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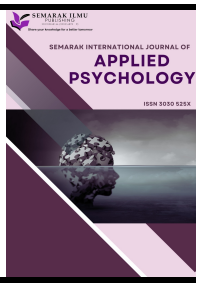

Sustainable Tech: Exploring Consumer Valuation and Investment in Refurbished Smartphones

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ABSTRACT

Electronic waste poses negative effects toward the environment and human health. With a goal to reduce e-waste, this research promotes SDG 12: "Responsible Consumption and Production" by encouraging the use of sustainable electronics. This paper examines the factors impacting consumers' willingness to pay (WTP) for refurbished smartphones in the UK by analysing secondary data on eBay using ordinary least squares (OLS). It was found that WTP was higher in three situations: 1) when actual photos were used instead of stock photos, 2) when a longer warranty period was offered, and 3) when no descriptions were provided versus when negative descriptions were used. Further, consumers regard aesthetics as more important than functionality. These findings show that there is promising potential in the market for refurbished electronics, and ultimately, in promoting sustainability.

1. Introduction

Electronic waste, or e-waste, are electronic devices that are thrown away due to them being broken, no longer desired, or are at the end of their life cycle. E-waste includes large appliances as well as smaller electronic devices [1]. The amount of e-waste in 2023 was 61,300,000 metric tons. This colossal amount is expected to increase more than twenty percent by the year 2030 [2]. This is, undoubtedly, a worrying issue for the world population.

Why is this worrying, you may ask? E-waste is dangerous to human health because it contains arsenic, polyvinyl chloride (PVC), and cadmium [3]. Further, e-waste poses negative effects toward the environment through soil contamination, water pollution, and air pollution [4-5]. In recent years industries have started to focus on refurbishing as a way to curb e-waste problems [6].

Refurbishing electronics benefits the world population in many ways. There are economic benefits of refurbishing mobile phones, and there is a growing demand for such products [7]. Additionally, reusing a product rather than recycling it preserves its value better, lessens economic

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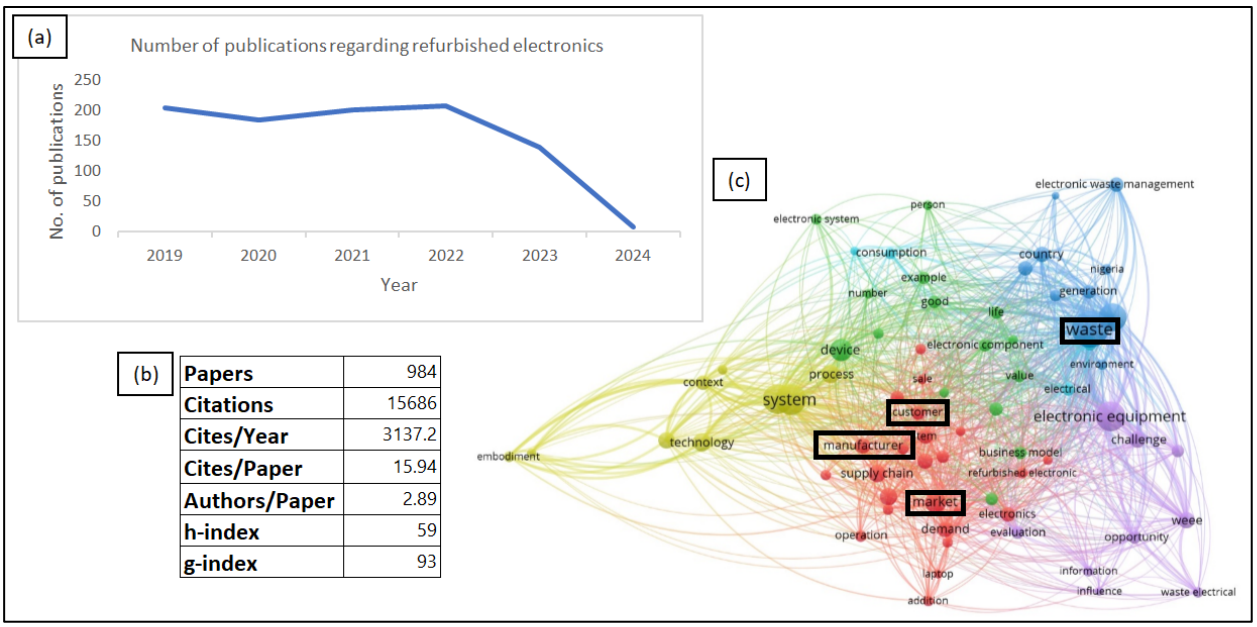
impacts, and lowers environmental impacts [8]. Refurbishing a product consumes less energy compared to producing new ones [9]. The importance of refurbishing (and therefore extending the life cycle) of products is further substantiated through the establishment of SDG 12: Responsible Consumption and Production [10].

