

# Hierarchy of Reuse Options in Smartphone Selection and Strategies to Support Circular Economy

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# Hierarchy of Reuse Options in Smartphone Selection and Strategies to Support Circular Economy

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**Abstract.** The increase in smartphone users as well as sales in Indonesia coupled with the smartphone's short life cycle has raised serious concerns for sustainability. Circular economy has recently becomes one of the important studies which addresses the limitation of natural resources as well as the landfills. Refurbishment and direct reuse are part of circular economy approaches; however, the existence of new low-end smartphones has started to erode the customers' interest in the reuse smartphones. This paper studied the hierarchy of reuse options in smartphones selection using analytical hierarchy process to identify the decision hierarchy. The AHP results show that both worker and student-alumni groups prioritize their choice on new low-end smartphones. On the other hand, refurbished and secondhand smartphones are part of circular economy activities, where the life of the end-of-use smartphones are extended rather than discarded. Furthermore, we propose several strategies to improve customer behavior to support circular economy.

## INTRODUCTION

The sales of smartphone users in Indonesia are increasing in the last 5 year [21] as well as the smartphone users. In 2020, the estimation of smartphone users in Indonesia is 191.6 million [2]. Currently, Indonesia is ranked as the fourth largest smartphone market after China, India and the United States. However, smartphones are categorized as products with short life cycle. Several studies show that the average usage of smartphones in Indonesia is less than three years [3,4]. Therefore, the e-waste generated by discarded phones could exhaust the landfills. Circular economy is becoming a more important topic of discussion in relation to sustainability due to the concerns on how the natural resources are used and the scarcity of some resources. Also, circular economy is considered not only bring positive impacts to the environment, but also brings social and economy benefits [5]. There are several approaches in implementing circular economy, namely remanufacturing, refurbishment, repair, and direct reuse.

Currently, to the best of our knowledge there is no smartphone OEM or authorized third party that engages in smartphone remanufacturing or refurbishment. There are five aspects that considered as barriers to the remanufacturing or refurbishment practices in Indonesia which are regulation, the quantity and quality of supply, cannibalism, and consumer's preference. However, the demand for refurbished smartphones can be recognized by observing the existence of this market, both physical stores as well as online stores. There are quite numerous refurbished smartphones can be found in the leading e-commerce platforms such as Shopee, Tokopedia, Bukalapak, Bibli, and Lazada. The market for secondhand smartphones is also considerable. According to [6,7], the highest option for smartphone at its end-of-use stage is selling it to the secondhand market, hence the demand is also quite notable. The appeal of secondhand smartphone is that the price is significantly cheaper than the new one, so customer can buy

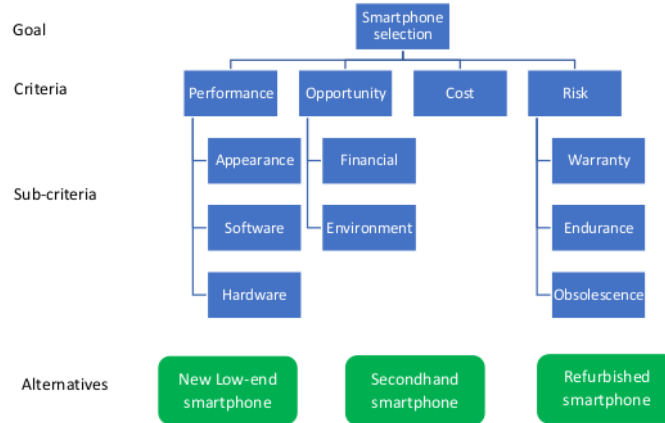
one with better features on a limited budget. The demand of secondhand smartphone is usually higher during holiday seasons. Previous study shows that low-end customers, i.e., customers with low income, are the potential market segment for refurbished smartphones. However, in the current development, there are numerous new smartphone brands selling products with low price but higher feature with lower quality (compared to the prominent brands at the similar price), which further we call as new low-end smartphones. The emergence of this type of smartphone has enticed low-end customer to shift from refurbished or secondhand to new low-end smartphone. This customer behavior is not supporting circular economy.

