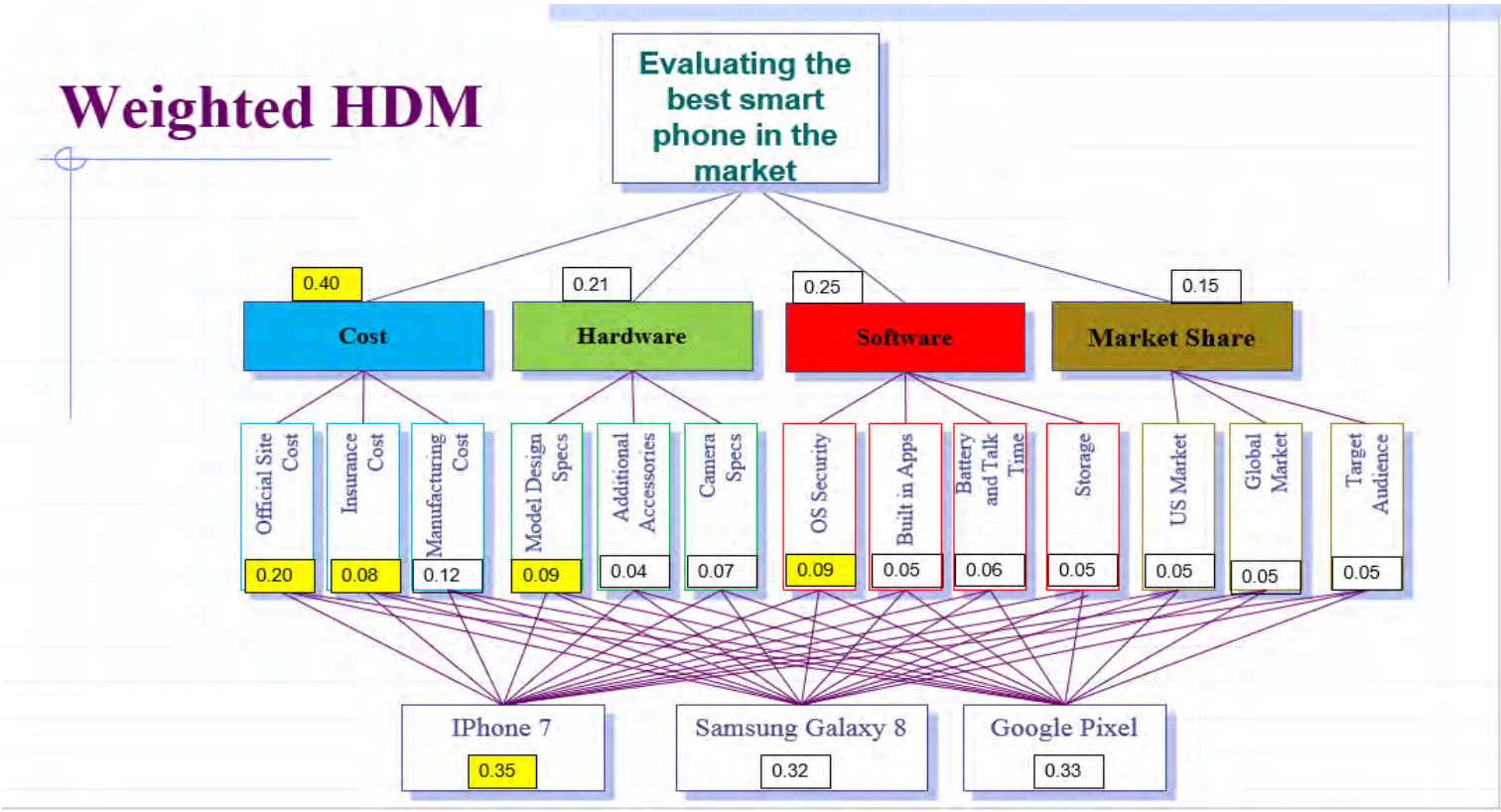
Evaluating the best smart-phone in the market								
Level-1 - Final result	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8
IPhone 7	0.28	0.48	0.25	0.3	0.26	0.23	0.46	0.53
Samsung Galaxy 8	0.27	0.27	0.41	0.3	0.48	0.32	0.27	0.22
Google Pixel	0.45	0.25	0.34	0.4	0.26	0.45	0.27	0.25

Once the aggregated data are identified as shown above, the average of these data are taken to evaluate the best alternative. Therefore, the result of average synchronizes with the tool with the same weight as mentioned below. The result indicates **IPhone 7** as the best alternative model in the current market.