In order to promote the refurbishing of products among businesses, this research looks at the consumers side and digs into their purchasing behaviors. This research attempts to add knowledge to existing studies about willingness to pay (WTP) for refurbished products by looking at factors affecting WTP. The objective of this research, therefore, is to examine the factors affecting WTP for refurbished iPhone 11 smartphones. Two hypotheses are developed: first, the use of stock photos has a negative impact on WTP for refurbished iPhone 11 smartphones as opposed to the use of actual photos, and second, the longer the length of warranty, the higher the level of WTP for refurbished iPhone 11 smartphones.

Previous authors on this topic have concluded their studies recommending further research about the topic [11] and have highlighted some research gaps: the way consumers perceive refurbished products, and their WTP for such products, are not yet fully understood [12]. Taking into account these research gaps, this research aims to improve the understanding of consumers' WTP for refurbished electronics by focusing on refurbished iPhone 11 smartphones listed on eBay (https://www.ebay.co.uk/). The novelty of this paper is such that it includes a bibliometric summary of refurbished electronics, and is the first paper to focus on WTP of refurbished iPhone 11 smartphones.

1.1 Literature Review

Figure 1 shows the bibliometric summary of refurbished electronics studies. Figure 1(a) shows the trend of research over the past five years, with Figure 1(b) summarising the publication data. There has been a lot of research about refurbished electronics, with the most prevalent keywords highlighted in Figure 1(c). Most common keywords include 'waste', 'customer', 'manufacturer', and 'market'. It is apparent that this is an increasingly important topic to be studied.



Papers	984
Citations	15686
Cites/Year	3137.2
Cites/Paper	15.94
Authors/Paper	2.89
h-index	59
g-index	93

Fig. 1. Bibliometric summary of refurbished electronic studies; (a) Number of publications from 2019-2024, (b) Publication data, (c): Bibliometric network of research keywords

1.1.1 Defining WTP and refurbishing

Willingness to pay, or WTP, is defined as the highest amount that a consumer is prepared to pay for a predefined amount of product or level of service [13]. WTP indicates the intrinsic value of a product in monetary terms [14].

Refurbishing is the act of fixing a used item and turning it into a near-new condition. It is defined as a manufacturing operation to recover the element of a product that is no longer functioning, and as a result reinstates the function of that product [15]. The process includes inspection, deconstruction, replacement of parts, cleaning, reconstruction, and final testing [16-19].

1.1.2 Firms practicing refurbishing

One of the firms that have successfully refurbished their own products is Alcatel-Lucent, with a goal to decrease the environmental impact of their products through reverse logistics. In the year 2008 they managed to keep equipment from filling up landfills by refurbishing and subsequently selling more than 600 metric tons of bays, panels, and circuit packs [20]. Apple and Huawei are also known to refurbish their own electronics by appointing authorized refurbishing firms such as Ifengpai for Apple products in certain areas and Aihuishou for Huawei products [21]. In other areas, Apple operates its own refurbishing services, and so does HP and Cisco. BestBuy is also known to operate its own refurbishing facilities for electronic products [22].