In this study we investigate the hierarchy of reuse option, specifically refurbished and secondhand smartphones, and compare it to the new low-end smartphone at a comparable price. Furthermore, we propose several strategies to improve the customer behavior to support circular economy.

## METHODS

First, we perform a survey targeting low-end customers and students, then Analytical Hierarchy Process (AHP) is applied to find the hierarchy of reuse option in smartphone selection. From these results we propose strategies for improving customer behavior in favor to circular economy based on the survey results and from the related literature. In the AHP, we start by determining the criteria and alternatives, then performing the survey for data collection starting with trial sample of 10 respondents and validate the results. Once validated, data is collected from 75 respondents, consists of 45 workers and 30 students-alumni.

Determination of criteria and alternatives in the hierarchical model in this study was carried out by interviews, pre-questionnaires, and browsing results from electronic journals and reports to find out whether the criteria and alternatives were in accordance with the actual conditions. According to Oentoro [8], there are 4 factors that influence respondents' decisions in choosing a smartphone, namely cost, performance, opportunity, and risk factors. Interviews were conducted face to face with several respondents. Performance criteria consists of three sub-criteria, namely appearance, software, and hardware. The opportunity criteria consist of two sub-criteria, namely financial and environmental. The risk criteria consist of three sub-criteria, namely durability, obsolescence, and warranty. Alternatives for choosing smartphones in this study are new low-end smartphones, second-hand smartphones, and refurbished smartphones. The hierarchical structure of smartphone selection can be seen in Figure 1.



**FIGURE 1.** Hierarchy structure of smartphone selection

Data collection for the questionnaire trial was carried out offline and online. Online data retrieval using google form with the target respondents are students. Offline data retrieval is intended for lower-middle class workers, such as security guards, cleaning services, and parking guards. The questionnaire consists of 5 sections as follows:

Section 1: demographic questions and the current smartphone owned

Section 2: price criteria and comparing alternatives

Section 3: performance criteria, pairwise comparisons, and comparing alternatives

Section 4: opportunity criteria, pairwise comparisons, and comparing alternatives

Section 5: risk criteria, pairwise comparisons, and comparing alternatives

Validation is a process to ensure that the questionnaire created is in accordance with the desired results. The validation process consists of two stages. The first stage is testing the questionnaire to find out whether there are deficiencies in the questionnaire and questions that have not been understood by the respondents. The results of the first stage of the validation process contained several descriptive questions that needed to be added options, as well as improvements to the use of language that was easily understood by all groups. The second stage of the validation process is to find out whether the questionnaire that has undergone repairs is in accordance with the desired results. The validation process is carried out using the data from the second questionnaire test which was conducted on workers and students-alumni. The second validation stage uses Super Decision software. The test data of the questionnaire was then processed by entering the value of pairwise comparisons to obtain a consistency ratio. The next step is to check the consistency of the data. This stage is useful to find out whether the data from the test results of the questionnaire have met the consistent value that has been determined. The data can be said to be consistent if the results inconsistency value is less than 10%. The results from the validation stage of the questionnaire test data obtained an inconsistency value of 0.02365, so the questionnaire test data has been consistent. This shows that the respondent has understood the questions on the questionnaire.

## RESULTS AND DISCUSSIONS

The results are presented in two sub-sections. First, the result of AHP showing the hierarchy of smartphone selection, specifically the hierarchy of the reuse options, which are refurbished and secondhand smartphones. Second, the proposed strategies to improve customer behavior in favor to circular economy.

### The results of Analytical Hierarchy Process

The AHP analysis is started by entering consistent data into the SuperDecision software. The purpose of the analytical hierarchy process analysis is to find the weight value of each variable using pairwise comparisons. The weight of this research is divided into two groups, namely the worker group and the student-alumni group. For instance, for cost criteria, the results of grouping the weight values can be seen in Table 1 for worker group and Table 2 for student-alumni group.