Evaluating the best smart-phone in the market									
Level-1 - Final result	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Average
IPhone 7	0.28	0.48	0.25	0.3	0.26	0.23	0.46	0.53	0.35
Samsung Galaxy 8	0.27	0.27	0.41	0.3	0.48	0.32	0.27	0.22	0.32
Google Pixel	0.45	0.25	0.34	0.4	0.26	0.45	0.27	0.25	0.33

Referring to Appendix A, the overall disagreement is around 9% which is acceptable based on the Hierarchical Decision Model requirement.

Applying the data and analysis of weights per each level, the final weighted model shown below in Appendix B provides normalized weight view of goals, four criteria, thirteen sub criteria and the four alternatives for evaluation purposes.



Appendix B: Final Weighted HDM Model

Therefore, based on the final model described above, the best alternative based on the identified criteria and sub criteria is IPhone 7 which got ranked higher due to elements pertaining to the Cost. Followed by the sub elements of cost from site and insurance with the Hardware and Software representation with OS Security and Model Design Specs.

Looking at the IPhone website, the cost of IPhone 7 is about $649 which can be paid in installments. In terms of approaching the insurance cost for the IPhone 7, the Apple has come with the AppleCare+ process which will cost $99 while purchasing the warranty plan for iPhone

7 or 7 Plus. The insurance cost also has different options based on various carrier options. IPhone 7 design model comes with wide color displays with dual domain pixels for wide view along with fingerprint-resistant oleophobic coating. It is rated IP67 under IEC standard 60529 which makes the device splash, water, and dust resistant. IPhone 7 software consist of iOS 10 system with new design and features such as: Airdrop, Airplay, Multitasking, iCloud, Night Shift, Siri, Spotlight Search etc…..

In terms of the iOS security, the iOS device combines software, hardware, and services designed to work together for providing maximum security and transparent user experience. iOS not only protects the device and its data, but also the entire ecosystem which includes everything users do locally, on network, and along with key internet services. Some of the features iPhone 7 provides to enhance the iOS security deals with system security, encryption and data protection, application security, network security etc….

FUTURE RESEARCH

Some of the problems encountered during the study dealt with not getting response from many experts which would have represented the diversity in this study based on their age, experience, and ethnicity. Therefore, a clear identification of experts and their expertise should be performed well from the beginning to evaluate each criterion with accurate and experienced ranking. In this model, the ethnicity mostly evaluated the model are Indians. It is very crucial to have wide range of view point to make decisions, therefore, clear identification of experts, their personal demographics such as age, gender, background and their experience is of the valuable element which can help determine the result of the model.

One of the key elements in evaluating the model is the criteria and sub-criteria. Thus, one development area for the future research highlights considering some other criteria and sub criteria in the evaluation process such as: Manufacture brand name analysis, network technology (Ex: GSM, CDMA, 4G), Carrier services, Future Trends, SIM card(s) accessibility, memory etc….. The identification of major criteria and sub criteria can be evaluated in the future by contacting experts such as cell phone representative and asking and identifying major elements required in-order to create the hierarchical decision model.

Another key element is identifying more alternatives and not limiting to just top three options. Currently in the market there are other widely used smart phone devices which were not considered in the report such as OnePlus 3T, LG G6, Huawei P10, HTC 10, Lenovo P2, Motorola Moto X Force etc….. Identifying the most prominent phones from the list can be used in the future study to further evaluate the smart phones. Including them may also vary the results which has been currently established in the model.

Also, one more data analysis segment can be included in the future study which deals with the Sensitivity analysis. Using the mathematical deduction method to ensure the optimality of the result under any changing conditions. Sensitivity analysis in future can be performed by analyzing each level by deducting the most significantly high weighted element from each level and evaluating the change in the ultimate result and over all model.

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