1.1.3 Factors affecting WTP for refurbished products

Literature has shown that there are several factors affecting WTP for refurbished products. One of the factors is product perception [11]. For example, consumers that assume there is a risk in terms of quality of refurbished products tend to move away from such products. One particular study researched 1716 iPod listings on eBay to find out what exactly differentiates the prices between three iPod conditions: used, refurbished, and new [12]. The research found that while consumers rely on positive descriptions when purchasing used iPods, they do not need reassurance of quality when it comes to refurbished iPods. It was also found that there is a wide range of prices of used iPods compared to refurbished iPods, insinuating that consumers regard all refurbished products to be of uniform quality. Additionally, while literature has assumed that refurbished products are affiliated with lower quality, consumers' perception of quality actually depend on information given by organizations throughout the supply chain. As such, the method of sharing information and the amount of such information are important aspects of attracting consumers toward refurbished products [23]. Similarly, other research has found that visual information about the products' previous usage resulted in negative perceptions towards refurbished products. In situations where there are no visual signs of wear and tear on the products, verbal information about the products' prior usage also resulted in negative perception of refurbished products [24].

Interestingly, one study found that product appearance is not an important aspect in consumers' purchasing decision with regards to refurbished products [25]. This is supported by other studies, which found that consumers value refurbished products through their functionality rather than their cosmetic condition [26], and that consumers feel that cosmetic condition of refurbished smartphones do not increase their willingness to purchase those products [27].

Another factor affecting WTP for refurbished products is consumer loss aversion [28], where it was found that consumers are willing to pay a higher price if it means they can lessen the risk of losses. Therefore, manufacturers of refurbished products impose higher prices when warranty is

included in the products. As a result, manufacturers earn more profit from warranties. The study concluded that in order to attract consumers and stimulate demand for refurbished products, warranty can be used as a marketing tool for manufacturers.

Product pricing also affects WTP for refurbished products. Given that refurbished products are cheaper than new products, consumers that are price-sensitive preferred refurbished products over their counterpart [29].

In another study, it was found that demographic variables had a large impact towards WTP for refurbished products in the Chinese market. Consumers in the older age group, consumers with higher education levels, and consumers with higher income were more inclined to purchase refurbished products compared to the opposite groups [11].

In the same study, it was found that individual subjective variables also affected WTP for refurbished products. For example, some consumers prefer older models of products and hence were willing to pay for refurbished products instead of new products. Additionally, consumers with a high level of environmental awareness had greater inclination toward purchasing refurbished products. One recommendation is that if there is no carbon tax constraint of refurbished products, consumers can be stimulated to use refurbished products [30].

Figure 2 summarizes the factors affecting WTP for refurbished products according to literature.

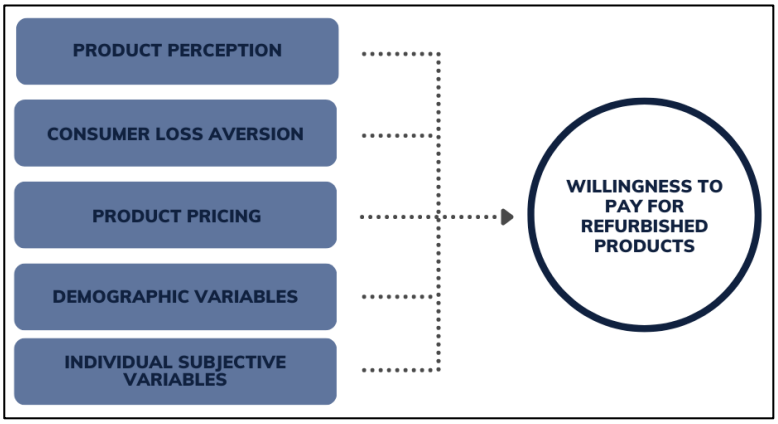


Fig. 2 Factors affecting WTP for refurbished products

1.1.4 Factors affecting online purchasing behaviors

When it comes to online purchasing, studies have found several factors that increase sales of products, one of which is the use of photos. Product photos play a role in influencing consumers' purchase decision [31] – the absence of a product's actual photo on its website resulted in a lessened willingness in purchasing the product [32]. In fact, sellers on social media platforms built trust by using actual photos of products rather than using stock photos. This resulted in them gaining more trust from consumers [33]. On the contrary, one study found that even though misleading photos were used in advertisements, there was an increased trust level among participants when advertisement was done by a microcelebrity. These studies show that while photos affect online purchasing behaviour the majority of the time, there are situations in which it is not the case [34].

Surprisingly, with regards to non-refurbished items, a study actually found that warranty did not have a positive impact towards consumers' online purchasing intentions. While other factors such as payment methods and good website useability affected purchasing intentions, they found that consumers did not care about warranty [35].