TABLE 1. Summary of alternative weighting value of cost criteria for worker group

	Low-end	Refurbished	Secondhand
P-01	0.493	0.195	0.310
P-04	0.493	0.195	0.310
P-07	0.493	0.195	0.310
P-10	0.814	0.071	0.113
P-12	0.416	0.126	0.457
P-15	0.814	0.071	0.113
P-18	0.658	0.185	0.156
P-19	0.497	0.366	0.135
P-22	0.773	0.087	0.139
P-30	0.493	0.195	0.310
P-32	0.708	0.112	0.178
P-34	0.814	0.071	0.113
P-35	0.730	0.188	0.080
P-36	0.609	0.224	0.165
P-37	0.708	0.112	0.178
P-39	0.814	0.071	0.113
P-44	0.785	0.148	0.065

The average weight values are then determined as the overall weight value of each variable. For cost criteria, the average weight value of worker group and student-alumni group can be seen in Table 3 and 4 respectively. The results show that both worker and student-alumni groups prioritized their alternatives to new low-end smartphone, based on cost criteria, and the percentage is 66% and 65% for worker and student-alumni respectively. The same weighting process is also carried out for each variable. The purpose of finding the weights for each variable is to combine them into a hierarchical form.

**TABLE 2.** Summary of alternative weighting value of cost criteria for student-alumni group

	<b>Low-end</b>	<b>Refurbished</b>	<b>Secondhand</b>
M-01	0.742	0.063	0.193
M-04	0.652	0.285	0.062
M-07	0.536	0.364	0.098
M-17	0.814	0.113	0.071
M-18	0.412	0.327	0.259
M-19	0.795	0.121	0.082
M-20	0.549	0.368	0.082
M-21	0.536	0.364	0.098
M-22	0.814	0.113	0.071
M-23	0.067	0.199	0.733
M-24	0.785	0.148	0.065
M-25	0.773	0.139	0.087
M-27	0.733	0.199	0.067
M-28	0.770	0.067	0.161
M-30	0.804	0.121	0.0737

**TABLE 3.** The average weight value of cost criteria for worker group

	<b>Average</b>	<b>Percentage</b>
Low-End	0.6541	66%
Refurbished	0.1543	15%
Second-hand	0.1916	19%

**TABLE 4.** The average weight value of cost criteria for student-alumni group

	<b>Average</b>	<b>Percentage</b>
Low-End	0.6527	65%
Refurbished	0.1998	20%
Second-hand	0.1475	15%

The decision hierarchy values are determined using even weight for all four criteria, and uneven weights based on the previous results. When the criteria weight considered evenly, new low-end smartphone achieved the highest hierarchy which is 0.6273, and it is superior on all four criteria which are performance, opportunity, cost, and risk. Refurbished smartphones and secondhand smartphones are not yet a prioritized alternatives for worker group as shown in Table 5. Respondents chose new low-end smartphones due to lack of knowledge about refurbished one and some respondents had unpleasant experiences with secondhand smartphones. The combination of variable values that make up the decision hierarchy of worker group is also carried out with different criteria weights, and it does not change the decision. Worker group consistently chose new low-end smartphones as the main alternative in purchasing smartphones. Similar results are obtained for student-alumni group which can be observed in Table 6. Software is the most important sub-criteria of the performance criteria to this group. Student-alumni respondents in the opportunity

criteria tend to prioritize the financial aspect in choosing a smartphone. The durability of the mobile phone is very important for respondents in the risk criteria. Most respondents will replace their smartphones when they are damaged.

The AHP results show that low-income worker and student-alumni prioritize new low-end smartphones on their decision hierarchy in purchasing smartphones. Refurbished and secondhand smartphones are not preferable due to several concerns such as legal consumer protection, quality assurance process, obsolescence, and durability; some of these aspects are consistent with findings in Wahjudi et al. [9]

**TABLE 5.** The decision hierarchy for worker group

	<b>Even weight</b>	<b>Uneven weight</b>
Low-End	0.6273	0.6388
Refurbished	0.1724	0.1646
Second-hand	0.2001	0.1965