1.1.5 Literature review:Summarized

From literature, quite a lot of factors affect willingness to pay for refurbished products and online purchasing behaviours. The factors are contradictory, depending on the situation and the type of product. This study therefore aims to identify which factors are associated with the willingness to pay for refurbished iPhones through online purchase on eBay. This study focuses on three variables from this literature review. First, product perception, by looking at two things: the type of photos used which are either actual photos or stock photos, and the cosmetic grade based on the description in the listings. Second, consumer loss aversion, by looking at the length of warranty offered. Lastly, product pricing, which translates to the level of willingness to pay.

2. Methodology

Past research have used a few methods in determining WTP for refurbished products, such as studying completed auctions [36], questionnaires [11,37-39], and studying a combination of completed auctions and fixed price transactions on eBay [40]. This research adopts the method by Xu *et al.* (2017)[40], studying completed listings of auctions and fixed price transactions on eBay.

iPhone 12 was released on 23rd October 2020 [41], kicking off the sale of second-hand or used iPhone 11 smartphones on various online and offline platforms. Apple sold over 90.1 million iPhones globally during the last quarter of 2020 [42]. iPhones are suitable to be studied given that they are commonly sold in refurbished conditions. eBay is suitable to be used as a research tool because it allows users to view listings of items that have been sold, as well as filter listings according to product conditions.

A pilot study was carried out through an online poll on 18th May 2021 that was accessible for 24 hours. The question asked during the pilot study was “Would you buy refurbished electronics if there’s the same warranty as new products?”. 67% of respondents answered “Yes” and 33% answered “No” with a total of 18 respondents. When given the option to give a reason, one respondent said “With refurbished items, I feel that warranty does not mean that the item will not malfunction. It just means that I will not have to pay for the repairs. On the contrary, when purchasing a new item, I am confident that it will not malfunction within the warranted duration.” This perception that refurbished products have a higher probability of malfunctioning within the warranty duration conforms to previous studies which highlight the significance of product perception towards WTP of refurbished products [11].

Following the pilot study, an analysis was done on a larger number of data on eBay (https://www.ebay.co.uk/) to further investigate what affects WTP for refurbished products. This study focuses on the condition ‘seller refurbished’. The condition ‘certified refurbished’ were not studied as there were only 3 completed listings of that condition as of 8th June 2021. 242 listings of refurbished iPhone 11, iPhone 11 Pro, and iPhone 11 Pro Max on eBay that were marked as ‘sold’ were saved as single file web pages – these were the raw data for this study. The purchase of the listed items were completed between 10th May 2021 and 25th June 2021. The data were then scrutinised and only phones that were fully functioning were included; listings with descriptions such as “Face ID not working” or “mute button does not work” were excluded from this study. Further, only items located within United Kingdom, with visible sold prices, and where the network was unlocked were included so as to maintain a controlled environment. 201 listings remain after this scrutiny.

Variable data such as iPhone model, price, cosmetic condition, type of photos used, storage capacity and warranty were extracted manually from the listings and saved into an Excel file. Three

models of iPhone 11 were studied – iPhone 11, iPhone 11 Pro, and iPhone 11 Pro Max. As for the storage capacity, all four standard types were included, which were 64GB, 128GB, 256GB, and 512GB.

With regards to cosmetic condition, the listings were grouped into five categories according to the keywords used in the description. Where descriptions contained the words "pristine", "immaculate", "like new", "no scratches or marks", or "no signs of use", the items were graded as 'A+'. Where descriptions contained the words "minor cosmetic marks" or "minor marks that are only visible up close", the items were graded as 'A'. Where descriptions contained the words "moderate signs of wear and tear" or "some marks or scratches", the items were graded as 'B'. Where descriptions contained the words "significant or deep scuffs", "deep scratches", "dents", or "slight crack on screen", the items were graded as 'C'. Lastly, where there were no descriptions of cosmetic condition, the items were categorised as 'no description'.

Data from the Excel file were then copied and pasted into SPSS software. iPhone model, cosmetic grade, type of photos used and storage capacity were inserted as nominal variables in SPSS. They were then transformed into dummy variables with values of 0 and 1 indicating the absence or presence of each subset of the variable. Each subset was in a separate column – for example for type of photos used, there were two columns. Each column was either labelled 'actual photo' or 'stock photo'. If actual photos were used in a listing, the column 'actual photo' was marked with '1', otherwise it was marked with '0', and vice versa for all other columns with different subsets.

Price and warranty duration were inserted into SPSS as scale variables. Where a warranty duration was vaguely described, for example "less than four months", it was inserted in SPSS as three months warranty, and similarly for other vague warranty descriptions.

The dependent variable (price) was calculated as the total amount paid by the customer. This means that it can either be the price of the iPhone with free delivery, or the price of the iPhone plus delivery cost stated in the listings.

There were two major groups of independent variables in this study. The first group are things that sellers cannot necessarily change or fix without exceptional efforts, namely iPhone model, cosmetic condition and storage capacity. These are things that are a given; it is already widely understood that they affect the price of iPhones. The second group of independent variables are things that the sellers can control, which are type of photos used in the listings (actual versus stock photos), and length of warranty offered by the sellers. These are the variables that were studied in this research to prove that there are additional factors affecting WTP on top of the obvious factors of iPhone model, cosmetic condition, and storage capacity.

To test H1 "The use of stock photos has a negative impact on WTP for refurbished iPhone 11 smartphones as opposed to the use of actual photos" ordinary least squares (OLS) was used to find out the relationship between type of photos used and price paid. Similarly, to test H2 "The longer the length of warranty, the higher the level of WTP for refurbished iPhone 11 smartphones", OLS was used to find out the relationship between length of warranty offered and price paid. Both relationships were interpreted based on the Beta value computed by SPSS against all variables.

3. Empirical Results

Among the 201 listings studied, the basic model of iPhone 11 was most frequently purchased, making up more than twice the percentage of that of iPhone 11 Pro and iPhone 11 Pro Max combined, as seen in Table 1. Table 2 shows that in terms of cosmetic grade, most people purchased grade A iPhones, which were items described with "minor cosmetic marks" or "minor marks that are only visible up close". 4% of the listings did not contain any description of cosmetic condition. Referring to Table 3, all 201 listings contained photos, being either actual photos or stock photos.

More than half of the listings (122 listings) had actual photos, while only 79 listings had stock photos. When it came to storage capacity, most people purchased iPhones with a storage capacity of 64GB, while the least number of people purchased iPhones with a 512GB storage capacity, as seen in Table 4. Shown in Figure 3, the price paid for iPhones varied between £154.85 and £799.00. The mean price was £454.03, while the mode price was £350.00. The majority of iPhones purchased did not come with warranty. Where warranty was offered, it varied between one month and thirteen months, with twelve months being the most frequent length of warranty offered, as depicted in Figure 4.

Table 1
Frequency of listings according to iPhone model

iPhone Model	Frequency	Percent	Valid Percent	Cumulative Percent
iPhone 11	104	51.7	51.7	51.7
iPhone 11 Pro	53	26.4	26.4	78.1
iPhone 11 Pro Max	44	21.9	21.9	100.0
Total	201	100.0	100.0	

Table 2
Frequency of listings according to cosmetic grade

Cosmetic Grade	Frequency	Percent	Valid Percent	Cumulative Percent
A	87	43.3	43.3	43.3
A+	48	23.9	23.9	67.2
B	23	11.4	11.4	78.6
C	35	17.4	17.4	96.0
No description	8	4.0	4.0	100.0
Total	201	100.0	100.0	

Table 3
Frequency of listings according to type of photo used

Type of Photo	Frequency	Percent	Valid Percent	Cumulative Percent
Actual Photo	122	60.7	60.7	60.7
Stock Photo	79	39.3	39.3	100.0
Total	201	100.0	100.0	

Table 4
Frequency of listings according to storage capacity

Storage capacity	Frequency	Percent	Valid Percent	Cumulative Percent
128GB	17	8.5	8.5	8.5
256GB	48	23.9	23.9	32.3
512GB	3	1.5	1.5	33.8
64GB	133	66.2	66.2	100.0
Total	201	100.0	100.0	