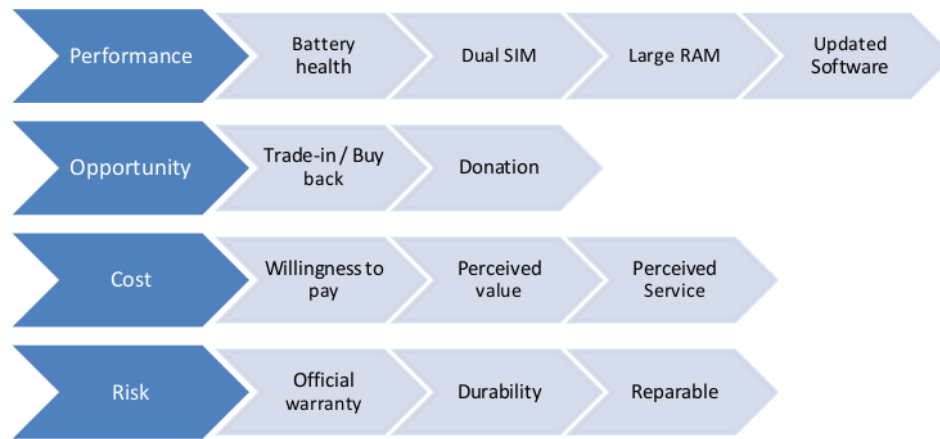
**TABLE 6.** The decision hierarchy for student-alumni group

	<b>Even weight</b>	<b>Uneven weight</b>
Low-End	0.6719	0.6866
Refurbished	0.2027	0.1980
Second-hand	0.1252	0.1152

### **The proposed strategies to improve customer behavior to support circular economy**

The survey conducted not only for finding decision hierarchy, but also designed for collecting customers' preferences. The criteria and sub-criteria that are important to the respondents are marked as the input for formulating the strategy. The strategies are categorized according to the four criteria

1. Performance: appearance, software, hardware  
The results from the survey show that 85% expect long battery life and fast charging – consistent with [10, 11], 76% prefer to have smartphone with dual SIM card and memory card, 70.67% considers RAM is very important. Therefore, the strategies are (1) focusing the refurbishment process on the important features which are battery health, dual SIM, large RAM, and updated software; (2) communicating the highlighted specifications to the customer. The current refurbished or secondhand product display in online stores does not provide this important information to help customers recognize the preferable features
2. Opportunity: financial and environment  
77.33% respondents bought their smartphones with cash, which decreases the chance for old phone returns under trade-in or buy-back programs. 44% and 33.33% respondents gave the end-of-use smartphones to family/friends and kept it at home, respectively. This behavior can be directed to reuse option under donation scheme [12]. The strategies are (1) Collaboration with big brands and telecommunication companies to offer trade-in or buy back program as a bundling in buying new product or purchasing a telco contract; (2) campaigning for smartphone donation; (3) using digital platforms for the ease of collecting end-of-use smartphones
3. Cost  
When inquired about their willingness to pay for smartphones, 73.33% said that they would not buy secondhand while 66.67% would not buy refurbished smartphones. Therefore, it is important to improve perceived values so customers could appreciate those products. The strategies are (1) communicating the economy, social, and environmental benefits to customers to improve the perceived value of reuse smartphone; (2) providing services to increase customer's value [13] hence the willingness to pay
4. Risk: warranty, endurance, obsolescence  
78.67 respondents expect to get official warranty instead of distributors or retailer warranty which is the common warranty provided for refurbished smartphones. Overheat seems to be a frequent problem for customers, 72% expect to have a smartphone with waterproof and not fast heating. The proposes strategies are (1) offering official warranty; (2) collaboration with retailers or third party to ensure ease of repair service.



**FIGURE 2.** Notable criteria, sub-criteria, and their extension according to survey responses

## CONCLUSION

This paper studied the hierarchy of reuse options in smartphones selection using analytical hierarchy process. The AHP results show that both worker and student-alumni groups prioritize their choice on new low-end smartphones. On the other hand, refurbished and secondhand smartphones are part of circular economy activities, where the life of the end-of-use smartphones are extended rather than discarded. Therefore, it is important to identify what could have been the problem that customers are reluctant to buy them. The survey results also show several notable criteria, sub-criteria and their extension that could help to formulate the proposed strategies to improve customer behavior to support circular economy. Finally, there are several strategies proposed which can be detailed and studied further to make sure the effectiveness as well as the potential in the implementation.

## ACKNOWLEDGMENTS

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