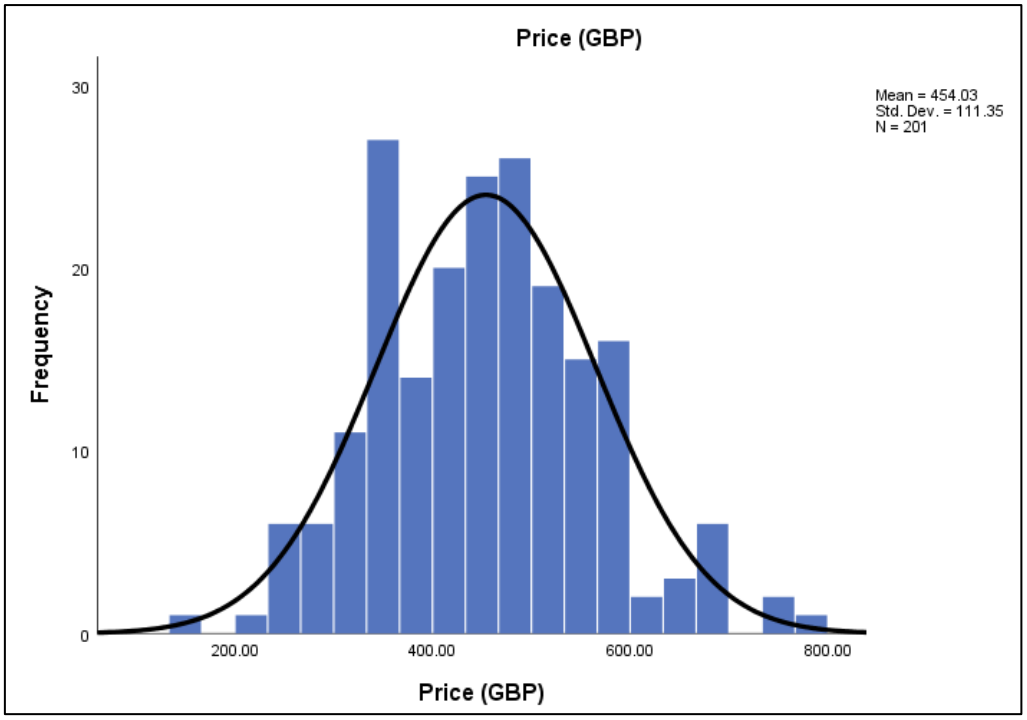


Fig. 3 Distribution of iPhone prices

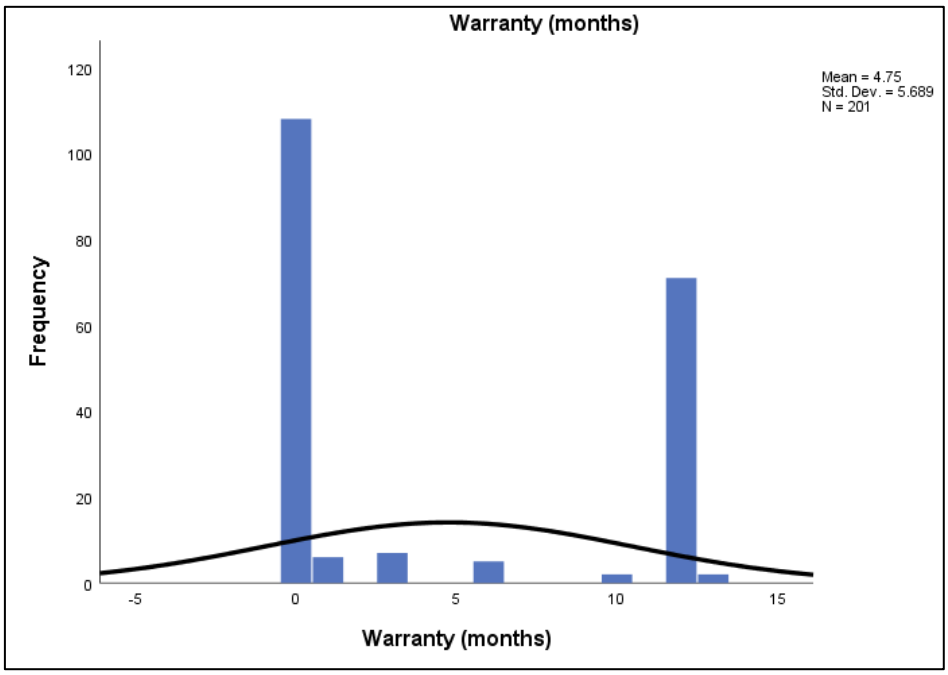


Fig. 4 Distribution of length of warranty offered

The result of regression analysis is shown in Table 5 below. iPhone model, cosmetic grade, type of photos and storage capacity are dummy variables, with the base for reference being iPhone 11, grade A, actual photo, and 256GB storage capacity respectively. As they are the reference level, they are not shown by SPSS in the table.

The Beta values show that there is a relationship between the dependent variable and all the independent variables studied. Therefore the objective of this research "to examine the factors

affecting WTP for refurbished iPhone 11 smartphones" is achieved, where the factors are warranty, iPhone model, cosmetic grade, type of photo used, and storage capacity.

Variables such as iPhone model, cosmetic grade, and storage capacity are intuitive and simply logical. iPhone 11 Pro and iPhone 11 Pro Max yields higher levels of WTP compared to iPhone 11. The better the cosmetic grade, the higher the levels of WTP as well. Similarly, the bigger the storage capacity, the higher the levels of WTP. These results are not surprising and could generally be estimated.

The Beta value for 'Photo=stock' is -39.207. This means that when an actual photo is not used, the mean price for iPhones decreases by 39.207 (£39.21). In other words, the mean price for iPhones, *ceteris paribus*, decreases by £39.21 when stock photos are used as opposed to actual photos. This supports H1 "The use of stock photos has a negative impact on WTP for refurbished iPhone 11 smartphones as opposed to the use of actual photos." This means that people are less inclined to pay a high price for refurbished iPhones when stock photos are used in the listings.

The Beta value for 'Warranty (months)' is 11.182. This means that the price for iPhones, *ceteris paribus*, increases by £11.18 for every months' increase in warranty. This supports H2 "The longer the length of warranty, the higher the level of WTP for refurbished iPhone 11 smartphones." In other words, people are more inclined to pay a high price for refurbished iPhones if a longer warranty duration is offered.

Table 5
Results of regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	400.990	11.990		33.443	.000
	Warranty (months)	11.182	1.465	.571	7.633	.000
	Model=iPhone 11 Pro	110.164	9.640	.437	11.428	.000
	Model=iPhone 11 Pro Max	152.648	11.000	.568	13.877	.000
	Grade=A+	27.856	10.297	.107	2.705	.007
	Grade=B	-40.234	12.785	-.115	-3.147	.002
	Grade=C	-69.318	11.019	-.237	-6.291	.000
	Grade=No description	17.779	21.031	.031	.845	.399
	Photo=Stock	-39.207	16.447	-.172	-2.384	.018
	Storage=128GB	6.539	17.146	.016	.381	.703
	Storage=512GB	-91.054	31.854	-.099	-2.858	.005
	Storage=64GB	-55.952	9.748	-.238	-5.740	.000

a. Dependent Variable: Price (GBP)

3.1 Discussions

These results are important from many aspects. Looking at the relationship between type of photos and WTP, a recommendation can be made to online sellers of refurbished iPhones, and possibly other refurbished products. This research has shown that consumers' level of WTP declines when stock photos are used in the listings. In other words, consumers are willing to pay more when they can see the actual product in the photos. This is supported by previous studies which state that one of the ways online sellers build trust among consumers is by using actual photos rather than stock photos [33], even if some situations prove otherwise [34]. Therefore, one recommendation is for sellers to go the extra mile by taking photos of the actual product and using those photos rather than recycling the same stock photo for all their listings.

As for the relationship between warranty and WTP, a recommended action for sellers is to offer warranty with every refurbished iPhone being sold. As seen in this research, offering warranty allows sellers to sell refurbished iPhones at a higher price. If offering one month of warranty can increase iPhone prices by £11.18, offering 12 months of warranty can hike up the price by £134.18. In fact, other studies suggest that sellers can earn profit by marking up prices by offering warranties for refurbished products [28].

Surprisingly, the Beta value for 'Grade=No description' is higher than the Beta values for 'Grade=B' and 'Grade=C'. This shows that when cosmetic flaws are mentioned in the description, people are willing to pay less for refurbished iPhones compared to when there are no descriptions of cosmetic condition at all. This agrees with prior research which concludes that information about the products' prior usage resulted in negative perception of refurbished products [24]. This opens up the idea that ignorance of consumers results in higher WTP. As the old saying goes, "ignorance is bliss". Perhaps future research can be done focusing on the effect of negative descriptions on WTP for refurbished iPhones compared to neutral descriptions or lack of descriptions to further strengthen this analysis. Sellers may find this information useful when they are describing product conditions in future listings.

Another surprising find is that cosmetic condition has a higher impact on WTP compared to storage capacity. As seen in Table 5, a bigger storage capacity does not necessarily result in higher WTP, as previously thought. The Beta value for 'Storage=512GB' is -91.054. On the other hand, the Beta value for 'Grade=A+' is 27.856. Even the lowest grade, 'Grade=C' has a Beta value that is much higher than that of 'Storage=512GB'. This goes against past research which found that cosmetic condition of refurbished products is not as important as functionality [25-26]. This reveals new areas for research: Do consumers value cosmetic condition over functionality when it comes to refurbished iPhones? Is a storage capacity of 512GB not a necessity or natural choice for consumers? One recommendation is for manufacturers to produce more durable iPhones that will not easily show signs of use. On top of that, refurbishing firms can now see that changing the outer parts of iPhones so that it looks new will yield higher levels of WTP.

3.2 Future Work

There were a range of variables in this research – three models of iPhones, four types of storage capacity, and five categories of cosmetic grade. A more accurate analysis result could be achieved if a similar sample size was maintained but with a smaller range of variables, for example focusing on only one iPhone model and/or one type of storage capacity and/or one category of cosmetic grade. There is a possibility that the analysis could result in a stronger or weaker relationship between the dependent variable and independent variable in that case. One recommendation for future research is to have fewer subsets of variables.

There is also the possibility of sellers using certain keywords but wanting to portray something else. One seller's use of "very good" could easily be another seller's "like new", since cosmetic condition is a subjective thing and cannot simply be quantified or statistically measured. One recommendation for future research is to find a way to ascertain the true meaning of these descriptions, for example by comparing product photos and their descriptions.

A larger sample size could result in more reliable and valid results. Therefore it is recommended that future researchers gather larger amounts of data for analysis.

4. Conclusions

This research found that firstly, the factors affecting WTP for refurbished iPhones are warranty, iPhone model, cosmetic grade, type of photo used, and storage capacity. Secondly, consumers were more inclined to purchase refurbished iPhones when actual photos were used in eBay listings as opposed to stock photos. Thirdly, warranty plays an important role in increasing the levels of WTP for refurbished iPhones.

Unexpectedly, this research also found that when listings did not describe the cosmetic condition of an iPhone, it yielded a higher level of WTP compared to when listings negatively described the cosmetic condition. Another unexpected find was that cosmetic condition played a bigger role in affecting WTP compared to storage capacity.

This research adds knowledge to existing studies to improve the understanding of consumers' willingness to pay for refurbished products. In terms of practical importance, this research will educate manufacturers and retailers on how to market refurbished products through correct techniques of information-sharing with consumers, i.e. through the use of actual photos and the use of correct lingo. For example, a lot of sellers on eBay use the same keywords when describing a certain cosmetic condition. Therefore one recommendation is for sellers to study the correct lingo for each online platform to ensure that their description is widely accepted and understood by the consumers of that platform. This is to prevent misrepresentation, for example some sellers state the condition as 'excellent' while others use 'pristine' even though they both intend to portray that the phone has no scratches and looks like new.

Additionally, while it was not studied in this research, it was observed that the majority of listings included battery health of iPhones, and that a higher level of battery health did not always mean a higher level of WTP. This can be studied in future research to determine consumers' perception of functionality versus cosmetic condition.

Hopefully, this research will result in used electronics being sold in refurbished conditions instead of filling up landfills and polluting the air and water, and that it encourages manufacturers to adopt closed-loop manufacturing as a more sustainable production system. As strongly promoted by previous researchers, both the economy and the environment are critical stakeholders in making the world a better place for both consumers and producers [43]. The fact that consumers these days are well-informed about environmental impacts sheds a positive light on the move towards a greener supply chain [44].

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